

Graduate School of Business

**A Study on the Adoption and Diffusion of Information and
Communication Technologies in the Banking Industry in Thailand
Using Multiple-Criteria Decision Making and System Dynamics
Approaches**

Arunee Intrapairot

**“This thesis is presented as part of the requirements for
the award of the Degree of Doctor of Philosophy
of the
Curtin University of Technology”**

August 2000

TABLE OF CONTENTS

	page
TABLE OF CONTENTS	ii
LIST OF TABLES	xii
LIST OF FIGURES	xiv
LIST OF APPENDICES	xviii
ABSTRACT	xix
ACKNOWLEDGEMENTS	xxi
CHAPTER 1: INTRODUCTION AND OVERVIEW	1
1.1 Introduction.....	1
1.2 Objectives and Research Questions	4
1.3 Significance and Contributions.....	5
1.4 Contents of the Dissertation.....	7
1.5 Summary.....	10
CHAPTER 2: TECHNOLOGY ADOPTION AND DIFFUSION	11
2.1 Introduction.....	11
2.2 Information and Communication Technologies (ICT)	13
2.3 Technology Adoption and Diffusion	15
2.4 Banking Technologies	17
2.4.1 Smart Cards.....	19
2.4.2 Data Warehouse	22
2.4.3 Video Conferencing	25
2.4.4 Home Banking Services (Internet/ Extranet Banking)	28
2.4.5 Electronic Fund Transfer at Point of Sales (EFTPOS)	31
2.5 Summary.....	35

CHAPTER 3: DECISION-MAKING ISSUES.....	37
3.1 Introduction.....	37
3.2 Decision-making.....	38
3.2.1 Group Decision-Making	40
3.2.2 Decision-Making Model	41
3.3 Multiple Criteria Decision-Making (MCDM)	43
3.3.1 Definition	43
3.3.2 MCDM in this Study.....	45
3.3.3 MCDM Software Application in this Study	46
3.4 System Dynamics (SD).....	47
3.4.1 Definition	47
3.4.2 Systems	49
3.4.3 Simulation Model.....	50
3.4.4 Qualitative and Quantitative System Dynamics	52
3.4.5 System Dynamics Conceptual Framework.....	53
3.4.5.1 Process Structure	53
3.4.5.2 Information Feedback.....	54
3.4.5.3 Delay.....	55
3.4.5.4 Organisational Boundaries	55
3.4.5.5 Policies	55
3.4.6 Model Construction.....	56
3.4.6.1 Feedback Loop Approach.....	56
3.4.6.2 Modular Approach.....	57
3.4.7 SD Software Application	58
3.5 Summary	58

CHAPTER 4: LITERATURE REVIEW.....	60
4.1 Introduction.....	60
4.2 Technology Adoption and Diffusion	60
4.2.1 Problems regarding Technology Adoption and Diffusion.....	62
4.2.2 Factors Driving Technology Adoption and Diffusion	67
4.2.3 Adoption and Diffusion Models	72
4.3 Banking Technology.....	74
4.4 Group Support Systems	77
4.5 Multiple Criteria Decision-Making (MCDM)	79
4.5.1 Multiple Criteria Decision-making (MCDM) in.....	82
Group Environments	
4.6 System Dynamics (SD).....	85
4.6.1 System Dynamics (SD) in Group Environments	88
4.6.2 System Dynamics and Technological Issues	93
4.7 Summary	94
CHAPTER 5: RESEARCH METHODOLOGY.....	98
 AND RESEARCH DESIGN	
5.1 Introduction.....	98
5.2 Research Methodologies.....	100
5.2.1 System Development Research.....	102
5.2.2 Case Study.....	102
5.2.3 Research Methodologies in this Study.....	103
5.3 Research Design.....	104
5.3.1 Research Design Framework	105
5.3.2 Method of Data Collection.....	108
5.3.2.1 Observations	108
5.3.2.2 Interviews	108

5.3.2.3	Questionnaires	109
5.3.2.4	Documents.....	110
5.3.3	Data Analyses	112
5.3.4	Testing the Validity.....	113
5.3.5	Data Collection in Practice	118
5.3.5.1	Conceptual Phase.....	118
5.3.5.2	Field Work.....	119
5.3.5.3	Model Validation Stage.....	125
5.4	Practical Problems of Data Collection.....	125
5.5	Summary	127
 CHAPTER 6: CASE DESCRIPTION.....		129
6.1	Introduction.....	129
6.2	Thai Economy.....	129
6.3	Thai Commercial Banks	133
6.3.1	Historical Background	133
6.3.2	Banking under the Economic Crisis.....	134
6.4	Banking Technologies in Thailand	135
6.5	The Siam Commercial Bank, PCL	136
6.5.1	Vision.....	137
6.5.2	The Main Objectives.....	137
6.6	Current Status of Information and Communication Technologies (ICT):.....	138
	Research Question 1	
6.6.1	Main Purposes for Technology Use.....	138
6.6.2	Decision-Making Process	139
6.6.3	Problem Description	141
6.6.4	Technological Development	145

6.6.4.1	Technological Development Plan I	146
6.6.4.2	Technological Development Plan II	147
6.6.5	Obstacles in Using and Learning Technology	151
6.6.6	Supportive Factors in Learning and Using Technology	153
6.7	Summary	156

CHAPTER 7: TECHNOLOGY ADOPTION AT SCB USING 158
MULTIPLE CRITERIA DECISION-MAKING
(MCDM)

7.1	Introduction.....	158
7.2	Method of Data Collection.....	159
7.3	Decision-Making Based on Intuitive Judgement.....	161
7.4	Decision-Making Based on MCDM.....	162
7.4.1	Structuring a Problem	162
7.4.2	Eliciting Information and Values.....	167
7.4.2.1	Weighting.....	167
7.4.2.2	Scoring.....	169
7.4.3	Evaluation and Sensitivity Analysis	169
7.4.3.1	MCDM Analysis Based on Real Scale.....	170
7.4.3.2	MCDM Analysis Based on Local Scale.....	171
7.5	Intuition versus MCDM Analysis.....	173
7.5.1	Result Discussion.....	174
7.6	Requisite Group Model of ICT Adoption: Research Question 2.....	177
7.7	Summary.....	179

CHAPTER 8: GENERAL MODEL OF THE DIFFUSION OF	182
INFORMATION AND COMMUNICATION	
TECHNOLOGIES (ICT) USING SYSTEM DYNAMICS	
8.1 Introduction.....	182
8.2 A Model of ICT Diffusion based on Qualitative System Dynamics	183
8.2.1 Problem Description	184
8.2.2 Actors, Goals and Decisions	184
8.2.3 Process Structure of the SCB.....	187
8.2.4 Organisational Boundaries.....	190
8.2.5 Feedback Loops	192
8.3 A Model of ICT Diffusion Based on Quantitative System	203
Dynamics Approach	
8.3.1 List of Variables of ICT.....	204
8.3.2 A Baseline Model of ICT Diffusion	206
8.3.3 The Impact of “Training Support” on Technology Diffusion.....	210
8.3.4 The Impact of “Backlog of Problems” on Technology Diffusion	212
8.3.5 The Impact of “Potential Market” on Technology Diffusion	214
8.3.6 The Effect of “Investment in New Technology” on	215
“Economic Returns on Investment”	
8.3.7 “Economic Gains” for “Investment in New Technology”.....	217
8.4 Model Validation	218
8.4.1 Structure Validity Tests	220
8.4.2 Behaviour Validity Tests	223
8.4.3 Policy Implication Tests.....	225
8.5 Requisite Group Model of ICT Diffusion, and Requisite Policies	227
for Adoption and Diffusion: Research Questions 3 and 4	
8.6 Summary.....	228

CHAPTER 9: ANALYSIS I: DIFFUSION OF	230
A DATA WAREHOUSE AT SCB	
9.1 Introduction.....	230
9.2 Methods of Data Collection.....	232
9.3 General Background	233
9.3.1 Clients of Data Warehouse	236
9.3.1.1 Prospective Clients	236
9.3.1.2 Current Clients.....	239
9.3.2 Level of Actual Performance of Data Warehouse	239
9.3.3 Relative Advantages from Data Warehouse	241
9.3.4 Problems in Using Data Warehouse	243
9.4 Model Analysis Using Qualitative System Dynamics Approach.....	244
9.4.1 Basic Concept	244
9.4.2 Present State of Data Warehouse.....	245
9.4.3 Identified Constraints of Data Warehouse Diffusion.....	248
9.4.4 Redesign of Strategic Policies.....	249
9.5 Model Analysis Using Quantitative System Dynamics Approach.....	253
9.5.1 List of Variables of Data Warehouse.....	254
9.5.2 Model Analysis 1: A Price-Less Model.....	255
9.5.3 Sensitivity Analysis	261
9.5.4 Model Analysis 2: An Estimated Price Model.....	267
9.6 Policy Analysis	273
9.6.1 Using DSS for Strategic for Policy Analysis.....	278
9.7 Model Validation.....	282
9.8 Requisite Group Model of Diffusion of Data Warehouse,	285
and Requisite Policies for Adoption and Diffusion:	
Research Questions 3 and 4	
9.9 Summary	286

CHAPTER 10: ANALYSIS II: DIFFUSION OF EXTRANET.....	288
BANKING AT SCB	
10.1 Introduction.....	288
10.2 Methods of Data Collection.....	289
10.3 General Background	290
10.4 Model Analysis Using Qualitative System Dynamics Approach.....	296
10.4.1 Influence Diagram.....	298
10.5 Model Analysis Using Quantitative System Dynamics Approach.....	300
10.5.1 List of Variables of Extranet Banking	300
10.5.2 Model Analysis	302
10.5.2.1 Base Run 1: Using a Diffusion Target	304
10.5.2.2 Base Run 2: Using a Growth Rate of Diffusion	305
10.5.2.3 Base Run 3: Adding Training.....	305
10.5.2.4 Base Run 4: Adding a Backlog of Problems.....	305
10.6 Policy Analysis for Extranet Banking.....	308
10.7 Model Validation	315
10.8 Requisite Group Model of Diffusion of Extranet Banking,.....	317
and Requisite Policies for Adoption and Diffusion:	
Research Questions 3 and 4	
10.9 Summary.....	318
CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS	320
FOR FUTURE RESEARCH	
11.1 Introduction.....	320
11.2 Using ICT as a Lever for Competitive Advantage:	320
Research Question 5	
11.2.1 Technology Usage in the Large Banks	321
11.2.2 Technology Usage in the Middle-Sized Banks.....	325

11.2.3	Technology Usage in Small Banks	325
11.2.4	Technology Usage in Branches of Foreign Banks.....	326
11.3	Summary.....	327
11.4	Major Findings.....	328
11.4.1	Current Status of ICT Usage in.....	329
	the Siam Commercial Bank PCL (Research Question 1)	
11.4.2	A Requisite Group Model of ICT Adoption.....	329
	(Research Question 2)	
11.4.3	A Requisite Group Model of ICT Diffusion.....	330
	(Research Question 3)	
11.4.3.1	A Model of Diffusion of Information and.....	331
	Communication Technologies (ICT)	
11.4.3.2	A Model of Diffusion of a Data Warehouse (DW)	332
11.4.3.3	A Model of Diffusion of Extranet Banking.....	333
11.4.4	The Requisite Policies for Adoption and.....	334
	Diffusion of ICT for the Bank (Research Question 4)	
11.4.5	Using Information and Communication Technologies.....	335
	as a Lever of Competitive Advantage for the Banking Industry in Thailand (Research Question 5)	
11.5	Implication for the Models of ICT Adoption and Diffusion.....	335
11.5.1	Implication for the Bank	335
11.5.1.1	Using MCDM as a Decision-Making Tool	335
11.5.1.2	Using System Dynamics as a Decision-Making Tool.....	336
11.5.1.3	Recommendations based on the Proposed.....	336
	Model of ICT Diffusion	
11.5.1.4	Recommendations based on the Model of.....	337
	Diffusion of Data Warehouse	
11.5.1.5	Recommendation based on the Model of.....	337
	Diffusion of Extranet Banking	

11.5.1.6 Downsizing Business Performance	338
11.5.2 Implication for Policy Makers	338
11.6 Study Limitations.....	339
11.7 Future Research	341
11.8 Conclusion	343
REFERENCES	345
APPENDICES	374

LIST OF TABLES

		page
Table 2.1	Technology Component Life Cycles	13
Table 2.2	Technology Alternatives based on SWOT Analysis.....	33
Table 3.1	Phases of Decision-Making	39
Table 3.2	Major Group Dynamics Threatening Effective Decision-Making	41
Table 3.3	Types of Problems and Appropriate Decision-Modelling	43
	Technique	
Table 3.4	Qualitative and Quantitative System Dynamics	52
Table 5.1	Research Methodologies in the Context of the Positivist	101
	and Interpretivist Paradigms.	
Table 5.2	Limitations of Each Method of Data Collection.....	111
Table 5.3	Core Confidence-Building Tests.....	116
Table 5.4	Data Collection	121
Table 6.1	Thailand’s Macroeconomic Framework	131
Table 6.2	The Siam Commercial Bank Public Company Limited	137
	Highlights	
Table 6.3	Level of Seriousness of Technological Problems	142
Table 6.4	SCB Information Technology Development Stages.....	148
Table 6.5	The Siam Commercial Bank’s Technologies.....	149
Table 6.6	The Siam Commercial Bank’s IT Applications.....	150
Table 6.7	Obstacles in Using and Learning Technology	151
Table 6.8	Supportive Factors in Learning and Using Technology	154
Table 7.1	Data Collection for Technology Adoption Model	160
Table 7.2	Level of Importance of Technologies in Fulfilling	161
	the Bank’s Mission.	

Table 7.3	Level of Importance Criteria in Selecting Technologies	168
Table 7.4	Example of Criteria Scoring	169
Table 7.5	Example of Converting Real Scales to Local Scales	172
Table 7.6	Technology Rank	174
Table 8.1	Actors, Goals and Decisions	185
Table 8.2	The SCB Process Structure	188
Table 8.3	Lists of Variables of ICT	205
Table 9.1	Data Collection	232
Table 9.2	Level of Actual Performance of Banking Technologies.....	237
Table 9.3.	Level of Actual Performance of Data Warehouse	240
Table 9.4.	Relative Advantages from a Data Warehouse	242
Table 9.5.	Lists of Data Warehouse Variables.....	254
Table 9.6.	List of Strategic Policies of Data Warehouse	275
Table 9.7	Comparison of the Impacts from Exerting Strategic Policies.....	276
Table 10.1	Data Collection	290
Table 10.2	Numbers of Business Transactions with a Bank per Month.....	291
Table 10.3	Methods of Business Transaction with a Bank	292
Table 10.4	Plan to Use Internet/Extranet Banking in the Future	293
Table 10.5	Reasons for Not Using Internet/Extranet Banking	294
	by Prospective Customers	
Table 10.6	Lists of Variables of Extranet Banking (EB)	301
Table 10.7	Comparison of Simulation Results using an	304
	Incremental Approach	
Table 10.8	List of Strategic Policies of Extranet Banking.....	310
Table 10.9	Comparison of the Impacts of Exerting Strategic Policies	311

LIST OF FIGURES

	page
Figure 1.1 Organisation of the Thesis	7
Figure 3.1 Influence Diagram and Corresponding Diagram using <i>ithink</i> Software	54
Figure 5.1 A Framework of Research	99
Figure 5.2 Research Methodologies	103
Figure 5.3 A Research Design Framework	105
Figure 5.4 Selected Tests of Formal Model Validation	117
Figure 6.1 Comparison of Obstacles in Learning and Using Technology between Staff at the Main office and those at the Branches	153
Figure 6.2 Comparison of Supportive Factors in Learning and Using Technology between Staff from Main Office and those from Branches	155
Figure 7.1 Level of Importance of Technologies in Fulfilling the Bank's Mission according to Intuitive Decisions	162
Figure 7.2 Criteria for Technology Adoption.....	165
Figure 7.3 Criteria Hierarchy for Technology Adoption.....	166
Figure 7.4 Evaluation of Technological Alternatives Based on Real Scales	170
Figure 7.5 Evaluation of Technological Alternatives Based on Local Scales ...	173
Figure 7.6 Technological Evaluation Based on Customer Behaviour	176
Figure 8.1 The SCB Technology Group.....	186
Figure 8.2 Organisational Boundaries	191
Figure 8.3 Variables of Diffusion of Information and Communication Technologies (ICT) from Literature	193
Figure 8.4 The Influence Diagram of the Information and Communication Technologies (ICT) Diffusion Model	195
Figure 8.5 ICT Requirement (Negative Feedback Loop A).....	196

Figure 8.6	Relative Advantages and Customer Satisfaction 197 (Positive Feedback Loops B1 and B2)	197
Figure 8.7	Costs (Negative Feedback Loop C) 198	198
Figure 8.8	Training (Negative Feedback Loops E and F) 199	199
Figure 8.9	Training Costs (Negative Feedback Loop G) 199	199
Figure 8.10	A Backlog of Problems 200 (Negative Feedback Loops H1 and H2)	200
Figure 8.11	Impacts from a Backlog of Problems 201 (Negative Feedback Loops I1 and I2)	201
Figure 8.12	Total Costs (Negative Feedback Loop J) 202	202
Figure 8.13	Potential Market (Negative Feedback Loop K) 203	203
Figure 8.14	Technological Investment and Profits 203 (Negative Feedback Loop L)	203
Figure 8.15	A Baseline Model of ICT diffusion 206	206
Figure 8.16	A Baseline Model of ICT Diffusion 209 (Feedback Loops A, B1, B2, and C)	209
Figure 8.17	Impacts of Training Support on Technology Diffusion 211	211
Figure 8.18	Impacts of a Backlog of Problems on Technology Diffusion 213	213
Figure 8.19	Impacts of Market Potential on Sales 215	215
Figure 8.20	Impacts on Profits of Investment in Technology 217	217
Figure 8.21	Extreme Test of the Impact of a Backlog of 221 Problems on Diffused Technology	221
Figure 8.22	Behaviour Sensitivity Test: Impacts of Level of 224 Innovativeness on Profits	224
Figure 8.23	Behaviour Anomaly Test: Impacts of 225 Level of Innovativeness on Profits	225
Figure 8.24	Policy Sensitivity Test: Percentage of 226 Resolved Problems on Profits	226

Figure 9.1	Conceptual IT Structure of the Siam Commercial Bank	234
Figure 9.2	Level of Actual Performance of Banking Technologies.....	238
Figure 9.3	Level of Actual Performance of Data Warehouse	241
Figure 9.4	Relative Advantages from Data Warehouse	243
Figure 9.5	The Basic Conceptual Model of Data Warehouse	245
Figure 9.6	Conceptual Model: The Present State of..... Data Warehouse (DW)	246
Figure 9.7	Conceptual Model: The Constraints of..... Data Warehouse (DW)	248
Figure 9.8	Redesigned Strategic Policies of Data Warehouse	252
Figure 9.9	Influence Diagram of a Price-less Model	257
Figure 9.10	Simulation Model of the Price-less Model	258
Figure 9.11	Diffused Data Warehouse from the Price-less Model	260
Figure 9.12	Comparison of Diffused Data Warehouse using..... Different Training Delays	262
Figure 9.13	Comparison of Diffused Data Warehouse using..... Different Percentage of the Backlog of Problems	263
Figure 9.14	Comparison of Diffused Data Warehouse using..... Different Resolution of Problems	265
Figure 9.15	Comparison of Diffused Data Warehouse using..... Different Percentages of Technology Abandonment	266
Figure 9.16	Comparison of the Estimated Price Model	268
Figure 9.17	Comparison of Economic Gains from	269
	the Estimated Price Model	
Figure 9.18	Simulation Model of Investment in Technology and..... Economic Gains	272
Figure 9.19	Impacts on Economic gains of Investment in Data Warehouse.....	273
Figure 9.20	Comparison of Diffused Data Warehouse among	277
	Different Policies	

Figure 9.21	Comparison of Economic Gains among Different Policies	277
Figure 9.22	User Interfaces of System Dynamics Based Decision Support System	281
Figure 9. 23	Impacts on Economic gains of Investment in Data Warehouse.....	284
Figure 10.1	The Influence Diagram of Extranet Banking	297
Figure 10.2	Comparison of the Rate of Technology Diffusion and Diffused Extranet Banking between Different Scenarios	307
Figure 10.3	Comparison of Rate of Technology Diffusion from..... Different Policies	312
Figure 10.4	Comparison of Diffused Extranet Banking from Different Policies	312
Figure 10.5	Comparison among Profits from Different Policies	314

LIST OF APPENDICES

	page
Appendix 5.1	Banking Technologies374
Appendix 5.2	Evaluation of Banking Technologies377
Appendix 5.3	Data Warehouse (DW).....381
Appendix 5.4	Technology and Bank Staff385
Appendix 5.5	Data Warehouse Users386
Appendix 5.6	Prospective Customers of Internet/Extranet Banking387
Appendix 5.7	Policy Analysis388
Appendix 7.1	Variables of Technology adoption.....390
Appendix 8.1	Variables of Technology Diffusion395
Appendix 8.2	Model of Diffusion of Information and402 Communication Technologies (ICT)
Appendix 9.1	Technology Diffusion of a Data Warehouse:409 The Price-less Model
Appendix 9.2	Technology Diffusion of a Data Warehouse:413 The Estimated Price Model
Appendix 10.1	Model of Diffusion of Extranet Banking421

ABSTRACT

The main objective of this study is to develop requisite models for information and communication technology (ICT) adoption and diffusion in the banking industry in Thailand. The research, combining two study areas of multiple criteria decision-making (MCDM) and system dynamics (SD), is conducted using two research methodologies: system development and a case study of the Siam Commercial Bank PCL in Thailand.

The study shows how to combine the two decision-making tools of MCDM and system dynamics effectively. The requisite group models of ICT adoption and diffusion provide ways to select the most preferred technology and to allow forward planning to diffuse the adopted technology more effectively. With an embedded decision support tool, decision-makers are able to apply the models with their available information, intuition, knowledge, and experience to improve their decision-making and enhance their learning.

Initially, the research revealed that the Siam Commercial Bank currently employs various types of information and communication technologies (ICT) to facilitate work processes, fulfil customers' requirements, and retain its competitive advantage. However, the bank still confronts problems relating to technology adoption and diffusion.

A requisite group model of ICT adoption was developed using MCDM as a decision-making tool. The model illustrated how to select the most preferable technological alternative that fulfilled the mission of the bank. Results from the MCDM analysis revealed that the preferred technology was Extranet banking followed by a data warehouse. The requisite group model of ICT diffusion was further developed using the system dynamics approach in order to enhance understanding of system behaviour of the selected technology and then provide ways to diffuse it more effectively. The model analyses were divided into three sub-models of information and communication technologies (ICT), a data warehouse, and Extranet banking.

The generic model of ICT can be applied to any particular technology. Results revealed that the pattern of technology diffusion follows the S curve and the dominant variables that may impact on technology diffusion are training, a backlog of problems, and market potential. Furthermore economic returns are obtained only after spending substantially on technological investment. Thus, it is necessary to balance between technological investment and economic returns. The model of diffusion of a data warehouse was developed highlighting the necessity of quality and quantity of knowledge workers. Therefore, training support is an important factor to diffuse this technology. On the other hand, the model of diffusion of Extranet banking revealed that the success of this technology comes from the acceptance by customers. Thus, perceived relative advantages, positive features of the technology and promotional advertising should be taken into consideration. The S curve pattern of technology diffusion is also confirmed by the two technologies.

The policy for technology adoption involves the selection of technology, which best fits with identified criteria. The policy analyses of the three technologies confirm that the core important policies that increase technology diffusion and economic gains are *increasing positive features of technology, decreasing perceived complexity, increased perceived relative advantages and increasing co-operation between IT people and users*. If technology is to support the work performance in an organisation, *training support* is the dominant policy, whereas if technology facilitates customers directly, marketing strategy such as *promotional advertising* is vital.

The study implied that the banking industry in Thailand is able to use ICT as levers for competitive advantage. However, technological investment in each bank differs depending on size, objectives and readiness in terms of capital and human resources.

All the findings have implications for the bank and could be applied to other banks and general policy makers in various business enterprises.

ACKNOWLEDGMENTS

This dissertation was conducted as part of the requirements for the degree of doctor of philosophy, in management information systems, at the Graduate School of Business, Curtin University of Technology, Perth, Western Australia. The research was successfully completed with the support of a number of people and organisations.

I would like to express my gratitude to my supervisor, Associate Professor Mohammed Quaddus for his knowledge, supervision and guidance for this research. His patience, generosity and dedicated assistance has contributed greatly to my doctoral degree and helped to develop my readiness for future research and my career.

I am grateful to my associate supervisor, Associate Professor Ron Goddard, for his advice that I found very useful to my research and Dr Max Kummerow, for his comments on my data analyses and English editing.

I would like to express my appreciation to my former lecturers: Dr Doug Atkinson, my former supervisor in information systems, for giving me a very good background for undertaking PhD. Research; Dr Mingsan Kaosa-ard, my former supervisor in Economics, for inspiration to be a good researcher and a hard worker; Professor Graham Pervan for the knowledge of research methodology and research design; Mrs. Lian Ee, for her support and providing me with confidence to study in Australia.

I gratefully acknowledge my sincere thanks to many people at the Siam Commercial Bank for their kindness, co-operation and support of information and facilities: Mr. Vichit Amonviratsul, First executive vice president of the technology group; Mr Sinchai Chaisiripoomkere, Mr. Pisit Jirapinyo, Mr Thongchai Pingkarawat, Mr Suwat Taveesuksiri, Dr Amarit Laorakpong, Mr. Wanchai Lewsirivongse, and all the respondents of my study.

I would like to express my sincere thanks to the Australian Agency for International Development (AusAID) for their financial support that helped me to complete my study and also to the AusAID's staff for their support and understanding. I am grateful to Curtin Business School and the staff for the provision of knowledge, support, and facilities. I always appreciated my work place, Rajamangala Institute of Technology, Northern Campus, Chiang Mai, Thailand and to all my colleagues for allowing me to further my studies.

I would like to express my appreciation to Mr. Tony Doulman for his assistance in the editing of this dissertation. Thanks are also to Ms. Rita Ringis for her generosity and assistance in English editing for all published papers.

Finally, I would like to express my gratitude to my family and friends who have given mental support and assistance whenever needed.

CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 Introduction

Information and communication technologies (i.e. ICT) have become a major technological force that impacts on the financial sector. Organisations of the financial sector are being forced to adopt these technologies not only to seek business and economic opportunities but also to ensure their survival.

Currently, technological adoption and diffusion is still, however, a controversial issue in some countries. On the one hand, technology is the means for increasing economic growth, achieving a sustainable competitive advantage, creating business opportunities, enhancing business performances and improving the quality of life (Madu, Kuei, & Madu, 1991). On the other hand, it can also have detrimental effects such as, economic dependency, unwelcome culture transfer, technological mismatches, social retardation, economic stagnation and environmental pollution (Madu, 1989; Remenyi, 1988).

As a consequence, careful planning which requires appropriate decision-making is vital for the success of technological adoption and diffusion. Unfortunately, in reality

most organisations have not integrated adoption of new technologies into their strategic plans because managers may neglect technological planning or the technologies change too rapidly. Accordingly, the rejection of technology, especially information and communication technologies, occurs commonly (Gagnon & Toulouse, 1996).

Making decisions in the fast changing areas of information and communication technologies is a difficult process. Initially, the decision-makers are confronted with constraints such as time and resources. Additionally, the problem is more complicated because it involves many dimensions not only the technological problem itself, but also in other areas such as, the environment, social, economic and political. Decision-makers, therefore, have to deal with multiple alternatives and criteria in an uncertain environment. Finally, it involves many stakeholders. That is, decision-making is a collective process rather than purely individual. Group decision-making is far more difficult because each decision-maker has his/her own perceptions, attitudes, motivations and personality (Bui, 1987). It is difficult to find an optimal solution whereby all affected parties are satisfied.

When an organisational environment or a problem becomes more complex, more competitive and subject to fluctuations, subjective decision-making techniques contingent upon experience, judgement and intuition cannot achieve all of the aims of the organisation. Hence, appropriate, objective decision-making paradigms are attractive.

A multiple criteria decision-making process (MCDM) (Belton, 1984) is, therefore, proposed as a suitable decision-making tool to be employed for selecting the most preferable technology during the technological adoption phase because it is capable of evaluating the best alternative from various conflicting criteria.

However, it must be emphasised that, benefits from information and communication technologies not only come from an appropriate technology selection but also in fact from intensity of usage. That is, prospective advantages cannot be obtained directly from the mere provision of the actual physical technology. Therefore, once

technologies are adopted, making a full effort to diffuse them effectively throughout organisations, business units and work groups is a must (Kwon & Zmud, 1987).

The success in technology diffusion relies on a fabric of many factors, not only technical but also organisational. Furthermore, its diffusion process is contingent upon explicit time dependence (i.e. dynamic) involving technology life cycle stages and relating to variables such as the economic life of the technology and time delays (e.g. training, perceived satisfaction). Therefore, the system dynamics model (Coyle, 1996; Wolstenholme, 1994), is proposed as a suitable decision-making tool to develop a diffusion model because it is capable of handling interrelationships between variables and dynamic aspects.

Quite often, potentially suitable decision-making models developed by model analysts (or researchers) do not meet executives' requirements. Whereas researchers may spend years "playing" with their models, executives have a limited time for co-operation or implementation. While researchers may try to work out every little detail, business people require only practical ways to help them solve their problems. Researchers may desire complicated tools to develop their models, executives on the other hand, are willing to use only user-friendly tools. Furthermore, traditional mathematical or statistical results proposed by researchers rarely provide transparent insights for executives and seem difficult to them to understand, making them reluctant to use these as decision-making tools.

Given these consequences, to bridge that requirement gap a decision-making model has to be designed employing the concept of decision support systems (DSS). DSS is a system that utilises decision models, a database and a decision-maker's own insights in an ad hoc, interactive analytical modelling process to analyse a situation and from that, make decisions (O'Brien, 1996). That is, model analysts spend time in undertaking complicated, underlying, and detailed structures of models. Then, they design appropriate models using user-friendly tools or interfaces through which executives are able to bring together their business knowledge and availability of rich organisational information, and thus use the models to aid their learning processes and to improve their decision-making.

In effect, *the multiple-criteria decision making and system dynamics approaches* using DSS framework in the case of technology adoption and diffusion of information and communication technologies will allow prospective decision-makers to incorporate their insights in the model. They may select the most preferable technology, add variables, change relationships between variables, run sensitivity analyses to see the impacts from each variable and from strategic policies, and visualise holistic outcomes. These may lead to helping an organisation to justify their decisions regarding technology adoption, speed up the diffusion process of adopted technologies, obtain extensive benefits from it, and minimise problems. This model can also be applied to other interesting scenarios or issues to leverage considerable business knowledge and available data.

1.2 Objectives and Research Questions

The main objective of this research, "*A study on the adoption and diffusion of information and communication technologies in the banking industry in Thailand using multiple-criteria decision making and system dynamics approaches*", is to develop a holistic modelling framework for information and communication technologies (ICT) adoption and diffusion in the banking industry combining multiple criteria decision-making (MCDM) and system dynamics modelling (SD) in a group environment.

The specific purpose of this study is to develop a model to detect the inter-relationship among variables for a specific commercial bank in Thailand, identify problems, and then find out requisite and operational policies for the bank.

The model was tested and evaluated to gain more understanding with respect to five research questions.

- Q1. What is the current status regarding ICT of the bank?
- Q2. What is a requisite group model of ICT adoption?
- Q3. What is a requisite group model of ICT diffusion?

- Q4. What are the requisite policies for adoption and diffusion of ICT for the bank?
- Q5. Can information and communication technologies be used as a lever of competitive advantage for the banking industry in Thailand and if so, why and how?

1.3 Significance and Contributions

Decision-makers, nowadays, are inclined to tackle technological issues in a complex collective process, as they are involved in dynamic situations rather than in simple, individual and static ones. Consequently, multiple-criteria based system dynamics modelling (i.e. the combination of two decision-making tools: multiple criteria decision-making (MCDM) and system dynamics (SD)) was proposed as a suitable model that may mitigate problems regarding technologies because this approach combines the strong competence of each decision-making tool.

- MCDM can be used to tackle actual problems in the real world because it provides ways to select a solution from many alternatives based on multiple conflicting criteria and under specific constraints.
- SD is suitable to be incorporated with MCDM to deal with a dynamic approach of the problems and interrelationships among variables. A decision-maker is able to explore factors or exert operational policies that can improve or solve the problems without disrupting routine operations and costs. Furthermore, running a simulation via SD before real implementation prevents an organisation from potential risks derived from wrong decisions.

This research was conducted in a group environment involving stakeholders to study actual decision-making occurring in real world situations. Supporting group decision-making is always complex as a group creates more ideas as well as conflicts, promotes as well discourages participation, and enhances as well impedes implementation.

Previous studies of technology adoption and diffusion (details in Chapter 4) have revealed an insufficiency in capturing dynamic processes, providing transparent tools

for executives to make decisions and develop a decision-making framework. The literature based on MCDM and SD also has not revealed much research explicitly conducted by integrating the two study areas in a group environment. Therefore, the study of adoption and diffusion of information and communication technologies using multiple-criteria based system dynamics group modelling contributes to providing realistic collective decisions. That is, it provides requisite solutions in accordance with dynamic situations, mitigates conflicts among group members leading to easy implementation for the banking industry in Thailand, and promoting a learning process for prospective decision-makers. Additionally, this research bridges the gaps between previous and proposed research.

This research provides three major contributions.

- The study displayed the means of combining two decision-making tools effectively. Initially, MCDM was employed during the technology adoption phase to select the most preferred technology that might fulfil the bank's objectives. Subsequently, SD was employed during the diffusion phase to handle dynamic aspects and interrelated variables of the selected technology.
- The study directed the decision-making tools of MCDM and SD for practical problem solving in one of the largest banks in Thailand (i.e. the Siam Commercial Bank PCL). The requisite models of ICT adoption and diffusion initially developed from previous research were customised using relevant information gained from the bank. The proposed models allow decision-makers to identify existing systems and exert operational policies to improve system behaviours, solve problems and promote forward planning.
- The learning model is based on the concept of decision support system (DSS). The model is useful to decision-makers as a learning tool. They may improve their decision-making processes by running sensitivity analyses, visualising the impacts of their decisions, detecting effective policies, and applying the model to other issues or scenarios using massive information of an organisation.

1.4 Contents of the Dissertation

The study comprises 11 chapters. The first four chapters address the general background with regard to aspects of technology and decision-making. Chapter 5 discusses research methodologies and research designs of the study. Chapter 6 introduces the Thai banking industry and the Siam Commercial Bank PCL, (a case study). All this information is used to develop the model and conduct analyses in Chapters 7 to 10. Chapter 7 proposes a model of technology adoption using the MCDM analysis. The system dynamic models of technology diffusion consist of three sub-models based on three cases from the bank: information and communication technologies (ICT); a data warehouse; and Extranet banking. The whole thesis is recapitulated in Chapter 11 (see Figure 1.1).

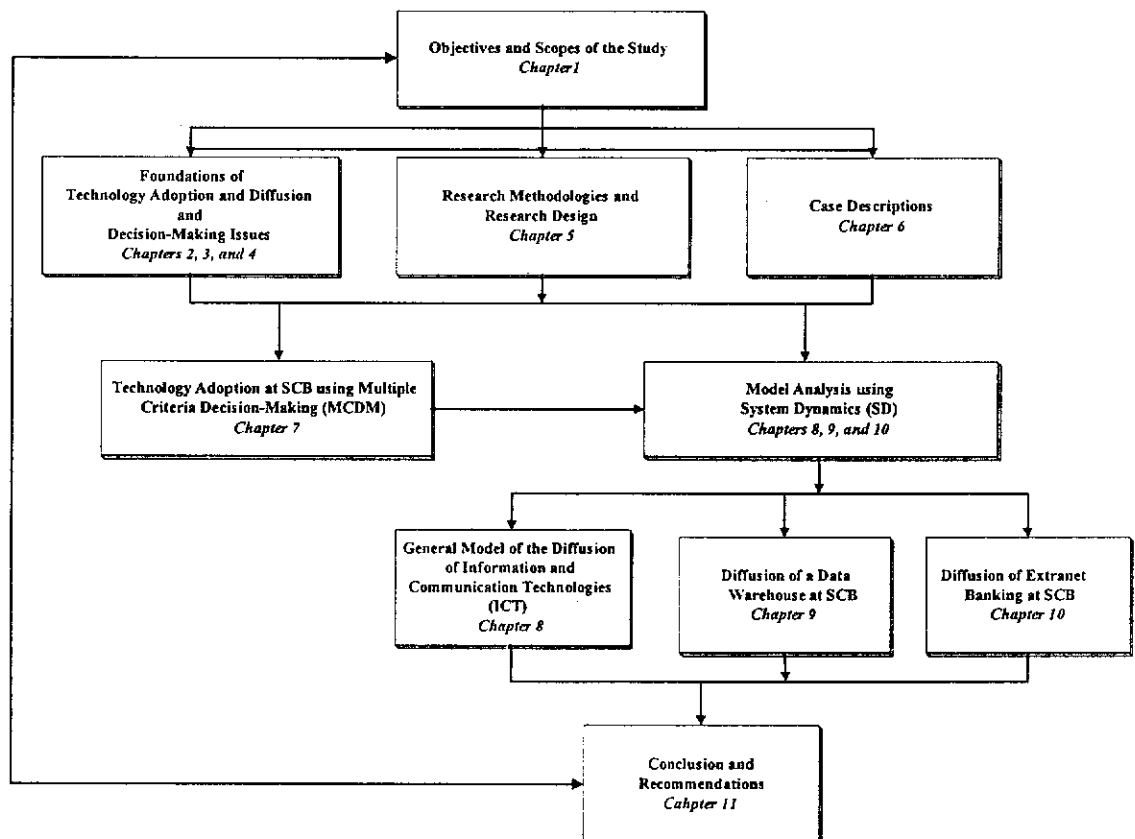


Figure 1.1. Organisation of the Thesis

Brief summary of chapter contents follows.

- Chapter 1. **Introduction and overview.** This chapter is an introduction and overview of the study including objectives, research questions, significance, contributions and outlines of the study.
- Chapter 2. **Technology adoption and diffusion.** This chapter provides general backgrounds on information and communication technologies (ICT) highlighting technology adoption and diffusion, and banking technologies, which are employed in the case study bank. These technologies are smart cards, a data warehouse, video conferencing, home banking service (i.e. Internet/Extranet banking) and Electronic Fund Transfers at Point of Sales (i.e. EFTPOS).
- Chapter 3. **Decision-making issues.** The details in decision-making issues beginning with decision-making in general are presented and then elaborated to group decision-making. The decision-making model is divided into two main areas: multiple criteria decision-making (MCDM) and system dynamics (SD).
- Chapter 4. **Literature review.** Previous research relating to the research domain are reviewed capturing five main areas, technology adoption and diffusion, banking technologies, decision-making, multiple criteria decision-making (MCDM) and system dynamics (SD).
- Chapter 5. **Research methodology and research design.** This study employed two types of research methodologies: system development research (i.e. engineering research), and case study. The research design includes an explanation of research development based on a system development research approach, methods of data collection, research design in practice, validation and reliability, and practical problems of data collection.
- Chapter 6. **Case description.** The Thai economy, the banking industry and banking technologies in Thailand are reviewed. Then, the main case

study (i.e. the Siam Commercial Bank PCL) is introduced in order to understand its vision, objectives, business processes, and current usage of information and communication technologies of the bank. Research question 1 is addressed in this chapter.

Chapter 7. **Technology adoption at SCB using multiple criteria decision-making (MCDM).** This is the first chapter for model analyses employing the MCDM approach for technology evaluation. This chapter illustrates how MCDM is used to select identified technological alternatives for the bank. The model analysis is divided into three stages, 1) structuring a problem, 2) eliciting information and values, and 3) evaluating and sensitivity analysis. Divergent results between using intuitive perception and MCDM analysis are also discussed. Research question 2 is addressed in this chapter.

Chapter 8. **General model of the diffusion of information and communication Technologies (ICT) using system dynamics.** Model analyses using the system dynamics approach are subdivided into three models (Chapters 8, 9 and 10) because of differences in the specific properties of each technology. This chapter presents a generic model of diffusion of information and communication technologies (ICT). The model is developed based on both qualitative and quantitative system dynamics approaches. Impacts of strategic policies such as training support, a backlog of problems, potential market, and controlled investment on technology diffusion are tested. Research questions 3 and 4 are addressed in this chapter.

Chapter 9. **Analysis I: Diffusion of a data warehouse at SCB.** This chapter tailors the model analysis based on the bank staff's intuitive perceptions (details in Chapter 7), focusing on data warehousing technology. Policy analyses and testing for validity and reliability are presented. Research questions 3 and 4 are addressed in this chapter.

- Chapter 10. **Analysis II: Diffusion of Extranet banking at SCB.** This chapter presents the diffusion model of Extranet banking, the preferred technology based on the MCDM analysis in Chapter 7. The issues covered in this chapter are similar to those of Chapter 9. Research questions 3 and 4 are also addressed in this chapter.
- Chapter 11. **Conclusions and recommendations for future research.** This chapter summarises the entire research and provides a direction for future research. Research question 5 is addressed in this chapter. All the information and model analyses are debriefed and discussed. Obstacles, limitations, implications, and potential future research are presented and recommended.

1.5 Summary

This first chapter presented an overview of the research. Objectives and the five research questions were addressed. Then, the significance of the study was pointed out, and the research contents were outlined. The chapter aims at acquainting the readers with the holistic picture before elaborating on the research theme in the subsequent chapters.

The following two chapters provide information in regards to technological and decision-making issues in order to prepare the reader for the introduction of the discussion of model analyses.

CHAPTER 2

TECHNOLOGY ADOPTION AND DIFFUSION

2.1 Introduction

Most developing countries have trouble in acquiring, retrieving, processing and disseminating information. Information poverty means a lack of raw information and a means to convert it into knowledge. Also, insufficient timely and reliable information leads to low productivity, poor-quality research, and valuable time is wasted. This leads to obstacles for policy-makers trying to solve fundamental problems in the areas of poverty alleviation, health and education programs. The policy-makers also face difficulty in dealing with urgent problems such as an epidemic, a flood or a financial crisis. All of these problems affect decision-making outcomes, and reduce business opportunities (Sirimance, 1998).

It is widely accepted that information and communication technologies (ICT) affect every function within an organisation and every industry in terms of reducing costs, providing new jobs, delivering new products/services, raising competitiveness, generating new markets, and creating new opportunities for investment. Developing countries, therefore, are attracted to adopt many types of information and communication technologies

(ICT) with an anticipation that the technologies will bring about those benefits and resolve the problems resulting from lack of valuable information.

However, gaining benefits from useful technologies requires an investment not only in physical technologies but also capacity-building, including skills and infrastructure. Human skills may be developed by investment in education in schools and universities, emphasising computer literacy and informatics in engineering, business and technical schools (Siamwalla, 1996; Young, 1997). Local infrastructure such as communication facilities (phone, fax, etc.) and uninterrupted electricity is also vital. Nevertheless, most developing countries lag behind in developing these capacities due to high costs, and because they are lower priorities compared to severe problems relating to the political, social and economic issues (Sirimance, 1998).

Without the willingness to make full use of technologies, most often technologies are adopted and then rejected after spending a lot of resources on pilot projects or implementation. Careful planning, therefore, is vital for the success of technology adoption and diffusion. Without an appropriate plan, technologies may be under-utilised, wrongly utilised or may totally fail (Quaddus, 1995a). Thus, many organisations have begun to integrate their IT strategic planning with business and management plans in order to maximise utility of invested technologies (Earl, 1987; Manross & Rice, 1986).

Taking Thailand for example, the rest of the world has an impact on the Thai economy through the technology that became accessible (Siamwalla, 1996). The extraordinary high rate of ICT diffusion once contributed to the achievement of the "East Asian Miracle" whereby technologies brought about success through the cycle of export, output, productivity growth, and new employment (Kivel & Rubin, 1996b).

Yet, in 1997 the Asian economic crisis that originated in Thailand reflected the adverse sides of ICT. Thailand's economy is currently confronted with a major crisis originating in the property and financial sectors. While globalisation of the world economy through ICT undoubtedly contributed to the flood of capital investment, which fuelled Thailand's 8% annual growth since 1988. The flight of this capital made the collapse (beginning in July, 1997) more severe, with the 40% depreciation of the

baht (Thai currency) and the local SET share index falling to a third of its highs. Insufficient skilled people to control the financial mechanisms because of the high capacity of ICT in transferring information and capital was blamed as one cause of the crash. To prevent a repetition of such damaging outcomes in the future, the ability of financial institutions to adopt and diffuse improved ICT may be a necessary key to financial control mechanisms.

This chapter presents background on information and communication technologies (ICT) emphasising technology adoption and diffusion. The main technologies employed by the case study bank (i.e. the Siam Commercial Bank PCL) are also described to promote understandings of each technology before subsequently proceeding to model analyses.

2.2 Information and Communication Technologies (ICT)

Technology is a combination of a physical tool and the related known-how either to make or use that tool. It comprises four basic components: technoware (e.g. tools, machines, and facilities), humanware (e.g. skills, experience, and wisdom), infoware (e.g. process, specifications, and theories) and orgaware (an institution that furnishes the integration of the previous three components). Each component follows its life cycle stages as indicated in Table 2.1 (Technology Atlas Team, 1987, p. 380).

Table 2. 1. Technology Component Life Cycles

Technoware	Humanware	Infoware	Orgaware
Research/selecting	Rearing	Collecting	Conceiving
Developing/ adapting	Telling	Screening	Preparing
Testing	Teaching	Classifying	Designing
Demonstrating	Educating	Associating	Installing
Producing	Training	Analysing	Operating
Diffusing	Developing	Synthesising	Guiding
Substituting	Upgrading	Emulating	Evolving

Source: (Technology Atlas Team, 1987, p. 381)

Information technology (IT) is composed of hardware, software, telecommunications, database management, and other information processing technologies used in computer-based information systems (O'Brien, 1996, p. G-10).

Information and communication technologies (ICT) are computer-based technologies used to support information and communication. Information support refers to computer-based applications to support structured decision-making processes whereas communication support refers to computer or telecommunication-based applications for communication purposes (Sayeed & Brightman, 1994).

Information and communication technology is considered as a powerful tool for both public and private sectors. Not only are the public sectors able to use accurate and timely information to develop policies, allocate and deliver resources to their people more efficiently and effectively, but also private sectors are able to access new market opportunities, better decision-making, and improve work processes. ICT is also integrated into strategies for solving the fundamental problems of the nations such as poverty, disease, or environmental deterioration (Marleau, 1997). It is believed that inadequate information increases the competitive gap, which widens the development gap of the country (Sirimance, 1998). In addition, ICT creates jobs because most information-related services are highly labour-intensive. Therefore, developing countries have great potential to create jobs both for highly skilled workers (systems analysts, scientists, programmers) or relatively lower-skilled data clerks and keyboard operators for administrative, accounting and other back-office work (Sirimance, 1998).

Currently, information and communication technologies (ICT) are the most pervasive technology having economic effects and exert wide impacts on societies in many respects. First, with ICT, massive data and digital information can be handled and dispersed more easily, quickly, and cheaply than before. Second, thanks to the reduction in transaction costs of information flows, ICT enhances efficiency in using resources, improve returns to management functions, and promote more flexible and decentralised management and decision-making structures. Third, ICT results in a major change of the structure of capital investment in service industries. Previously, service organisations such as banks have spent massive investment on unproductive

capital (e.g. buildings). Switching heavy investment in ICT equipment enables them to gain economic returns from their investment and concurrently reduces demand for office buildings. Fourth, information itself has increased in potential tradability because information becomes a weapon to gain advantages in global markets (Barras, 1994; Bayar, 1998; Howells, 1995; Quaddus, 1995b).

Although information and communication technologies (ICT) contribute various advantages, according to data collected during this study (details in Chapter 6), critical problems with regard to ICT still exist. These include rapid obsolescence of adopted technologies, selection of inappropriate technologies, low productive usage of those adopted, lack of capable employees, and high costs of technologies, coupled with an unexpected performance and low acceptance from staff and customers. Therefore, appropriate decisions in regard to adopt useful technology and diffuse it to maximise the full benefits from the technology are important.

2.3 Technology Adoption and Diffusion

Adoption is a decision to make full use of an innovation as the best course of action whereas rejection is a decision not to adopt an available innovation (Rogers, 1983, p.21). There are two levels of adoption. Initially, innovation must be purchased, adopted, or acquired by an organisation. Subsequently, ultimate users in that organisation and community must accept it (Manross & Rice, 1986).

Diffusion is the process during which an innovation is communicated among members of a social system via certain channels over time. A diffusion process consists of four main elements: an innovation, communication channels, time and a social system (Rogers, 1983).

- An innovation is a new idea, practice, or object that is introduced to individuals or organisations.
- A communication channel is the means of transferring messages from an individual/organisation that has innovative knowledge to those that do not yet have it.

- Time is involved in a process of technology diffusion in many respects. Diffusing innovative knowledge takes time for an individual/organisation to adopt or reject. An adopter, classification based on a level of innovativeness (i.e. innovators, early adopters, early majority, late majority and laggards) relates directly to time. A rate of adoption is measured as the number of adopters in a given time period.
- A social system is a set of interrelated units (e.g. individuals, organisations, and/or subsystems) that are co-operating to solve a joint problem or to accomplish a mutual goal.

Technology diffusion follows the three broad stages of initiation, decision to adopt, and implementation and is based on a logistic curve (a s-shape) rather than a production curve because of a limitation of demand and saturation of a market. At the beginning it takes some time for people to adopt technology. Then, when people accept the technology, a diffused technology curve takes off and its widespread adoption makes the curve increase rapidly. When a new technology comes and the market is mature, the curve levels off because the technology cannot be easily diffused. However, there is variation in the slope of the s-shape curve. If technologies diffuse relatively rapidly, the s-shape is quite steep. On the other hand, some technologies may have a slower rate of diffusion and its s-shape will be more elastic (Rogers, 1983).

Once new technologies are adopted, organisations put in great effort to diffuse them quickly, enterprise-wide or throughout customers, to avoid prohibitive costs due to a high obsolescence rate of evolving technology. However, as a matter of fact, new technology often requires a lengthy time before it is widely diffused.

Many factors obstruct the rapid rate of technology diffusion process. Prospective adopters may fail to gain complete knowledge to understand, implement and diffuse technologies (Fichman & Kemerer, 1994). Some technologies are not compatible with the values, beliefs, and past experiences of the social system. Some change agents diffuse technologies based on “innovation-oriented” rather than “client-oriented” philosophies leading to insufficient acceptance or even resistance.

Furthermore, even when innovation has obvious and proven advantages realised by potential adopters (e.g. citrus for scurvy and the Dvorak keyboard) this does not guarantee rapid diffusion (Rogers, 1983). Therefore, selecting the most appropriate technology and finding ways to speed up the rate of technology diffusion are still the main concern of many individuals and organisations.

2.4 Banking Technologies

Banks are under pressure to adopt new technologies and make changes in existing technologies. Bank managers consider that numerous advantages are to be gained from technological investment and development of integrated technological infrastructure in order to prevent themselves from losing their market position to other institutions that recognise the importance of technology (Lunsford, Brewer, & Brennan, 1994).

Banking technologies have been initially employed for the purpose of providing increased benefits to customers because the success or failure of technological investment is contingent upon customer demand. At present, customers require extensive services from a banking system such as time and location convenience, ease of use, protection against fraud and invasion of privacy, and better access to financial information and payment transactions through a variety of consumer electronic devices. Above all, convenience-oriented is considered as one of the most critical success factors for competitive advantage in the banking industry (Allen, 1995).

Banks also anticipate direct and indirect returns from such investment. Technologies allow banks to expand the range of services and products by customising them to satisfy customer individually and deliver them electronically (e.g. ATM, telephone banking, and Internet banking) leading to less paper work, paper handling and low costs. Technologies transform data into information and ultimately knowledge that will be used for improving data analyses and decision-making in areas such as sales and marketing, relationship management, risk management and control, personnel management, mortgages, portfolio management, and credit-card applications. In addition, the following benefits are generally expected from technological

investment: eliminating manual work processes; automating the work flow between front and back offices; increasing profit; achieving sustainable competitive advantage; creating new business opportunities; decreasing physical branches; enhancing business performance; retaining market share; bettering image; and trimming costs (Allen, 1995; "Internet banking," 1999; Global Banking Intelligence Corp., 1996; Jordan, 1996; Kersell, 1994; Radding, 1991; Sirimance, 1998).

Nevertheless, it is also clear that banks may not ascertain that technologies bring about a good return on investment. First, technology is usually an additional way of delivering services. Therefore, costs from technological availability always increase relative to revenues. For example, ATMs have not replaced branches, but have been additional withdrawal outlets. Internet banking is a great accessible channel to reach potential customers but may create additional costs because banks cannot shut down old channels and certain transactions cannot be undertaken (e.g. withdrawing cash) via the Internet. Second, banks have often extravagantly spent on technological investment, and much of it has been wasted because of the different perspectives between IT people and the bankers who run the business. Normally, IT people are often blamed for delivering the wrong services. Third, better technology removes some barriers to entry into a banking industry. In Britain, supermarkets such as Sainsbury and Tesco provide retail financial services, and grab some business from banks. Fourth, many new problems relating to technology occurs forcing banks to solve these new problems. For example, every bank has to spend massive amounts of money to solve the millennium bug (i.e. Y2K problem), to stockpile cash reserves for people who will withdraw money due to the belief that the system will be adversely affected, and spend money for an advertising campaign to reassure worried customers ("Without technology," 1999).

Banking technologies have been in effect since 1980 in the form of electronic banking and home banking services. Electronic banking authorises customers to make financial transactions via ATMs (i.e. Automatic Teller Machines) and EFTPOS (i.e. Electronic Fund Transfer at Point of Sales), whereas home banking services allow customers to get access to the banks via communication devices. Currently, three potential developments in banking technologies are; the introduction of stored-value

cards (i.e. smart cards), an expansion of home banking facilities and a rapid growth in the use of EFTPOS (Federal Bureau of Consumer Affairs, 1995).

There are two factors that increase the abundance of ICT throughout the bank: the advances in chip integration producing more computer power in smaller packages at lower cost and the decreasing cost of computer processing (Radding, 1991). Banks are inclined to adopt numerous promising technologies to facilitate their activities and improve services. Therefore, for the purpose of this study, a preliminary visit to a bank that is used as the case study (i.e. the Siam Commercial Bank PCL in Thailand) was made in order to confine the scope of study only to predominant technologies in the bank. The current information and communication technologies identified by key persons of the bank were smart cards, data warehouse, video-conferencing, home banking services (i.e. Internet/Extranet banking) and Electronic Fund Transfer at Point of Sales (EFTPOS). These five technologies were subsequently used as technological alternatives for the bank to fulfil its visions. Descriptions of these technologies now follow.

2.4.1 Smart Cards

A smart card is a plastic card containing microchips, which provides the capacity of processing and storing data. It has a complex structure capable of performing multiple functions. The transaction data stored on the card can later be read by computers to update the card's records (Hutchinson & Sawyer, 1996).

Smart cards were developed in France in the early 1980s for the main purpose of eliminating paper money and is already being used in Europe for cash transactions and phone calls (Dvorak, 1997). However, it was not until the 1990s, that banks and financial institutions had become interested in this technology. The increasing interest results from decreasing costs of chip cards, increasing concerns about fraud from magnetic-stripe cards, increasing usage of telecommunications via telephones and personal computers, and searching for new opportunities from electronic banking services (Allen, 1995).

Smart cards can be classified into three main categories (Allen, 1995; Dvorak, 1997).

1. **Smart cards as a medium of payment.** A smart card (i.e. stored-value or prepaid card or electronic-purse) is used to replace cash for transactions. A reloadable smart card allows a cardholder to withdraw or add the amount from specific machines or ATMs. Apart from banks, many telecommunications, entertainment, transit, and retail businesses are also issuing these cards for their own business.
2. **Smart cards as information managers.** Smart cards have capacity for information storage and processing capability because of embedded computerised memory and processing power.
3. **Smart cards as customised delivery systems.** With the progression in memory and processing power, future smart cards will be able to carry screen sets and personal information that will possibly make the smart cards the ultimate in personal and mobile computing.

In a financial area, smart cards are being used to replace magnetic stripe cards (e.g. ATM, credit and debit cards) and used as a stored value card (i.e. an electronic purse). Smart cards differ from magnetic stripe cards in that they are capable of storing large volumes of data, which can be structured or altered whereas magnetic stripe cards store readable information without the capacity to process the information (Federal Bureau of Consumer Affairs, 1995).

Therefore, there are numerous potential advantages in replacing magnetic stripe cards with smart cards. Smart cards may provide better security, offer a greater capacity to store information (e.g. account balances and transaction records), and allow multiple functions within one single card (e.g. earning points from commercial privilege programs, storing hotel reservation, connecting to mass transit systems, paying for small-value transactions) (Federal Bureau of Consumer Affairs, 1995; Visa International, 1998).

Smart cards are expected to provide various mutual benefits and opportunities for customers, merchants and the institution issuing the card (e.g. banks). For customers,

the primary benefits are ease of payments and the greater accessibility of account information. They may save time at the point of transaction, gain convenience and ease of use by eliminating the need to carry coins and small notes, replace cash for small transactions, lead to an increase sense of security, and enable budgeting and managing money. Merchants may also save time at the point of transaction (i.e. no requirements for cardholder identification, a receipt and change). They are able to reduce costs relating to cash and coin handling, leading to keeping less cash on their premises that may result in lower insurance premiums. Smart cards may decrease costs from theft and pilferage, and increase sales. Retailers can use information stored on the cards to improve customer relationships by offering discounts to regular customers and to participate in cross-promotion or cross-selling. Issuers may enhance a product line, attract new customers from additional value-added services, increase payment transactions, minimise transaction costs, reduce the amount of circulating cash, fulfil requirements of various services, and improve efficiency and productivity. Smart cards would allow issuers (i.e. banks) to consolidate more financial services, thus increasing customer loyalty to a particular institution, extend the relationship with customers, move into payments that have so far been cash only, and offer customers other products and services. Banks may also gain additional revenue from selling information which will be on cards and can be decrypted by monitors (AAP, 1997; Dvorak, 1997; Llewellyn, 1998; Muhammad, 1996; The Smart Card Cybershow, 1997).

Financial and government institutions may be able to decrease administrative costs associated with paper documentation, increase security and discourage fraud. Since smart cards transform a financial economy into a cashless economy in which all transactions can be traced, illegal activities such as bank robberies, tax avoidance, money laundering, drug dealing, black market activities and bribes may only be undertaken with much more difficulty (Llewellyn, 1998; Muhammad, 1996).

In effect, customers may gain a slight improvement in security, more convenience, more information and more versatility. However, smart cards have not yet accomplished dominance in financial markets because of high costs (e.g. cost of technology and costs of updating writing/reading devices world-wide) and the

existing success of magnetic stripe cards in fulfilling customers' basic needs of financial transactions (Zoreda & Oton, 1994). In addition, consumers still hesitate to adopt the technology because they are worried about privacy and security issues, the potential for fraud, and counterfeit cards (Dvorak, 1997; Muhammad, 1996). The slow acceptance of smart cards may also relate to "network externalities" effects (i.e. situations in which one individual's behaviour has spillover effects on others). Currently, smart cards still lack sufficient standardisation, and compatibility (Caskey & Sellon, 1996).

Thus, if consumers perceive that smart cards do not bring substantial benefits or decide to wait until various smart cards are compatible or attain some initial success, they may hesitate to replace a cheap technology with an expensive one. In reverse order, a delay in adopting the technology results in insufficient demand for card issuers to launch a smart card project successfully (Caskey & Sellon, 1996; Federal Bureau of Consumer Affairs, 1995).

Smart cards are still expected to gain popularity the same way as magnetic stripe cards have in the future. For example, Telstra (i.e. an Australian telecommunications company) is piloting Australia's first smart card payphones that allow customers using Telstra's smart card to undertake a number of functions (e.g. sending and receiving e-mails, accessing Internet, paying bills, purchasing, and making reservation) (Llewellyn, 1998). Keycorp company is also developing multi-application cards for the Australian market (Johnstone, 1999).

Promotional efforts, technological change, and price reduction (e.g. cost of smart cards and card readers) are considered as key factors that may accelerate the rate of technology diffusion for smart cards (Caskey & Sellon, 1996).

2.4.2 Data Warehouse

A data warehouse (DW) is a central source of data that has been extracted, standardised and integrated from various operational and management databases of an organisation (O'Brien, 1996). It is designed as a subject-oriented, integrated, time-variant, and non-volatile collection of data in support of management's decision-

making process (Inmon & Hackathorn, 1994). Therefore, data from a data warehouse contain these following properties.

- **Subject-oriented.** Data are organised around major subjects of an organisation such as customer, vendor, and product.
- **Integrated data.** Data from an operational environment must be integrated before entering a warehouse in order to get rid of redundancy.
- **Time-variant.** Data are represented over a long time horizon (e.g. from five to ten years); therefore, every key structure in a data warehouse contains an element of time (e.g. day, week, and month).
- **Non-volatile.** When data is loaded into a warehouse and is accessed there, the data in the warehouse does not change (i.e. non-volatile).

Given these required properties, data from operational databases must be transformed before loading into a data warehouse. The processes in transforming include:

- a. **Data retrieval.** Data must initially be extracted from different operational databases, legacy systems of an organisation and external sources (e.g. textual documents, e-mail, spreadsheets, images, multimedia objects, and external commercial databases).
- b. **Consolidation.** Data is merged from various data sets based on a standardisation of data types and fields in one master data set.
- c. **Scrubbing.** Data is cleaned to remove inconsistencies or inaccuracies.
- d. **Summarising.** Once data have been consolidated and cleansed, elements of the resulting data need to be summarised using more usable formats, such as spreadsheets, text document, charts, and other graphical presentation, personal databases, and animation. The summarised data is delivered to or available to appropriate customers to access within a reasonable response time for any query, and is more convenient and useful.

- e. **Update repository.** A repository (i.e. meta-data) should be kept up to date with any new data definitions (i.e. should be current and consistent).
- f. **Allow for periodic update.** New operational data must be added at regular intervals in a warehouse to update the data (Hackathorn, 1995; Inmon & Hackathorn, 1994).

Intense competitiveness is the key factor that triggers investment in a data warehouse. Organisations require this technology because data from operational applications are not suitable for providing information for decision support system (DSS) processing. The decision support system, however is a highly reliable tool that banks can use in converting data into strategic information leading to an improvement in their marketing strategy and strategic planning (Makos, 1995).

The critical success factors for a data warehouse are similar to those of any information systems (IS) applications. For example, it should preferably be based on an open platform that permits easy data sharing with other hardware. In addition, computer based facilities, including operating systems, networks and desktop productivity tools must be substantially available (Butler Group, 1997a).

Besides technological aspects, there are fundamental ideas behind the success of data warehousing technology. First, a data warehouse is mainly required for support of decision-making because traditional operational applications are not suitable. Second, its design should be based on the demand for detailed and summary data of knowledge workers in an organisation. Third, this technology requires senior management support because maintaining the quality of corporate data consumes massive resources of an organisation. Fourth, the more data that is stored, the more valuable a data warehouse becomes because users can access and analyse more available data. Fifth, providing users with a catalogue of accessible data (i.e. meta-data) may encourage them to consider the possibilities available to optimise the access and utilisation (Butler Group, 1997a; Lambert, 1996).

A data warehouse typically provides value to a knowledge worker by providing breadth (integrating data from several sources), cleansing (reconciling differences in

semantics, transaction dates, currencies, etc.) and depth (consolidating data to higher levels while still supporting queries down to the detailed level) (Sahin, 1997). Thus, the benefits from successful data warehouses are greater accuracy through elimination of redundancy, improved efficiency through timely access to information and more effective decision-making. Data warehouses also help organisations avoid costs before they occur and capitalise on business opportunities that previously would not have been recognised. Companies use warehouses' data to change their marketing strategies from mass production (i.e. selling everything to everyone) to mass customisation of products and services to fit customers' requirements (Butler Group, 1997a; 1997b; Horrock, 1996; Kelly, 1994; Stedman, 1998).

Costs for building a data warehouse is expensive. According to Walter Sauls, a data warehouse consultant with Systems Techniques Inc., Atlanta, a data warehouse developed for a small bank costs \$800,000 to \$1.5 million and an enterprise-wide warehouse for a large bank runs from \$10 million to \$15 million. However, potential benefits from a data warehouse are still considered low, intangible and inconclusive, and projects take longer than expected (nine months up to two years). Consultants and vendors estimate that a data warehouse can compensate the investment within six months to three years, with paybacks ranging from 100% to 700%. However, actual investors particularly banks rarely reveal benefits from investment, because they are trying to protect a "competitive advantage" or because they have as yet not quantified the benefits (O'Sullivan, 1996). In fact, trying to quantify the benefits of a warehouse is hard. Investors conceive that they can get benefits but cannot quantify how much.

In addition, many data warehouse projects fail even before full implementation and many have recently got the reputation of providing little payback from the massive investment. The failures are viewed as a huge resource-consuming project lacking any significant economic returns (Hackathorn, 1995; Horrock, 1996; The Siam Commercial Bank's executives, personal communication, December 15-20, 1996).

2.4.3 Video Conferencing

Video conferencing is one type of teleconferencing linking people from disperse places using technologies in telecommunication to transmit live pictures and sound to

an extensive network of receiving stations (Hutchinson & Sawyer, 1996). It is another form of long distance conferencing held in real time where two-way audio and two-way video systems are set up to link two or more decision rooms together. Thus, participants from different distant sites are able to interact verbally and visually (Hicks, 1993; O'Brien, 1996).

Video conferencing is suitable for smaller-disperse environmental settings of Group Support Systems (GSS). The basic equipment for a video conferencing meeting room consists of a camera, a document camera, two television sets and microphones. An ordinary conference room can be used for video conferencing (Hogan, 1993).

Video conferencing already has been widely used in education, medicine and business (Gibson, 1994). The main benefit gained from this technology is decreased travel expenses and time away from regular duties because costs of video conferencing would be cheaper than a face-to-face meeting in the case of long distances between participants. Video conferencing also promotes inter-office communication, meetings and information exchanges, enhances a learning process via long distance training programmes and increases efficiency of a meeting process because of the well-managed use of time and effort (Dillon, 1997; Hogan, 1993). An organisation is able to use it for a recruitment process to conduct virtual face-to-face job interviews with applicants to reduce travel, effort and time costs ("Recruitment goes high tech," 1994). For a large organisation, (e.g. BankAmerica Corp) video conferencing enhances productivity of the worker because they do not need to stop working and congregate in one place (Dillon, 1997).

Despite many anticipated advantages, video conferencing has as yet to become mainstream because of high costs, lack of ease of use and unwillingness of the users to be recorded (Gibson, 1999).

Video conferencing meetings may be inferior to face-to-face communications in the following aspects. First, the main drawback of video conferencing is the lack of physical presence and intuitive feeling of meetings leading to boredom for the participants. Second, participants could be uncomfortable with a socio-technical environment. Third, quality of sound and images may not approach those of face-to-

face meetings because of a delay in transmitting video and audio. Therefore, the body language or hand gesture is important and adds to the understanding for the other participants ("Recruitment goes high tech," 1994; Hogan, 1993).

Currently, video conferencing has stepped from traditional room systems to desktop video conferencing equipped with advanced ATMs or kiosks. New ATM machines are being tested and implemented to provide additional services apart from obtaining cash such as dispensing stamps and coupons, cashing checks and interacting with a bank officer via video conferencing during conducting banking transactions (Gugliermo, 1996; Strauss, 1994). Huntington Bancshares, Inc. in Ohio was the first bank in the United States that provided fully automated branches in October 1994. Customers are able to access branches with full-service via videoconferencing 24-hours a day without tellers (Gugliermo, 1996; O'Sullivan, 1997).

This new type of video conferencing supports group strategic planning, decreases internal costs, provides specific applications such as portfolio management, distance learning and communication support between remote users and decision-makers at a head office (Dillon, 1998). According to Huntington Bancshares Inc. and Mellon Bank Corp., they are able to save the costs from branch establishment, building maintenance and trained employees because small branches can be established where tellers use videoconferencing systems to serve many customers at the same time (O'Sullivan, 1997). The new video conferencing may also increase new accounts and customer satisfaction, especially innovative people who prefer convenience and modernised tools (Fryer, 1995).

The Siam Commercial Bank PCL (the case study bank in this research) introduced a video conferencing system in January 1996 with 36 conferencing centres. The video conferencing is used for many purposes: supporting internal communication; dispersing training and educational projects; conferencing between bank managers around the country; sending information between the head offices and branches; supporting self learning; and promoting good image as an innovative leader to customers and external institutions (Pentium, 1996b).

2.4.4 Home Banking Services (Internet/ Extranet Banking)

Home banking service is an electronic home-banking system using web technology. With this service, bank customers are able to conduct their business transactions with the bank through personal computers in order to reduce costs and time for transportation (Kivel & Rubin, 1996b). The basic computer-based communications systems through this service can be divided into three types: Internet, Intranet and Extranet (Marin, 1998).

1. The Internet is the publicly accessible electronic communications system allowing any person or corporation to access the banks' web pages through the World Wide Web.
2. The Intranet is a private network designed to limit access within given institutions that require web browser technology. Banks use Intranets for sharing internal information, work-group collaboration, and communication between a bank and particular clients. For example, Sparbanken, a Swedish bank developed an Intranet to support 1,000 branches and 9,000 employees. (Kenneally, 1997).
3. The Extranet is a system by which banks can provide Internet/Intranet access to customers and suppliers. The Extranet is considered the safer way of conducting online banking services compared with the Internet system.

There are three main categories of Internet usage: informational, intermediate and full service. Informational usage highlights information content without interactive service or financial transactions. Intermediate usage provides some customer service transaction capabilities but financial transactions are limited to inquiry. Full service provides a set of banking functions, including account opening and transferring of funds (Kivel & Rubin, 1996b)

Investment and integrated technological infrastructure has become essential in the banking industry to assist their customers in terms of convenience, security improvements, better access to information and an alternative to cash, all of which may ultimately return advantages to the industry. In intensive competition, each bank

needs to constantly maintain and improve its image, with relatively little product differentiation to attract its customers. Therefore, Internet banking has become a popular technology because it allows bank customers to conduct real-time, remote banking at any location and time where convenient and without the need to physically transport themselves to a bank, eliminating dealing with tellers, unpleasant weather or traffic. This is especially advantageous in Bangkok where travel may easily take up to 2 hours due to traffic congestion. In addition, customers are able to access more updated information online and make their selection for the best financial incentives (Hogan, 1999; WebAustralia, 1996).

On the other hand, the banks themselves may gain fundamental benefits from Internet banking in terms of saving costs for branch establishment and operational costs (e.g. tellers and equipment). The cost of setting up full-service Internet banking is quite similar to opening a single new branch but Internet banking reaches more customers. Furthermore, customers from Internet banking are inclined to be younger, more affluent and better educated than traditional customers. That may lead to a higher demand for financial products and services and more opportunities for cross-selling (Phillips, 1998; Tapscott, 1998). The low costs also enable banks to offer more reasonable interest rates, lower fees and more competent services ("Internet banking," 1999; Woolley, 1998; Yakal, 1999). For example, NetBank, a two-year-old Internet-based banking service, is able to reduce the average cost of a transaction from \$1.07 to three or four cents because of an increase in both customers and revenue (Woolley, 1998).

Internet banking delivers many advantages to a bank: reduction of internal operation costs; retention of customer base; increase in sales and new services; provision of access to information; receipt of more service fees; attracting customers from areas not served by branches; and minimisation of investments in establishing "bricks-and-mortar" branches. At the same time, bank customers are able to reduce their own costs, times, and inconvenience in physically visiting banks by conducting their transactions via personal computers (Kivel & Rubin, 1996b; Monroe, 1996; Smith, 1997). Small and medium size companies are the target groups of Internet banking. With cash management services, they can access their bank accounts 24-hours a day,

transfer money, invest in money markets, monitor their accounts, and receive payments in their own time, place and convenience (Marin, 1998).

Benefits from Internet banking are contingent upon the completion of the infrastructure in telecommunication, confidence in the security of the system, and acceptance by customers. Therefore, banks wishing to implement this technology need to extend infrastructure, improve skills of their personnel and intensify their security systems (Kivel & Rubin, 1996b; Monroe, 1996; Smith, 1997).

However, providing Internet banking may increase overall costs unless a bank reduces expenditures by closing branches, downsizing staff, and re-engineering operational systems. Internet banking alone may not reduce branch staffing costs or the number of transactions handled at branches because typical transactions (e.g. deposits, cheques, and withdrawals) are currently not well undertaken via Internet. Additionally, while banks may save costs for customer support due to self-servicing systems in the long run, in the short run, they have to meet additional costs for technical and new products/services to support the technology usage. Apart from bill payment fees, potential fees from Internet banking services are as yet unproved. For example, convenience-based services such as statement and cheque viewing are unlikely to provide any fees. Finally, some problems such as the millennium bug may require banks to spend money to resolve the problem and build up the confidence of their customers ("Internet banking," 1999; Kivel & Rubin, 1996b).

Since 1995 when Security First Network Bank (SFNB), one of the world's first Internet banks, was opened (Kivel & Rubin, 1996a; Mahan, 1997), many banks have shown willingness to provide Internet banking; nevertheless, the benefits from it are as yet unclear. According to Meridien Research, (i.e. a consulting firm) by the year 2000, 90 per cent of North America's biggest financial institutions will be offering transactions over the Internet (Orr, 1998). Early bank adoptions of the technology suggests that Internet banking is used not necessarily for making money but at the least for retaining banks' images as innovative organisations, defending their market position from their competitors, and building customer relationships (Orenstein, 1998).

Banks are sometimes placed in a dilemma. If they do not provide Internet banking they may lose the market to their rival banks or even non financial businesses such as post offices or wholesales and retail shops (Phillips, 1998). However, their provision of Internet banking does not assure complete success. The failures of Internet banking are well documented. For example, despite being known as the first Internet banking service, Security First Network Bank (SFNB) sold its banking operations to Royal Bank of Canada in March 1998 (Orr, 1998). Another example, the NatWest, a British bank, rejected Internet banking after a trial of two and a half years ("Internet banking," 1999).

Therefore, in order to maximise utility of invested technologies, once Internet/Extranet banking is adopted by a bank, it is vital for the organisation to quickly diffuse the service to customers before the technology is obsolete, or act faster than its competitors to absorb a limited market.

2.4.5 Electronic Fund Transfer at Point of Sales (EFTPOS)

Electronic Fund Transfer at Point of Sales (EFTPOS) is the transaction that initiates an automatic transfer of money from a customer's account to a retailer's account, authorised at the point of sale using a debit card and Personal Identification Number (Federal Bureau of Consumer Affairs, 1995; Norton, Reed, & Walden, 1995).

EFTPOS provides convenience for customers, offers an alternative to cash, assures payment, prevents money being lost on dishonoured cheques or credit card fraud, improves cash flow for business, reduces paperwork and office time, and adds security due to less cash on hand (Advantage Group Limited, 1996).

EFTPOS plays a significant part in the move from cash and cheque based payments to electronic payments. The usage of EFTPOS was initially slow due to the following reasons. First, EFTPOS requires considerable investment, but takes a long time before there is a return on the investment. Second, in the short run, financial institutions and customers are still satisfied with existing systems. Third, high-income groups and business users gain benefits from the delay between cheque writing and account debiting. On the other hand, low-income groups with minimal

reserves and credit must depend on cash. Fourth, some consumers lack complete confidence in computer-based performances and some prefer the social intercourse in their banks. Fifth, banks may dislike the emphasis on withdrawal transactions (Federal Bureau of Consumer Affairs, 1995; Mysior, Shuman, & Linstone, 1984).

However, in the long run, if EFTPOS becomes increasingly available and consumers are familiarised to its functions, it may continue its rapid expansion. On the other hand, once EFTPOS machines are operated, investors may endeavour to diffuse them in order to gain returns on investment, preserve competition, facilitate consumer convenience, reduce costs for branch establishment, and provide customers with 24-hour services (Mysior et al., 1984).

EFTPOS has been widely accepted in Australia as one of the mediums of payment. An electronic-fund terminal is found on a cashier's desk at almost every Australian retailer and restaurant because it is cheap and reliable for small businesses. The Commonwealth bank is Australia's leading EFTPOS provider, with a nation-wide network of 87,000 terminals and a 42% share of the market (Johnstone, 1999).

The properties of these five banking technologies are compared in Table 2.2 using a SWOT analysis (i.e. a simple analytical tool to facilitate decision-making, which assists in identifying the impacts of a particular decision) (Kelly, 1994). The author conducted the SWOT analysis by interviewing executives of the bank incorporating with data from literature reviews.

Table 2. 2. Technology Alternatives based on SWOT Analysis

Technology	Strength	Weakness	Opportunity	Threat
Smart Card	<ol style="list-style-type: none"> 1. Providing better security. 2. Having a greater capacity to store information. 3. Providing multiple functions leading to more convenience. 4. Providing faster completion of transaction. 5. Reducing various frauds. 	<ol style="list-style-type: none"> 1. More expensive than stripe cards. 2. Holders of multiple-function cards may be charged for unwanted services. 3. Lack of standardisation. 	<ol style="list-style-type: none"> 1. Increasing payment transaction. 2. Minimising transaction costs. 3. Reducing circulation of cash. 4. Reducing risk of counterfeit hard cash. 5. Fulfilling the requirements of various financial services. 6. Improving efficiency, productivity for organisations and customer service in long run. 7. Reducing paperwork. 	<ol style="list-style-type: none"> 1. Low acceptance (especially for Thai people). 2. Leading to business frauds.
Data Warehouse	<ol style="list-style-type: none"> 1. Providing systematic data. 2. Providing information for decision-making and for management, and customer support. 3. Eliminating unnecessary transactions. 4. Providing greater accuracy through elimination of redundancy. 5. Improving efficiency through timely access to information. 	<ol style="list-style-type: none"> 1. Difficulty in understanding users' requirements. 2. Difficulty in accessing the source data. 	<ol style="list-style-type: none"> 1. Improving internal banking process (paperless). 2. Supporting flat communication. 3. Increasing sales through more effective customer segmentation and product cross selling. 4. Minimising time for loan approval and for servicing customers. 5. Increasing customer satisfaction through tailoring services for individual customers' needs. 6. Providing financial consultancy with 'what-if' tools. 	<ol style="list-style-type: none"> 1. Requiring close communication and joint responsibility between users and builders. 2. Difficulty in justification of economic returns on a data warehouse. 3. Requiring high support from high level management. 4. Difficulty in selecting the components for a data warehouse because there are many factors involved in the final choice of products.
Video-conferencing	<ol style="list-style-type: none"> 1. Minimising travelling expenses and time. 2. Promoting inter-office communication, meetings and information exchanges. 3. Enhancing a learning process 	<ol style="list-style-type: none"> 1. Lacking physical presence and intuitive feeling of meeting. 2. Being uncomfortable with a socio-technical environment. 3. Slightly differing from face-to-face communication. 	<ol style="list-style-type: none"> 1. Promoting a learning organisation's concept. 2. Supporting training and internal communication. 	<ol style="list-style-type: none"> 1. Using for a short time and then rejecting it due to a bandwagon effect.

	via long distance training programmes.	4. Expensive.		
Home banking services (i.e. Internet/ Extranet Banking)	<ol style="list-style-type: none"> 1. Reducing costs, time and inconvenience involved in physical visits. 2. Providing information about customer finances, business information and retail banking services to customers at home. 3. Retaining customer base. 4. Increasing product cross selling. 5. Receiving more service fees. 6. Attracting customers from areas not served by branches. 7. Transferring money among organisations and to a third party. 8. Reducing a bank's internal operation costs. 	<ol style="list-style-type: none"> 1. High costs. 2. Problems regarding security. 3. Depending on communication infrastructure. 	<ol style="list-style-type: none"> 1. Increasing customer satisfaction. 2. Minimising costs for customer support. 3. Creating new services. 4. Increasing an image 5. Increasing service fees for retail banking services 6. Reducing investments in establishing new branches. 7. Preserving competition 8. Enhancing leverage by combining with data warehousing technology. 	<ol style="list-style-type: none"> 1. Benefits are still inconclusive for banks. 2. A bank's overall costs may increase with the provision of Internet banking. 3. The success of Internet banking depends on customers' acceptance and externalities (e.g. infra structures, knowledge of users and volume of business transaction).
EFTPOS	<ol style="list-style-type: none"> 1. Providing convenience for customers. 2. Offering an alternative to cash. 3. Assuring payment. 4. Preventing money lost on dishonoured cheques or credit card fraud. 5. Reducing paperwork and office time. 6. Adding security due to less cash on hand. 	<ol style="list-style-type: none"> 1. Considerable investment but taking long time to get returns. 2. Customers fear computer errors. 3. High-income groups want to gain the benefits of the delay between cheque writing and account debiting whereas low-income groups still depend on cash. 4. Consumers prefer the social intercourse in a bank. 	<ol style="list-style-type: none"> 1. Preserving competition. 2. Facilitating consumers' convenience. 3. Preserving the right to privacy for users. 4. Reducing costs for establishment new branches. 5. Expanding business hours. 	<ol style="list-style-type: none"> 1. Accommodating with many parties (e.g. customers, retail shops, various users). 2. Thai people may prefer credit cards to debit cards. 3. Leading to frauds. 4. Customers are still satisfied with existing systems.

Sources: (Advantage Group Limited, 1996; Butler Group, 1997b; Federal Bureau of Consumer Affairs, 1995; P. Jirapinyo, personal communication, December 19, 1996; Kelly, 1994; Kivel & Rubin, 1996b; Mysior et al., 1984; The Siam Commercial Bank's executives, personal communication, December 15-20, 1996)

2.5 Summary

This chapter presented information with regard to the adoption and diffusion of information and communication technologies (ICT) and the properties of banking technologies, which are being used in the case study bank: smart cards, data warehouse, video-conferencing, Internet/Extranet banking and Electronic Fund Transfer at Point of Sales. These technologies are employed as technological alternatives to be evaluated in Chapter 7. Diffusion models in Chapters 8-11 represent diffusion of the selected technologies.

In effect, banks have invested in technology in hopes of leapfrogging their rivals in terms of competitive advantages, cost reduction, and coping with an increasing volume of business. Therefore, banking industries have increased technological investment dramatically. Unfortunately, technological expenses sometimes as yet more than offset improved productivity and gained promising returns. Customers blame decreased productivity on under-trained employees and an increasing use of computers in self-service systems, whereas bank staff makes excuses blaming customer errors and incompetence in using information and communication technologies (ICT) (Hackett, 1994).

A bank faces a dilemma. If it does not invest in a highly popular technology, its image as an innovative leader declines. However, if it does invest, benefits from technologies (e.g. cost reduction, a reduction in branch establishment and staffing, increased customer retention and increased revenue opportunities) are still difficult to obtain (Kivel & Rubin, 1996b). Benefits such as image and customer satisfaction are difficult to measure. The bank has to take risks since the costs are explicitly discerned, but benefits seem to be implicit. Also, gaining the full benefits from technological investment is related to many factors (e.g. staff and customers). Examples of problems include 1) the under utilisation of EFTPOS and video conferencing, 2) using data warehouse without any decision-making purposes, 3) providing Internet banking in societies where customers do not use computers and with imperfect communication facilities.

Therefore, successful ICT adoption and diffusion requires improved skills and capabilities of staff, integration with the structure of routine operations, meeting customers' requirements, reduced operating expenses, and consistency with organisational policies and procedures (Hackett, 1994).

In the next chapter, information relating to decision-making issues is provided as a background in order that prospective decision-makers would use appropriate decision-making tools to evaluate technological alternatives and provide ways to maximise benefits from the selected technology.

CHAPTER 3

DECISION-MAKING ISSUES

3.1 Introduction

People usually make trivial and wrong decisions by using their intuition, experience or their own judgements. They make trivial decisions probably because the topics of concern are not important, or the options are obvious to them to select the best option, or the effects from making the wrong decision is not serious (e.g. selecting movies, or buying lunch). However, from time to time they have to make hard decisions (i.e. important, complex, confusing and stressful decisions) whereby the problem involves uncertainty, multiple conflicting objectives and multiple stakeholders (Goodwin & Wright, 1993; Von Winterfeldt & Edwards, 1986). Hard decisions are far beyond a person's capability of using intuition to solve the problem.

As previously mentioned in Chapter 1, making decisions with regard to the adoption and diffusion of information and communication technologies is hard. Decision-makers have to confront organisational constraints (e.g. time, resources, and skill), take many factors into account (e.g. technology, organisation, economic and politic), deal with multiple alternatives and criteria, and accommodate many stakeholders (e.g. technological staff, end users, customers, and vendors). Therefore, rational decision-

making seems more appreciated than decisions taken using intuitions to facilitate the decision-making processes for decision-makers.

This Chapter presents fundamental information on decision-making issues beginning with decision-making, group decision-making and decision-making models. Decision-making tools should be selected based on the types of problems. Two decision-making tools: multiple criteria decision making (MCDM) and system dynamics (SD) are considered to be suitable for handling problems with regard to technology adoption and diffusion. The details and the justification for using these two decision-making tools are explained and discussed.

3.2 Decision-Making

Amoroso (1993, p.5) describes decision-making as:

“a process that collects information, and then evaluates it in order to search for alternatives and choose the most preferable alternative.”

According to Simon (1977), decision-making involves initially four principal phases: intelligence, design, choice, and review activity. The review activity is changed to an implementation phase (Alter, 1996). Alter (1991) (as cited by Atkinson 1995) expanded the decision-making process to comprise five phases: intelligence, design, choice, implementation and control (as indicated in Table 3.1).

1. **Intelligence phase.** In this phase, a decision-maker is aware of the existence of problems or opportunities. He/she will define a problem by identifying objectives, related variables, constraints, and potential benefits from the results of decision-making. During this phase, data both external and internal are collected from various sources and can be analysed by many techniques ranging from judgement, intuition, experience and computerised-technology support (Amoroso, 1993).
2. **Design phase.** A decision-maker searches for and assesses alternatives. This phase is subdivided into two stages. The first stage is to generate feasible alternatives and then propose a selection. During the second stage, each

alternative is evaluated according to determined criteria (Simon as cited by (McKenna, 1980)).

3. **Choice phase.** After the proposed alternatives are evaluated by using various models, the most appropriate or the most preferable alternative is selected for implementation.
4. **Implementation phase.** In this phase the selected alternative is brought into daily operation. Concurrently, further decision-making can be performed if unexpected problems arise.
5. **Control Phase** The process of decision analysis allows decision-makers to inspect or to audit outcomes of their decisions. Generally, decision-makers can control their decision-making process and outcomes at any phase. Therefore, there are feedback loops between one phase and its previous phases. For example, when data are collected, decision-makers sometimes have to go back to redefine their problems.

Table 3. 1. Phases of Decision-Making

Phase	Characteristics
Intelligence	<ul style="list-style-type: none"> - Being aware of the existence of problems or opportunities. - Defining a problem by identifying objectives related variables, some constraints and potential benefits.
Design	<ul style="list-style-type: none"> - Generating feasible alternatives and proposing them for a selection. - Evaluating each alternative according to determined criteria.
Choice	<ul style="list-style-type: none"> - Selecting the most appropriate or the most preferable alternative for implementation. - Using sensitivity analysis, if deemed necessary.
Implementation	<ul style="list-style-type: none"> - Placing the selected alternative into daily operation. - Performing further decision-making, if unexpected problems arise.
Control	<ul style="list-style-type: none"> - Inspecting or auditing the outcome and making necessary adjustments.

Source: (Alter, 1996; Atkinson 1995)

3.2.1 Group Decision-Making

DeSanctis and Gallupe (1987, p. 589) define group decision-making as:

“two or more people are jointly responsible for detecting a problem, elaborating the nature of the problem, generating possible solutions, evaluating potential solutions or formulating strategies for implementing solutions.”

Generally, the decision-making of one person always has an impact on other persons, groups and organisations. Large organisations and businesses are inclined to make decisions in groups rather than as individuals. It is believed that group decision-making brings about more efficiency and effectiveness in solving problems, maximises the satisfaction of an organisation as a whole, and promotes better decision-making.

Yet, disadvantages of group problem solving also exist such as competition, conformity, lack of responsibility, time wastage and increased risk taking (Stevens, 1988). Group members sometimes tend to support each other and co-operate against external threats leading to groupthink (Janis, 1972). Additionally, they may change their objectives or preferences for outcomes during the decision process, and some may be biased to certain aspects of the problems (Franz, Reeves, & Gozalez, 1986).

In effect, the major dynamics of groups that can lead to less than effective decision making are: social loafing; diffusion of responsibility; polarisation (i.e. risky shift phenomenon); de-individuation; and groupthink (Forsyth, 1990). The details of characteristics and negative effects on group decision-making are illustrated in Table 3.2.

Table 3. 2. Major Group Dynamics Threatening Effective Decision-Making

Group dynamics	Characteristics	Negative effects
Social loafing	A reduction of individual effort when working in a group.	Reduction in making effort to complete the work.
Diffusion of responsibility	A reduction of personal responsibility in a group	<ul style="list-style-type: none"> - Less personal effort to complete group task. - Fail to take responsibility for their actions. - Tend to take greater risky decisions.
Polarisation (risky shift phenomenon)	A tendency for groups to make more risky decisions than individuals.	Negative effects from risky decisions.
De-individuation	Individuals lose a sense of themselves in a group as consequential participants	<ul style="list-style-type: none"> - Run the risk of behaving in irrational ways. - Lack of concern for others.
Groupthink	A distorted style of thinking that renders group members incapable of making a rational decision due to a cohesive ingroup pressure.	<ul style="list-style-type: none"> - Take riskier decision - Lack of creativity. - Fail to consider or generate other alternatives. - Poor decision- making because group members support each other and unite against external threats.

Source: Adapted from (Atkinson, 1996)

3.2.2 Decision-Making Model

There are two types of decisions: structured and unstructured decisions. Structured decisions are based on clear logic and most are quantitative. The factors and the outcomes are well defined and the decision making process is repetitive. On the contrary, unstructured decisions involve heuristic, trial and error approach, intuition and common sense. The logic is vague and most are qualitative. The decision-makers deal with ad hoc and seldom repeated problems. Structured decisions are made by lower managerial level, whereas unstructured decisions are made at the middle and top level of management in the organisation (Licker, 1997).

Unstructured decision-making is a difficult process due to the characteristics of decision problems (e.g. involving multiple objectives, accommodating uncertainty, complex structures, and relating to multiple stakeholders) (Goodwin & Wright, 1993). Furthermore, people rarely perceive rationality to be an information-bounded condition. First, they do not identify all decision options. Second, they make decisions based on limited rather than perfect information. Third, the outcome of the decisions cannot be predicted with accuracy due to the complexity of the information relationships in the system (Simon, 1982).

Therefore, a model is employed to facilitate a decision-making process. A decision-making model is built to foster understanding of complex relationships within a system.

A model is an abstraction of reality and can be conceptually regarded as a representation for a real system. Thus, a model can be used to examine real world situations with less risk, time and money instead of investigating and experimenting with the real system. Given this, models are a valuable aid to strategic policy analysis and policy-making (Kornbluh & Little, 1976, p.8).

Generally, people use models whenever they try to think systematically about some phenomena. The fundamental model is a mental model, which is formed through people's experience, knowledge and intuition to understand the phenomena. Since mental models may be insufficient for capturing complex systems, decision-making models have been developed to structure processes, clarify interrelationships, handle complex data, and apply a decision-modelling technique in accordance with the types of problem (Kornbluh & Little, 1976).

Table 3.3 indicates how problems and decision-modelling techniques can be matched. For example, multiple criteria decision making (MCDM) is suitably employed to evaluate a limited number of discrete alternatives based on multiple criteria or stakeholder perspectives, examine strengths and weaknesses of options, develop new alternatives and select the best option. On the other hand, system dynamics (SD) is employed to understand long-term implications of decision alternatives in situations where change occurs over time and the complexity of

change is compounded by inter-related effects (Reagan-Cirincione, Schuan, Richardson, & Dorf, 1991).

Table 3. 3. Types of Problems and Appropriate Decision-Modelling Technique

Modelling Technique	Type of Problem	Potential Applications
Multiple Criteria Decision Making (MCDM)	<ul style="list-style-type: none"> - Evaluating a limited number of discrete options based on multiple criteria or stakeholder perspectives. - Examining the strengths and weaknesses of options. - Developing new options and selecting the best choice. 	<ul style="list-style-type: none"> - Site selection - Personnel selection - Selecting a technical or performance standard.
System Dynamics (SD)	Understanding long-term implications of decision alternatives in situations where change occurs over time and the complexity of change is compounded by inter-related effects.	<ul style="list-style-type: none"> - Selecting policy alternatives by understanding their short and long-run consequences - Designing systems that deliver services over long periods of time.

Source: Adapted from Reagan-Cirincione et al., 1991

Nevertheless, decision-making models are difficult to apply with real problems because, although a decision model is an intellectual tool, a process of decision modelling always accommodates social and political issues.

3.3 Multiple Criteria Decision-Making (MCDM)

Multiple criteria decision-making (MCDM) is a decision-making tool employed to prioritise technology alternatives under a technology adoption phase of this research. The following sections will explain MCDM in detail.

3.3.1 Definition

Zionts (1979) defines multiple criteria decision-making (MCDM) as decisions that involve conflicting objectives.

Korhonen, Moskowitz and Wallenius (1992, p.362) give a definition of multiple criteria decision-making (MCDM) as follows:

“A single DM (decision-maker) has to choose among a countable (usually finite) or uncountable set of alternatives using two or more (multiple) criteria... Negotiations/ group decision-making: A natural extension of MCDM when more than one decision-maker is present.”

MCDM is an approach that takes explicit account of multiple conflicting criteria in decision-making. It helps decision-makers understand a problematic situation, and thus to make appropriate judgements leading to better decisions (Belton, 1990).

MCDM constitutes both descriptive and prescriptive models of decision-making. MCDM models are descriptive because they require information from decision-makers to derive accurate models for a decision-making process. They remain prescriptive models within the constraints posed by the decision-makers (Nazareth, 1993).

MCDM is considered as a method that is suitable to deal with problems in the real world. In the first place, a decision problem is complicated because it is associated with multiple alternatives and criteria. Furthermore, in a decision-making process, decision-makers are confronted with constraints such as time, available resources and potential competence. Therefore, it is difficult to find an optimal solution where every affected party achieves satisfaction. Finally, most criteria conflict with each other. For example, to achieve the best technical feasibility requires prohibitive costs to develop that technique and leads to an impact on economic feasibility. Thus, decision-makers have to trade-off among different alternatives.

Thanks to MCDM, decision-makers are able to handle complex and difficult decisions. Firstly, they can compare end results between using their intuition and using a MCDM analysis supported by user-friendly software leading to enhancing their level of understanding and learning, and subsequently improving their decision-making. Secondly, the steps in MCDM can be undertaken in an organisation without difficulties or interpersonal conflict, and encourage people to shift from their intuition to rational

decision-making. Thirdly, an MCDM analysis can be conducted for group decision-making, accommodating many participants at different time and places.

In effect, MCDM is suitable to be employed in the technology adoption phase because it helps decision-makers evaluate and prioritise competitive technological alternatives that can enhance the achievement of the business goals of an organisation. Once the best technology is selected, the organisation can elaborate on the technology using other decision tools in order to utilise it productively.

3.3.2 MCDM in this Study

According to the MCDM approach, the two techniques extensively used to evaluate alternatives are the Simple Multi-Attribute Rating Technique (SMART) and the Analytic Hierarchy Process (AHP) (Belton, 1990). Belton (1986) made a comparison between the two techniques and concluded that both approaches have been widely and successfully used in practice. However, she felt that the SMART approach is more transparent and easily understood. Given this, the technique employed in this study is the Simple Multi-Attribute Rating Technique (SMART).

The Simple Multi-Attribute Rating Technique (SMART), developed by Ward Edwards, places emphasis on simplicity of rating methods. SMART is the technique used to make a provisional decision by weighting the identified criteria based on levels of importance (Edwards, 1977).

SMART is a simplified approach of multi-attribute utility theory (i.e. MAUT) (Quaddus, Atkinson, & Levy, 1992). MAUT can be classified under MCDM, but it is usually treated separately when risks or uncertainties have a significant role in the definition and assessment of alternatives (Dyer, Fishburn, Steuer, Wallenius, & Zionts, 1992). SMART is suitable for evaluating a limited number of discrete options based on multiple criteria or stakeholders' perspectives, examining the strengths and weaknesses of options, developing new options, and selecting the best option (Reagan-Cirincione et al., 1991).

SMART has been widely applied because of the simplicity of its use and its transparent process of analysis. Decision-makers thus can understand the problems better and the

process of result acquisition becomes clearer than the use of the mathematical decision analysis approaches. Additionally, SMART can be employed in a group decision-making environment (Goodwin & Wright, 1993).

The basic idea of SMART measurement is very transparent. Every outcome of an action may have a value on a number of different criteria. The technique is to discover those values, one criterion at a time, and then to aggregate them across criteria using a suitable aggregation rule and weighting procedure. The technique of SMART follows these ten steps (Edwards, 1977).

1. Identifying persons or organisations whose utilities (values) are to be maximised.
2. Identifying an issue or issues (i.e. decisions) to which the utilities needed are relevant.
3. Identifying alternatives to be evaluated.
4. Identifying relevant criteria of value for evaluation of the alternatives.
5. Ranking the criteria in order of importance.
6. Rating the criteria in importance, preserving ratios.
7. Sum the importance weights, and divide each by the sum.
8. Measuring the location of each alternative being evaluated on each criterion.
9. Calculating utilities for alternatives.
10. Deciding if a single act is to be chosen, maximise utilities.

3.3.3 MCDM Software Application in this Study

Many software applications have been developed to facilitate MCDM analysis which can be classified as follows (Quaddus & Siddique, 1994):

1. MCDM based on a simple weighted sum model (e.g. HIVIEW, EQUITY, V.I.S.A., and PREFCALC),

2. MCDM based on Analytical Hierarchy Process (e.g. EXPERT CHOICE, and CRITERIUM),
3. MCDM based on outranking method (e.g. PROMETHEE), and
4. MCDM based on holistic visual display (e.g. GRADS).

Vetschera (1994) introduced the MCView system for the graphical support of multi-attribute decision problems providing the user with a better understanding of the consequences of information.

The software application employed in this study is Visual Interactive Sensitivity Analysis (V.I.S.A.). This software, developed by Belton and Vicker (1989), is based on a linear additive value model. V.I.S.A. is a useful tool to evaluate multiple conflicting criteria problems. It helps decision-makers to clarify various obscure and uncertain issues, and to fulfil a need for more sophisticated sensitivity analyses and an effective way of presenting the information gathered from such analyses.

3.4 System Dynamics (SD)

System dynamics (SD) is a decision-making tool used, in this research, for more detailed analyses of the preferred technologies selected from the MCDM analysis in order to capture dynamic aspects and inter-relationship among variables. It is used for model development of technology diffusion.

3.4.1 Definition

System dynamics was first developed by Jay Forrester in 1956 as 'industrial dynamics' at the Massachusetts Institute of Technology (MIT). System dynamics is perceived as a practical problem solving approach. In system dynamics one tries to understand the structures that produce undesirable symptoms in order to find changes in system structure and policies that will improve system behaviour (Forrester, 1992).

Wolstenholme (1994, p.3) gives a definition of system dynamics (SD) as

“a rigorous method for qualitative description, exploration and analysis of complex systems in terms of their processes, information, organisational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and control.”

The definition of SD is further elaborated by Coyle (1996, p.10).

“System Dynamics (SD) is a study of the time-dependent behaviour of systems with the aim of describing the systems and understanding, through qualitative and quantitative models, how information feedback governs its behaviour, and designing robust information feedback structures and control policies through simulation and optimisation.”

SD methodology puts emphasis on conceptualisation, formulation and simulation (Richardson, 1996). It is divided into two stages, qualitative and quantitative analysis. Initially, modellers identify system descriptions for problem development and formulate a qualitative model. Subsequently, the relationships formulated in the conceptual model are developed for quantified analysis using simulation techniques (Wolstenholme & Coyle, 1983).

SD is used to elicit people’s knowledge and get them to articulate perceptions. Feedback structures of a problem are created from those perceptions, and then simulated through them. This helps people to learn about complex dynamic systems and test new policies to improve the system behaviour or resolve the problem (Sterman, 1994).

Since people think statically rather than dynamically, assign responsibility for performance to external factors rather than internal, and think correlatively rather than operationally, SD has been developed to get rid of barriers to learning habits by shifting people’s minds in three respects (Richmond, Peterson, & Charyk, 1994).

- from straight-line to closed-loop causality, (i.e. from a static to a dynamic orientation),

- from an externally oriented to an internally-oriented responsibility for performance, and
- from a causal (e.g. what factors will influence performance?) to an operational view (e.g. what are the relationships that generate performance, and how are they generated?).

3.4.2 Systems

System dynamics puts emphasis on analysing a problem in a holistic perspective of a system rather than dividing it into fragments.

Ackoff (1971, p.106) defines a system as

“a set of interrelated elements...Each of a system’s elements is connected to every other element, directly or indirectly... No subset of elements is unrelated to any other subset.”

A system is a collection of parts organised for a purpose (Coyle, 1996, p.4). It incorporates information relationships relevant to well-recognised processes (Saeed, 1990). It concentrates on the analysis and design of the whole because the whole is more than merely a sum of its parts. The parts acquire certain characteristics due to their existence in the whole (Kornbluh & Little, 1976).

A system consists of sub-systems. Each sub-system performs part of the system function. In modelling sub-systems are used to decrease complexity, which therefore leads to enhancing understanding of a system. A system boundary incorporates organisations related to a topic of concern; anything outside the system boundary is a system environment. The main objective to define the system boundary is to clarify which organisations or people control each rate variable in a process (Wolstenholme, 1994). A system also incorporates feedback, which is the idea of monitoring actual system output and comparing it to the system goal or desired results. When performance of a system varies within an acceptable range, it is considered to be stable. When its performance falls outside, a system may display erratic or unsatisfactory behaviour. Once the instability occurs, adjustments to the system are

usually made by changing inputs or control elements of the system such as rules, policies, processes, and procedures (Kornbluh & Little, 1976).

As a matter of fact, people feel that it is hard for them to capture system behaviours because a system accommodates many variables. Therefore, some are inclined to study a system based on a piecemeal and analytical approach by dividing it into discrete and unique pieces. Then, each piece is examined separately to gain a better understanding (i.e. a divide and conquer orientation) (Keeney, 1982). This method, however, cannot improve system behaviours because it fails to consider objectives for the total system and the interrelationships of the parts and their effects (Kornbluh & Little, 1976). Consideration of problem issues based on the whole system is important.

3.4.3 Simulation Model

According to Forrester (1994), people make decisions mostly based on their mental models. Mental models are sets of assumptions and observations gained from experience. Making decisions based on mental models, however, cannot provide good results due to serious shortcomings of the models including incompleteness, internal contradictions, inability to draw correct dynamic conclusions from the structural and policy information, and omitting feedback, time delays, accumulation and non-linearity.

As a consequence, simulation is used to compensate for deficiencies of mental models. A simulation model is a dynamic model involving changes in the state of the system through time. It expresses dynamic relationships among variables, constants, and parameters by imitating the behaviour of a system, step by step over time (Kornbluh & Little, 1976).

Generally, a simulation model is useful for the following situations (Forrester, 1994).

- A system is poorly understood and decision-makers attempt to gain more insight about its relationships.

- A system is complex. Therefore, its interactions and relationships are not obvious and make system behaviour hard to predict.
- A process is changing so that statistical results are improved by using non-statistical information.
- A decision analyst wants to test the impact of policy interventions or sensitivity analyses quickly and cheaply.
- Data are insufficient, non-existent, suspect, or too short for reliable or valid estimation based on statistical analyses.
- A decision analyst tries to keep good track of processes with stocks, flows, time lags, feedback or feed-forward controls.

Numerous advantages are anticipated from using a simulation model. First, the simulation model may provide new and deep insights into system behaviour. Second, decision analysts can use the model to conduct experiments on system behaviour in order to observe and test the impact of current or potential policies on future system behaviours. Third, although a simulation model cannot eliminate risk, it allows decision analysts to clarify the nature of various risks leading to a reduction in risks. Fourth, it can be used as a learning device for policy-makers. Fifth, the development and implementation of a simulation model may support more open communication among interested parties (Kornbluh & Little, 1976). In addition, simulation is considered as an important element of successful learning laboratories to develop systems thinking and to promote organisational learning in real organisations where decision-makers are involved in the situation (Senge & Sterman, 1992).

System dynamics is widely employed to simulate possible scenarios for businesses in order to gain more understanding of the complicated, long-term interrelationships and feedback loops of complex problems leading to decreasing uncertainty and gaining more confidence before implementation (Reagan-Cirincione et al., 1991; Wolstenholme, 1994). It is also used as a practical way to test models or policies, speed up and strengthen the learning feedback. Without simulation, system behaviours can only be tested and improved by relying on the learning feedback through the real world,

which is very slow and rendered ineffective due to dynamic complexity, time delays, ambiguous feedback, poor reasoning skills, defensive reactions and high cost of experimentation (Sterman, 1994).

3.4.4 Qualitative and Quantitative System Dynamics

A system dynamics modelling process is divided into two phases: qualitative and quantitative. The objectives of each phase are indicated in Table 3.4. Qualitative system dynamics employs influence diagrams to depict cause and effect of system behaviours in order to explore and analyse a system. Then, the influence diagrams are converted into a quantitative model using computer software applications to quantify and simulate them by changing or exerting parameter values, structures and strategies in order to gain a better understanding, re-design system structures, and detect leveraged strategies to improve system behaviour (Senge, 1992; Wolstenholme, 1994).

Table 3. 4. Qualitative and Quantitative System Dynamics

Qualitative System Dynamics	Quantitative System Dynamics (Simulation phase)	
<ul style="list-style-type: none"> - Creating and examining feedback loop structure of systems. - Providing a qualitative assessment of the relationship between system processes, information, organisational boundaries and strategy. - Estimating system behaviour and postulating strategy design changes to improve behaviour 	<p>Stage 1</p> <ul style="list-style-type: none"> - Examining the quantitative behaviour of all system variables over time. - Examining the validity and sensitivity of system behaviour to changes in information structure, strategies and delays/uncertainties. 	<p>Stage 2</p> <ul style="list-style-type: none"> - Designing alternative system structures and control strategies based on intuitive ideas and control theory algorithms in terms of non optimising robust policy design. - Optimising the behaviour of specific system variables.

Source: (Wolstenholme, 1994)

3.4.5 System Dynamics Conceptual Framework

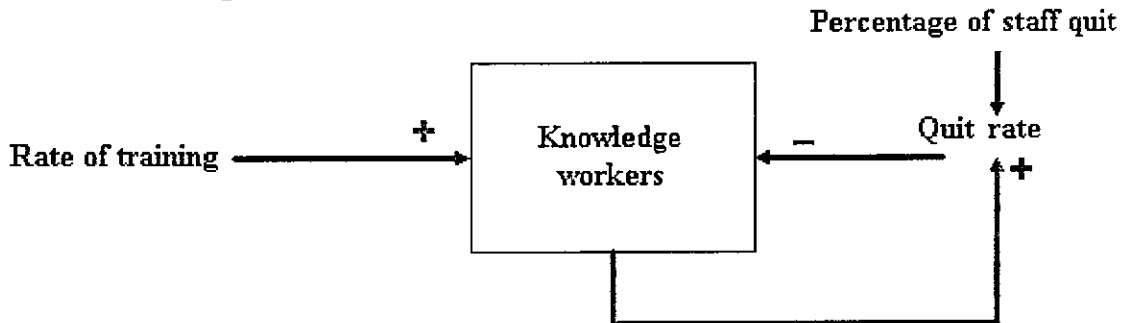
A system dynamics framework consists of five building blocks; process, information feedback, delays, organisational boundaries, and policies (Stevenson, 1993).

3.4.5.1 Process Structure

Process structures of systems are represented by resource flows, which consist of stocks (i.e. levels) and flows (i.e. rates). A stock of a resource (e.g. money) can accumulate the resource and can be quantified at any point in time. Its dimension is in resource units (e.g. dollars). A flow variable is used to change or control resources by increasing or decreasing stocks. Its dimension is in units per period of time (e.g. dollars per month) (Wolstenholme, 1994).

In an influence diagram, arrows represent flows whereas boxes represent stocks. The polarity of influences is specified by a plus or minus sign. If a change of the two variables is in the same direction, then the link is positive. On the other hand, if a change is in an opposite direction, then the link is negative. All the variables are linked creating feedback loops. For example, “knowledge workers” (i.e. stock) will increase if an organisation increases “rate of training” (see Figure 3.1). The numbers of these knowledge workers will decrease when they leave the organisation. The higher rate of quitting results in fewer knowledge workers. The influence diagram (Figure 3.1a) can be transformed into a pipe diagram (Figure 3.1b) with the same concept using *ithink* software. The pipe diagram represents flows (i.e. rates) by pipe arrows, and stocks (i.e. levels) by rectangles (Stevenson, 1993).

a. Influence diagram



b. Pipe diagram using *ithink* software

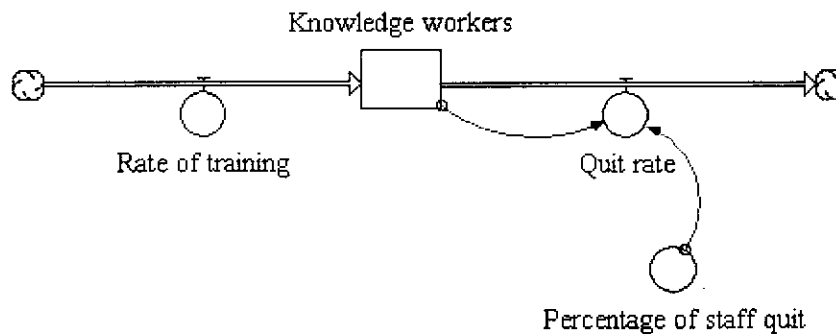


Figure 3. 1 Influence Diagram and Corresponding Pipe Diagram using *ithink* Software

3.4.5.2 Information Feedback

The major use of a system dynamics diagram is to identify information feedback loops, which have been created by linking stocks and flows. The analysis of feedback loops facilitates understanding of how processes, organisational boundaries, delays, information, and strategies of systems interact to create system behaviour. Feedback fundamentally determines the behaviour of all real world systems. A decision in a system causes a change, which affects the next round of decision-making. Therefore, each decision creates an outcome which influences future decisions (Wolstenholme, 1994). Feedback may occur on two levels, through automatic adjustments to a system and through feedback of data to a human monitor who interprets these data and makes the necessary adjustments (Kornbluh & Little, 1976).

There are two types of a feedback loop, positive and negative, which are identified by multiplying together the signs of all individual influence links in a feedback loop in order to obtain the net effect (Wolstenholme, 1994). A positive feedback loop (i.e. reinforcing, or growth producing) generates growth or decay in a variable. It tends to accelerate towards extremes, leading to greater system instability. On the other hand, a negative feedback loop (i.e. balancing, goal seeking, or controlling) helps a system adapt to unexpected and undesirable changes. It corrects to a balance or desired norm or reduces a gap between a variable and a target variable (Coyle, 1996; Kornbluh & Little, 1976; Stevenson, 1993).

3.4.5.3 Delay

A delay is a lag between the start and finish of a resource conversion activity (Stevenson, 1993; Wolstenholme, 1994). Delays are involved in quite a few activities and their quantities are based on various types of issues. For example, it takes a few seconds to send data via electronic banking technologies, a few days to train staff in an organisation, a few months for customers to perceive benefits from new products, and years to realise the adverse effects in social, economic or ecological systems.

3.4.5.4 Organisational Boundaries

Organisational boundaries are specified in order to clarify which organisations or people control each rate variable in the process. Since there are many organisations controlling different parts of a process, the process will not flow smoothly unless organisations integrate their control strategies, management perspectives and policies (Wolstenholme, 1994).

3.4.5.5 Policies

A policy is a set of rules which managers use as a basis for decision-making (Stevenson, 1993). One of the main objectives in employing a SD model is to detect and subsequently exert high leveraged policies in order to create change and/or stabilise performance in the system leading to improving system behaviours. However, finding high impact policies may be difficult because there are many interconnecting feedback loops in a complex system. A policy, which is intended to

solve a problem, may result in unexpected or unintended outcomes. According to Forrester (1994), 98% of the policies in a system have very little leverage to create change, only a few high leveraged policies can alter the behaviour of the system.

3.4.6 Model Construction

System Dynamics models can be constructed by a feedback loop approach or a modular approach. The feedback loop approach is to identify feedback structures similar to “reference mode” behaviour. Since certain types of simple feedback loops create certain known types of system behaviour, this approach can promote understanding of how the loop contributes to behaviours. If the reference mode behaviour is not available, the modular approach is more suitable. This approach starts with one or two key variables as the cause of concern. These variables are manipulated to indicate process, information, delay, strategy and organisational boundaries of a system. (Wolstenholme, 1994).

5.4.6.1 Feedback Loop Approach

The process for constructing the SD modelling using the feedback loop approach follows these steps (Saeed, 1992).

1. Organising historical information into a reference mode, which is used to formulate a dynamic hypothesis.
2. Creating important feedback loops existing among the decision elements in the system to show the particular time-variant patterns contained in the reference mode.
3. Constructing a formal model, incorporating the dynamic hypothesis and the other structural details of the system related to the problem.
4. Testing the model structure under extreme conditions and conditions identifiable in the real world to gain credibility.
5. Testing the behaviour of the model using computer simulation after a correspondence between the model and the real world has been reached.

The model is accepted as a valid model when a close correspondence is simultaneously achieved between model structure and theoretical and experimental information about the system, and between model behaviour and empirical evidence about the behaviour of the system.

3.4.6.2 Modular Approach

The steps to develop the SD modelling using the modular approach are as follows (Wolstenholme, 1994, p.28):

1. Recognising the key variables associated with the perceived cause(s) of concern. Where possible, obtain data on the behaviour of these variables over time and define a reference mode for the existing system behaviour over a suitable time horizon.
2. Identifying some of the initial system resources associated with the key variables.
3. Identifying some of the initial states (levels) of each resource.
4. Constructing resource flows for each resource, containing the identified states and their associated rates of conversion and including any significant process delays in the resource flows.
5. Identifying organisational boundaries, behavioural information flows and strategies, and including any significant delays in the information flows within each resource flow.
6. Identifying similar organisational boundaries, behavioural/information flows and strategies between different resource flows.
7. Identifying any new states of existing resources, or new resources, which affect the variables created and add these to those identified in steps 2 and 3.
8. Reiterating if necessary.

This study employs the feedback loop approach to develop models of technology diffusion following the process of both qualitative and quantitative system dynamics. Because a 'reference mode behaviour' of diffused technology based on previous research is available, which follows an s-curve (Brancheau & Wetherbe, 1990; Quaddus, 1995a; Rogers, 1983).

3.4.7 SD Software Application

Many software applications have been developed to aid system dynamic analyses including COSMOS, DYNAMO, DYSMAP2, *ithink*, Stella, Powersim, and Vensim (Coyle, 1996).

This study employs *ithink* software for system dynamics analyses because the software supports users at each stage of the modelling process (i.e. conceptualisation, model construction, model simulation analysis and communication) (Peterson, 1992). *Ithink* has tools to represent the building boxes (e.g. process structure, information feedback loops, delay, organisational boundaries and policies), has several methods of representing delays (e.g. conveyor) and includes a sector tool to define internal boundaries. Furthermore, it has an unique ability to explore links between process/feedback structure and dynamic behaviour which is an ideal tool for policy analysis and design (Stevenson, 1993). Most "power users" may prefer other packages. However, the biggest advantage of *ithink*, is a good interface for presentation to non-modelled users which is suitable for bank staff (the case study) to use it more easily than other packages.

3.5 Summary

This Chapter presented and discussed decision-making issues in order to provide the readers with a fundamental background on decision-making, both individual and group. Two decision-making tools: multiple criteria decision-making (MCDM) and system dynamics (SD) were summarised.

In conclusion, MCDM is a suitable tool for technology evaluation. It helps decision-makers rationally select an appropriate choice based on a set of criteria. Since

MCDM contains an insufficient ability in capturing inter-relationships among criteria and dynamic effects, a further analysis using SD allows decision-makers to rectify this inadequacy, explore factors and exert operational policies to exploit more advantages from the selected choice. MCDM will be used for evaluating technological choices in Chapter 7. SD will be used for analysis of technology diffusion in Chapters 8, 9 and 10.

The research from the areas of technology and decision-making will be reviewed in the next chapter for the purpose of enhancing understanding and finding differences between the proposed and previous research.

CHAPTER 4

LITERATURE REVIEW

4.1 Introduction

This chapter reviews previous literature and research findings related to the research topic. Five main research areas covered are technology adoption and diffusion, banking technologies, decision-making (highlighting group support systems), multiple criteria decision-making (MCDM) and system dynamics (SD). The knowledge obtained from this literature review not only contributes to the research process but also reveals differences between previous research and this study, thereby confirming the significance of this study.

4.2 Technology Adoption and Diffusion

Information and communications technology (ICT), at present, is the main technology acquired in most countries, with more than 50% of the acquired technology adopted via imports from developed countries (Papaconstantinou, Sakurai, & Wyckoff, 1998). ICT that impacts on organisations are individual work support, group work support, advanced organisational automation, and enhanced global communications (Thach & Woodman, 1994).

An adoption of ICT is initiated mostly through equipment purchase. When this happens, relevant software applications are required. However, the decision to adopt one specific technology may relate to other technology adoptions, learning and skill management, and other strategic choices in an organisation. In addition, technologies are implemented within a social context accommodating various factors such as economic, political, cultural, and behavioural, which are unique for each society (Stoneman & Kiederer, 1994). Thus, considering only physical properties of the adopted technology, without taking relating factors into account cannot fulfil the requirements of the organisation and may inhibit the success of technology adoption and increase the risks of failure for subsequent diffusion (Harris & Davison, 1999).

Since the efficacy of technology and its advantages depend on management of technology rather than the physical technology, technology adoption and diffusion should focus on managerial/organisational processes, and social contexts, and adapt to local cultures, markets and the circumstances (Bhatnagar, 1994; Gozlu, 1994). Furthermore, an organisation should find ways to incorporate business needs, technology empowerment and knowledge people, and take all the actions that may help the organisation to exploit maximised benefits of technology (Cervantes, 1997; Currid, 1993).

Various studies suggest ways to ensure the success of technology adoption. For example, Geisler (1992) identified seven criteria for IT adoption including the capabilities of technology, consistencies between technologies and organisational requirements, user acceptance, extendibility, compatibility, and life cycle of technology. Factors such as business size and executive characteristics are critical for the success of technology adoption. The preferred characteristics of chief executives are innovative orientation, positive attitude toward technology adoption, and sufficient IT knowledge (Thong & Yap, 1995). Fink and Kazakoff (1997) suggested that staff of an organisation need to: 1) assess IT benefits, organisational culture and compatibility between IT and organisation environment; 2) determine availability and sufficiency resources and appropriate procedures for the successful selection and implementation; and 3) evaluate external environment, support and resources, to decide if outsourcing is needed. Furthermore, in a competitive environment, an organisation should have a strategic management of technology that promotes an

ability to understand technological status and trends, focus on process technologies rather than product technologies, and enhance an ability to accurately assess new technology (Price, 1996).

Technology, once adopted, needs to be diffused to prospective customers as quickly as possible in order to gain benefits before it is obsolete. Rogers (1983) cited conclusively that the diffusion of an innovation follows a s-shape curve over time. Subsequently, the s-curve is considered a normal pattern (i.e. a reference mode) for any technology diffusion and evident in many studies despite the different types of technologies (Brancheau & Wetherbe, 1990; Liberatore & Breem, 1997; Quaddus, 1995a; among many others).

Critical success factors for technology implementation are top management support, interactions during implementation, compatibility between technology being used and its organisation and tasks, motivated and capable users, and sufficient available organisational resources (e.g. capable developers, time, funding, technical skills) (Kwon & Zmud, 1987).

A success of technology adoption and diffusion requires an appropriate technological choice and effective management strategy. Gagnon and Toulouse (1996) emphasised that during an adoption process, managers who behave like administrators can manage the process more adequately than ones who behave like entrepreneurs, because they will develop rational and analytic plans based on data analysis to create a cohesive plan before implementation. Furthermore, an organisation must learn to integrate business and technology in order to bring technology to be an integral part of the business strategies rather than to have it as a supportive role (Saeed, 1990; Sharif, 1994a; Takac & Singh, 1992).

4.2.1 Problems regarding Technology Adoption and Diffusion

In spite of spending massive resources on technology adoption and implementation, the rejection of technology occurs commonly because organisations can not overcome the problems. Socio-economic and political impediments for the success of an adoption and diffusion process are lack of institutions of higher/technical education, poor facilities, difficulty in retaining qualified technical personnel, ignorance of local conditions, differences in culture and work habits, insufficient

management support, and user attitudes (Odedra-Straub, 1994; Pradhan, 1994). Manross and Rice (1986), concluded that failure in new technology implementation comes from lack of an understanding of the politics of organisational decision-making, technical difficulties, professional norms, lack of training, insufficient support, and absence of user involvement.

Following problems, which hinder the adoption and diffusion of technology, have been obtained from the literature.

- **High costs of technologies.** Many organisations are mainly concerned about costs of technology because during an adoption period, advantages from technology are implicit and take long time to obtain whereas short run costs are readily available. The study of Desai, Wright and Fletcher (1998) emphasised that cost is perceived as a hindrance factor to adopt the database marketing systems in financial services. Generally, a more costly technology is less likely to be adopted. However, once it is adopted, organisations have to put much effort to diffuse it because of the large investment made by the organisation (Gerwin, 1988; Tornatzky & Klein, 1982).
- **Rapid obsolescence.** Organisations hesitate to invest in new technology because of the rapid rate of technological evolution. They can not ascertain whether or not technology will provide a good return on investment before its obsolescence (Geisler, 1992).
- **Selecting inappropriate technologies.** Quite often, organisations reject new adopted technologies despite spending massive resources on implementation. The cause of rejection is that the organisations have selected inappropriate technologies (Manross & Rice, 1986).
- **Cannot use an adopted technology productively.** Using technology productively is contingent upon not only the capacity of technology itself but also other factors. The four major factors that impact the rate of technology adoption and diffusion are users, organisations, tasks and organisational environments. Such factors have to be in readiness and

compatible to speed up the rate of diffusion of technology (Kwon & Zmud, 1987; Rogers, 1983).

- **Acceptance by customers.** Customer acceptance is a key issue for organisations to determine whether to adopt new technologies or not. Despite many opportunities and advantages, people usually hesitate to be early adopters because being in the forefront they may be confronted with a large number of risks (Schulman, 1997). Furthermore, even though technologies have been already adopted, the technologies are sometimes switched from an implementation phase to a 'wait and see' phase (Barras, 1994; Jenkins & McKenzie, 1997; Mysior, Shuman, & Linstone, 1984). The Bank of Scotland for example, extended an ATM programme because its 'Scotcash' (i.e. cash dispenser), failed to achieve consumer acceptance (Scarborough & Lannon, 1994). The history of banking technologies (e.g. ATM's and EFTPOS) indicates that the public acceptance of new technology takes between ten and twelve years (Jenkins & McKenzie, 1997). Customer resistance to technology usage are due to customer's free will, the inability to understand, incompatibility of the innovation with existing systems, and lack of confidence in computer competence (Herbig & Day, 1992).
- **Acceptance by users in an organisation.** Although organisations purchase new technology, an adoption will not be completed or implementation is hard to be successful unless ultimate users accept that technology. Factors considered barriers for user acceptance are absence of user involvement, lack of an understanding regarding politics of organisational decision-making, technical difficulties, lack of training, insufficient support from top executives, and perceived complexity (Manross & Rice, 1986; Wynkoop, Senn, & Conger, 1992). Therefore, it is vital for an organisation to create user awareness of new technology and manage its organisational diffusion effectively to ensure that adopted technology can bring a good return on investment (Agarwal, Higgins, & Tanniru, 1991).

Insufficient communication between IT people and users is considered as one of the main causes for user resistance. Many studies provide ways to

promote better communication. For example, change agents should clarify the concept of new technology, explain expected benefits tailoring to each group of users, evaluate technology's impact on the organisation, involve users during technology development phase, and provide technical training as one of a project team (Blackler & Brown, 1985; Chen, 1985). Mittermier, Hsia, and Yeh (1987) suggested three other techniques to enhance effectiveness in communications: objective analysis (i.e. investigating pre-requirement problems); prototyping; and a scenario technique (i.e. providing users with an actual feeling of the operation and performance of a future system). Martinsons and Chong (1999) pointed out that proactive and supportive human resource roles might increase user satisfaction and lessen problems associated with organisational change. Furthermore, the positive relationships between the two groups can be accrued if IT people eliminate the following myths in regard to users' ability: 1) users don't know what they want; 2) users keep changing their minds; 3) users want every thing yesterday; 4) users react emotionally and illogically; 5) users are stupid; 6) users resist change (Oliver & Langford, 1987).

- **Lack of capable employees.** Evidently, human resources, in terms of sufficient numbers of competent and motivated employees, contribute to the achievement of technology adoption and diffusion, especially, high or knowledge-intensive technologies (Martinsons, 1995; Martinsons & Chong, 1999; Nambisan & Yu-Ming, 1999). However, quite often, organisations tend to seize opportunities for technological adoption without planning for resources required for an implementation phase. Scarcity and insufficiency of people with technological competence always leads to difficulty in operation and maintenance (Barras, 1994; Gagnon & Toulouse, 1996; Manross & Rice, 1986; Phananimamai, 1995; Pradhan, 1994).
- **Lack of high level executive support.** Top management support is a critical factor for success or failure of technology adoption and diffusion. Without the full support from top executives, technology cannot be successfully implemented (Cooper & Zmud, 1990; Gagnon & Toulouse,

1996; Kwon & Zmud, 1987; Lambert, 1996; Manross & Rice, 1986; Tye & Chau, 1995).

- **Receiving incorrect information.** Organisations obtain information mainly from vendors who always make great efforts to promote it with positively biased and exaggerated aspects. Furthermore, on the one hand, justification based on business managers' views cannot cover all technological aspects due to insufficient knowledge and experience in technology. On the other hand, to hand over the same issue to technical staff may lead to lack of consideration of business issues (Geisler, 1992; Gerwin, 1988; Manross & Rice, 1986; Redman, 1995).
- **Technology did not deliver expected performance.** Information technology (IT) applications are considered as risky investments. Organisations always anticipate various relative advantages from technology before adopting it. However, during an implementation phase, technology may not provide promised returns or its actual outcomes may deviate from expectations due to both technical and non-technical factors (e.g. human factors, organisational environments, and human resource management issues associated with IT diffusion). Thus, if initial expectations of technology are not met when it is used, implementation will not be successful (Dos Santos & Peffers, 1995; Rifkin, 1987; Wynekoop et al., 1992).
- **Technological mismatch.** An important factor affecting an adoption rate of any innovation is its compatibility with values, beliefs, past experiences of an organisation, and its existing facilities. Technological mismatch occurs commonly due to the disparities between a donor of technology and adopters in terms of differences in culture, management philosophies, and work habits (Pradhan, 1994; Rogers, 1983). Gerwin (1988) stated that during implementation expectations would tend to be high due to arguments of innovation's advocates, while performance would tend to be low due to inconsistency between technology and infrastructure.

- **Technical difficulties.** According to previous research, lack of understanding of new technology is a significant barrier to technology diffusion (Geisler, 1992; Gerwin, 1988; Manross & Rice, 1986; Sharif, 1994b).

4.2.2 Factors Driving Technology Adoption and Diffusion

A survey of 1,000 companies from Business Week using integrated services digital networks (ISDN) as a case study revealed that companies most receptive to adopt technology are larger, less open, have more slack resources, more technology expansion actions, and fewer technology restriction actions (Lai & Guynes, 1997). Additionally, since technology adoption requires an overall return on its investment, factors such as economic returns, effectiveness, cost, security, reliability and linkage have to be considered (Takac & Singh, 1992).

Increasing returns due to technology adoption may be a primary factor that drives technology diffusion. Firstly, employing new technologies, users may promote development of a learning process that leads to improving technology use and product improvement. Secondly, economies of scale deriving from technology diffusion may result in higher margins leading to further adoption by both users and producers. Thirdly, widespread use of a main technology always brings about other “infrastructure technologies”. Fourthly, as technology becomes more widespread, users may gain advantages from “network externalities” (i.e. a positive relationship between a value of a product and number of consumers using the same product) (Caskey & Sellon, 1996; Fichman & Kemerer, 1994).

A review of literature shows that the factors that enhance the rate of adoption and diffusion are as follows:

- **Relative Advantages.** Many researchers advocate that relative advantage or expected benefit is the key factor that attracts organisations to adopt technology. The greater the perceived benefits, the more likely the innovation will be adopted (Fried, 1993; Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989; Rogers, 1983;

Thompson, 1987a; 1987b; Tornatzky & Klein, 1982; Waema & Walsham, 1990; Wynekoop et al., 1992)

Relative advantage refers to benefits including increased sales, extended market shares, increased competitive advantages, improved efficiency, more accurate and timely information, better image, reduced costs, and effective decision-making.

A competitive advantage means that an organisation has found a better way to serve its customers or acquire new customers through an adoption of new technologies. A competitive advantage brings about a greater market share, a higher profit or a better return on investment (Dos Santos & Peffers, 1995; Mysior et al., 1984; Paich & Sterman, 1993; Preece, 1989; Remenyi, 1988; Scarbrough & Lannon, 1994; Takac & Singh, 1992). The results of an extensive longitudinal study of the effects of early adoption of ATM by banks on market share and income, conducted by Dos Santos (1995), advocated that organisations can gain long-term competitive advantages by early adoption of new IT applications.

Increased performance efficiency (e.g. quicker turnaround time, reducing credit risk exposure, decreasing bad-debts) is one of the reasons for adopting information technology cited by many researchers (Foschini, 1989; Mysior et al., 1984; Preece, 1989; Saeed, 1990; Takac & Singh, 1992).

Quite a few managers are unaware of the quality of data they use. Poor data can cause economic harm, lead to wrong decisions, and have negative indirect impacts on organisations. Although information technologies do not always insure perfect data, they enhance more accurate quality data, get access to data more quickly, speed up information processing, and improve decision-making processes in terms of timeliness, accuracy, comprehensive and availability (Preece, 1989; Redman, 1995; Sayeed & Brightman, 1994).

The adoption of information technology may provide a better image attracting customers to organisations resulting in increasing business transactions (Preece, 1989).

Organisations tend to adopt technologies that reduce operational costs such as labour costs, operational costs, paper work, rework, and costs for branch establishment (Mysior et al., 1984; Preece, 1989).

- **Technological Features.** Technological features (e.g. costs, complexity, reliability, risk, compatibility with existing systems, trialability, observability, and standardisation) are the main contextual factors which impact on the decision to adopt technology (Barras, 1994; Kwon & Zmud, 1987; Sharif, 1994a).

Generally speaking, technology should be easy for staff to learn or to use, otherwise implementation will not be successful (Manross & Rice, 1986; Wynekoop et al., 1992). Technology is considered as an opportunity to reduce uncertainty and risk. Yet, it also creates one kind of uncertainty in the minds of adopters. Therefore, reliability (i.e. fewer breakdowns) and security (i.e. less openness to abuse fraud) enhance a rate of technology adoption (Herbig & Day, 1992; Rogers, 1983; Takac & Singh, 1992).

Previous research reveals that successful innovation occurs when task and technology are compatible. Apart from available facility aspects, compatibility also means that a new idea is perceived to be in accordance with potential adopter's prior experience, beliefs and values (Caskey & Sellon, 1996; Cooper & Zmud, 1990; Kwon & Zmud, 1987; Manross & Rice, 1986; Tornatzky & Klein, 1982).

The other two factors that influence technology adoption are trialability (divisibility) and observability. New technology should give potential adopters a trial (i.e. an ability to test it) and be visible for them to observe how it works (Manross & Rice, 1986).

- **Organisational Issues.** Positive organisational factors contribute to the success of technology diffusion. For example, the strengths of the Japanese organisations regarding rapid organisational learning capability, horizontal information flows, strategic networking, and a consensus decision-making system promote rapid technology adoption and diffusion (Bowonder, Miyake, & Linstone, 1994). Organisational issues include available

facilities, executive support, staff acceptance, communication amount, economic externalities, and experience in technology (Bowonder et al., 1994; Kwon & Zmud, 1987; Manross & Rice, 1986; Sharif, 1994a).

Kwon and Zmud (1987) commented that successful technology implementation occurs when organisational resources (e.g. time, funding, and technical skills) are positively supported for initial motivating and an implementation effort.

Perceived management commitment exerts a significant impact on technological adoption and diffusion because an adoption and subsequent implementation of technology consumes massive resources of an organisation (Cooper & Zmud, 1990; Gagnon & Toulouse, 1996; Kwon & Zmud, 1987; Lambert, 1996; Manross & Rice, 1986).

Staff acceptance exercises positive impacts on technology adoption and diffusion. Thus, promotion for staff acceptance thereby mitigating failures deriving from lack of understanding (both technological and organisational aspects), providing sufficient training and support, and increasing user involvement is essential (Kwon & Zmud, 1987; Manross & Rice, 1986).

As new technology is adapted, a backlog of unsolved problems associated with its functioning begins to build up. Organisations have to mitigate the backlog of problems because it has a potential not only to discourage further adoption but also encourage abandonment by existing adopters (Barras, 1994; Bowonder et al., 1994; De Castro & Schulze, 1995; Kwon & Zmud, 1987; Pennings & Harianto, 1992; Saeed, 1990).

Pennings and Harianto (1992) indicated that prior experience in information technology, combined with a variety of inter firm linkages affect the decision of technology adoption.

An "externality" is a situation in which one individual's behaviour has spillover effects on others. Positive "network externalities" exist when an individual increases benefits from using a product because of an increase in product uses by others or an increase in complementary uses of that product.

For example, the usefulness of a personal computer depends on the number of people who use computers and the wide range of available software (Caskey & Sellon, 1996).

Externalities may hinder adoption of new technologies because potential customers may resist using a certain product provided by several producers because of the lack of compatible technological standards. They may decide to wait until the product is extensively used (Bowonder et al., 1994; Caskey & Sellon, 1996; Herbig & Day, 1992; Pennings & Harianto, 1992; Takac & Singh, 1992).

- **Customer behaviours.** Although technologies seem promising, sometimes an organisation hesitates to implement them because of worries about customer acceptance (Herbig & Day, 1992; Jenkins & McKenzie, 1997; P. Jirapinyo, personal communication, December 19, 1996). Non-price factors such as convenience (i.e. providing better customer service), acceptance, security, simplicity, ease of use and flexibility have to be taken into account for the success of technology diffusion (Caskey & Sellon, 1996; Mysior et al., 1984; Preece, 1989; WebAustralia, 1996).
- **Economic environment.** There is an inextricable link between technology and economy. Diffusion of technology must occur through information relationships underlying the behaviour of the economic and political actors in the system (Saeed, 1990; Sharif, 1994b). P. Jirapinyo (personal communication, December 19, 1996) pointed out that apart from features of technology and customer behaviour, the Siam Commercial Bank PCL (i.e. the case study bank) is very concerned about the economic environment as one of most important criteria for technology adoption.

Besides these five main factors, the incentives to adopt and diffuse technologies are as follows: improving budgets; keeping up with new technologies; improving quality of new products and communication methods; solving work problems; increasing flexibility; and helping retain/recruit skilled people (Foschini, 1989; Gozlu, 1994; Preece, 1989; Sayeed & Brightman, 1994; Scarbrough & Lannon, 1994).

4.2.3 Adoption and Diffusion Models

Quaddus (1995a) explored a number of IT diffusion models and their applications to facilitate choosing the most appropriate model for a specific application. The models were subsequently classified into two main categories, implicit time dependent (i.e. stage or static models) and explicit time dependent (i.e. dynamic models).

Most IT diffusion models have been developed under the static approach, which puts emphasis on phases of a diffusion process and technological impacts. According to Rogers (1983) technology diffusion follows the three broad stages of initiation, decision to adopt, and implementation which can be further elaborated in five stages. These five stages are agenda-setting, matching, redefining/ restructuring, clarifying, and routinising. Huff and Munro (1985) developed the information technology assessment and adoption (ITAA) model using six phases: awareness; interest; evaluation; trial; implementation; and diffusion. They also revealed that the driving forces underlying an adoption process are issues (i.e. problems) and technology. Manross and Rice (1986) studied the diffusion of an intelligent telephone system employing diffusion stages similar to those of Rogers'. They pointed out that innovations perceived as high in relative advantage, compatibility, communicability and divisibility but low in complexity gained a more rapid rate of adoption. Cooper and Zmud (1990) examined the diffusion of the material requirements planning technology (MRP) dividing the process into six phases; initiation, adoption, adaptation, acceptance, routinisation and infusion. Brancheau and Wetherbe (1990) employed four stages of a diffusion process (i.e. knowledge, persuasion, decision and implementation) to study the diffusion of spreadsheet software in organisations. The characteristics of earlier adopters were also detected. Applegate (1992) studied the transfer and assimilation of group technologies into organisations using the IBM computer conferencing case to support co-operative work. The model in this study consists of three phases: innovation development; assimilation; and institutionalisation.

The static models of technology adoption and diffusion have been applied in various areas. Robertson and Gatignon (1986) studied how competitive environments affect technology diffusion and reported that rapid diffusion depends on reputation of technology suppliers, allocation of marketing resources, and demand uncertainty.

Sivarama-Prasad and Somasekhara (1990) used the combined methodologies of a Delphi method and AHP (Analytic Hierarchy Process) to illustrate the choice of technologies for Indian telephone design and investigated the problem of technology requirements and technology selection. Samuels (1994) conducted his study in Japan and revealed that technology in this country can be diffused throughout the economy in both dimensions: horizontal (i.e. between and among prime contractors) and vertical (i.e. among prime contractors, subcontractors and suppliers). Taylor, Moore, and Amonsén (1994) conducted an empirical test to predict the adoption categories of Hewlett Packard laser printers using the psychographic model (e.g. risk attitude, importance of computer) and the benefit-price model (e.g. print quality, productivity, price sensitivity). The results revealed that the benefit-price model predicted the buyer adoption better than the psychographic model. Ganesh and Kumar (1996); and Ganesh, Kumar, and Subramaniam (1997) found that technology such as retail point-of-sale scanners can be rapidly diffused from lead countries into lag countries because of the learning process, which is determined by country characteristics, product/innovation characteristics, and time lag. Parthasarathy and Bhattacharjee (1998) reported the study on the post-adoption behaviour of technology adoption that the decision to remain continued adopters depends on their sources of influence (external and interpersonal), perceived satisfaction from innovation in terms of benefits and compatibility, and network externality during their time of initial adoption.

IT diffusion models based on a dynamic approach deal with the time related spread of IT usage. Generally, if new technology adopted by early adopters is successful, a bandwagon effect will tempt potential adopters to imitate. It has been observed that technology diffusion and an imitation process over time can be modelled by a logistic or s-shaped curve (Quaddus, 1995a; Rogers, 1983).

Brancheau and Wetherbe (1990) applied a dynamic model to study the diffusion of spreadsheet software and found that its diffusion followed a dual s-curve. Sharif and Haq (1979) used a causal diagram and a system dynamics model to study factors affecting the diffusion and substitution rate. Loh and Venkatraman (1992) studied the diffusion of IT outsourcing by applying three types of dynamic models (i.e. internal influence, mixed influence, and external influence). Quaddus (1995b) employed a

system dynamics model to capture the adoption and diffusion decision process. Based on an adoption process, a positive feedback loop was observed (e.g. a weak status of IT will finally result in more weakness in IT) whereas two negative feedback loops exist in a diffusion process.

4.3 Banking Technology

Currently, banking and financial institutes are able to gain their reputation not only from their robust financial status but also from adoption of new technologies. For example, the reputation of Wells Fargo Bank was enhanced from the early adoption of the Internet and Mondex's electronic cash product. The First Union Corp. was well known for developing an Internet strategy (Sraeel, 1996). As previously mentioned, banking technologies contribute great benefits not only to banks themselves but also to their customers (e.g. convenience, security, improvements, better access to information and an alternative to cash).

Banking technologies have been introduced since 1980 in the form of electronic banking and home banking services (Federal Bureau of Consumer Affairs, 1995). In fact, banks are being forced to adopt new technologies and make technological changes for many reasons. First, older technologies cannot be extended. Second, new technologies provide more lucrative opportunities. Third, old technologies cannot keep up with business growth rates or fulfil organisational needs (Inmon & Hackathorn, 1994). Consequently, the banking industry is prompt to integrate various kinds of banking technologies with their business performance. Prendergast and Marr (1994) revealed the greatest potential bank technologies (i.e. ATMs, EFTPOS, telephone banking and credit cards) and predicted that human tellers in transaction-based services would be replaced by self-service technologies. Their finding is consistent with that of Smith (1984) who suggested that ATMs and EFTPOS would dominate up until 1995. Roth and Van Der Velde (1989) reported that self-service technology such as ATMs conduct the vast majority of routine transactions in the USA, however, smart cards were not perceived as being a major force in technology within the near future.

Research regarding banking technological adoption and diffusion has been conducted mostly based on exploratory aspects using surveys, interviews and Delphi

techniques. Arthur Anderson and Co. (1989) interviewed banking executives and technology suppliers in Australia to identify the shape of banking technologies in the 1990s. Prendergast (1993) surveyed the use of three key self-service technologies (i.e. Automatic Teller Machines- ATM, Electronic Fund Transfer at Point of Sale- EFTPOS and telephone banking) in New Zealand to identify stages of adoption of these technologies and recommended strategies to enhance the rate of diffusion. Prendergast and Marr (1994), using a Delphi study, indicated that the adoption of all technologies will increase, but the level of adoption is different for each. Those with the greatest potential are ATMs, EFTPOS, telephone banking and credit cards. Their findings were consistent with those of Roth and Van Der Velde (1989).

Sayeed and Brightman (1994), investigating the use and effectiveness of computerised information and communications to support within the banking industry, revealed the following facts. First, branch managers frequently use computerised information and communications to support their activities. Second, technologies are used for resolving both strategic and operational problems. Third, IT applications enhance managerial intelligence by promoting planning, learning from experience and quick information access from a large number of sources. However, when compared to non-computerised support, computerised information or communications support did not produce more accurate problem finding.

Previous studies of banking technologies have highlighted the characteristics of adopters, critical factors for technological adoption and diffusion, and technological impacts. Swinyard and Ghee (1987) examined the characteristics of ATM cardholders in Singapore. Their findings indicated that favourable attitudes toward ATMs come from cardholders who are young, and have a high income. Education, occupational status, computer knowledge and experience with other banking technological products also contribute to favourable attitudes to ATMs (e.g. credit cards and telephone banking). Prendergast and Marr (1993) pointed out the main reasons that consumers use banking technologies were time utility and place convenience whereas the main reason for not using banking technologies was a preference for dealing with humans in banking. Herbig and Day (1992) identified characteristics that appear to influence and impede consumer acceptance of innovation using a case study of electronic banking. The barriers for technological

acceptance were customer's free will, ability to understand, external stakeholders, and incompatibility of the innovation with existing workflows. However, the impediments sometimes are contingent upon the characteristics of technology. For example, Internet adopters have to consider structural issues of the technology such as information, technology infrastructure, languages, cultures and legal frameworks (Samiee, 1998).

Apart from Internet banking and data warehousing technology, which were previously reviewed in detail in Chapter 2, Electronic Data Interchange (EDI) appears to have become a popular technology that many organisations are attempting to adopt and research. Burn (1995) reported the impact of culture on the EDI diffusion using a case study from China. Iacovou, Benbasat, and Dexter (1995) captured three major factors influencing the EDI adoption. These include readiness, external pressure to adopt, and perceived benefits. Size of the firm, competitive pressure, customer support, and top management are the main factors that discriminate EDI adopters from non-adopters (Premkumar, Ramamurthy, & Crum, 1997).

The success of banking technology relies heavily on factors such as training, reliability of machines and the extent of the machines' network. In turn, these factors depend on educational level of potential customers, level of economic activities and business practises of the market (Kouzelis, 1987). Kouzelis reported that sales of ATM services could be improved through the attraction of new deposits, enlargement of the ATMs network and direct mail advertising campaigns. Pennings and Harianto (1992) indicated that experience in information technology and technological networking (a variety of interfirm linkages) are the two main factors for a bank's decision to adopt technology. Hannan and McDowell (1990) examined the impact of bank adoptions of ATMs on subsequent levels of concentration. The results suggested that adoption by large organisations tends to increase concentration levels more than adoption by smaller ones.

Bank investors also realise that not all technologies bring about a good return on investment without risks. For example, home banking, in operation since the 70's still gives rise to problems (Global Banking Intelligence Corp., 1996). Since banking technologies are available in plenty for banks to adopt, it is vital for them to initiate

an objective approach in selecting appropriate technologies (Earl, 1987; Manross & Rice, 1986). Therefore, strategic planning is vital for management of banking technology adoption and diffusion. The effective planning may help organisations to adopt only mature technology which will prevent them from wasteful investment, ensure the success of technology implementation, and maximise utility of technologies (Moore, 1995; 1998).

However, few decision-making models or strategic planning have been used for technology adoption. Takac and Singh (1992) proposed an information framework combining business and investment planning (BIP) and information systems planning (ISP) for technological adoption and management to improve decision-making and planning processes. Buzzacchi, Colombo and Mariotti (1995) developed a conceptual model to analyse innovations in the banking sector. The model emphasised the role played by demand-pull variables in stimulating innovative behaviour. Fletcher and Wright (1997) combined strategic integration of information technology (IT) and marketing plan for an adoption of database marketing systems (DBM). Clark (1993) identified the successful adoption procedures: information technology planning; vendor evaluation and selection; cost analysis and justification; negotiation of a viable contract; and management of the implementation process. Fink (1998) further advocated that the procedures should be carried out in phases and evaluated at the end of each phase to minimise the overall risk of technology acquisition and to make decisions on continuing adoption. The identified phases consist of determining IT benefits, evaluating available IT, recognising the internal environment, reviewing IT management procedures, and assessing the external environment.

4.4 Group Support Systems

Using a computerised group support system (GSS) can support research conducted in a group environment. GSS is a combination of computers and communication and decision support technologies designed to support group work. Its environmental settings are determined by differences in group size and proximity of group members. The four environmental settings are decision rooms, legislative sessions, local area decision networks and computer-mediated conferences (DeSanctis & Gallupe, 1987).

The main benefits of GSS are parallel communication, anonymity, reporting (i.e. group memory) and structure.

Parallel communication promotes broader input into the meeting process and reduces chances of a few people dominating the meeting (Nunamaker, Dennis, Valacich, Vogel, & George, 1991). GSS allows more equal participation because participants can enter information simultaneously through individual microcomputers leading to generating many ideas (Atkinson & Lewis, 1994).

GSS emphasises the availability of anonymity in the generation and evaluation of ideas. Anonymity protects shyness and hesitation of group members leading to more contributions. Anonymity mitigates apprehension and conformance pressure (Nunamaker et al., 1991), therefore, participants feel more comfortable in suggesting ideas, and are able to discuss sensitive issues more candidly or to express strong or negative feelings towards other group members (Massey & Clapper, 1995). The usefulness of anonymity depends on the level of trust between group members and the degree of hierarchical structure in the group meeting (Dennis, Nunamaker, & Vogel, 1991).

GSS research supports the idea that GSS enhances group memory (Alavi, 1993; Atkinson & Lewis, 1994). GSS provides group memory by recording all electronic comments and results. Group memory enables members to pause and reflect on information and opinions of others during the meeting and serves as a permanent record of what occurred (Nunamaker et al., 1991). Nunamaker, Dennis, Valacich, Vogel and George (1993) further revealed that group memory can reduce failures to remember, attention blocking and incomplete use of information and may promote synergy and more information.

GSS employs specific tools and meeting scripts (i.e. agendas) to provide a structured process to the meeting or problem solving process (Keleman & Lewis, 1990). Process structure helps a group focusing on key issues and prevents irrelevant digressions and unproductive behaviours (Nunamaker et al., 1991). It contributes to improving group consensus, gaining higher quality decisions and generating more ideas (Dennis et al., 1991).

Nevertheless, computer supported GSS also lead to shortcomings for group meetings. Jelassi and Beauclair (1987) reviewed relevant research in order to point out weaknesses in current GSS design. A series of behavioural issues such as diffusion of responsibility, problems of co-ordination, pressure toward consensus and deindividuation were addressed. Ackermann and Eden (1994) pointed out some drawbacks of network GSS regarding location, flexibility of design, data capture, presentation difficulties, managing complexity of data, client control, and management of group dynamics.

Besides computer supported GSS, two other categories are partially computer-based and non-computer supported GSS. The former systems (e.g. strategic options developments analysis (SODA), and decision conferencing) use computers as support tools but do not rely on networks nor require direct operation from participants. Non-computer supported systems employ one-to-one interviews, Nominal Group Techniques and Delphi techniques to capture group opinions (Ackermann & Eden, 1994). The GSS in the United Kingdom have been developed mainly for decision modelling without networked computer support. However, the US systems are highly contingent upon computer systems (Eden, 1994b).

4.5 Multiple Criteria Decision-making (MCDM)

Human beings make decisions in every walks of their lives, both consciously and subconsciously. Decision-making is a process of identifying a set of feasible alternatives, and from these, choosing a course of action (Dunham & Pierce, 1989). Since decision-makers are considerably affected by their own and others' decision-making, they try to employ the best decision-making method to attain the preferable alternative among those proposed.

According to classical economic theory, decision-making is based on a single objective and the aim of the objective is related to the acquisition of an optimised solution (Hollander, 1987). In the 1950s, the single objective was modified to double objectives to provide decision-makers with higher satisfaction (Baumol, 1967). Business goals then have shifted to attaining multiple objectives. For example, an organisation attempts to achieve many business goals simultaneously (e.g. high level of return, growth rate, market share, and customer satisfaction) (Minkes, 1987).

Since the objectives of decision-making have changed towards multiple goals, gaining whole optimisation is seemingly an insurmountable problem due to conflicts among objectives. A decision-maker has to make a trade-off or compromise among alternatives. Multiple criteria decision-making (i.e. MCDM) is a field of study that is concerned with these issues.

MCDM originated in management science accommodating the four sub areas of multiple criteria mathematical programming, multiple criteria discrete alternatives, multi-attribute utility theory, and negotiation theory (Zionts, 1992). The Simple Multi-Attribute Rating Technique (SMART) and the Analytic Hierarchy Process (AHP) are the two techniques extensively used to evaluate alternatives in practice (Belton, 1990). In comparing these two techniques, Belton (1986) preferred the SMART to AHP technique because of its transparency for understanding. However, the decision to select the best MCDM method involves two key issues: an accuracy of the method as a representation of the decision-maker's preferences; and the quality of the prescriptive insight that will be gained from its use (Ozernoy, 1992).

MCDM research in the 1970's placed emphasis on mathematical programming of multiple objectives, and the development of procedures and algorithms to solve multiple objective linear programming problems and discrete problems. During the 1980s, emphasis shifted towards the implementation of MCDM models on computers with the aid of decision support systems (DSS) (Dyer, Fishburn, Steuer, Wallenius, & Zionts, 1992).

Since 1980, research has shifted towards providing multiple criteria decision support to decision-makers and practitioners leading to the highlighting of actual decision behaviour. Communication facilities, decision-making based on organisational context, and the promotion of all phases of decision-making processes have been subsequently developed and expanded upon (Korhonen, Moskowitz, & Wallenius, 1992).

MCDM is suitably employed when a decision-maker is confronted with a difficult problem in which none of its alternatives tower over the others as the best alternative. MCDM allows decision analysts to conduct decision-making under several conflicting criteria simultaneously, whereby the improvement or achievement of one criterion can occur at the expense of another. These criteria may be either quantifiable (e.g. explicit

costs and tangible benefits) or non-quantifiable (e.g. quality of service, risk, image and aesthetics). Additionally, decision-makers are able to account for a subjective evaluation that actually represents characteristics of the real world decision-making problems. According to the subjective evaluation, the decision-makers can express their preferences by weighting evaluation criteria, making comparisons between pairs or simply arranging an ordinal ranking of a set of alternatives (Boucher & MacStravic, 1991; Bui, 1987).

MCDM can be applied to solve a variety of problems from buying personal commodities for self satisfaction to high level strategic and development planning problems for the betterment of a society especially in the areas of resource allocation, planning, and evaluation (Mustafa & Goh, 1996; Quaddus & Siddique, 1994). Examples of using MCDM methods for practical problem solving are as follows. Malakooti (1986) developed a model to detect the best-compromised solution between costs and energy conservation for the US glass industry under the conflicting criteria of profit and consumption of energy. Khorramshahgol, Azani and Gousty (1988) employed goal programming (GP) to develop a model to help decision-makers identify and prioritise organisational objectives in order to achieve those objectives. Subramanian and Gershon (1991) applied MCDM for the selection of computer-aided software engineering (CASE) tools. Mohanty and Venkataraman (1993) used an analytic hierarchy process (AHP) to justify problems of automated manufacturing systems (AMS) based on strategic, technological, and social impacts. AHP was also used by Ahire and Rana (1995) to identify and select key pilot TQM projects. Mollaghasemi, Pet and Gupta (1995) investigated the impact of a buy or lease decision for a government agency and reported that taking subjective criteria into consideration, the lease was a more preferred option.

MCDM is suitable for use with decision support systems (DSS), which is known as MCDSS. Since DSS combines the strengths of computers with those of human beings to solve semi-structured or un-structured problems (Licker, 1997), decision-makers are able to use appropriate structures of computers, analytical aids, and supportive tools, together with their own judgement to make decisions. This leads to extending the range and capability of their decision processes and in turn helps them improve their effectiveness. (Keen & Scott, 1978). In addition, with the decision

support system, decision-makers are able to perform sensitivity analysis in order to eliminate imprecise and changeable data in MCDM problems (Triantaphyllou & Sanchez, 1997). For example, the model of interactive decision support system for bank asset liability management (IDSSBALM) help decision-makers conduct sensitivity analysis for urgent planning problems and objectives (Langen, 1989). Antunes, Almeida, Lopes and Climaco (1994) developed a DSS as an experimental framework design that offers users some representative MCDA (Multiple Criteria Decision Analysis) methods in the evaluation of a set of alternatives over several criteria. The MCDSS prototype developed by Quaddus (1997) is used for information system project portfolio planning in an IS department.

Eom and Min (1992) advocated that MCDM and MCDSS are the core of decision support systems and reported that about 30% of the MCDSS applications were developed to support strategic decisions, and about 70% support tactical and operational decision levels (Eom, 1989). Currently, MCDM has become one of the most active, international, and inter-disciplinary fields of management research. It is becoming a part of the mainstream of operation research, management science and decision support systems (Eom, Lee, & Kim, 1993). The research in this area is gaining popularity in research areas due to the interdisciplinary nature of MCDM, the predominance of multiple criteria in decision problems, good communications networks and it provides ways to solve practical problems in the real world (Korhonen, 1992).

4.5.1 Multiple Criteria Decision-Making (MCDM) in Group Environments

MCDM in a group environment (i.e. MCGDSS) is a tool that decision-makers can use to manage conflicts and facilitate a group decision process (Hwang & Lin, 1987). In reality, MCDM is suitable for supporting group decision-making. The existence of multiple and conflicting alternatives is substantially more predominant in group decision-making rather than in individuals because of the unique characteristics of human beings (Bui, 1987). Iz (1992) advocated that multiple decision-makers are commonly involved in solving actual problems. Therefore, the implicit assumption of a single decision-maker behind MCDM techniques impedes the progress of the

application. Consequently, many research studies try to integrate MCDM with GSS to enhance the effectiveness of decision-making.

Zionts (1979) also supported MCDM in group environments by arguing that the three base assumptions (i.e. there is a fixed set of alternatives to be chosen, the alternatives are known by decision-makers, and the optimal alternative is selected) are not true. He pointed out that many decisions are made by groups and the emotions of group members may affect the outcome of a decision. Belton (1984) described the successful use of a simple multiple criteria model in facilitating a decision-making process. The model aimed to allow group members to explore and learn about the problem and their preferences. It enabled the group to share in understanding, and justify their intuition resulting in the provision of a useful framework for the problem identification. Goodwin and Wright (1993) commented that the MCDM in a group environment was the best method for providing a guide to action, not a 'black box' prescription for action. Phillips (1988) proposed the requisite decision modelling which treated problem solving as a dynamic process. Based on this model, all affected actors became clearer about the problem, developed an understanding of it, and agreed on a set of perceptions of the problem situation.

Hwang and Lin (1987) indicated that the problems of group decision-making under multiple criteria are widely varied. Decision analysis must be extended to account for the conflicts among different groups who have different objectives, goals, criteria and so on. They introduced the complexity of analysis by using a social choice theory, an expert judgement, a group participation analysis, and a game theory approach.

Iz (1992) revealed that MCGDSS provides the system that allows frequent feedback on individual and aggregated preferences. It also allows for group discussions focused on resolving such conflicts. Therefore, decision-makers are satisfied and have more confidence in the decision outcomes.

Research methodologies employed in the study of MCDM in a group environment are mostly based on a quantitative perspective. Limayem (1992) conducted a laboratory experiment to evaluate the impacts of decision guidance on learning and decision outcomes. A group using MCDM without decision guidance was compared to groups with embedded decision guidance. Hong (1989) designed a prototype of a MCDM

supported by GDSS to facilitate the process of eliciting, formulating, utilising, aggregating, and analysing preferences for individuals within groups to develop a new approach that focuses on preference knowledge of individual participants in a group. In 1992, he developed a system architecture for designing a GDSS to help in collaborative MCDM processes that helps a group to choose among competing alternatives in an organisational decision-making context (Hong, 1992).

The following are examples of MCDM research in a group environment. Franz, Reeves and Gozalez (1986) introduced a computer guided interactive approach, which can be used by multiple decision-makers to reach a consensus to multiple objective problems. The approach enlarged the users' perceptions of the problem and improved the quality of the final decision. Bui (1987) proposed the implementation of Co-Op, which is a GDSS for multiple criteria group decision-making. Harker (1989) used an analytic hierarchy process (AHP) model to help the group to define, revise, and analyse the problem. The group process also allowed a dynamic discussion, revision of judgements, addition or deletion of alternatives. Gear and Read (1989) studied the consequences of structuring feedback to a group working as a team on some complex task by using an on-line system. The system enables each member of a decision-making group to communicate individual decisions and judgements during discussion. Iz (1992) presented an integrated approach for operation of an MCDM technique as a modelling component in GDSS. The major finding from the study was that the DSS (Decision Support Systems) which used AHP in aggregating preferences failed to compete successfully with the system which used a less sophisticated ranking procedure. Watabe, Holsapple and Whinston (1992) introduced a model providing a basis for supporting negotiation and persuasion leading to consensus for the selected plan. Davies (1994) demonstrated how MCDM can overcome the difficulties arising from the complexity, subjectivity and lack of group consensus. Curtin University of Technology has studied MCDM in group environments under the name of decision conferencing. (Atkinson & Marshall, 1990; Quaddus, Atkinson, & Levy, 1992).

Davies (1994) considered the benefits of incorporation of MCDM models in GSS. MCDM supported by GSS methods were expected to be highly interactive systems and the interface with users assisted to enhance the effectiveness of the systems. However, the results of Davies' study did not confirm that MCGDSS was a more effective

decision support aid. Quaddus, Atkinson and Levy (1992) used the SMART technique supported by software called HIVIEW for decision conferencing and concluded that it promotes shared understanding and can gain commitment to action. Iz and Gardiner (1993) reviewed existing research on combining three study areas of group decision theory, MCDM and GDSS and concluded that MCGDSS helps group decision-makers in reaching agreement on multiple criteria decision-making.

MCGDSS is becoming an extremely interesting field of research because it can be employed to solve actual problems in the real world. Additionally, thanks to GSS technology, the efficiency and the effectiveness of decision analysis are potentially enhanced. Therefore, many researchers (e.g. M. Jarke, M.T.Jelassi, T.X. Bui and E.A. Stohr; among many others) are defining a new subgroup of decision support systems (DSS), that is the combination of Group DSS and MCDM models (Eom et al., 1993).

4.6 System Dynamics (SD)

System dynamics (SD) is a method for qualitative and quantitative description, and analysis of complex systems. SD facilitates simulation modelling and analysis for the design of system structure and behaviour. It is also used to design robust information feedback structures and control policies through simulation and optimisation in order to improve the system behaviours (Coyle, 1996; Wolstenholme, 1994).

Three components are required for SD modelling: decisions, information sources and policies. A decision-making process consists of three parts: the creation of a desired state, the actual state, and decisions to control action that will be taken in accordance with any discrepancy between the two. The information used for SD model building based on three databases: mental, written and numerical. Policy management is the process of converting information into action (i.e. decision-making) (Forrester, 1992).

SD models were initially developed to quantify and validate models of the systems of interest using computer software applications to cope with highly complex problems (Foschini, 1989; Peterson, 1992; Wolstenholme, 1994). However, many practitioners have currently highlighted structures within the system (i.e. qualitative analysis) rather than the numbers. For example, Lane (1992) proposed "Modelling as Learning"

as a consultancy methodology for decision support using analytical tools in close involvement with clients. Senge (1992) constructed qualitative modelling based on word and arrow archetypes. Wolstenholme (1993) proposed a revised framework for system dynamics (i.e. system thinking) which combines knowledge acquisition and both qualitative and quantitative modelling, supported by microworlds and archetypes to gain more insights of system behaviours.

Recently, SD has become more accessible to policymakers and the academic community due to developments in this field. First, there had been improvements in the symbols and software to create system structures. Second, new ideas adopted from behavioural decision theory help policymakers to transform their knowledge into computer models. Third, improvements in simulation analysis provide better insights about dynamic behaviour. Fourth, games and computer simulations make models transparent to comprehend (Morecroft, 1988). Richardson (1996) also added other significant revolutions in this field. First, practising modellers have expanded SD far beyond university training. SD has shifted from modelling to improving a process for the purpose of improving people's mental models. Third, SD has moved from quantitative modelling to qualitative using word and arrow archetypes as represented in *the Fifth Discipline* (Senge, 1992).

However, Richardson (1996) raised eight problem areas of SD studies that still remain to be revised: understanding model behaviour, accumulating wise practice, advancing practice, accumulating results, making models accessible, qualitative mapping and formal modelling, widening the base, increasing confidence and validation.

SD has been employed to enhance strategic and holistic insights and promote understanding about the effectiveness of different policies in various areas. Schmidt (1989) demonstrated computer-based decision support of strategic planning and management for the German federal railway. Gupta and Gupta (1990) investigated a Japanese production system (just in time- JIT) and an inventory system (i.e. a kanban). Chambers (1991) proposed an evaluative technology assessment (TA) framework to evaluate capacity and capability, technological substitution needs, resource requirements, socio-economic impacts, and strategic planning of Australian chemical, fuels, and energy transition programs. Morecroft and Van der Heijden

(1992) developed a model for oil producers to provide new insights for OPEC and non-OPEC producers. Chowdhury and Sahu (1992) studied the long-term dynamic behaviour of the Indian oil and gas exploration/exploitation industry. Williams, Eden, Ackermann and Tait (1995) investigated the delay and disruption in an engineering project and quantified the effects by an auditable model. Thurlby and Chang (1995) examined and monitored the re-engineering of value processes. Dyner, Smith and Pena (1995) presented a model to support policy-making on energy efficiency. Larsen, Ackere and Warren (1997) discussed the potential growth and limitation of a service company. The model highlighted two conflicting pressures: the need to spend on meeting customer expectations in order to increase sales and the need to meet profit targets from headquarters in order to win the capital to fund expansion. Saeed and Prankrakma (1997) presented a model of a dual economic system incorporating both the behavioural responses of the economic actors to competition and their ability to innovate. The model is used to test for appropriate technological development policies to support economic growth and change income distribution.

Abdel-Hamid and Madnick (1987) and Abdel-Hamid (1989a; 1989b; 1990) developed the system dynamics model of software development to rectify problems occurring in software development projects (e.g. poor portability of software development). The model aimed at identifying managerial factors that impact costs, and quantifying the degree of that impact. The studies provided interesting insights into the policies both explicit and implicit for managing projects and human resource management. Yin, Abdel-Hamid, and Sherif (1997) developed the Software-Engineering Process Simulation model (i.e. SEPS) to observe the interaction among various software life-cycle development activities and decision-making processes, examine trade-off of cost, schedule and functionality, and test different policies on a project's outcome. Rodrigues and Bower (1996), and Rodrigues and Williams (1997; 1998) developed a conceptual model of the SYDPIM for software project management. SD was employed to support a traditional decision-making process by quantifying the influence of client behaviour on a project (e.g. schedule restrictions, high demand on progress reports, approval delays, and work-scope changing). They concluded that traditional and system dynamics models provide complementary support to project management. The traditional model supports the detailed

operational problems whereas the SD model provides strategic insights and understanding about the effectiveness of different managerial policies.

Saeed (1989), and Morecroft, Jarsen, Lomi and Ginsberg (1995) constructed SD models to gain more understanding about resource allocation. The analysis of Saeed enhanced the understanding of circular cause and effect relationships that shape internal trends affecting a government's commitment to economic development plans and its ability to resolve political conflict generated over an implementation phase. The study of Morecroft, et al. (1995), inferred from the two-shower model, illustrated the causes and consequences of interdependence in resource allocation and indicated changes that can improve the co-ordination of decision-makers.

SD also has been employed in order to minimise conflicts among stakeholders. Saeed and Brooke (1996) reviewed the difficulties occurring in the implementation of macro-engineering projects (e.g. time and cost overruns). They recommended that a better design of the project role systems and the project's interaction with its environment can be created through translating known and inferred experiential information into a model and experimenting with it prior to formulating the terms of the contract.

System dynamics can also be employed in scientific areas. For example, a detailed multi-group model of the spread of AIDS in the Tanzanian population has been developed to capture complex virological and behavioural traits of the epidemic and illustrate the medical and economic consequences. (Heidenberger & Flessa, 1993). Vezjak, Savsek, and Stuhler (1998) examined the effects of eutrophication (i.e. a phenomenon observed in the bodies of water that receive large influxes of nutrients) on plankton seasonal dynamics in lakes in order to predict the effect of nutrient additions on lake biota and examine ways to improve water quality.

4.6.1 System Dynamics (SD) in Group Environments

Involving clients is vital in the SD process to support effective group model building. The most commonly employed techniques for eliciting knowledge are interviews and group discussion (Vennix, Anderson, Richardson, & Rohrbaugh, 1992). Wolstenholme and Coyle (1983) presented guidelines for modellers to improve their ability to translate mental models into meaningful system diagrams.

The formal step in group model building is planning for the modelling conference beginning with goal setting in order to define the scope of work. The next step is to interview key managers with the help from a gatekeeper. The rule of thumb is that all the key stakeholders must be willing to devote up to two full days, without interruptions, to the modelling task. A variety of approaches in group model building, depends on the specific circumstances of a group model-building project (e.g. type of problem, number of participants, whether participants are geographically dispersed) (Andersen & Richardson, 1997).

Morecroft (1988; 1992) explained that modellers can create computer-based learning environments for policy-makers and suggested that models can be used to support different cognitive and group processes in management teams and can be combined with other academic areas (e.g. group decision support, behavioural decision theory and management science). Morecroft and Van der Heijden (1992) presented a modelling procedure involving a group of senior managers and planners from a major oil company. The group discussed and worked with simulation models regarding the changing structure of the oil industry in order to improve group understanding, and create new insights into the power and stability of OPEC, the dynamics of oil prices, and investment opportunities. Vennix, Gubbels, Post and Poppen (1990) presented a structured approach to elicit knowledge for conceptual model building of the Dutch health care system using a three-step approach; a Delphi questionnaire, a workbook and a structured workshop.

Reagan-Cirincione, Schuman, Richardson and Dorf (1991) developed a process of three decision conferences combining the SD simulation and multi-attribute utility models. First, a SD model was developed and various policy options were formulated and tested. Second, these policy options were evaluated using a multi-attribute utility model and three comprehensive proposals were formulated. Finally, the proposals were compared using both SD and multi-attribute utility models.

Vennix et al. (1992) designed five steps in model-building (i.e. problem, conceptualisation, formulation, analysis/evaluation and policy analysis) and explored the literature on mapping and eliciting knowledge in a small group process for SD modelling by combining with decision conferences. However, they did not provide any details regarding the operational process.

Richardson and Anderson (1995) defined five roles for consultants and clients (i.e. facilitator, modeller, process coach, recorder and gatekeeper) in a group model-building project. They explored strategies for accelerated group model building in three public policy problem areas (i.e. foster care in New York, Medicaid costs in Vermont, and the homeless policy in New York City) and suggested that group modelling effectiveness can be increased by explicitly recognising the roles.

Vennix, Ackermann and Rouwette (1996) conducted a qualitative system dynamics study within a group to create a platform for strategic change and to build consensus and commitment. The results indicated that consensus and commitment with regard to the problem were established but that the project was not successful in creating a full consensus on the course of action. Andersen and Richardson (1997) suggested that group modelling rely on fairly sophisticated pieces of small group processes (i.e. scripts). His study aimed to initiate a large discussion of shared scripts and techniques for group model building.

SD models aim to enhance understanding of the system's behaviour and find robust policies to tackle strategic problems. The primary objective in strategic decision-making is to encourage team learning, to foster consensus and to create commitment to the resulting decisions rather than to find a robust policy (Vennix et al., 1996). Therefore, currently, SD models are viewed as tools for learning about business and social systems rather than tools for prediction or persuasion because no model can precisely represent reality. Furthermore, managers, in general, dare not act on the prediction from someone else. Therefore, models that fit scenario planning should have the capability to stimulate possible policy options that help decision-makers to develop their own insights to tackle their problems via learning processes rather than provide them with accurate predictions. Microworld (i.e. computer-based learning environments), simulation analysis, and model-supported case studies have been used to help decision-makers to test their knowledge of business and social systems. That leads to creating learning environments and improving strategic thinking skills (De Geus, 1992; Morecroft, 1988; 1992; Morecroft & Van der Heijden, 1992; Senge, 1989).

Lane (1992) proposed "Modelling as Learning" as a consulting tool to support his clients' decision-making. Opel (1993) revealed that SD contributed to sharing and

improving mental models used in decision-making. Graham, Morecroft, Senge, and Sterman (1992) suggested that model-supported case studies (i.e. the combination of computer simulation models with conventional case studies), such as the *People Express Management Flight Simulator*, creates learning environments for management education and improves strategic thinking skills.

Sterman (1994) stated that complex dynamic systems impede a process of learning. Overcoming the barriers requires: learning tools to elicit participant knowledge; perceptions and maps of the feedback structure of a problem; simulation tools to assess the dynamics of those maps and test new policies and methods to improve scientific reasoning skills; strengthen group process; and overcome defensive practices of the participants.

Therefore, SD can be used more effectively in organisations that have an organisational learning environment. Andersen and Richardson (1997) studied the impact of computer models on policy making and concluded that most of the learning takes place in the process of building the model, rather than after the model is finished. SD has then shifted towards modelling as learning and modelling for organisational learning. Model building is seen as a method to structure debate and to create a learning environment in which assumptions and strategies can be discussed and tested.

Navis, DiBella and Gould (1995) defined organisational learning as the capacity or process within an organisation to maintain or improve performance based on experience. Three learning-related factors are important for their success: well-developed core competencies for new products and services; an attitude that supports continuous improvement; and the ability to fundamentally renew or revitalise. Organisational learning is the process whereby shared understandings change, as a key to flexibility and competitive advantage. Organisational learning processes are more effective when they help managers develop a more systemic and dynamic perspective (Senge & Sterman, 1992).

A revised framework for system dynamics under a learning concept is now referred to as system thinking. System thinking is a framework for exploring complex systems in terms of five building blocks (process, information feedback, delays,

organisational boundaries, and policies). It emphasises explicitly building models with participants' involvement, the importance of providing learning environments and combining qualitative and quantitative phases. Under the qualitative phase, models can facilitate knowledge, capture and explore processes, structures and strategies. Under the quantitative phase, they are capable of being developed into computer-based microworlds and games to inform decisions (Senge & Sterman, 1992; Stevenson, 1993; Wolstenholme, 1993).

System thinking accommodates systems as cause thinking, closed loop thinking, and operational thinking (Richmond, 1994). However, the definition of system thinking according to Jay Forrester differs from that of Richmond. Forrester perceives system thinking as a small subset of system dynamics whereas Richmond sees system thinking as system dynamics with an aura. Currently, large organisations such as AT&T, the BBC, BT, Exxon, Ford, IBM, and Shell regularly use systems thinking and system dynamics to improve the quality of decision making and planning. Systems thinking can be used as a very powerful tool in the process to help maximise performance improvement (Davis & O' Donnell, 1997).

Reagan-Cirincione et al. (1991) emphasised that the successful application of modelling to strategic decisions require: an understanding of various modelling techniques, the ability to diagnose a real problem and select appropriate techniques, and the participation of decision-makers. Therefore, system dynamics is widely integrated with many methodologies such as multi-attribute utility techniques, decision conferencing, the soft system analysis, group support systems, and cognitive mapping methods.

Thurlby and Chang (1995) combined soft system analysis with SD to identify the problem of the re-engineering value processes. Eden (1994a) employed a method that integrated a cognitive mapping method and SD to deal with complicated problem structuring. Vennix et al. (1992) combined system dynamics modelling with formal multi-attribute utility techniques for evaluation tasks to evaluate the effects of a variety of policy. Williams et al. (1995) used cognitive mapping with COPE to elicit the relationships of variables of a large design and manufacturing engineering project. Cognitive mapping provides the initial structure of an influence diagram and then system dynamics was used to quantify the effects. The participative business

modelling method (PBM) is a management consulting method based on a synergetic mix of (system dynamics) modelling, group knowledge elicitation techniques, and a process consultation attitude. PBM was used to assist in the development of a European logistics strategy for an American pharmaceutical firm setting up operations in Europe (Akkermans, 1995). Bui and Loebbecke (1996) presented a design methodology embedding functionalities that integrate cognitive feedback in a computer-based decision support environment to forecast the demand for cellular telecommunications up to the year 2005 for Vietnam. Buongiorno (1996) combined econometric and mathematical programming with SD for policy analysis and forecasting the forest product industry. Lane and Oliva (1998) presented the theoretical framework of system dynamics (SD) and soft system methodology (SSM). SSM is employed to identify diverse perspectives on a problem situation and addresses the socio-political elements of an intervention. However, SSM lacks the capability to capture the dynamic interaction of the system behaviour. Using system dynamics could suitably compensate for that inadequacy. Quaddus (1996) showed how GSS can be used followed by system dynamics for IT planning. The SD model was developed using GSS technology (decision conferencing) to elicit the group's information, strategies, and policy options and used an MCDM approach to evaluate the proposed strategies. Subsequently, the SD models show the effect of various policy interventions whereby stakeholders can gain more understanding through a learning process.

4.6.2 System Dynamics and Technological Issues

Innovation is highly contingent upon time, and accommodates many affected stakeholders starting from acquiring to implementing. Furthermore, its impacts influence various actors inside and outside an organisation. System dynamics, therefore, appears to be an appropriate tool to deal with technological issues. The following are examples of research applying SD in technological areas.

Anderson and Joglekar (1996) presented the Technology Ramp-Up Simulation (TRUSIM) using the SD methodology. The model focused on the evolution of technological performance and competitive structure by dividing the process into three phases. At the beginning of a new product's life, product innovation occurs rapidly. The rate of innovation begins to decline after a certain period with the

appearance of a dominant design. During the "transitional" phase, product innovation slows down whereas process innovation accelerates and reaches a peak. Market competition between firms begins to shift from product features to price and quality and the industry becomes concentrated as surviving firms struggle to take advantage of economies of scale. During the last phase, processes are capital intensive and neither product nor process can be easily changed due to their interdependence. In this environment, change becomes difficult leaving industries vulnerable to breakthroughs that reset the cycle.

Maier (1995) reveals that the diffusion of innovation over time is influenced by various factors including price, advertising, product quality, competition, the time of market entry, negative word of mouth, substitution among successive product generations, potential repeat purchases and market potential.

Kim and Juhn, (1996) developed a system dynamics model for investigating dynamic behaviour of network growth and decay highlighting two variables: network externality; and crowding effects. They pointed out that an inferior product with network externality might defeat a better-quality and lower-price product, with no network externality. However, the influence of crowding effects (i.e. excessive increase in the number of consumers) can exceed that of network externality.

Winch (1995) developed a SD model to capture the situation of an industry experiencing the switching of its production plants to a new process technology. The model aimed at providing understanding of the complex dynamics of switching, investigating critical issues in switch timing, gaining consensus and gathering confidence to face the uncertainties of the change process.

4.7 Summary

This chapter presents a review of previous literature relating to the research topic including technology adoption and diffusion, banking technology, group support systems (GSS), multiple criteria decision-making (MCDM), and system dynamics (SD).

The main purpose was to obtain the background information for conducting the proposed research. These are summarised below:

1. Problems regarding technology adoption and diffusion were used to develop questionnaires for detecting the technological problems that the Siam Commercial Bank PCL (i.e. the case study) has currently confronted.
2. Factors that drive technology adoption and diffusion reported in the literature were considered as variables for model development with additional factors based on the bank staff's perceptions.
3. Information on banking technologies provides technological trends and understanding of each technology. It is useful for technology selection of the technology adoption model and policy analyses of the technology diffusion models. Five technologies were finally selected as technological alternatives including smart cards, video conferencing, a data warehouse, EFTPOS, and Extranet banking.
4. Information on adoption and diffusion models was used to justify appropriate models that suit the research domain. The dynamic approach was considered more suitable than the static one.
5. Previous research on MCDM and system dynamics provides background in developing a framework and models for the study (e.g. SMART technique, group model building, and models for learning).
6. Research on GSS contributed to the development of models that are appropriate for group environments in Thailand. The non-computer supported GSS tool was selected.

The other purpose of this chapter is to find gaps in previous research. Five main issues have been identified as gaps between the previous research and this study.

1. The earlier studies of technological and decision-making issues have been mainly done using a static approach. Therefore, they tend to be deficient in capturing rapidly changing and the broad impacts of technologies.
2. Besides the studies of Sharif and Haq (1979), and Quaddus (1995b), most decision-making research employing a dynamic approach has been conducted using traditional mathematical tools. The traditional tools may

not be suitably employed for decision-making processes in the real world because business people prefer to use simple, transparent tools to aid their decision-making rather than the difficult ones.

3. Studies of banking technological adoption and diffusion have emphasised exploring and forecasting technological trends in the banking industry. A framework to improve a decision-making process to adopt and diffuse technologies has not been widely developed yet.
4. The literature based on MCDM and SD also has not revealed much research explicitly conducted by integrating these two techniques in a group environment.
5. Most of the group support systems (GSS) research supports conducting the research based on computer-based GSS.

This research reported in this thesis differs from previous research in five aspects.

1. The research uses both static and dynamic approaches. The static approach employs the MCDM technique for technology selection during the adoption phase. The study, however, puts emphasis on the dynamic approach using system dynamics for elaborating the static model analyses and testing policy analyses during the diffusion phase.
2. Computer simulation using *ithink* software is employed to tackle problems and provide policy options in accordance with the concepts of decision support systems. Decision-makers may use the model as a learning tool to improve their decision-making processes and test their intuitive perception by running sensitivity analyses, exerting effective policies, visualising the impacts, and modifying the model to other issues or scenarios.
3. A framework for technology adoption and diffusion was developed and proposed to improve a decision-making process. Furthermore, the framework will be developed based on the concept of decision support system. Therefore, decision-makers are able to use the model to test all the policies by themselves using their own experience, knowledge, intuition and information via user-friendly tools. These may contribute in helping an

organisation to speed up the diffusion process of technology, obtain extensive benefits from it and minimise problems.

4. The study will illustrate how to combine two decision-making tools: MCDM and SD effectively, in chapters 7, 8, 9, and 10.
5. The research is conducted in a group environment using the non-computer GSS technique. Although there are many benefits from computer supported GSS, the non-computer supported GSS tool using an interview method is suitable for this research because it is more compatible with the bank's culture (i.e. The Siam Commercial Bank PCL) and its available technologies. First, it is hard to bring bank executives to meet and make decisions at the same time and same place for the purpose of conducting research due to constraints on the executives' time and their overwhelming routine workloads. Second, the interface of GSS software applications (e.g. Meeting ware, or Group system 5) is in English, which is not suitable for conducting a GSS session because Thai language is the only major national language. The different language interface is the main obstacle for conducting this research via computer supported GSS. Third, taking Thai executives prefer verbal communication, frustration and inhibition in using computers are still predominant.

This proposed study will be undertaken using two research methodologies: system development research; and the case study. The research methodologies and its design will be presented in the next chapter.

CHAPTER 5

RESEARCH METHODOLOGY AND RESEARCH DESIGN

5.1 Introduction

This chapter presents and discusses the issues relating to the research methodology and research design of the study.

Research is defined as:

“systematic investigation to establish facts or principles or to collect information on a subject (Wilkes & Krebs, 1995, p. 1316).”

A framework for research, illustrated in Figure 5.1, is a relationship between a body of knowledge (i.e. research domains and research methodologies) and a research process. The research domain (i.e. the subject matter under study) of this study is entitled “*A study on adoption and diffusion of information and communication technologies in the banking industry in Thailand using multiple-criteria decision making and system dynamics approaches*”. A research methodology is the combination of processes, methods and tools that are used in conducting research in a research domain. The process employed in this project is *system development*

research and case study.

A research process comprises understanding the research domains, asking meaningful research questions and applying valid research methodologies for these questions. Results from a research project contribute to the body of knowledge by promoting clear understanding and enhancing knowledge in a given research domain (Nunamaker, Chen, & Purdin, 1990-91).

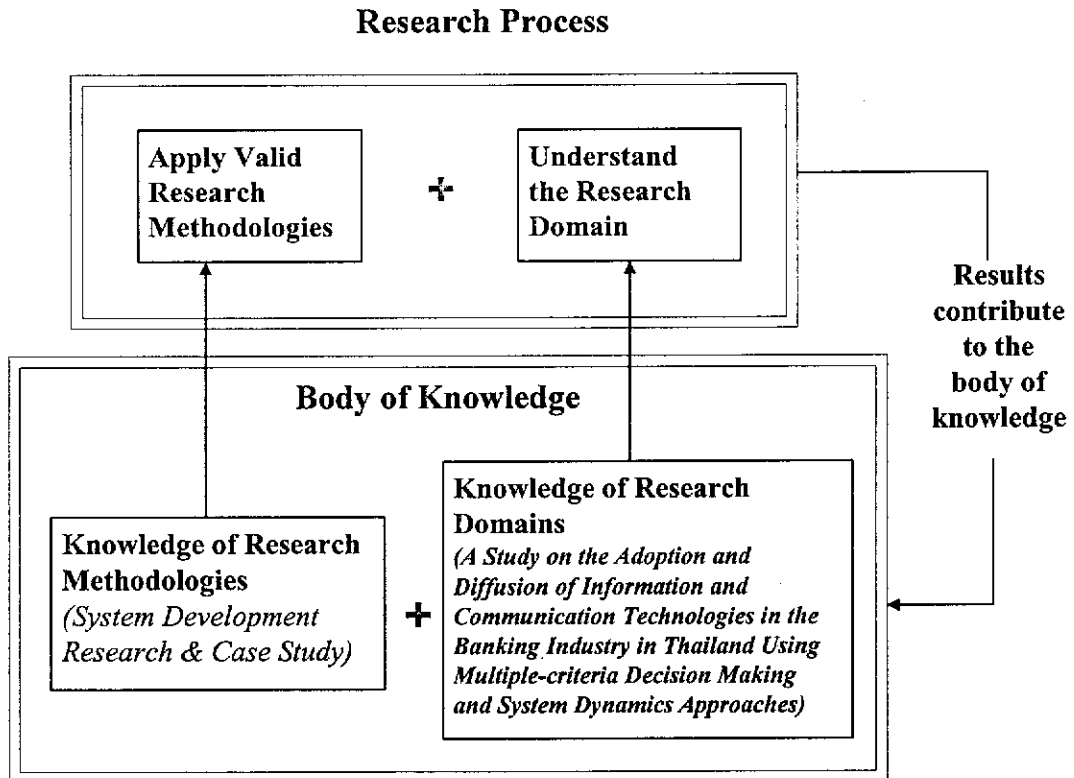


Figure 5. 1. A Framework of Research

Source: Adapted from Nunamaker et al., 1991, p. 92.

The research design comprises data collection and data treatment. The data for this research is both primary and secondary data. The primary data was derived from three sources: interviews, questionnaires and observation. The secondary data was obtained from an in depth review of the related literature including technology adoption and diffusion, banking technologies, group support systems (GSS), multiple criteria decision-making (MCDM), and system dynamics (SD) in order to define all the related variables and gain knowledge for research development. The data was then used for model analyses using two decision-making tools: multiple criteria

decision-making (MCDM) and system dynamics (SD).

5.2 Research Methodologies

Researchers use research methodology, a combination of a continuing process, methods and tools for conducting research, to inform their readers exactly how they intend to undertake their research and how to handle data.

Galliers (1990) divided research methodologies used in information systems (IS) research into two paradigms (i.e. basic sets of beliefs to guide actions: (Guba, 1990, p.17)): positivist (i.e. scientific) and interpretivist.

Positivism may be described as a research philosophy assuming that the phenomena being studied have a stable reality measurable from the outside by an objective observer (Levin 1988 as cited by (Pervan, 1994, p.487)).

Interpretivism may be described as a research philosophy interested in human meaning in social life and in its elucidation and exposition by the researcher (Erickson, 1986, p. 119).

Instead of positivism and interpretivism, the terms quantitative and qualitative paradigms are used by some researchers (Leedy, 1993; Reichardt & Cook, 1978). The quantitative paradigm has positivistic objectives. It is an outcome-oriented approach and focuses on natural science worldviews. On the other hand, the qualitative paradigm is inductive, holistic, and subjective. It is a process-oriented approach highlighting social and anthropological worldviews.

Laboratory experiments, field experiments, surveys, case studies, theorem proofs, forecasting and simulation are classified under positivism, whereas subjective/argumentative reviews, action research, descriptive/interpretive, future research and role/game playing are bound under interpretivism. Descriptions of research methodologies are presented in Table 5.1.

Table 5. 1. Research Methodologies in the Context of the Positivist and Interpretivist Paradigms.

Paradigm	Research Methodologies	Description
Positivism	Laboratory Experiments	The study of precise relationships between controlled variables using non-stakeholding participants solving an artificial problem. A small number of factors are allowed to vary
	Field Experiments	An experiment involving stakeholding participants dealing with a real problem. The number of examined variables will usually be small.
	Surveys	A snapshot of opinions or a real-world situation at a particular point in time, usually utilising a questionnaire to all participants and analysed using statistical methods.
	Case Studies	A planned and focused investigation of hypothesised relationships in one or more organisations. A researcher is an observer. A large number of variables is involved with little or no control.
	Theorem Proof	The development and testing of theorems through mathematical modelling of situations in which truth is derived based on a well specified set of derivation rules.
	Forecasting	The use of various extrapolation methods to take facts and /or opinions using particular assumptions in order to deduce future outcomes.
	Simulation	An investigation of behaviour in a system which is an abstraction of the real world with some controlled variables, but not to the extent of a laboratory experiment.
Interpretivism	Subjective/ Argumentative Reviews	An expression of the views of the research(s) based mostly on opinion and speculation derived from a range of experiences or reviews of literature.
	Action Research	An investigation of relationships in one or more organisations where the research is involved and the researcher's impact must be acknowledged and identified.
	Descriptive/ Interpretive	Research based on the researcher's interpretation of situations, events, phenomena, previous literature, or past developments.
	Future Research	Similar to forecasting.
	Role/ Game Playing	Similar to simulation.

Sources: Adapted from Galliers (1990, p. 160) and Pervan (1994, p. 486).

5.2.1 System Development Research

Besides those presented, system development is widely used in information systems (IS) research. System development research or engineering research is an artistry of design and the spirit of “making something work”. It is a valid research technique using the proof-by-demonstration approach (Nunamaker et al., 1990-91).

The idea of system development as a research methodology fits into the category of applied science and belongs to the engineering, developmental and formulative types of research (Nunamaker et al., 1990-91). Applied science is the application of knowledge to solve practical problems of immediate concern or detect practical reasons. Engineering research puts emphasis on design and making something to confirm theoretical predictions. It is widely employed in software engineering areas to assist software developers to plan, design, implement, and control software projects (Kemerer, 1998). Developmental research is the systematic use of scientific knowledge to produce useful materials, devices, systems or methods, and to design and develop prototypes and processes. Formulative research (i.e. exploratory research) aims at identifying problems for more precise investigation, developing hypotheses, gaining insights and increasing familiarity with the problem area.

5.2.2 Case Study

Yin (1994, p.13) defined a case study as

“an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident... A case study is used to cover contextual conditions because they might be highly pertinent to the phenomenon of the study.”

A case study is a research methodology focusing on understanding or investigating of hypothesised relationships in either one or many organisations (single or multiple cases). It can be used for many purposes including providing description, testing theory, and generating theory. A researcher is able to employ multiple levels of analysis within a single case using combined sources of data collection such as archives, interviews, questionnaires and observations. However, based on this

research strategy a researcher is an observer and a large number of variables is involved with little or no control. Outcomes deriving from a case study can be either qualitative or quantitative or both (Eisenhardt, 1989; Galliers, 1990).

5.2.3 Research Methodologies in this Study

This study employed two research methodologies: system development research and case study, supported by computer simulations. The two research methodologies complement and provide valuable feedback to one another. The interaction of the research methodologies is illustrated in Figure 5.2.

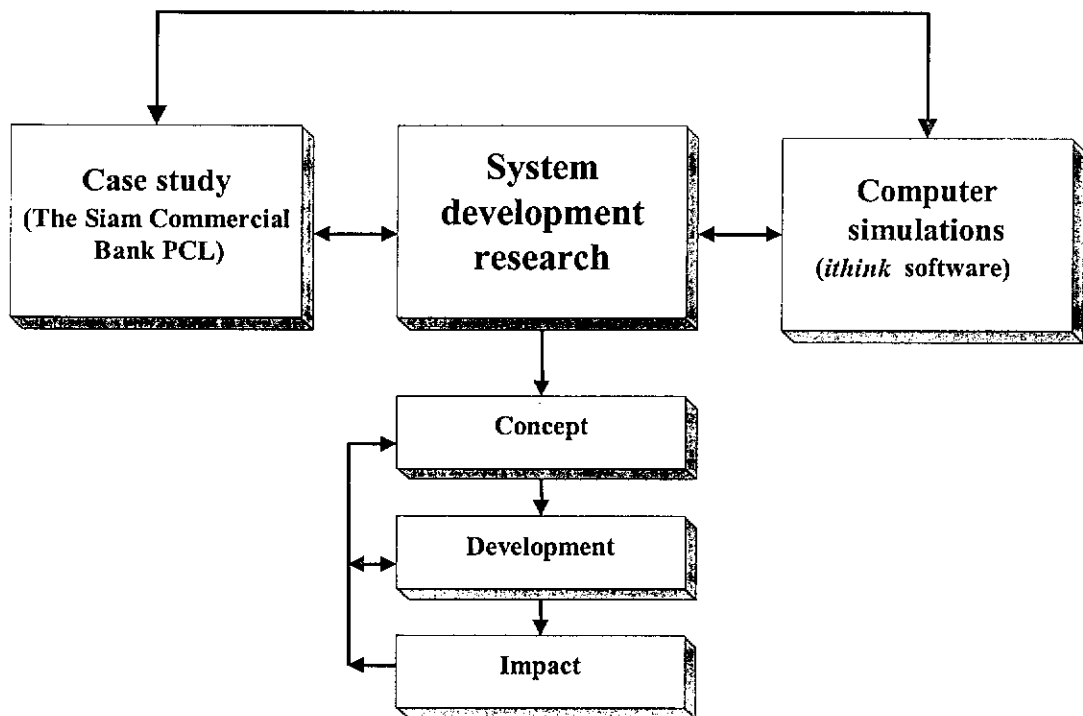


Figure 5. 2. Research Methodologies

System development research. System development is suitably employed for information systems (IS) research to interact with other research methodologies to form integrated and dynamic research. Generally, the advancement of IS research comes from new concepts. Then, systems have to be developed to test those concepts. Finally, the developed systems provide results for communities or provide knowledge for future research (Nunamaker et al., 1990-91).

System development was employed because the model development of technology adoption and diffusion fits well with the concept and follows the steps of system development research of concept-development-impact. Initially, concepts regarding the ways to adopt and diffuse information and communication technologies (ICT) effectively were accumulated from literature reviews to identify the concrete research questions. Then, a generic conceptual framework was constructed to detect answers for those questions, guide the design of computer simulations, and conduct systematic observations using a case study. The conceptual framework was elaborated to design and develop the models of technology adoption and diffusion using multiple criteria decision-making and system dynamics methodologies. Ultimately, stakeholders or decision-makers are able to use the models to observe and test the system behaviours and impacts on any factors of concern in order to improve deflect behaviour via policy analyses.

Case study. A case study was used to investigate organisational and managerial processes of an organisation to gain more holistic and meaningful characteristics of real world events. It is helpful in describing what actually happens, and generating relevant and useful hypotheses which can be tested in a more rigorous fashion (Andersen, Richardson, & Vennix, 1997).

The Siam Commercial Bank PCL in Thailand was employed as a case study in order to get general feelings for what is involved in a research domain, tailor the generic variables to a specific case, and to provide sufficient contextual and environmental conditions to improve validity.

Computer simulations. Computer simulations with *ithink* software were used to refine theories, test system behaviours and perform sensitivity analyses for strategic policies. Since computer simulations provide visualised results of model analyses within relatively short time they are useful for enhancing insights about system behaviours and ways of improving them.

5.3 Research Design

A research design acts as a “blueprint” of research. Once a researcher formulates problems of a study concretely, he or she develops a research design as a strategic plan

to conduct the study. A research design provides an overall framework for systematic and feasible methods of data collection, handling multiple natures of data, and analysing or interpreting the data. The design is a format for detailed steps in a study to tackle previously identified research questions. Research designs depend upon statements of problems (Leedy, 1993; Yin, 1994).

5.3.1 Research Design Framework

The research design framework used to conduct this research was developed based on Nunamaker et al. (1990-91); and Vennix, Anderson, Richardson and Rohrbaugh (1992). The research design consists of five stages: problem definition (Stage 1), constructing a conceptual framework (Stage 2), developing system architecture (Stage 3), testing and validation (Stage 4), and policy experiments (Stage 5). The details of each stage are as follows (Figure 5.3).

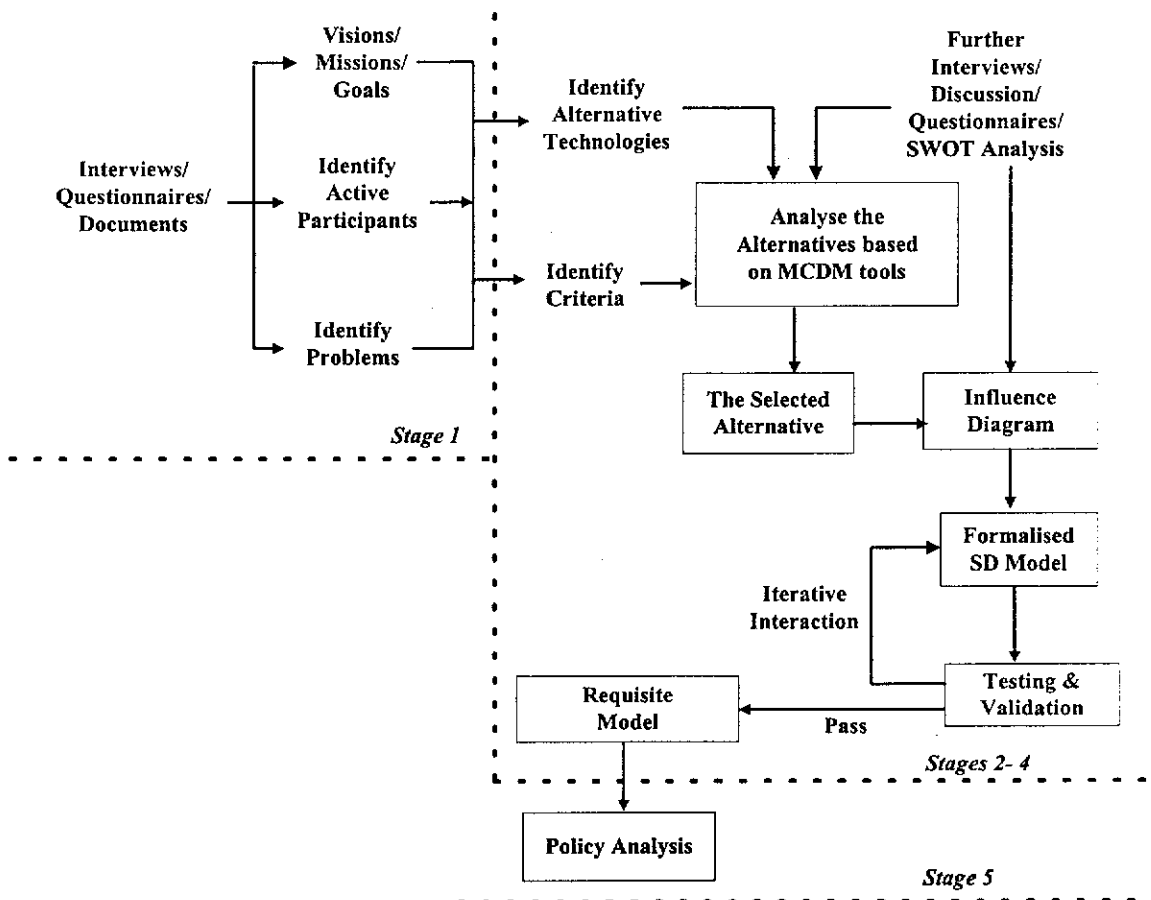


Figure 5. 3. A Research Design Framework

1. **Problem definition:** At this stage, a topic for decision-making and a case study (i.e. the Siam Commercial Bank PCL) were chosen. Information with respect to the topic and its problems were initially collected from literature reviews and documents. The knowledge acquisition process also involved interviewing, questionnaires and discussions with staff in the bank to understand its existing systems and future requirements. The acquired information was used to define system boundaries, and develop a statement of the problem.

2. **Constructing a conceptual framework:** The obtained information was used to create the preliminary conceptual model. The activities during this stage were as follows:
 - Officials in the bank were interviewed. They were asked to complete questionnaires and do a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) to elicit the current situation. They also identified possible strategies and the major factors of each strategy regarding information and communication technologies (ICT) in order to fulfil the mission of the bank.

 - The data from the previous stage, with related written documents, was then organised. Bank personnel were asked to evaluate the technological alternatives based on multiple criteria decision-making (MCDM) methodology. The technology evaluation was facilitated by V.I.S.A. software. Subsequently, the most preferred technology was identified.

 - The data relating to the selected technology were transferred to influence diagrams to develop a preliminary conceptual model using system dynamics (SD) methodology.

3. **Developing system architecture:** This step developed the final conceptual model and formalised it.
 - The preliminary conceptual model was revised based on the knowledge of people in the bank using interviews and/or the questionnaire approach.

- The refined model was used to create the final conceptual model, formalised using SD methodology, and then simulated with the *ithink* software application.
4. **Testing and validation:** The models were presented to the bank for evaluation. They were analysed for validity and reliability using tests to build confidence in system dynamics models (Barlas, 1996; Forrester & Senge, 1980).
 5. **Policy experiment:** This stage provided some strategic policies for the problems of concern. The officials were further questioned using interview or questionnaire techniques to detect policy parameters and structural changes of the model. The proposed policies were formulated and simulated using system dynamics methodology.

The research design framework (Figure 5.3) was undertaken in order to provide the answers for the identified research questions in Chapter 1.

- The first research question (i.e. what is the current status of ICT usage in the bank?) was answered at the end of research design Stage 1.
- The answers for the second and third research questions (i.e. what are requisite group models of ICT adoption and diffusion?) were derived from the research design Stages 2 to 4.
- The policy experiment at the end of Stage 5 provided answers for the fourth research question (i.e. what are the requisite policies for adoption and diffusion of ICT for the bank?)
- The answers for the fifth research question (i.e. can information and communication technologies be used as a lever of competitive advantage for the banking industry in Thailand and if so, why and how?) were analysed from literature reviews, analysis of results, and addition information from other commercial banks, apart from the Siam Commercial Bank PCL.

5.3.2 Method of Data Collection

This study employed four methods of data collection including observations, interviews, questionnaires, and documents. Additional information was generated by simulation models.

5.3.2.1 Observations

Observation is one of the most effective data collection methods for obtaining an understanding of subjects (e.g. persons, groups, and systems) under study. A researcher is able to observe the subjects perform activities as a participant or as an onlooker (Whitten, Bentley, & Barlow, 1994).

Data from observations consists of detailed descriptions of peoples' activities, behaviours, actions, and the full range of interpersonal interactions and organisational processes. Researchers use observational data to understand the context of the observed subjects to an extent not entirely possible using interviews or written documents. They also have the opportunity to see things that may routinely escape conscious awareness among participants. Therefore, direct experience gained from observations allows researchers to create a holistic perspective, be open, be discovery-oriented and inductive in approach (Patter, 1990).

This study used an observation technique by working in the bank as an external student trainee for two months in order to experience the bank work processes, understand technologies being used, collect data relating to the real perceptions of respondents towards technological issues, and validate data from other sources.

5.3.2.2 Interviews

Data from interviews consists of direct quotations from people about their experiences, opinions, feelings, and knowledge (Patter, 1990).

Henerson, Morris and Fitz-Gibbon (1987, p.24) defined an oral interview as:

“A face-to-face meeting between two or more people in which the respondent answers questions posed by the interviewer who is free to pursue interesting response if he/she feels it useful.”

There are two types of interviews: formal and informal. Formal interviewing (i.e. guided or focused interviews) is conducted in a uniform way (e.g. the questions that are asked, their sequence and wording) and is recorded in a standardised form whereas informal interviewing does not require set questions or pre-determined framework (Moser & Kalton, 1986).

Interviews can also be conducted by using less formal interviewing, that is, interviewers can exercise their knowledge of the research topic to enable interviewees to probe beyond the 'yes' or 'no' responses and expand their responses to questions (Jones, 1991). They may not have a set questionnaire at all but only a number of key points around which to build the interview. Interviews are usually recorded and transcriptions of the tapes are generally analysed individually (Walker, 1985).

This research employed the less formal interviewing technique (Moser & Kalton, 1986), which allowed the researcher to vary the sequence of questions, explain meanings, and add additional words or change the wording. The ways of asking and the sequence of the questions were determined by the confronted situations during the interviews. However, the questions were prepared in advance as a guideline to aid the memory, although not all were used. Interviews were conducted in order to gain additional information regarding interviewees' perceptions because it is difficult to access perceptual information through session observation which reveal only overt behaviours.

5.3.2.3 Questionnaires

A questionnaire is a tool for observing data beyond the physical vision of an observer in order to detect deep data within minds, attitudes, feelings, and opinions of respondents. A questionnaire differs from an interview, as it is a more impersonal probe.

Many reasons support the popularity of self-completed questionnaires as research methods (Forsgren, 1989).

- They are relatively cheap compared with other types of data collection.
- Information can be obtained very quickly without interviewer biases and variability inherent in face-to-face techniques.

- Anonymity is assured leading to increasing chances of more responses.
- Respondents have time to think about the answers before completing questionnaires.
- They can be widely sent out to many respondents at the same time and respondents do much of work.
- Data are easily analysed and interpreted due to uniformity.

This study employed both open-ended and closed questionnaires. Open-ended questionnaires were used to gain understanding and capture the points of view of respondents without predetermining those points of view through prior selection of questionnaire categories. On the other hand, closed questionnaires were used to facilitate respondents understanding of topics of concern, remind them of the points that they may not think about, and involve many respondents within a limited time.

5.3.2.4 Documents

Documents are obtained directly by reading them from program records, memoranda correspondence, official publications, reports, personal diaries, and open-ended questionnaires. Documents provide basic information as a background for conducting research or making decisions and stimulate a researcher to generate additional ideas to pursue through more direct observation and interviewing (Patter, 1990).

The documents of this study derived from the written data obtained from related literature, observations, interview transcriptions, written questionnaires, information from the Intranet system, other records and publications of the Siam Commercial Bank PCL. Documents promoted more understanding and insight because they can be kept as records to review repeatedly. They also contributed to data analyses because some interesting categories came out from the context that persuaded the author to search for additional data, and then compare and contrast the data until an informed meaning was found.

Each method of data collection contains limitations in some respects (Henerson et al., 1987; Patter, 1990). For example, conducting interviews is a time consuming process, not only the time used for an interview session but also time for preparation, time for

making an appointment, and transportation. On the other hand, written questionnaires do not allowed for flexibility, and create more chance for misunderstandings due to language usage and interpretation. The details are indicated in Table 5.2.

Table 5. 2. Limitations of Each Method of Data Collection

Method of Data Collection	Limitations
Observations	<ol style="list-style-type: none"> 1. Subjects may behave in some atypical ways when they know they are being observed. 2. Data collected may be influenced by selective perception of an observer. 3. Observers can observe only external behaviours of subjects but are unable to perceive peoples' minds. 4. Data collected may depend on the roles (participant observation or onlooker observation), and perspective of an observer. Participant observation allows observers to obtain experience and understanding; however, interpretation will be strongly influenced by the role.
Interviews	<ol style="list-style-type: none"> 1. A time-consuming method. 2. Perspectives and perceptions are subject to influence of personal bias, anger, anxiety, politics, and simple lack of awareness. 3. Data can be affected by an emotional or cognitive state of an interviewee at the time an interview takes place. 4. An interviewer is an evaluation instrument. He/ she, to some extent, can inhibit/ encourage respondents and cause them to modify their answers.
Questionnaires (Written)	<ol style="list-style-type: none"> 1. They are not constructed for situations demanding flexibility. 2. Misunderstandings can occur over language used and different interpretations from one respondent to another. 3. People may be better able to communicate meaning orally in an interactive situation rather than via writing a non interactive situation. 4. A low response rate, may introduce bias or error.
Documents	<ol style="list-style-type: none"> 1. Documents are subject to variety of measurement errors. 2. They may be incomplete and inaccurate. 3. They may be selective for only certain aspects (e.g. positive aspects).

Source: Adapted from (Henerson et al., 1987; Patter, 1990)

Taking the above limitations into account, information obtained from various sources is important for conducting system development research because it provides comprehensive perspectives on the study, contributes to validation and cross-checking findings, and compensates the limitations of one method of data collection with the strengths of the others. For example, observations provide holistic perceptions and experience. Interviews allow a researcher to go beyond external behaviour to explore the internal states (e.g. minds, ideas, attitudes) of persons who have been observed. Documents provide a behind-the-scenes look at issues that may not be directly observable and which the interviewer might not ask appropriately. Taken together, these diverse sources of information and data give a more complete picture (Patter, 1990).

5.3.3 Data Analyses

All the derived data were analysed using two decision-making tools: multiple criteria decision-making (MCDM) and system dynamics (SD) in order to detect answers for the identified research questions. The definitions and the properties of MCDM and SD have been already described in detail in Chapter 2.

The answer to the first research question, “*what is the current status of ICT usage in the bank?*”, was derived from the questionnaires and interviews using content analysis.

Content analysis is a research technique for making replicable and valid inferences from data to their context (Krippendorff, 1980, p.21). It utilises a set of procedures to make valid inferences from text (Weber, 1985, p.9). Content analysis consists of latent content and manifest content analysis. The manifest content captures various surface characteristics of the words used whereas latent content captures the deep meaning embodied in the text (Erdener & Dunn, 1990).

This study employed content analysis as a method of data analysis by identifying the material to be analysed (e.g. conversation, interview, and the content of articles, publication and questionnaire), then classifying and summarising the findings (Seaman, 1987).

Answers for the second research question, “*what is a requisite group model of ICT adoption?*” were derived from model development using MCDM method. V.I.S.A.

software was used for model and sensitivity analyses to detect the most preferred technological alternative that can fulfil the mission of the bank.

System dynamics was used to develop the models of technology diffusion in order to provide the answer for the third research question "*what is a requisite group model of ICT diffusion?*" The analyses were elaborately divided into three sub-models of information and communication technologies (ICT), a data warehouse, and Extranet banking.

Policy analyses using computer simulations based on system dynamics (SD) technique provided the answers for the fourth research question, "*what are the requisite policies for adoption and diffusion of ICT for the bank?*"

The answers for the fifth research question regarding the possibility of using information and communication technologies as a lever of competitive advantage for the banking industry in Thailand were analysed using content analysis.

5.3.4 Testing the Validity

According to Barlas, (1996), there are two philosophical sides of model validation: the positivist and the pragmatist. The former sees a valid model as an objective representation of a real system whereas the latter sees it as one of many possible ways of describing a real situation. Therefore, validity based on the pragmatist approach means "adequacy with respect to a purpose" and model validation is a gradual process of "confidence building".

Many researchers (Forrester & Senge, 1980; Kornbluh & Little, 1976; Wolstenholme, 1994) also maintain that no one method can claim complete validation. Validity of any model, either mental or computer, should be based on users' confidence in a model and judged by its comparative usefulness for desired purposes rather than exact fit between model output and its past data, or extreme "true/false" or "accept/reject" calibration. The confidence builds from satisfaction of the structure of the model, its general behaviour characteristics, and its ability to generate accepted responses to set policy changes.

Checkland (1995) commented that 'hard' approach models must sufficiently represent a part of the real world whereas 'soft' approach models must only be internally valid. Therefore, model validation is to find the answer to the question of whether or not a model is actually 'relevant', and the answer for the technical question of whether a given model is competently built.

System dynamics (SD) has been criticised for relying too much on informal, subjective and qualitative validation procedures. However, Barlas (1996) argued that in reality validity cannot be entirely technical, formal, objective process because judging the validity of a model is similar to judging the validity of its purpose, which is a non-technical informal qualitative process. Furthermore, building confidence in the usefulness of a model is a gradual continuous process starting with problem identification to after the implementation of policy recommendations. Therefore, it is impossible to validate the prolonged-nature model as entirely technical, formal, objective process. Additionally, since a SD model is normally used to explain how real systems work, developing the model to explain an existing generated behaviour in order to improve it is more important than to generate accurate outputs or reproduce/predict its behaviour.

The proposed models of this study were tested and validated based on the formal criteria by Barlas (1996); and Forrester and Senge (1980), which involved three major stages: structure validity; behaviour validity; and tests of policy implications. The details of each test are indicated in Table 5.3.

1. Structure validity tests aim at assessing model structure and parameters of a model directly without examining relationships between structure and behaviour. Structure validity comprises a structure-verification test, parameter-verification test, extreme-condition test, boundary-adequate test, dimensional consistency test, and Turing test.
2. Behaviour validity tests, including a behaviour-reproduction test, behaviour-anomaly test and behaviour-sensitivity test, are used to measure how accurately a model can reproduce major behaviour patterns exhibited in a real system. There are two different types of behaviour tests. If a problem involves a transient, highly non-stationary behaviour (e.g. an S-shaped

growth) it is appropriate to compare graphical/visual measures of the most typical behaviour-pattern characteristic. On the other hand, if a problem involves a long-term steady-state pattern it is possible to employ standard statistical measures to validate the model. Since the system behaviour of technology diffusion follows an s-shape over time (i.e. logistic function), the system behaviour derived from the model analyses was visually compared with the real system behaviour.

3. Policy implication tests are used to verify whether or not response of a real system to a policy change corresponds with that predicted by a model. The study employed two tests: changed-behaviour-prediction test and policy-sensitivity test.

Table 5. 3. Core Confidence-Building Tests

Type of tests		Descriptions
Structure validity	Structure verification	Comparing form of equations of a model with relationships that exist in a real system and with generalised knowledge in literature.
	Parameter verification	Evaluating parameters of a model against knowledge of a real system, both conceptually and numerically.
	Extreme conditions	Assigning extreme values to selected parameters and comparing model-generated behaviours to observed behaviour of a real system under the same extreme condition.
	Boundary adequacy	Aggregating all appropriate relevant structure into a model.
	Dimensional consistency	Checking the right hand side and left-hand side of each equation for dimensional consistency.
	Turing test	Presenting a mixed collection of real and simulated output behaviour pattern to experts and asking whether they can distinguish between the two patterns.
Behaviour	Behaviour reproduction	Examining how well model-generated behaviour matches observed behaviour of a real system. Behaviour reproduction tests include a symptom-generation test, frequency-generation, relative phasing, multiple-mode test, and behaviour characteristics.
	Behaviour anomaly	Discovering anomalous features of model behaviour, which sharply conflict with behaviour of the real system. Using to defend particular model assumptions by showing how implausible behaviour arises if the assumption is changed.
	Behaviour sensitivity	Conducting sensitivity of model behaviour by experimenting with different parameter values and analysing their impacts on behaviour.
Tests of policy implications	Changed-behaviour prediction	Testing if a model correctly predicts how behaviour of a system will change if a policy is changed.
	Policy sensitivity	Conducting policy-sensitivity to reveal the degree of robustness of model behaviour, and identify the risk involved in adopting a model for policy making.

Sources: Adapted from Barlas (1996) and Forrester and Senge (1980).

The three stages of validation are contingent upon the purposes of a model, which are determined in problem identification. The steps for model validation initially start from tests of model structure. Once enough confidence has been built in its validity, tests of model behaviour and policy implications are subsequently carried out. The model is continuously revised until it passes the final step of policy implication tests, which provides an accuracy of pattern predictions, and is used for communication of results and implementation purposes (see Figure 5.4).

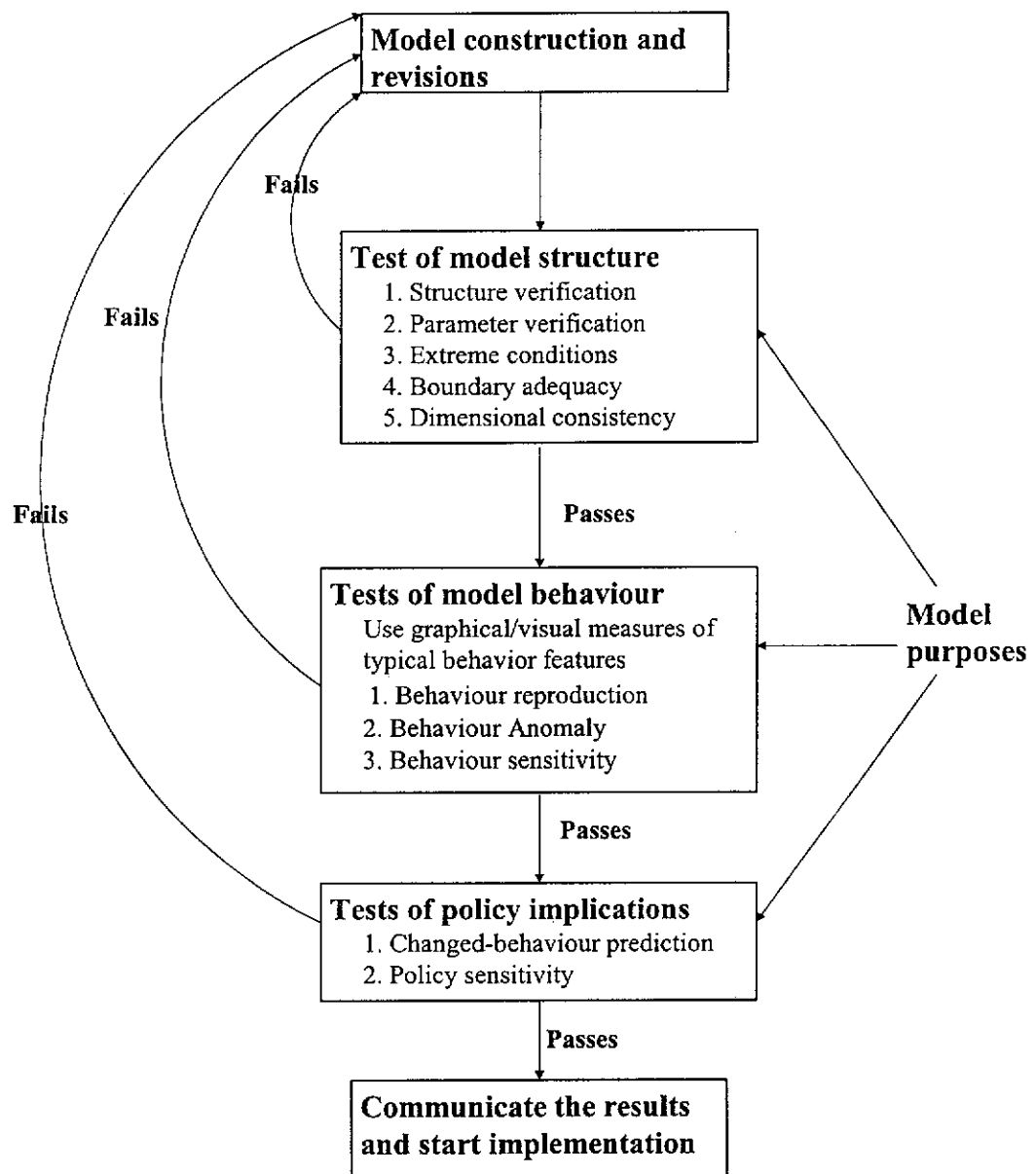


Figure 5. 4. Selected Tests of Formal Model Validation

Source: Adapted from Barlas (1996)

5.3.5 Data Collection in Practice

The steps involved in practical data collection comprise a conceptual phase, fieldwork, and a model validation stage.

5.3.5.1 Conceptual Phase

Initially, the conceptual models of technology adoption and diffusion were developed based on a theoretical approach under MCDM and SD concepts using the data from literature reviews. The models were used as a guideline for collecting data from the selected case study. Then, they were modified based on the data from the case study in order to adapt the theoretical models to reality.

An organisation suitable for the theoretical framework was selected for the case study. Since social and personal connections are vital for success in data collection in Thailand, potential organisations such as the Siam Commercial Bank PCL, Thai Petroleum Company, Loxlay Company (i.e. technology suppliers), and Bangkok Metropolitan Bank PCL were initially recommended by relatives and friends.

These organisations were then selected based on two criteria, the possibility in collecting data and organisational performance regarding technological issues. Finally, the Siam Commercial Bank PCL (i.e. SCB) was chosen as a case study for the following reasons. First, the bank has invested heavily in information and communication technologies (ICT) to enhance its business opportunities. Second, as one of the largest banks in Thailand, its technologies exert a wide impact on people in all walks of life and the nation, as well. Third, the bank management has adopted the concept of “a learning organisation” highlighting human resource development, which is compatible with a learning process of the model.

The preliminary visit to the bank was then made during December 1996 because high level co-operation from the bank was essential due to the new concept of conducting research highlighting a researcher-client approach. At the end of the first visit, all the fundamental information was derived such as available technologies in the bank, the main criteria for decision-making towards technology adoption and diffusion and, prospective respondents.

After the preliminary visit, additional information focusing on the preferred technologies of the bank was scrutinised (e.g. data warehouse, smart cards and Extranet banking). The data collecting method shifted to use questionnaires in order to get the basic ideas from key persons within a time limit. Most questions came from literature reviews organising into two parts, open-ended and closed questions. The open-ended questions are for capturing the respondents' information from the top of their heads towards the issues of interest. The closed questions aim at checking considerations, ideas and perceptions of people in the bank about the issues that cited by previous research, and detecting the level of importance of such issues.

The questionnaires namely "*Banking Technologies*" (Appendix 5.1) were developed to obtain information with respect to three main aspects; technological problems, technological alternatives, and criteria used to evaluate technology adoption and diffusion. These questionnaires were sent to 25 bank executives.

Most of the derived information was consistent; yet, some conflicting information still exists, such as the bank mission, visions or goals. Since the response rate was low only seven questionnaires were received within two months, at the end of this stage, the research design was, therefore, switched back to an emphasis on interviews, documents, and observations for data collection within the bank for two months.

5.3.5.2 Field Work

With the permission of the bank's first executive vice president, Mr. Vichit Amonviratskul, the formal data collection was undertaken at the main office of the Siam Commercial Bank PCL for two months from the 6 January to 28 February 1998. The bank provided a place and facilities at the applied technology group office and assigned Mr. Vanchai Liewisirivong as a co-ordinator under the supervision of the head of the office, Dr. Amarit Laorukpong.

The information was collected mainly from the departments relating to the technology group of the bank including

- system engineering department,
- technology and process engineering department,

- business relations department,
- applied technology office, and
- information systems audit department.

Many types of data were obtained beyond initial expectations due to unavailable and/or inconsistent data and additional interesting topics emerging from data analysis and recommendations from the bank staff. All the required data were captured to fulfil the objectives of the study with respect to the following five sub-topics: information and communication technologies (ICT), multiple criteria decision-making (MCDM), data warehouse, Internet/Extranet banking, and policy analyses (details in Table 5.4).

Table 5. 4. Data Collection

Topic	No. of respondents	Method of data collection	Name of questionnaire/ interview	Purposes
1. Information and Communication Technologies (ICT)	20	Questionnaire & Interview	"Banking Technologies"	Fundamental knowledge (problems, technological alternatives, criteria)
2. Multiple criteria decision-making (MCDM)	20	Questionnaire	"Evaluation of Banking Technologies"	MCDM analyses
3. Data warehouse	10 (people in charge)	Questionnaire & interview document	"Data Warehouse"	Variables regarding data warehouse
4. Technology and bank staff (Prospective users of data warehouse)	389 out of 500	Questionnaire	"Technology and Bank Staff"	Information regarding prospective users of data warehouse
5. Data warehouse users	54 out of 200	Questionnaire & interview	"Data Warehouse Users"	Information regarding the perception of data warehouse users.
6. Extranet banking (SCB Cash Management)	5 (people in charge)	Questionnaire & interviews document	"Extranet Banking"	Variables regarding Extranet banking
7. Prospective customers of Intranet banking	119 out of 140	Questionnaire & interview	"Prospective Customers of Internet/Extranet Banking"	Information regarding perspective customers (potential market)
8. Extranet banking customers	0 out of 200	Questionnaire	"Customers of Extranet Banking"	Information regarding the perception of Extranet banking customers
9. Policy analyses	16 (executives)	Questionnaire & Interview	"Policy Analysis"	Policy analyses

1. **Information and communication technologies (ICT).** The “*Banking Technologies*” questionnaires similar to those employed during the conceptual phase were used to follow up the staff who did not return them. The respondents were the executives and middle managers who are responsible for technological issues for the bank. Thanks to working in the bank, some respondents were interviewed instead in order to gain rich information and opinions. This type of questionnaire provided answers regarding the fundamental issues of technology adoption and diffusion in the bank such as its vision, technological objectives, problems, technological alternatives, and criteria. The details of this questionnaire are presented in Appendix 5.1.
2. **Multiple criteria decision-making (MCDM).** The “*Evaluation of Banking Technologies*” questionnaires required the same respondents as the previous questionnaires to evaluate technology alternatives based on the specified criteria (see Appendix 5.2). The data from these questionnaires were used to evaluate technological choices based on MCDM analyses and compare decision-making using intuition with that facilitated by computer software.
3. **Data warehouse.** According to the data from the “*Banking Technologies*” questionnaires, data warehouse was perceived intuitively by the respondents as the most preferred technology to help the bank fulfil its mission. Thus, the additional questionnaires namely “*Data Warehouse*” were developed to obtain information about variables used for system dynamics model analyses (see Appendix 5.3). The data were collected from 10 bank officials who are in charge of data warehousing technology using both interview and questionnaire techniques and supplemented with bank documents. All the information was integrated to verify the whole picture of this technology.
4. **Technology and bank staff (i.e. prospective users of data warehouse).** The “*Technology and Bank Staff*” questionnaires were developed for the purpose of identifying the current issues and perception of the bank staff as end users towards the general banking technologies and the data warehouse aspects (Appendix 5.4). The questionnaires were distributed to respondents both in the head office and branches around the country. There were 389

responses out of 500. The respondent rate was high (79.8 %) because the bank staff thought that the questionnaires were issued on behalf of the bank.

5. **Data warehouse users.** The additional questionnaire "*Data Warehouse Users*" in Appendix 5.5 aimed at capturing information about current users of the data warehouse and was developed because of insufficient information with regard to current usage, perceptions of users and advantages from the data warehouse. One of the executive managers suggested that the required information could be gained from current users. Therefore, the names of 23 departments that anticipated using the data warehouse were given. The questionnaires were distributed to personnel from the positions of team leaders up to executive managers.

Respondents were willing to complete the questionnaires because they were issued on behalf of the bank (i.e. the Applied Technology Office). Consequently, although the response rate was low (54 responses out of 200), they provided substantial information about the data warehouse and indicated the real numbers of people who use this technology or think they are using it.

6. **Extranet banking (SCB Cash Management).** Since technological evaluation was concurrently undertaken with data collection, the result revealed that Extranet banking is the most preferable technology of the bank based on MCDM analyses. Therefore, people in charge of Extranet banking were interviewed and they completed the "*Extranet Banking*" questionnaires. The contents of this type of questionnaire are similar to those of the "*Data Warehouse*" questionnaire in Appendix 5.3. All the information was used to develop the diffusion model of Extranet banking based on system dynamics analyses.

7. **Prospective customers of Extranet banking.** The short questionnaire for "*Prospective Customers of Internet/ Extranet banking*" (Appendix 5.6) aimed at finding the potential usage of the Internet/Extranet banking in Thailand. At first, telephone interviewing was employed to gather opinions and perceptions from people who have a computer background and have

high positions in companies and the public sector in Thailand. However, since it was a time consuming process and lacked standardisation, the short questionnaire was used instead and completed by highly educated people because most of them are working as middle managers in companies or the public sector and have the potential to begin using Extranet banking.

8. **Extranet banking customers.** *“Customers of Extranet Banking”* questionnaires were developed to gain the perception of current customers of the Siam Commercial Bank PCL towards this technology. The bank staff distributed the questionnaire because they wanted to assure the customers about confidentiality. Unfortunately, these questionnaires have not been returned despite every endeavour to get them back. Therefore, information regarding customers’ behaviour was derived from the perception of the persons in charge of Extranet banking.
9. **Policy analyses.** Information towards policy analysis was derived from the questionnaires and interviews on *“Policy Analysis”* (see Appendix 5.7). The open-ended part was used to interview executive staff about the policies of the bank and their opinions about how to solve the problems relating to technological issues. The closed part was to identify the level of importance of each policy based on the bank staff’s point of view. The interview data enhanced the level of understandings about each policy, revealed the perception of people in charge, clarified obscure information and detected more details.

These types of questionnaires provided sufficient information for model analyses and subsequently provided the answers for the first to fourth research questions. However, the information was inadequate to provide the answer for the research question *“can information and communication technologies be used as a lever of competitive advantage for the banking industry in Thailand and if so, why and how?”* The main reason for the inability to answer the question was because using a single case study in closed co-operation as a research-client approach prevented the opportunity of gaining in-depth information from the other banks. The precise answer for this research question was postponed until future research could be conducted using more suitable research methodologies.

However, in order to provide initial answers for this research question, the additional data were collected from two sources: publications with regard to technology from other commercial banks apart from the case study bank, and interviewing people in charge of technology. There were four respondents (one from a large bank, one from a medium-sized bank and two from small-sized banks).

5.3.5.3 Model Validation Stage

The state of formal validation activities took place after the initial model formulation had been completed and before the policy analysis/design step. The models were verified based on the selected tests of formal model validation as previously mentioned, and compared with information from literature reviews and the bank.

The results from the model analysis based on two technologies: a data warehouse and Extranet banking were proposed to experts in the bank. This type of validation as applied from the Turing test by asking the experts to compare the results with their knowledge and experience, give comments towards the proposed models, and suggest ways to revise the models. Their recommendations were used for model revisions and improvement.

5.4 Practical Problems of Data Collection

Problems occurring during the data collection process are common. The practical problems confronted are described in order to acquaint other researchers with them and to rectify them for future research. However, the problems are highly contingent upon the Thai organisational culture. They may not apply for other cultures.

- **Making an appointment.** It is hard to make an appointment with top executive people in a large private organisation. The first step is to contact their secretaries. Surprisingly, each Thai executive has his or her own secretary. Success in an appointment sometime depends on the judgement of secretaries because they are screening issues and persons for their bosses. Furthermore, time for an appointment with executives is limited with a maximum of 1 hour and may be changed due to urgent or more important issues. Making an appointment with bank officials in practical levels is not easy also because of their full routine workloads.

- **Revelation of information.** It is observed that executive people disclose their ideas or perceptions straightforwardly but they cannot provide accurate facts (e.g. figures) because these are outside of their areas of responsibility. On the other hand, people in charge hesitate to give data, although they have precise data, and convey their ideas directly for fear that they may break confidentiality of the organisation or cause unintentional effects that will rebound to give detrimental effects on them. This habit is embedded as part of Thai culture. People in an organisation are careful to keep good relationships with their superiors and their colleagues (Swierczek, 1988).
- **Interview.** Some caution has to be taken when interviewing. First, the interviewer has to ask interviewees whether they mind being taped (the ethic of informed consent). It is interesting that in Thai culture, many middle managers feel uncomfortable with tape recorders and dare not reveal some information because they are afraid that the information may give negative effects on them. Note-taking was used to capture the information from interviewees instead. Yet, its drawback is incomplete data. Second, telephones and visitors can interrupt the flow of conversation. Third, the language used was unfamiliar with jargon and technical terms that some are hard to translate precisely into the Thai language. In addition, the concepts of SD or MCDM were new and difficult for some people to explain within the limited time. Fourth, since the models using the bank as a case study were developed from scratch, it is hard to control the scope of interview or conversation despite good preparation because many issues seem interesting. Therefore, the information sometimes deviated from that intended.
- **Document.** Although the bank is a large and well-informed organisation, the information is still scattered. The collected data therefore derived from documents in the bank library, staff and the Intranet system. The data from the Internet system provide an understanding of the work performance of the bank. However, although the bank has developed the data warehouse as the main database, the problem of non-updated or incorrect data occurs frequently leading to difficulties and confusion.

- **Questionnaire.** Some data from questionnaires was difficult to understand because respondents did not answer the questions clearly. The non-interactive nature of questionnaires did not allow the researcher to validate meanings.

Language was considered as an obstacle for questionnaire development. Although most bank executives can use English it takes longer compared to the mother tongue. Therefore, the questionnaires were initially developed in English to communicate with Australian scholars and to ask for permission based on ethics issues. When the English version was approved, all the questions were translated into Thai before distribution to respondents. Eventually, all the data received from the respondents were then translated back to Thai again. Thus, problems regarding the use of appropriate vocabularies to preserve the actual meanings were hard to avoid. This problem was resolved by using both Thai and English and asking Thai people as a peer debriefing method for language editing in order to make the meaning clearer for readers.

Furthermore, sending questionnaires overseas delayed the process of data collection because it requires self-postage stamps to facilitate responses and takes time for sending back and forth.

5.5 Summary

This chapter presents research methodologies and research designs. System development research was the main research methodology selected as it was appropriate for conducting research in information systems domain and it also uses a concept-development-impact process. The study employed system development to transform the concepts of how to adopt and diffuse technologies effectively into the adoption and diffusion models that can be practically used for decision-making or strategic planning. The visual results of the model allow people to observe impacts of variables or strategic policies on the factors of interest. The case study of the Siam Commercial Bank PCL was supplementary research methodology to customise the generic models to a specific case.

The data derived from four main sources: observations, interviews, questionnaires and documents provided the rich data for data analyses, model development and model validation. Content analysis and two decision-making tools were used for data treatment. Multiple criteria decision-making (MCDM) was employed to develop the model of technology adoption whereas system dynamics (SD) was used to develop the models of technology diffusion and policy analyses. The models and their outcomes will be discussed in the subsequent chapters.

A case description will be presented in the next chapter in order to introduce the Thai economy, Thai commercial banks, and the Siam Commercial Bank PCL. The information derived from the case study bank provides answers for the first research question regarding the current status of information and communication technology of the bank.

CHAPTER 6

CASE DESCRIPTION

6.1 Introduction

This chapter is organised as follows. The first part of this chapter introduces Thailand discussing the Thai economy. The second part introduces the banking industry in Thailand focusing on commercial banks. The final part introduces the main case study, the Siam Commercial Bank PCL, with its vision and business performance. Then, the data from the “*Banking Technologies*” questionnaire supported by the data from interviews and documents are analysed to identify the answers for the first research question, “*what is the current status regarding information and communication technologies (ICT) of the bank?*”

6.2 Thai Economy

Thailand is situated in the Southeast Asian mainland with an area of 513,115 sq. km. It is divided into four regions: the North, the Central Plains or Chao Phraya River Basin, the Northeast and the South. Bangkok is the capital city of Thailand (The National Identity Board, 1995). The total population of Thailand as at 31 December

1997 was 60.8 million with approximately 14.6 million households (Department of Local Administration, 1999).

Traditionally, Thailand was an agricultural country. Abundant natural resources and rich land allowed the country to be one of the largest food exporters (e.g. rice, rubber, tapioca and maize) in the world. However, in recent decades, the economic structure has been diversified whereby the industrial and service sectors began to replace agriculture. The economic structural changes resulted from moving from basic staple crops to value-added products (e.g. frozen shrimps, canned pineapples, and sugar), and then expanding into new high demand products such as textiles, ready-made garments, integrated circuits, plastics, jewellery, footwear and knocked-down furniture (The National Identity Board, 1995).

The Thai government supported an industrialisation process under two main economic policies: the import-substitution policy (during the 1960s), and then the export-oriented policy (The National Identity Board, 1995). Many supportive factors have been promoted to facilitate and attract foreign investment including tax exemption, industrial zones, infrastructure, and relatively low labour costs.

Thailand has investment characteristics superior to those of her neighbours. For example, with a population of 60 million, domestic markets partially absorb products from investment. Foreign investors can also use Thailand as the gateway to the Indo-Chinese countries, which have the potential to provide abundant raw materials and virgin markets. Although the agricultural sector has been ignored, this sector still supply products, which are essential raw materials for food processing, agro-industries and other value-added farm products. Political stability, racial tolerance, available facilities and infrastructure are also the major incentives for investment. Thus, investment from foreign countries, particularly Japan, increased dramatically. Foreign investment together with export extension boosted the economic growth of the country.

With an average annual GNP growth rate of 8.2 percent during 1985 to 1994, (see Table 6.1), Thailand was classified as one of the 8 high-performing Asian economies (HPAE) including Japan, Hong Kong, Korea, Singapore, Taiwan, Indonesia,

Malaysia and Thailand. This was a remarkable record of high and sustained economic growth (Polkwamdee, 1998; Rafferty, 1985; The World Bank, 1993).

Table 6. 1. Thailand's Macroeconomic Framework

	1993	1994	1995	1996 revised	1997 ¹ estimate	1997 ² estimate	1998 3 rd review
Population	58.3	59.1	59.5	60.1	60.7	60.8	61.3
Real GDP growth	8.3	8.9	8.7	5.5	6.8	-0.4	-4 to -5.5
GDP per capita (US\$)	2,107	2,422	2,817	3,063	3,352		
Exports (billion US\$)	36.4	44.5	55.5	54.7	57.8	56.7	57.5
Exports (%change)	13.0	21.3	23.6	-1.9	7.7	3.8	1.4
Official reserves (billion US\$)	25.4	30.3	37.0	38.7	39.2	27.0	26-28
Inflation	3.3	5.0	5.8	5.9	4.7 ^{1/}	5.6	10.5
Exchange rate (bath per US\$)	25.32	25.15	24.91	25.34	25.97 ^{1/}	31.37	42.84

Source: Bank of Thailand, 1999

Note: 1. Estimated data before 2 July 1997

2. Estimated data November 1998

e- estimate

p- preliminary

However, a decade of economic growth planted the seeds of many unfavourable factors in the economy and caused changes in the behaviour of Thai people as well. Shortage of infrastructure and insufficient capable human resources became acute especially in the areas of science and technology (Phananiramai, 1995). Corruption, unequal income distribution, and materialism evidently existed.

An economic slowdown was experienced in Thailand in 1996. Eventually, on 2 July 1997, pressure on the baht forced the government to abandon the fixed exchange rate. This led to nearly 40 percent devaluation of the Thai baht leading to many adverse effects such as high interest rates, a credit crunch, collapsed domestic demand, increased unemployment, weakened financial sectors, increased corporate bankruptcies, and tightened budget expenditure (Moretti, 1998). For Thai people the success and joy from the "economic miracle" abruptly vanished.

The collapse of the Thai economy is a case study of interest to many countries and organisations because of the level of seriousness and its domino effects leading to the possibility of world economic recession. The crash was far beyond the expectations of economic forecasters. Many believed that the economic growth of East Asian would continue to outperform the rest of the world. For example, the Pacific Economic Co-operation Council's experts predicted that the growth in East Asian economies including Thailand would accelerate to 8% in 1998 (Holloway, 1997). The Bank of Thailand (1999) also estimated before the economic crisis that the GDP growth rate would be 6.8% in 1997, yet was compelled to revise this figure to -0.4% after the crisis.

Many causes for the severe economic crisis were evident with hindsight (i.e. once a certain event has taken place, people find it easy to explain it) (Makridakis & Wheelwright, 1989a, p.269). The main causes for the economic collapse are inappropriate fixed exchange rate, liberalised capital flows, decline in an export growth rate, massive deficit in current account, and collapse of the property sector (Bunyamanee & Nivatupumin, 1998; Hathaiseri, 1998; Terdudomtham, 1998).

The Thai economic crisis reflects the importance of inter-relationships between variables, time delays and the importance of information and communication technologies. Although some problems initially came from external factors (e.g. currency speculators), the situation got worse because of internal variables (e.g. inability of policy makers, greediness, and wrong internal monetary policies). The boom and bust also reflects problems relating to a time delay, a limit of growth, and negative effects from positive feedback loops. Additionally, information and communication technologies facilitate rapid movement of international funds, which is difficult to control by Thai organisations which lack experience and competent personnel in such matters.

Therefore, the economy needs control variables or warning signs to avoid unfavourable outcomes and people who have competence both in business and technology to keep track of the fast changing situations. It is necessary to have updated information and use it as a mechanism to prevent unfavourable outcomes in order to survive globalisation.

6.3 Thai Commercial Banks

The banking industry in Thailand consists of four types of banking systems: a central bank, commercial banks, savings banks and banks for specific purposes. The commercial banks are under the supervision of the Bank of Thailand (BOT). BOT first began operation in June 24, 1940 to undertake activities as a central bank. Its function is to formulate monetary policy, maintain monetary stability, act as banker to the government and other financial institutions, manage international reserves and public debt, maintain exchange controls, issue bank notes, and supervise financial institutions (Bank of Thailand, 1998; The National Identity Board, 1995).

6.3.1 Historical Background

The advent of the commercial banking industry resulted from the trade extension between Thailand and foreign countries after Thailand had joined the world economy by signing the Bowring Treaty in 1885. With this treaty, Thailand was forced to liberalise trade and revoke import and export monopolies by limiting the import duty on general merchandise to 3 percent ad valorem, and later 5 percent (Siamwalla, 1996). The increase in international trade attracted commercial banks from foreign countries to establish branches in Thailand. In 1888, the Hong Kong and Shanghai Bank was opened and subsequently followed by the Chartered Bank in 1894 (Tesawanich, 1991; The Siam Commercial Bank PCL, 1996a).

King Rama V gave full support to open Thai commercial banks for the purpose of economic development and prevention of the economy falling under the influence of foreign banks. The Siam Commercial Bank Capital Company Limited was opened as the first commercial bank in Thailand in 1906.

During the period from 1929 till 1931, many Thai commercial banks were established. However, critical economic crises such as the 1930's world economic recession, World War I, and the crisis that occurred when the value of the pound was not linked with gold, forced some vulnerable banks to merge with other banks or close down (The Siam Commercial Bank PCL, 1996a).

The Thai banking industry entered the "modern banking development period" in 1945 with the achievement from the successful internationalisation and standardisation of banking rules and regulations. It grew sharply during 1987-1997 due to economic and financial growth, protection from the government, and high interest rates. However, the number of the banks did not increase because of restrictions on granting new bank licences. Thus, the banks expanded their business via a branch system. As of June 1999, the Thai commercial banks comprised 13 head offices with 3,824 branches (Bank of Thailand, 1999).

An important development in this period was the introduction of ATM transaction services in 1983 (The Siam Commercial Bank PCL, 1995). ATM services have been widely accepted by bank customers and lead to the advent of the electronic banking period in Thailand. Many banks have implemented new technologies to provide distinctive services to satisfy their customers and improve their efficiency and effectiveness.

Many foreign banks began operations after the establishment of the Bangkok International Banking Facilities (BIBF) to liberalise international capital flows in March 1993. These included six new foreign bank branches and 19 new foreign banks under the international banking facilities-IBFs licences. As of 1999, there are 33 commercial banks: 13 domestic banks, 20 foreign bank branches and 19 new foreign banks with licenses for international banking facilities-IBFs (Bank of Thailand, 1999).

6.3.2 Banking under the Economic Crisis

The economic crisis forced Thai banks and finance companies to struggle against difficulties and to strive only for survival. The main changes leading to this period are as follows.

1. **Closing down and establishing new banks.** After the economic crisis, one domestic bank (i.e. Bangkok Bank of Commerce Public Co., Ltd) was permanently closed down due to the corruption of top executives and massive bad debts from non-performing loans. The government intervened to merge

five commercial banks with other banks or increase capital to strengthen their financial status. The remaining banks still confront an uncertain situation and a lack of confidence in financial institutions. As of 14 August 1998 only ten financial institutions from the original 16 did not face government intervention; all are large and medium sized banks. A new commercial bank, the Radhanasin Bank, was established in 1998 to manage the assets of the 56 financial companies that were permanently closed.

2. **Decreased profiles and profits.** As a matter of fact, all banks could not defend themselves from massive losses during the years 1997 and 1998. The profiles and profits of the commercial banks dropped very dramatically. Provision for possible loan losses increased extensively in 1997 due to non-performing loans and bankruptcies of businesses.

6.4 Banking Technologies in Thailand

During economic growth, each bank protected its market share by providing efficient and quality services to customers. Therefore, bank executive managers were inclined to give full support for adopting information and communication technologies with high expectations that such technologies may enhance efficiency in work processes, decrease expenditures and increase the capacity to compete with other banks.

Information and communication technologies (ICT) were initially used for clerical purposes (e.g. typing and document keeping in internal offices). Then, automated technologies were employed to automate monitoring of work performances. Currently, the objectives are shifting towards using technologies to get access to data for decision-making and detecting additional business opportunities.

Three large Thai banks: Bangkok Bank PCL, Thai Farmers Bank PCL, and the Siam Commercial Bank PCL, compete for innovative leadership by spending large sums of money on technological investment. For example, the Bangkok Bank planned to spend approximately US\$ 400-500 million for technological improvements over the next five years (Bangkok Bank Public Company Limited, 1999b).

Electronic banking began in Thailand when the Siam Commercial Bank installed a magnetic accounting recorder machine for withdrawal-deposit service in 1965. Later in the 1970s, Bangkok Bank PCL and the Siam Commercial Bank PCL began to service customers with deposit and withdrawal facilities at all branches. In the early 1970s, the Thai Farmers Bank introduced credit cards in Thailand and became the first Thai bank to introduce VISA® and MasterCard® credit cards. ATM transaction service was initially installed by the Siam Commercial Bank in 1983, which was the starting point for the banks to use electronic banking systems in order to provide new services to their customers. Bangkok Bank and the Siam Commercial Bank provided EFTPOS at the same time in 1985 (Tesawanich, 1991). The Thai Farmer Bank issued a "smart card", a combination of ATM and "electronic purse" card. In 1993, the bank initially adopted a program to "re-engineer" bank operations to improve customer service and operational efficiency (Thai Farmer Bank Public Company Limited, 1999a).

Yet the medium and small commercial banks use a 'wait and see' policy. They will only follow the large banks when the new technologies are shown to be productive.

6.5 The Siam Commercial Bank PCL

The Siam Commercial Bank PCL is one of the four largest banks in Thailand. The bank was recognised as one of the best banks in Asia by *Asia Money* magazine in 1996 due to its 25% growth loan base while attaining a respectable 1.89 % ROA (Rate of return on assets) in the process (Bank International Indonesia, 1996).

Table 6.2 shows highlights of the bank's profile during 1996-1998. The bank has a main office located in Bangkok with 416 branches nation-wide and 7 overseas. Assets in 1996 were 516 billion baht (20.6 billion US dollars) and increased to 705 billion baht in 1998 (19.5 billion US dollars). The value of assets in US dollars is lower due to the devaluation of Thai baht. The economic crisis in 1997 exerted a serious effect on the bank's profits. Net profit decreased from 6.6 billion baht in 1996 to -12.410 in 1998.

Table 6. 2. The Siam Commercial Bank Public Company Limited Highlights

(Billions of baht)

At End Of Period	1) September 1996	2) December 1997	2) December 1998
Assets	516	717	705
Deposits	389	558	591
Loans (Net of Provision for Possible Loan Losses)	432	550	512
Shareholders' Equity	38.53	41.7	38.0
Profit before Income Tax	8.9	5.232	-12.410
Net Profit	6.6	3.194	-12.410
Earning per Share (At par bath 10)	bath 17.4	baht 8.37	baht -21.57
Number of Offices (Branch)			
- Nation-wide	416	463	489
- Overseas	7		7
- Overseas Joint Venture	3		
- Representative Office	1		
Number of Employees (Person)	12,935	12,679	12,220

Sources: 1. (The Siam Commercial Bank PCL, 1996b)
2. (The Siam Commercial Bank PCL, 1999a)

6.5.1 Vision

The Siam Commercial Bank PCL has the vision of being “*the best managed bank with sustainable excellent performance*”. The mission statement includes the phrase “*acknowledged personnel performing quality work to best serve our customers*” (The Siam Commercial Bank's staff, 1998a).

6.5.2 The Main Objectives

According to information from the “*Banking Technologies*” questionnaire (Appendix 5.1), the bank attempts to achieve the following main objectives:

- maintaining competitiveness (i.e. retaining market share) through teamwork using “learning organisation” as a management concept;

- developing knowledge of people focusing on quality of work to serve customers;
- being the leading bank both regionally and globally in customer services and organisational management;
- applying modern technology to support decision-making and management; and
- applying technology to facilitate customers' requirements in order to maximise customer satisfaction.

6.6 Current Status of Information and Communication Technologies: Research Question 1

This section identifies the current status of information and communication technologies (ICT) of the bank including the main purposes for technology use, technological problems, technology plans, decision-making processes towards technology adoption and diffusion, obstacles in using/learning technologies, and recommendations for resolving the problems. The data was mainly derived from interviews and questionnaires of “*Banking Technology*” and “*Technology and Bank Staff*” (see Appendices 5.1 and 5.4) supplemented with data from documents, bank publications and personal discussions. All the data was subsequently analysed using content analysis. The information provides the answer for the first research question, *the current status regarding ICT of the Siam Commercial Bank PCL.*

6.6.1 Main Purposes for Technology Use

Generally, information and communication technologies are used for three main objectives: customer services, operational proposes, and decision-making support. Technology was first mainly employed to facilitate customers, marketing and business management. It added value to products or services which differed from competitors leading to increased market share, sales and profits. It was also used to facilitate work processes and manage documents far beyond human capabilities. Eventually, information and knowledge derived from using technology were used to

support better decision-making, to provide support for strategic planning, and to promote rational thinking (The Siam Commercial Bank PCL, 1995).

According to the executives of the bank, they perceived that the bank has invested in numerous technologies in order to fulfil the following objectives (The Siam Commercial Bank's staff, 1998a):

- improving banking services to suit customer's requirements;
- providing the best services to customers (rapid and modernised);
- facilitating and increasing efficiency in working processes;
- gaining appropriate information suitable for management and decision-making;
- increasing new business opportunities and competitive advantages;
- eliminating re-work and redundancy;
- reducing operational costs (e.g. paper, labour);
- facilitating staff convenience and effectiveness;
- being highly innovative, customer driven and the best managed bank; and
- maintaining the image of the innovative leader among Thai commercial banks.

6.6.2 Decision Making Process

The bank set up an organisation namely *the applied technology office*, as a technology research and development department. The office is sub-divided according to duties and responsibilities into five teams (Pentium, 1996a).

1. **Standard.** This team studies and identifies all standard systems (e.g. specification, details, and brand types) relating to information technology.

2. **Evaluation.** The duties of this team are to evaluate and select technology using two main criteria: efficiency in work performance and costs of technology.
3. **Research and development.** This team is responsible for research and development of new innovation.
4. **Prototype.** People in charge conduct experiments and pilot projects on technologies proposed from the research and development team in order to find out the feasibility for implementing the technologies.
5. **Support.** This team facilitates, controls, and procures software applications for end users of the bank.

In effect, personnel in this office are responsible for researching innovative technologies in financial business that will facilitate work performance or bring about new business opportunities. They also provide additional information, analyse technological trends, summarise results, and propose technological alternatives to the bank's top executives to support their decision-making on technological issues. When a proposed technology is approved, they negotiate with technology suppliers, develop prototypes or pilot projects, and evaluate results for full implementation, operation and maintenance.

Key persons who make decisions regarding the bank's technology adoption and diffusion comprise the president and chief executive officer, first executive vice president of the technology group, and an ICT committee. The committee consists of personnel from the technology group of the bank (i.e. applied technology office, systems engineering department, technology and process engineering department, and business relations department), and delegations from departments that are going to use selected technology.

Decision-making processes are supported by information from many sources such as technology information providers (e.g. Data Pro and Gartner), articles from Thai and overseas journals, attending seminars, Internet, vendors, technology suppliers and users.

The decision-making process for technology adoption and diffusion follows two main procedures: innovative-oriented and user-requirement procedures (The Siam Commercial Bank's staff, 1998a).

1. **Innovative-oriented procedure.** Staff in *the applied technology office* (i.e. Technology R&D of the bank) collects data from vendors/technology suppliers and other sources. The information is reported to high level executive managers. If promising technologies are available and suitable for the bank requirements, the bank will set up a committee for a feasibility study, with support from *the applied technology office*, and then select the most appropriate technology. The committee submits the proposed technologies to the first executive vice president of the technology group and, subsequently to the president and chief executive officer for final approval.
2. **User-requirement procedure.** New technologies are initiated from users' requirements. The step begins with users proposing their requirements to the technology group. The requirements will be sent to *the applied technology office* and a committee for further feasibility studies regarding business and technological aspects. Then, a project and a project team are set up for detailed studies in order to make a final decision whether or not to adopt new technology.

6.6.3 Problem Description

Problems regarding technology adoption and diffusion were initially collected from the literature reviews. Then, bank officials were asked to complete the "*Banking Technologies*" questionnaire, and give additional comments. They also gave the levels of seriousness of problems by using a scale from 1 (low) to 7 (high). Table 6.3 indicates the levels of seriousness of problems that the bank has confronted.

Table 6. 3. Level of Seriousness of Technological Problems

Problems	Level of Seriousness
Rapid obsolescence	5.71
Selecting inappropriate technologies	4.89
Cannot use adopted technology productively	4.79
Lack of capable employees	4.74
High costs of technologies	4.65
Technology did not deliver expected performance	4.17
Receiving incorrect information	4.16
Technological mismatch	4.05
Acceptance from bank staff	3.74
Acceptance from customers	3.63
Lack of high executive support	2.89

Source: (The Siam Commercial Bank's staff, 1998a)

1. **Rapid obsolescence.** The bank has to customise adopted technologies before implementation because working processes normally do not fit very well with available technologies in a market. The longer time for customisation exerts a risk due to rapid technological evolution. The rapid changes in technology without a clear-cut direction force the bank to keep up with technologies, and endeavour with much difficulty to make decisions on technological issues.
2. **Selecting inappropriate technologies.** Owing to high costs of technologies, the bank devotes intensive effort to select technologies. However, this task seems difficult for people in charge. First, information about technologies is mostly provided by vendors, who always try to convince the bank with exaggerated and optimistic claims about technologies. If the bank needs more accurate information, people in charge will be sent to get it from overseas, or conduct a pilot project that increases costs. Second, the banking system is complex with multiple functions and processes. Each function or process requires different types of technologies. Generally, certain

technologies are suitable for certain types of work and may not be applied to all of the functions or processes undertaken by the bank. Third, proposed technologies have not reached an implementation phase as yet. The success of technological implementation is contingent upon many factors (e.g. economic factors, staff and customers' behaviour). Therefore, outcomes from technologies may deviate widely from expectations.

3. **Cannot use technologies productively.** Technology cannot provide advantages unless users do understand its limitations, and how to use it productively. Using technologies productively depends not only on the capacity of technologies but also depends on skilled personnel. However, recruiting and retaining skilled employees is one of the critical issues in Thailand because of insufficient technological human resources. The bank has to compete with other organisations to recruit skilled people or provide training programs. Nevertheless, to recruit/train skilled people to/in an organisation is a time-consuming process and perhaps not worthwhile because some well-trained staff may switch to other organisations after training.
4. **Lack of capable employees.** As previously mentioned, end users with full technological capability are scarce. Staff are willing to be trained but the main obstacle is his/her routine workload. Apart from highly skilled users, the bank also has to provide technological knowledge to end users in every branch around the country in order that they are able to use technologies productively, mitigate technological errors, and maximise utilities from technologies. Training staff from various backgrounds to use diversified technologies consumes a lot of time, training costs, and effort.
5. **High costs of technologies.** The SCB has invested extensive money on information and communication technology development, approximately 13 per cent of its annual revenue. The budget for IT development is around 700 million baht ("Home banking via Internet," 1996). Apart from the costs of technologies, costs for research, promotion, maintenance and upgrading technologies are essential but also prohibitive.

6. **Technology did not deliver expected performance.** Using technologies requires skills, knowledge, understanding, and acceptance from staff and customers. It is difficult to convince staff to use technologies, yet it is far more difficult to convince customers unless they perceive distinctive advantages from the technologies. Diffusing technology among staff requires training or educational programs. On the other hand, assimilating technologies to customers requires positive word of mouth, promotion and advertising programs. However, doing so cannot guarantee good results due to unpredictable customer behaviour. For example, the ATM transaction system has been widely accepted since 1982-83, although some customer felt that it was not completely reliable. On the other hand, technologies such as EFTPOS and smart cards have not gained complete acceptance as yet. Thus, the bank dare not take the success of the ATM case to indicate certain success for other technologies.
7. **Receiving incorrect information.** Information and technological supports are mainly obtained from domestic or regional vendors or technology suppliers especially from Asia. Support from suppliers in Europe or America is still limited. Additionally, there is a lack of research, continuous development, and support from the public sector. Internal sources of data have not been completely integrated due to the functional systems of the bank. The bank endeavours to develop a data warehouse to integrate all the bank information systems that may provide complete and rapid access.
8. **Acceptance from bank staff.** Technology sometimes cannot fulfil users' requirements. Even if the bank staff feels it is inconvenient to use technologies, if technologies are part of their work or responsibility they have to learn how to use them.
9. **Acceptance from customers.** The bank cannot ascertain in advance that all new technologies will bring about good returns on investment. Generally, it is hard to convince customers to accept innovations before their obsolescence. For example, a smart card research project has consumed a lot of resources for a feasibility study without implementation for the time

being due to insufficient customer acceptance (P. Jirapinyo, personal communication, December 19, 1996). The bank avoids this problem by testing all technologies relating directly to customers via a pilot project before implementation, employing a wait and see policy, or conducting marketing research.

10. **Lack of high executive support.** Lack of high executive support is not the main issue for the Siam Commercial Bank. High level executives provide full support for technological development. The president of the bank is the CEO and all departments under the technology group communicate directly to the president of the bank.

6.6.4 Technological Development

The SCB has introduced information and communication technology into the banking system since 1975 with the main purpose of responding to customers' needs effectively. At the first stage computers were used for deposit transactions at the main office, subsequently expanded to the branches, and finally allowed withdrawals and deposits of money between different branches. Since 1983, the bank has been reputed as one of the innovative leaders of Thai commercial banking. The following lists the advanced technology introduced by the bank (Pentium, 1996b; The Siam Commercial Bank PCL, 1995; 1996a; 1997a; 1997b):

- ATM (1983);
- Tele-bank to allow customers to execute transactions with the bank from their homes (1984);
- Electronic Funds Transfer at Point of Sale (1985);
- Info-banking to facilitate information flows between banks and customers (1986);
- Geographic Information System to evaluate securities prices more rapidly (1989);

- Program BETAS (i.e. the Bank Enterprise Transformation Alignment Solution) to serve small and medium sized customers (1995);
- Video conferencing, Intranet, and SCB Cash Management (Extranet banking) (1996);
- Completed data warehouse, improvement on technological infrastructure, and the addition of a new network (1997).

In addition, the bank introduced two technological development plans in 1983.

6.6.4.1 Technological Development Plan I

The first plan (1983-1991) was divided into three phases (The Siam Commercial Bank PCL, 1995).

Phase 1. Using Technology for Serving Customers (1983-1985)

The bank used technology to serve customers' requirements and differentiate itself from competitors in terms of properties, strengths and ways to serve customers in order to create more value-added and promote cross selling. As there are many branches and types of services, it took the bank three years to fulfil the objectives of the plan.

In 1983, the bank introduced Automatic Teller Machines or ATM. With the high customer acceptance, ATM brought about a tremendous success to the bank that resulted in changing customers' behaviours and increasing technology adoption in the Thai banking industry. The accomplishment of the first plan and ATM technology contributed to an increase in the bank's customer base and market share.

Phase 2. Using Technology for Operation and to Increase Products (1986-1988)

Technologies were employed to increase productivity for operational processes by reducing steps in work procedures, minimising costs, and decreasing paper work. For customer services, technologies were employed to facilitate customers by decreasing time and procedure steps in sending and receiving information, reports and forms. On the other hand, for back offices, technologies such as office automation were used to receive and send data among the internal organisations to enhance flexibility and productivity.

Phase 3. Steps towards an Information Technology Society (1989-1991)

The bank has joined with large vendors (e.g. IBM) to develop software applications tailored for the bank. The efficiency of databases has been improved by dividing the information systems into four sub systems: customer management, financial management, market management, and human resource management, and controlled by centralised management information systems (MIS). These information systems provide integrated information for policy planning, data management (timely and precise information), work process improvement, and decision support.

6.6.4.2 Technological Development Plan II

All technologies, applications, and peripherals have been continuously invested in and developed to be an infrastructure for the growth of the bank at present and in the future. Currently, the bank employs various types of technologies to service customers and facilitate work performance including ATMs, EFTPOS, smart cards, databases, data warehouse, video conferencing, Internet, Extranet banking, and network systems.

Information technology development stages, information technologies, and technology applications of the Siam Commercial Bank PCL are summarised in Tables 6.4-6.6. For example, the characteristic of information and communication technology at present (stage 4) highlights database management and tele-banking or tele-communication. The main purposes of technology development are to enhance better customer relationships and managing risk by using technologies such as Internet banking, call centre, smart cards and a data warehouse.

Table 6. 4. SCB Information Technology Development Stages

	Stage 1. (1976-1982)	Stage 2. (1983-1989)	Stage 3. (1990-1996)	Stage 4. (Future)
Characteristics	- On-line Retail Banking - Inter-branch	- Electronic Banking - N/W with Customers - Wholesales Banking	- Transition Period (to 3-rd Generation) - Integrated On-line Systems - MIS/ Customer Information	- Database Marketing - Tele - Marketing - etc.
Main Purposes	- Efficiency - Volume Handling - Control	- Customer Services - IT Leadership	- Replace Legacy System - Support Re-engineering - Be ready for Liberalisation	- Customer Relationship - Segment-of-one - Risk Management - Etc.
Applications	- Deposits (SAFE = The System for Advanced Financial Environment)	- Retail Banking - Wholesales Banking - Operations - MIS	- Replace Legacy Systems - New Systems	- Internet Banking - Call Centre - Electronic Purse - Self-service Kiosk - Data Warehouse
Technologies	- One Main Data Centre	- One Main Data Centre - Two Regional Centres	- Two Main Data Centres	- Smart Card - ATM Network - Parallel Processor - N/W Centric Comp. - Data Mining

Source: (Jirapinyo, 1996)

Table 6. 5. The Siam Commercial Bank's Technologies

	Stage 1. (1976-1982)	Stage 2. (1983-1989)	Stage 3. (1990-1996)	Stage 4. (Future)
Technologies	- One Main Data Centre	- One Main Data Centre - Two Regional Centres	- Two Main Data Centres	- Smart Card - ATM Network - Parallel Processor - N/W Centric Comp. - Data Mining
Data Centre	One Main Data Centre	One Main Data Centre Two Regional Centres	Two Main Data Centres	
CPU	- SINGER S/10 - IBM's 4331, 4341	IBM's 4381, S/36, 3083, IBM's 3090/150, 3090/180, SERIES/I	IBM's 9021/500, 9021/660, HDS's GX 8112	
O/S	DOS/VSE, CICS/VSE	MVS/SP, MVS/XA	MVS/ESA, CICS/ESA	
D/B	VSAM	D/L 1	DB2	
Storage Dev.			820 GB	
N/W	Leased Line	Submarine Cable	Satellite	
Protocol	SNA	BSC	X.25, TCP/IP	
Peripherals		Laser Printer	Robotic Tape Drive	
Terminals Penetration		# 1,250	# 5,500 (2.2 Staff/term.)	
Branch Terminals - Server-Pentium - Client-Pentium			90 MHz, 16 MB, 4 GB, O/S2 75 MHz, 8 MB, 540 MB, O/S2	
Investment			USD 30.7 Millions (Ratio to expense = 9%)	

Source: (Jirapinyo, 1996)

Table 6. 6. The Siam Commercial Bank's IT Applications

Stage 1. (1976-1982)	Stage 2. (1983-1989)	Stage 3. (1990-1996)	Stage 4. (Future)
- Deposits (SAFE)	<p>Retail Banking</p> <ul style="list-style-type: none"> - Automated Teller Machine - Home/ Office Banking - SCB Cash Management - Tele-Banking - Point of Sales (EFTPOS) - Credit Card - Loan Services (CIS Credit) <p>Wholesales Banking</p> <ul style="list-style-type: none"> - Trade Finance (FRC) - SWIFT (MERVA) <p>Operations</p> <ul style="list-style-type: none"> - Cheque Clearing - G/L (FIS) - Payroll / Salary Payment (ATS) <p>MIS</p> <ul style="list-style-type: none"> - CIF/ VS (D/L 1) - Human Resources (Host-PIS) 	<p>Replace Legacy Systems</p> <ul style="list-style-type: none"> - Deposits (RB2020-Customer Based) - Loans - Automated Teller Machine (BASE24) - Point of Sales (BASE24) - Trade Finance (FITAS) - Credit card (FBS) - Electronic Clearing System (ECS) - Human Resources (Client/ Server) - Customer Information System (DB2) <p>New Systems</p> <ul style="list-style-type: none"> - Offshore Banking : IBF (IBIS) - Dealing (TRANSAC) - Loan Origination/ - Customer Profitability (CBS/CFS) - Capital Market (Custodian, Investor Corner) - Loan Monitoring and Collection (CLS) - Electronic Funds Transfer (BATHNET, ECS) <p>Operations</p> <ul style="list-style-type: none"> - Electronic Data Interchange (EDI) - Workflow Automation and Internet Communications (Internet/ Intranet, Lotus Notes, Video Conferencing) <p>MIS</p> <ul style="list-style-type: none"> - Management Information System (MIS) - Black List System (BKL) 	<ul style="list-style-type: none"> - Internet Banking - Call Centre - Electronic Purse - Self-service Kiosk - Data Warehouse

Source: (Jirapinyo, 1996)

6.6.5 Obstacles in Using and Learning Technology

The Siam Commercial Bank PCL has perceived the importance of information technology as a characteristic of banking in the future. The bank not only spends substantial investment in information technology but also emphasises the importance of the learning organisation concept adopted from Peter Senge (1989). This concept was developed in 1995 by the former president of the bank. The main purpose in applying this concept is to promote the learning environment and teamwork among staff. For example, training has shifted from ordinary personnel training to “learning support” by analysing the need for learning of staff and facilitating their acquisition of knowledge in accordance with their functions and promotion potential. This will lead to increasing skilled personnel, developing competitive advantage, and assuring customers’ satisfaction and benefits (“SCB sees new concept,” 1996; The Siam Commercial Bank PCL, 1997b).

Despite the promotion of a learning organisation, information from the “*Technology and bank staff*” questionnaire (Appendix 5.4) distributed to the bank staff at the main office and branches in Bangkok and other provinces in Thailand still revealed obstacles in using and learning technology (see Table 6.7).

Table 6. 7. Obstacles in Using and Learning Technology

Obstacles	Main office (Per cent)	Branch offices (Per cent)	Total (Per cent)
Insufficient training	75.86	76.37	75.52
Lack of understanding of new technology	51.23	62.09	55.93
Limitation of time in learning new technology because of routine work	53.69	58.24	55.41
Insufficient support from IT people	34.98	35.16	34.79
Technology changes too fast	27.09	27.47	27.06
Technology does not suit requirements	13.30	13.74	13.40

Source: (The Siam Commercial Bank's staff, 1998e)

The most important obstacle in using and learning technology was insufficient training from the bank (75.52% of respondents). Half of the respondents revealed

that lack of understanding and limitation of time due to routine workloads prevent learning and use of technologies. Thirty-four per cent of the respondents agreed that insufficient support from IT people may hinder technology usage. However, rapid changes in technological evolution and inappropriate matches between technologies and users' requirements were not the main causes impeding them from learning and using technology (27.06% and 13.40%).

The following are additional impediments in learning and using technologies (The Siam Commercial Bank's staff, 1998e):

1. Lacking of sufficient and timely information to keep up with technology or software applications which are changing rapidly;
2. Information from existing technology is not updated;
3. Lacking a learning system among peer groups, such as learning how to use routine software applications;
4. Lacking facilities and technological equipment (e.g. personal computers) to aid learning.
5. Technology sometimes increases the workload rather than decreasing the workload;
6. Superiors do not understand computer technology;
7. Work performance relates to fieldwork, which requires solving ad hoc problems rather than using computers to aid decisions.

The data in Table 6.7 and Figure 6.1 also point out that the obstacles to learning and using technology are more critical for staff in branches than those at the main office.

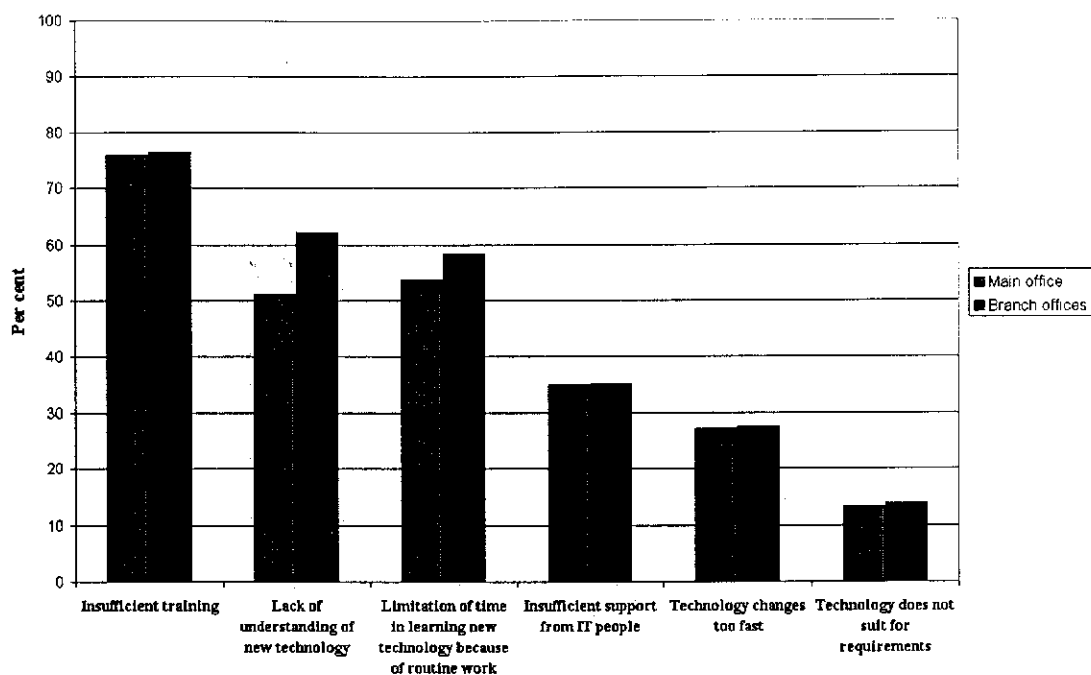


Figure 6. 1. Comparison of Obstacles in Learning and Using Technology between Staff at the Main office and those at the Branches

6.6.6 Supportive Factors in Learning and Using Technology

Most of the respondents agreed that the most important supportive factor that aids their learning and use of technologies was training from the bank (84.54% of respondents). Other factors were technological assistance (64.95%), user-friendly technologies (60.82%), involvement with IT people whenever the bank brings in new technology (56.89%), and support from high executive managers (54.64%). However, they disagreed that providing additional benefits as an incentive could enhance technology usage (15.21%) (See Table 6.8).

Table 6. 8. Supportive Factors in Learning and Using Technology

Supportive factors in learning and using technology	Main office (Per cent)	Branch offices (Per cent)	Total (Per cent)
Training from the bank	82.76	87.91	84.54
Support from high executive managers	51.72	58.79	54.64
Involvement with IT people when the bank brings new technologies to use	58.13	56.59	56.96
Technological assistance from IT people when problems occur	70.44	59.89	64.95
User friendly technologies	65.02	57.14	60.82
Provide additional benefits as an incentive in learning and using technology	12.32	18.68	15.21

Source: (The Siam Commercial Bank's staff, 1998e)

Additional factors that may support technological learning and usage were recommended:

1. Providing user manuals about how to use technologies to every department because of insufficient time to attend every training session;
2. Providing an opportunity to have or use technology;
3. Providing information and knowledge about available technologies via various sources of media (e.g. Intranet);
4. Implementing only technology that enhances or facilitates work performances, responds to real requirements of staff, decreases routine work and solves current problems or obstacles;
5. Using technology frequently;
6. Having exams to evaluate understanding;
7. Following up all implemented technologies because sometimes implemented technologies do not work well (e.g. e-mail cannot be sent);

8. Surveying problems that branch offices have confronted and solve them;
9. Improving infrastructures because slow processing will lead to boredom and high costs;
10. Promoting self-learning;
11. Updating information regularly.

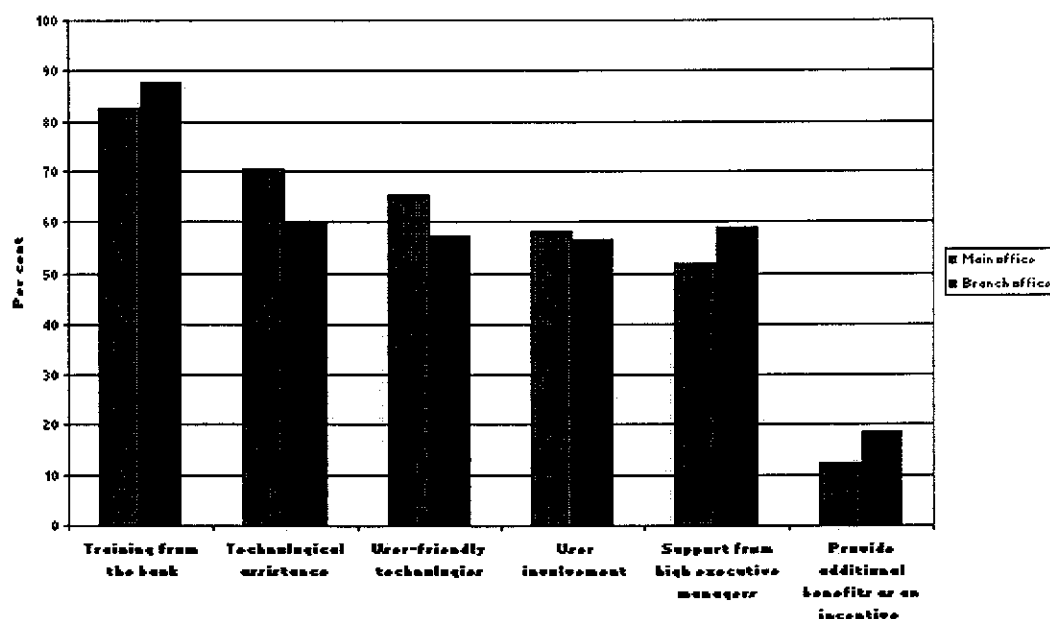


Figure 6. 2. Comparison of Supportive Factors in Learning and Using Technology between Staff from Main Office and those from Branches

As can be seen from Figure 6.2, perception towards supportive factors that mitigate obstacles in learning and using technologies differed slightly between staff at the main office and those at branches. People at the main office felt that technological assistance, user-friendly technologies and user involvement would support the process of learning and use of technologies, whereas those at the branches perceived that training and support from executive management were the two most important factors. Training and support from high executive managers were relatively unimportant for the main office staff because the actual levels of these two factors might be high due to proximity.

6.7 Summary

This chapter presents information relating to the case study, the Siam Commercial Bank PCL. The economic situation of Thailand was discussed to present the overall picture because economic indicators are an important external factor that may have positive or negative impacts on an organisation. The severe economic crisis in Thailand influences the banking industry in Thailand and the case study. Some data derived at the beginning of the research in 1996 were totally different from those of 1999. Updating data and keeping up with the situation is an important part of this chapter providing an opportunity to observe changing situations and conditions over time.

The section on the banking industry in Thailand provides an overview of the Thai commercial banks and their dynamic development in terms of numbers of the banks, profits and profile.

The information on the Siam Commercial Bank PCL provided the answers for the first research question, “*what is the current status regarding information and communication technologies (ICT) of the bank*”.

- The bank invests in information and communication technologies to fulfil its vision of being “*the best managed bank with sustainable excellent performance*”. Technologies are used for competitive differentiation, facilitating transaction processing, supporting decision-making, and improving quality and efficiency of work processes.
- Currently, the bank employs various types of technologies (e.g. ATMs, EFTPOS, databases, data warehouse, smart cards, video conferencing, an Internet system, and Extranet banking).
- The bank still has to confront critical problems relating to technologies such as rapid obsolescence of adopted technologies, selection of inappropriate technologies, low productive usage of those adopted, lack of capable employees, and high costs of technologies, coupled with unexpected performance and low acceptance from staff and customers in some cases.

It can be concluded that the Siam Commercial bank PCL has a high status regarding information and communication technology due to the following reasons. First, the bank has a transparent vision, mission and objective towards technological issues. Second, technology development has been planned and integrated with business strategies. Third, the decision-making process for technology adoption has been conducted based on both users' requirement and innovative interest. Fourth, the bank has substantially invested in technology, both applications and infrastructure (e.g. many types of technology, and high technological expenditure), and has supported the development of a sound technological environment (e.g. learning organisation concept, Intranet, video conferencing, and full support from high executives). Fifth, the technology group of the bank has been set up to be responsible directly for technological issues and research for new appropriate technology. Consequently, the bank is now well known as one of the innovative leaders of the banking industry in Thailand.

In the subsequent chapters, the results regarding hindering and facilitating new technology adoption and diffusion processes will be used in model analyses of technology adoption and diffusion in order to propose ways to adopt and diffuse technology more effectively.

CHAPTER 7

TECHNOLOGY ADOPTION AT SCB USING MULTIPLE CRITERIA DECISION-MAKING (MCDM)

7.1 Introduction

Generally speaking, human beings make decisions based on their intuitive judgement (i.e. a judgement is reached by an informal and unstructured mode of reasoning, without the use of analytic methods or deliberate calculation) (Kahneman & Tversky, 1982). However, when an organisational environment becomes complex, more competitive, and subject to fluctuations, these subjective decision-making techniques, contingent upon experience and intuition, may not be completely satisfactory for the organisations. As a consequence, MCDM could be considered a more effective method.

Multiple criteria decision-making (MCDM) is an approach or technique designed to help decision-makers select choices in accordance with their values under conditions characterised by multiple, non-commensurate, and conflicting criteria. It helps decision-makers to structure and understand problems and a problematic situation, and thus make appropriate judgements (Bogetoft & Pruzan, 1991).

Based on this definition, MCDM is able to deal with problems in the real world, because this method provides ways to select a solution from many alternatives based on multiple conflicting criteria and under determined constraints. It is considered a particularly suitable tool to evaluate technology investment, in which its criteria include both quantitative (financial and non-financial), and non-quantitative factors (Carter, 1992). In fact, many software applications have been developed in order to achieve satisfactory solutions more quickly and easily than using other “hit and miss” methods.

This chapter discusses the process of using MCDM to facilitate decision-makers in selecting the best technology by prioritising technological alternatives in the operation of the Siam Commercial Bank PCL. The model development will provide the answer for the second research question, “*what is a requisite group model of ICT adoption?*” MCDM is also employed for the purpose of narrowing the scope of the research. Instead of elaborating each technology, only preferred technologies are scrutinised and elaborated by the system dynamics model to capture the inter-relationships among variables and their dynamic aspects.

The contents of the chapter are organised into three parts. The first part presents decision-making based on intuitive judgement. The second part highlights decision-making based on MCDM analyses including model building and model analysis using real scales and local scales. Analytical results based on MCDM revealed that Extranet banking was the most preferable technology to fulfil bank objectives whereas intuitive judgements of the same respondents identified a data warehouse as the preferred technology. The third part, therefore, discusses the reasons for this divergence and offers some recommendations to bridge the gap.

7.2 Method of Data Collection

This study employed questionnaires and interviews as methods of data collection. Initially, a draft of questionnaires and interview questions were prepared based on reviews of literature with respect to decision-making and technology adoption. Then, key executives responsible for technologies at the Siam Commercial Bank PCL were interviewed during the preliminary visit to the bank in 1996. The interviews aimed at obtaining fundamental information regarding the mission, objectives, available or

promising technologies, as well as criteria for decision-making. The bank deploys many progressive technologies such as smart cards, a data warehouse, video-conferencing, Internet/Extranet banking and EFTPOS (Electronic Fund Transfer at Point of Sales) to fulfil its (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996).

After the preliminary visit, the questionnaire "*Banking Technologies*" (Appendix 5.1) was revised based on the information from the bank and, then distributed to 20 bank executive staff. The second questionnaire "*Evaluation of Banking Technologies*" (Appendix 5.2) was subsequently sent to the same respondents five months later in order to obtain information for technological evaluation. The details of collecting primary data are presented in Table 7.1.

Table 7. 1. Data Collection for Technology Adoption Model

Topic	No. of respondents	Method of data collection	Name of questionnaire/ interview	Purposes
1. Information and Communication Technologies (ICT)	20	Questionnaire & Interview	" <i>Banking Technologies</i> "	Fundamental knowledge (problems, technological alternatives, criteria)
2. Multiple criteria decision-making (MCDM)	20	Questionnaire	" <i>Evaluation of Banking Technologies</i> "	MCDM analyses

1. The "*Banking Technologies*" questionnaire was developed aimed at obtaining the information on the bank's mission and objectives with regard to technological issues, technological alternatives, and criteria used for technology evaluation. The respondents were the executives and middle managers responsible for technological issues at the bank.
2. The "*Evaluation of Banking Technologies*" questionnaire was used to identify the levels of relative preference among technological alternatives based on specified criteria in order to evaluate technological choices.

7.3 Decision-Making Based on Intuitive Judgement

The results from the “*Banking Technologies*” questionnaire revealed that the Siam Commercial Bank PCL has the mission of being “*the best managed bank with sustainable excellent performance*”. In this questionnaire, the respondents were asked to identify the level of importance for each technology that helps the bank to fulfil its objectives based on their own intuitive perception. The level of importance ranged between 1 and 7. The highest weight (7) indicated the most important technological alternative whereas the lowest weight (1) indicated the least importance. All the weights for each technology from the 20 respondents were averaged as the group weight. The results presented in Table 7.2 and Figure 7.1 revealed that the bank staff felt that preferable technologies were a data warehouse (6.47) and Extranet banking (5.79) (The Siam Commercial Bank's staff, 1998a).

Table 7. 2. Level of Importance of Technologies in Fulfilling the Bank’s Mission.

Technologies	Level of importance (Average weight)
Smart cards	4.26
Data warehouse	6.47
Video conferencing	3.79
EFTPOS	4.17
Extranet banking	5.79

Source: Data Derived from “*Banking Technologies*” Questionnaire, January 1998

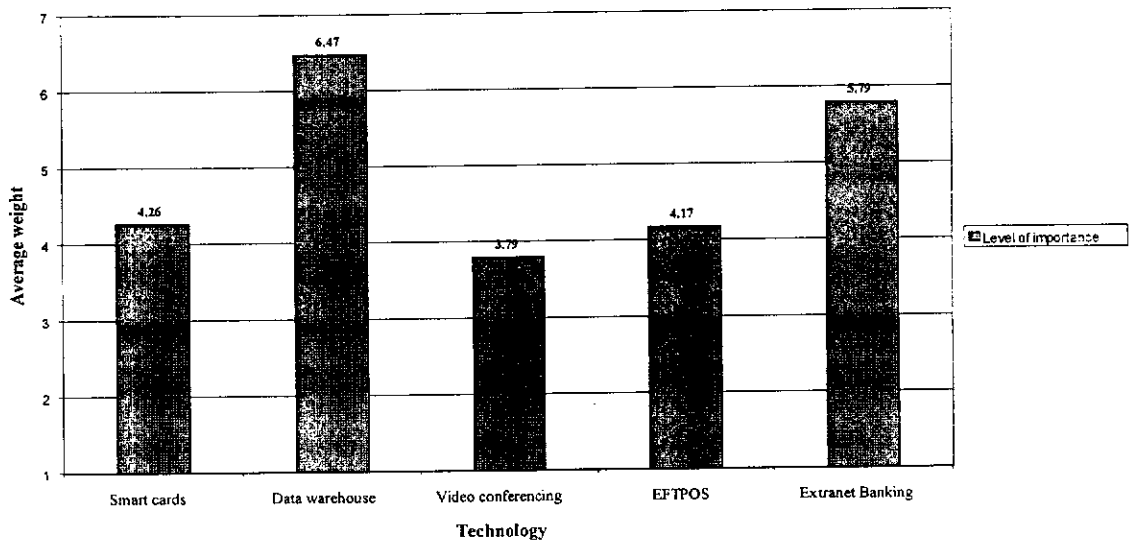


Figure 7. 1. Level of Importance of Technologies in Fulfilling the Bank's Mission according to Intuitive Decisions

Source: Data Derived from "Banking Technologies" Questionnaire, January 1998

7.4 Decision-Making Based on MCDM

Building the MCDM model required three fundamental stages, structuring the problem, eliciting information and values, and evaluation (Belton, 1995).

7.4.1 Structuring a Problem

At this stage, decision-makers initially set an objective and/or problem that they endeavoured to achieve and/or solve. Then, all alternatives that could be potential solutions were proposed for evaluation under a set of certain criteria.

The mission of the bank and all the technological alternatives that would fulfil its mission were similar to those previously identified for intuitive judgement.

The technological alternatives have been evaluated under the same criteria. The criteria used for developing the MCDM model of technology adoption derived from the

previous research in the field of technology adoption, which was previously explained in Chapter 4. The following is a brief explanation about the variables that enhance the rate of technology adoption as obtained from the research.

- **Relative advantages.** Perceived relative advantage is the key factor that drives an organisation to adopt new technology. Relative advantages are benefits from technology that may be different based on its properties. In general, expected advantages from technology use include increased sales, extended market share, increased competitive advantages, improved efficiency, more accurate and timely information, better image, reduced costs, and effective decision-making.(Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989; Rogers, 1983; Thompson, 1987; Waema & Walsham, 1990; Wynekoop, Senn, & Conger, 1992).
- **Technological features.** Technological features impact directly on new technology adoption. Technological criteria consist of costs, complexity, reliability, risk, compatibility with existing systems, trialability, observability, and standardisation (Barras, 1994; Kwon & Zmud, 1987; Sharif, 1994a).
- **Organisational issues.** Organisational environments should be suitable for accommodating new technology in order to exploit advantages from technology use. Organisational issues comprise sufficient facilities, executive support, staff acceptance, the extent of staff communication, economic externalities, and experience in technology (Bowonder, Miyake, & Linstone, 1994; Kwon & Zmud, 1987; Manross & Rice, 1986; Sharif, 1994a).
- **Customer behaviour.** Customer acceptance and satisfaction is the main concern for any technology that is used for commercial purposes or serving customers (Herbig & Day, 1992; Jenkins & McKenzie, 1997; P. Jirapinyo, personal communication, December 19, 1996).

- **Economic situations.** Economic situations directly influence the demand for technology adoption. For example, the Siam Commercial Bank highlights the economic environment as one of most important criteria for adopting new technologies (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996). Generally, during economic prosperity, many types of promising technologies are acquired and easily accepted. On the other hand, during recession, organisations are more careful to select only promising necessary technology, or even freeze technology policies (Saeed, 1990; Sharif, 1994b).

All variables were used as the potential criteria of technology adoption and subsequently customised based on the interview data during the preliminary visit to the bank in 1996 (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996). Only variables that interested the people in the bank were selected and used as technological criteria for the "*Banking Technologies*" questionnaire (see Appendix 5.1).

The main criteria consist of 1) relative advantages, 2) technology features, 3) organisational environments, 4) customer behaviours and 5) economic situation of the nations. Each main criterion consists of many sub-criteria. For example, relative advantages were further elaborated as increased sales, increased market share, more accurate and timely information and improved decision-making, etc. The entire criteria are illustrated in Figure 7.2.

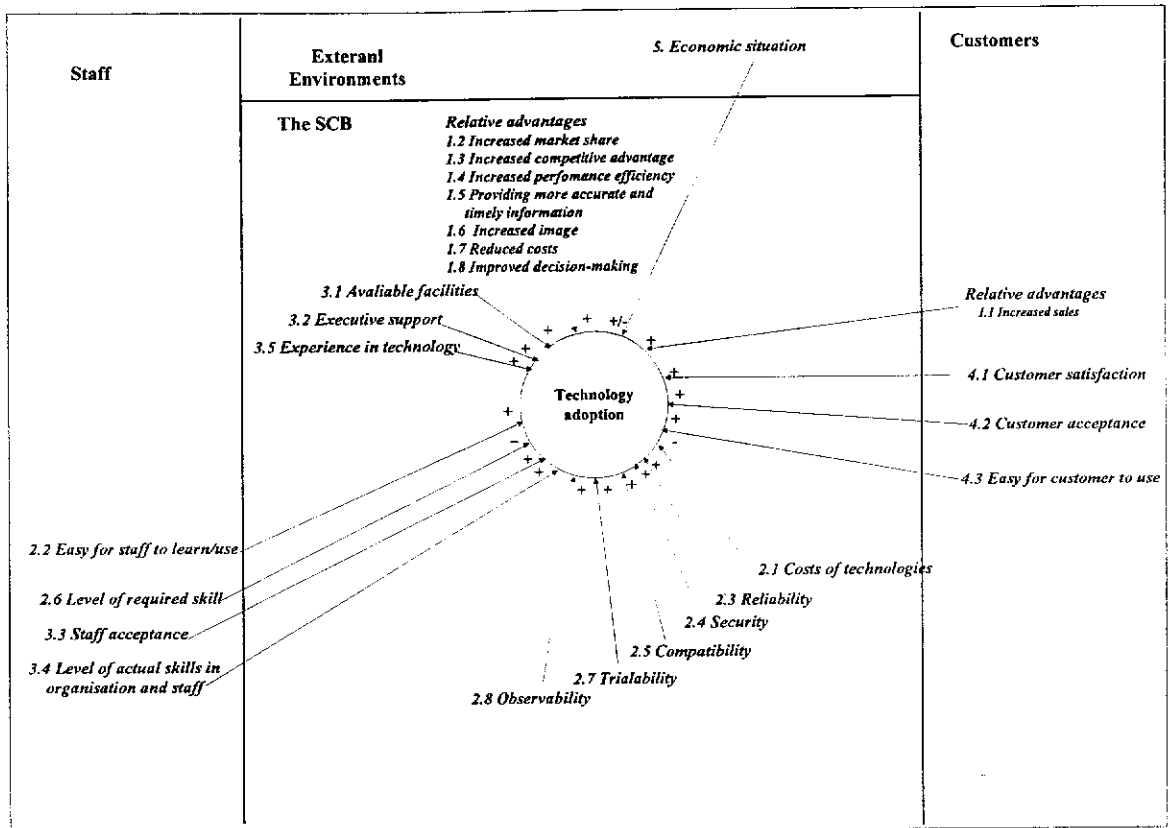


Figure 7. 2. Criteria for Technology Adoption

Source: Data Derived from "Banking Technologies" Questionnaire, January 1998

According to Figure 7.2, the variables that affect the rate of technology adoption may come from four system boundaries: the organisation itself (e.g. the Siam Commercial Bank); the external environment; staff; and customers. First, an organisation adopts technology because of an anticipation for increased relative advantages from that particular technology (e.g. increased market share, more accurate and timely information, and increased image). Soundness of technological features (e.g. reliability, security and compatibility) impacts technology adoption positively. Furthermore, readiness of organisational environments (e.g. available facilities, management support, and experience in technology) increases the rate of technology adoption. Second, apart from organisational concerns, variables relating to staff such as ease of use and learning, the level of required and actual skill, and staff acceptance have to be taken into consideration. Third, if technology is employed to serve customers directly, factors such as customer satisfaction/acceptance and ease of use

impact on the rate of technology adoption. Fourth, variables such as the economic situation of the country, which comes from the external environment, can impact positively or negatively on technology adoption. The details of each variable and its references are presented in Appendix 7.1.

According to the MCDM analysis using the V.I.S.A. software, all criteria are structured in a hierarchy. Therefore, this study divided criteria into two levels; high and low level criteria. High level criteria involved the main issues that are taken into account whenever the bank adopts new technology. On the other hand, low level criteria included specific issues detailed from the high level main criteria. All the criteria (high and low level) are illustrated in Figure 7.3.

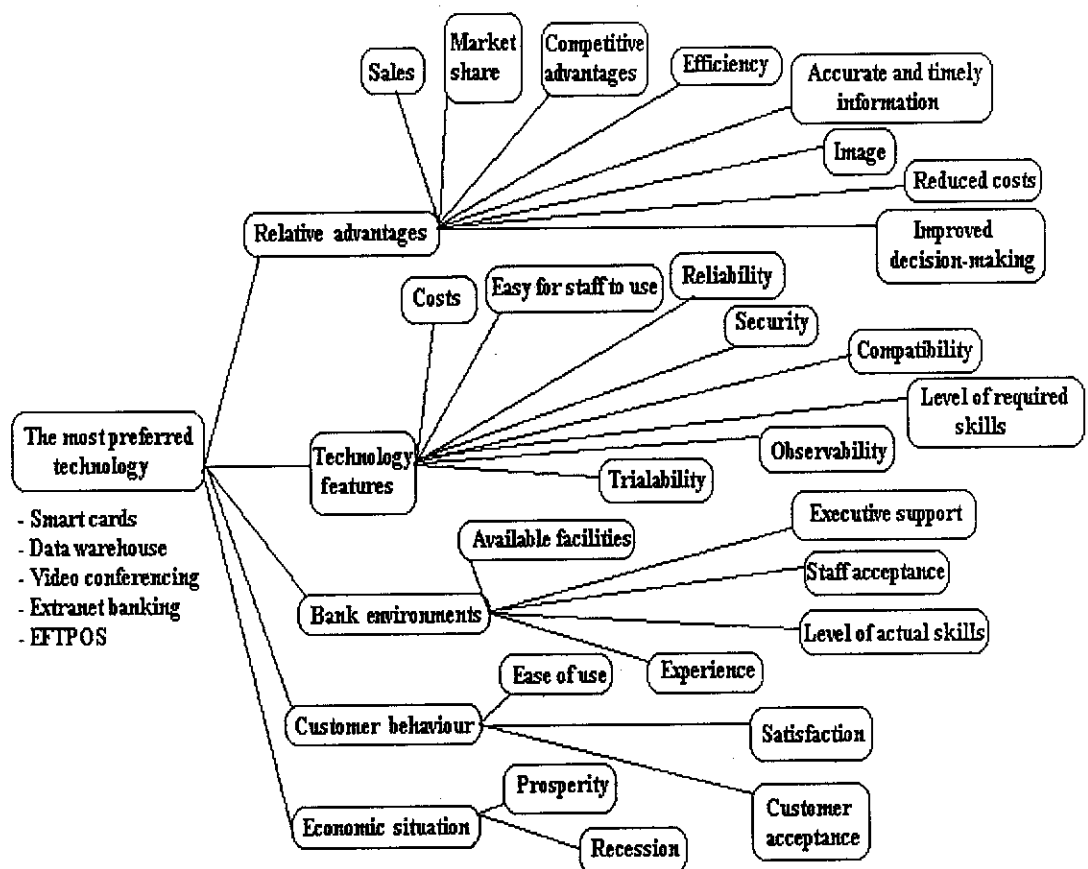


Figure 7.3. Criteria Hierarchy for Technology Adoption

Source: Data Derived from “Banking Technologies” Questionnaire: Using V.I.S.A. Software

7.4.2 Eliciting Information and Values

At this stage the “relative importance” of the specified criteria (i.e. weighting) and the performance of alternatives against the specified criteria (i.e. scoring) were determined.

7.4.2.1 Weighting

Initially, the bank respondents gave weights ranging from 1 to 7 on both the high and low level criteria in order to indicate the level of importance of each criterion. All the weights were averaged as a group weight. The level of importance of each high and low level criterion is indicated in Table 7.3. It can be observed that all the high level criteria are important for the bank staff to take into consideration whenever new technologies are adopted.

It is noted that, ideally the weights should have been the swing weights (Belton, 1995). But Quaddus et al. (1992) have observed that, in practice, it is extremely difficult to obtain the swing weights. Therefore, the importance weights as obtained from the “*Banking Technologies*” Questionnaire were used in this study.

Table 7. 3. Level of Importance Criteria in Selecting Technologies

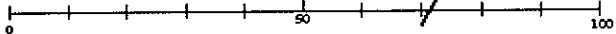
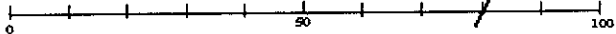
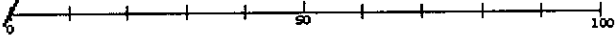
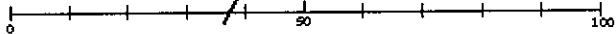
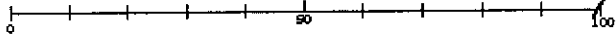
High level criteria	Level of Importance (Average Weight- 1 low and 7 high)	Low level criteria	Level of Importance (Average Weight- 1 low and 7 high)
Relative advantages	5.79	1.1 Increased sales	5.74
		1.2 Increased market share	6.21
		1.3 Increased competitive advantage	6.42
		1.4 Increased performance efficiency	6.21
		1.5 Providing more accurate and timely information	6.32
		1.6 Increased image	5.95
		1.7 Reduced costs (e.g. labour costs, operational costs, paper work, rework)	5.37
		1.8 Improved decision-making	5.95
Features of technology	5.63	2.1 Costs of technologies	5.00
		2.2 Easy for staff to learn/use	5.11
		2.3 Reliability (fewer breakdown)	5.84
		2.4 Security (less openness to abuse, fraud)	5.74
		2.5 Compatibility with existing systems	5.21
		2.6 Level of required skills for staff to use technology	4.53
		2.7 Trialability (ability to test it)	4.89
		2.8 Observability (ability to see if it works)	4.32
Bank environments	4.79	3.1 Available facilities (fit between existing facilities and new technology)	5.00
		3.2 Executive support	5.42
		3.3 Staff acceptance	5.05
		3.4 Level of actual skills in organisation and staff	4.47
		3.5 Experience in technology	4.84
Customer behaviour	5.47	4.1 Customer satisfaction	6.05
		4.2 Customer acceptance	6.00
		4.3 Easy for customers to use	6.21
Economic situation of the country	4.95	5. Economic prosperity, recession	5.22

Source: Data Derived from "Banking Technologies" Questionnaire, January 1998

7.4.2.2 Scoring

After the weights of both high and low level criteria had been determined, all the alternatives were scored against the specified criteria by using the “*Evaluation of Banking Technologies*” questionnaire (Appendix 5.2). The scores were entered on a 0 to 100 scale, where a higher value represented a more preferred outcome. For example, Extranet banking as the technology which does best on a particular criterion (e.g. increased sales) was assigned a score of 100. On the other hand, video conferencing, which does least well, was assigned a score of 0. All other alternatives were given intermediate scores, which reflect their performance relative to these two end points (Table 7.4).

Table 7. 4. Example of Criteria Scoring

Criteria	Scores	
	Preferred outcomes	More preferred outcomes
Increased sales	Smart cards	
	Data warehouse	
	Video conferencing	
	ETIPOS	
	Extranet banking	

Source: “*Evaluation of Banking Technologies*” Questionnaire, January 1998

7.4.3 Evaluation and Sensitivity Analysis

This stage aimed to synthesise information and values, evaluate them, and then investigate the impact of changing priorities and values.

Although, the “*Evaluation of Banking Technologies*” questionnaire explained how to score technological alternatives based on the concept of local scale - the best equals 100 whereas the worst equals 0 - quite a few respondents scored technological alternatives based on real scales. This may have happened because the concept of local scale and respondents’ perception contradict each other. They may have felt

that if two technological alternatives provide proximate outcomes, it is incorrect to put 0 for one alternative and 100 for the other. Therefore, they were inclined to rate scores based on the numbers that they perceived as a real scale for each technology. As a consequence, the technological evaluations were undertaken using both real scales provided by each respondent and local ones transformed from the real scales.

7.4.3.1 MCDM Analysis Based on Real Scale

The real scales provided by the respondents were averaged to find the group scores. Then, the V.I.S.A. software (Belton, 1995) was used to determine the final weighted scores. The results of the technological evaluation are indicated in Figure 7.4.

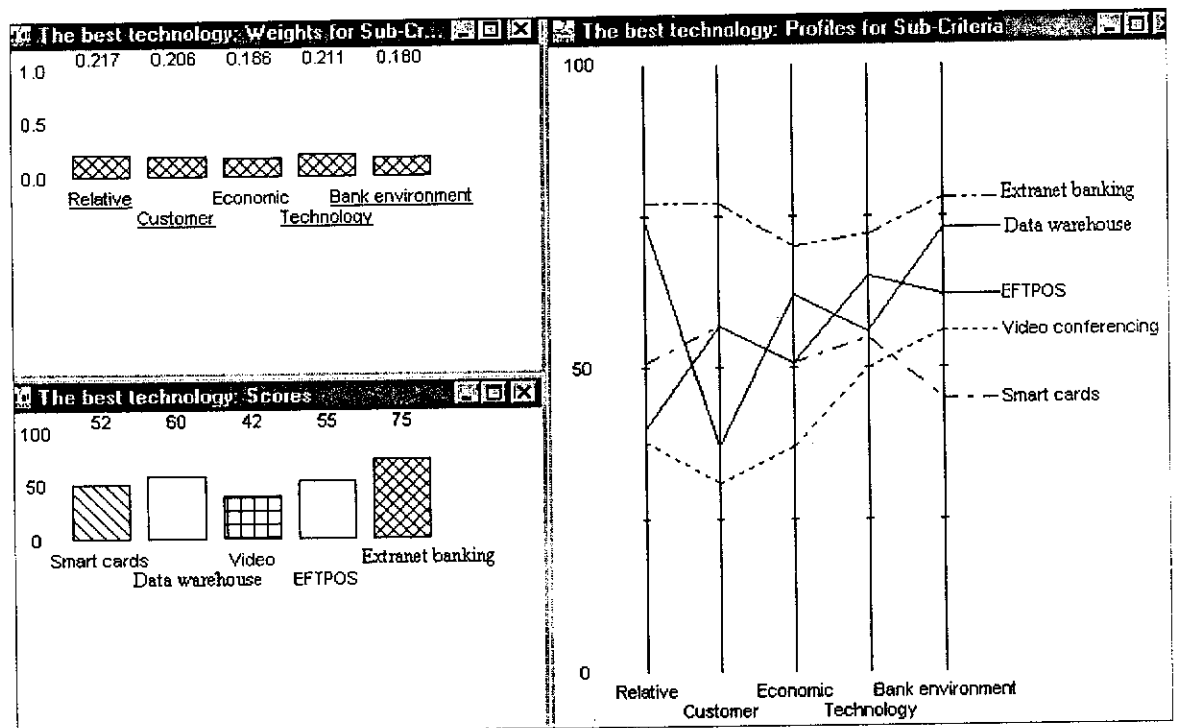


Figure 7. 4. Evaluation of Technological Alternatives Based on Real Scales

Source: Data Derived from "Evaluation of Banking Technologies" Questionnaire, January 1998 and Analysed using the V.I.S.A. Software

According to Figure 7.4, the best technology is Extranet banking with a score of 75 and the second choice is a data warehouse with a score of 60. Extranet banking was judged superior to a data warehouse in every criterion (e.g. relative advantages, customer behaviour, economic, features of technology and bank environments).

7.4.3.2 MCDM Analysis Based on Local Scale

The real scales were adjusted to local scales by setting the highest score at 100 and the lowest one at zero. The other scores were calculated using the formula below, which is adapted from the formula of Buchanan (1997).

$$\text{Local score} = \frac{(X - L) \times 100}{(U - L)}$$

Where X = Present Score

L = Lower Score

U = Upper Score

For example, with respect to the criterion of increased sales, Extranet banking has the highest real scale of 87 whereas video conferencing has the lowest score of 11. The real score of a data warehouse is 58 and this was modified to the local score using the formula below.

$$\text{The local scale of a data warehouse} = \frac{(X - L) \times 100}{(U - L)}$$

Where X = Present Score = 58

L = Lower Score = 11

U = Upper Score = 87

$$= \frac{58 - 11}{87 - 11} \times 100$$

$$= (47/76) \times 100$$

$$= 62$$

Using the above formula the real scale of a data warehouse of 58 is converted to the local scale of 62. The other real scales of each technology were similarly converted using the same formula as indicated in the example and are shown in Table 7.5.

Table 7. 5. Example of Converting Real Scales to Local Scales

Criterion:	Smart cards	Data warehouse	Video conferencing	EFTPOS	Extranet banking
Increased sales					
Real scale	56	58	11	47	87
Local scale	59	62	0	47	100

Source: Data Derived from “*Evaluation of Banking Technologies*” Questionnaire, January 1998

The obtained local scales were then evaluated using V.I.S.A. software. The final results are illustrated in Figure 7.5. According to Figure 7.5, the best technology is Extranet banking with the score of 90 and the second choice is a data warehouse with the score of 57. The graph on the right hand side indicates that Extranet banking was also superior to a data warehouse on every criterion.

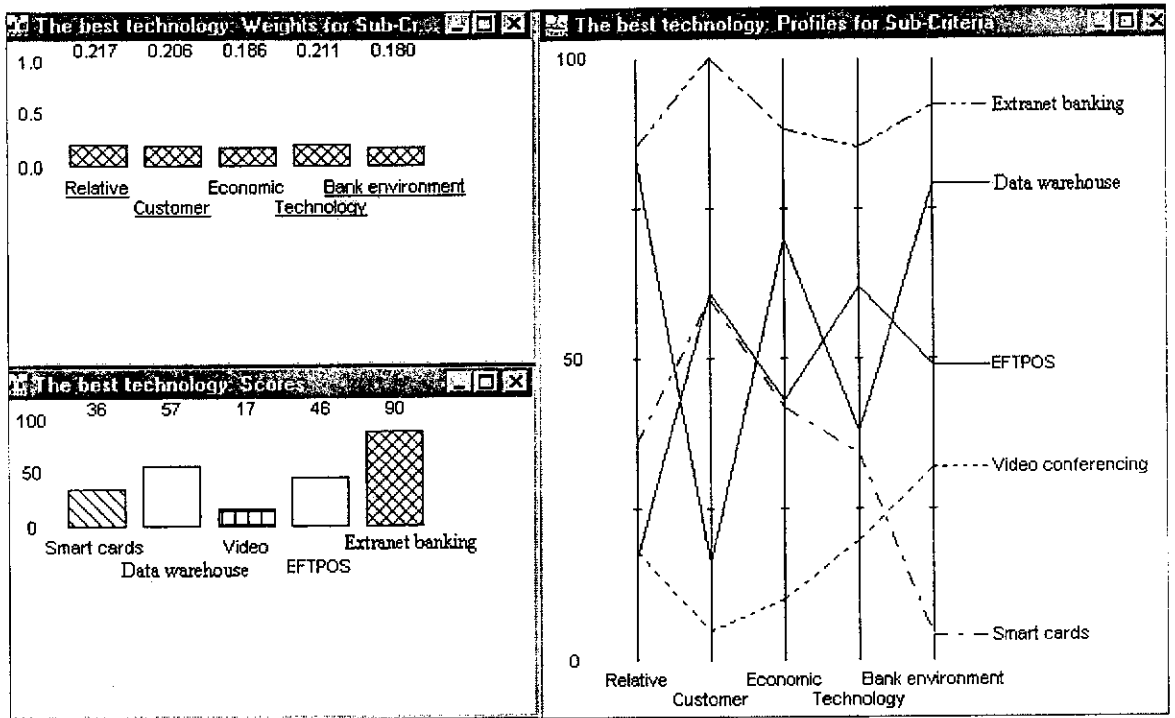


Figure 7. 5. Evaluation of Technological Alternatives Based on Local Scales

Source: Data Derived from "Evaluation of Banking Technologies" Questionnaire, January 1998 and Analysed using the V.I.S.A. Software

7.5 Intuition versus MCDM Analysis

The comparison of technological rank based on the two methods, intuitive judgement and MCDM model analysis- using both real and local scales- is presented in Table 7.6.

Table 7. 6. Technology Rank

Technologies	Technology Rank		
	Intuition	MCDM (Real scale)	MCDM (Local scale)
Smart cards	3	4	4
Data warehousing	1	2	2
Video conferencing	5	5	5
EFTPOS	4	3	3
Extranet banking	2	1	1

Source: Data Derived from “*Banking Technologies*” and “*Evaluation of Banking Technologies*” Questionnaire, January 1998

According to Table 7.6, ranking technological alternatives based on the MCDM analysis either using real or local scales revealed that Extranet banking was the best technology that can fulfil the bank’s mission and a data warehouse was the second best alternative. Yet, the results differed greatly from intuitive perceptions of the respondents, almost all of whom considered that a data warehouse was superior to Extranet banking.

7.5.1 Result Discussion

The divergent results of technological evaluation using MCDM analysis and intuitive perception of the respondents may result from the following issues.

1. **Utilising available information or data.** According to Makridakis and Wheelwright (1989b), quantitative methods do not capture all information but only the data being used, whereas intuitive judgmental methods allow people to use inside information or knowledge with selective bias, inconsistency, and emotional (optimistic or pessimistic) information. When the respondents select the best technology based on their own thinking and experience, they may consider other criteria (e.g. personal or political considerations) far beyond the explicitly identified ones used for MCDM analysis.

2. **Conscious awareness.** Conscious awareness for intuition is low but it is high for rational analysis (Wagenaar, Keren, & Lichtenstein, 1997). In terms of intuition, a data warehouse gains more general approval than Extranet banking because it is intuitively believed that with this technology, the bank may achieve long run competitiveness. However, when they have to objectively analyse each technology based on each criterion they can perceive only implicit and potential advantages from a data warehouse whereas high costs and technological complexity are obvious. Respondents may also be aware that data warehouse projects in many organisations failed even before full implementation due to massive resource consumption without significant economic returns (Horrock, 1996; The Siam Commercial Bank's staff, 1998c). On the other hand, Extranet banking is a small project with completed implementation. Through it, the bank obtains customers and gains benefits from subscription fees, transfer fees and other advantages. Therefore, when comparing these two technologies based on objective analysis, Extranet banking becomes superior to a data warehouse.
3. **Criterion usage.** As previously mentioned in Chapter 2, a data warehouse (DW) is a central source of data, which is designed to be used as a collection of data in support of management's decision-making processes (Inmon & Hackathorn, 1994; O'Brien, 1996). On the other hand, Internet/Extranet banking is an electronic home-banking service that allows bank customers to conduct their business transactions with their banks through personal computers (Kivel & Rubin, 1996b).

Based on the above characteristics of the two technologies, it is evident that clients of a data warehouse are mainly bank staff whereas Extranet banking deals directly with bank customers. Therefore, if customer benefits (i.e. customer satisfaction, acceptance and ease of use) are taken into account, a data warehouse is inferior to Extranet banking. The lower scores of a data warehouse under this criterion result in lower scores for the whole evaluation. As can be seen in Figure 7.6, the more weight on customer behaviour, the more Extranet banking is superior to a data warehouse.

Therefore, it can be concluded that one of the shortcomings of MCDM analysis is to use a specific criterion to evaluate two different alternatives where one alternative towers above the other. If other criteria are used, it may affect the results of the whole evaluation.

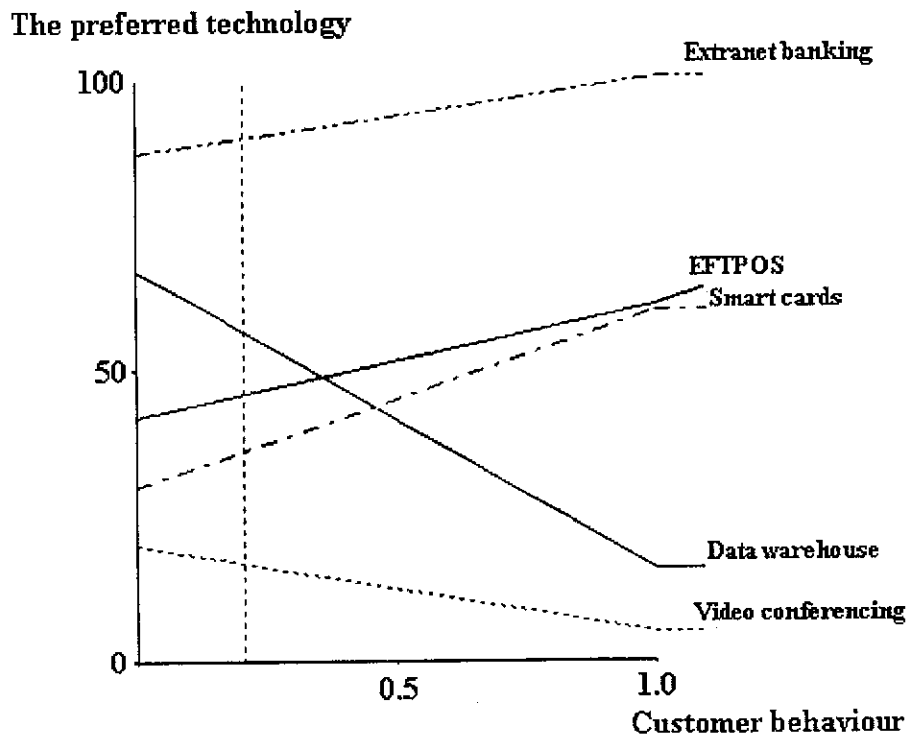


Figure 7. 6. Technological Evaluation Based on Customer Behaviour

Source: Data Derived from “*Evaluation of Banking Technologies*”
Questionnaire, January 1998 and Analysed using the V.I.S.A.
Software

4. **Surface and deep structure.** Most often decision-makers are presented with decision problems with surface structures (i.e. they contain a number of elements that are supposed to be irrelevant for a decision-making process) rather than deep structures (i.e. all information that could determine a decision is contained in a reduced representation) (Wagenaar et al., 1997). Within a short period of time people can easily perceive surface structures that comes to mind. However, when the problem is presented in a deep structure using hierarchical criteria, and if people have sufficient time to consider this by using certain criteria as a standard of measurement,

contradictions between the end results based on their initial perceptions and those with analytical thinking are common.

5. **Time Delay.** The two methods of decision-making were asynchronously undertaken due to the process of and obstacles in data collection. At first, the “*Banking Technologies*” questionnaire was sent to the bank staff to obtain information regarding general perceptions towards technologies and criteria weighting. This questionnaire was short to make it easy to complete in the hope of a high response rate. Unfortunately, the response rate was low and returns took a longer time than expected. The follow-up of the first questionnaire and the second questionnaire, “*Evaluation of Banking Technologies*” regarding technological evaluation (i.e. scoring) were sent five months after the distribution of the first ones. Since technology changes very quickly, the perceptions of people at different times may not be the same. For example in the first MCDM analysis using the complete data of 7 respondents, the results revealed that a data warehouse was the best alternative (Intrapairot & Quaddus, 1998). The analysis was carried out again six months later with the data from 20 respondents. At this point, Extranet banking turned out to be the best option (Intrapairot & Quaddus, 1999b).

7.6 Requisite Group Model of ICT Adoption: Research Question 2

This chapter illustrated the process required to develop the requisite model of ICT adoption to provide an answer for the second research question, “*what is a requisite group model of ICT adoption?*” The model development consisted of three stages: structuring a problem; eliciting information and values; and evaluation. The structuring a problem stage identified that the bank tries to achieve the mission of being the best managed bank with sustainable excellent performance. To achieve this, the bank employs various technologies. The eliciting information stage identified the potential technological alternatives including smart cards; a data warehouse; video-conferencing; Extranet banking; and EFTPOS. These alternatives

were evaluated based on the high and low level criteria such as relative advantages, features of technology, bank environment, customer behaviour, and the economic situation of the nation. The evaluation stage was to evaluate the specified alternatives and conduct sensitivity analysis using the V.I.S.A. software. The model analysis revealed that the preferred technology were Extranet banking and a data warehouse, respectively.

A requisite decision model is defined as a model that treats problem solving as a dynamic process, which helps all relevant actors become clearer about the problem and develops a deeper understanding of it over time. It shows the essential roles of problem structure and sensitivity analysis, and indicates how a decision model can be used in a group setting (Phillips, 1988). Based on this definition, the model of ICT adoption was justified as a requisite group model.

First, the model of ICT adoption treated problem solving as a dynamic process starting with structuring the mission that the bank tries to achieve. All the potential alternatives and criteria used for evaluation were identified and then evaluated using the user-friendly software that allows decision-makers to compare the results with their intuition in order to confirm their perception or further investigate the causes behind the different outcomes. Decision-makers are able to conduct sensitivity analysis or adjust the model to fit with their information, experience, and knowledge that helps them to enhance an in depth understanding toward the issues of interest.

Second, the model creates a deeper understanding for decision-making. Practically, when decision-makers adopt new technology, they may consider only a few variables such as customer behaviour, the economic situation of the nation, and features of technology (P. Jirapinyo, personal communication, December 19, 1996). However, information from the literature review reveals quite a few variables that should be taken into account (Chapter 4 and Figure 7.2). The model initially scrutinised all variables in detail from the literature but customised to fit the respondents' interest and arranged in a hierarchy of importance (Figure 7.3). This process helps decision-makers enhance their understanding and concern about other variables that may impact the technology adoption process.

Third, the model provided analytical results that differed from the intuitive judgements of the same respondents. The respondents can use sensitivity analysis to investigate this gap and elaborate interesting results for detailed analysis using other software applications.

Fourth, the model was developed in a group environment. In the business world, sometimes it is not easy to bring together all respondents who have a full routine workload and a limited time for aggregation. The model therefore was developed to support dispersed group decision-making using interviews and the questionnaires (Appendices 5.1 and 5.2). The information was gathered based on their convenience and time. The modeller analysed the information, developed the model, and investigated the outcome. The results from the model analysis were then proposed to the group for discussion and further investigation.

In effect, the model of ICT adoption developed by MCDM technique is the requisite group model that aids decision-making process. The model increases the level of understanding, solves organisational problems, compares analytical results with people's intuition, detects reasons behind objective outcomes, improves decision-making by conducting sensitivity analyses, and supports group decision-making.

7.7 Summary

This chapter illustrated the process of model development of technology adoption at the Siam Commercial Bank PCL using the multiple criteria decision-making (MCDM) technique. The model was developed in order to evaluate the most preferred technology that fulfils the bank mission as being a well managed bank with highly sustainable performance using five main technologies: smart cards, a data warehouse, video-conferencing, Extranet banking and EFTPOS based on the various identified criteria.

The model analyses provided the answers for the second research question, *what is a requisite group model of ICT adoption of the bank?* According to the MCDM analysis, Extranet banking was preferred technology, which help the bank achieve the mission.

However, this result was contradicted with respondents' intuitive perception. That is, a data warehouse was a more preferable choice.

Although decision analysts sometimes do not appreciate intuitive judgement, it may be appropriate for some decisions and is a normal practice in business organisations (Gluck, 1994; Schoemaker & Russo, 1993). Survival in intense competition demands that executive managers have the ability to combine their business experience with a sense of "computer intuition" to visualise which information technologies could provide a positive competitive impact (Vogt, 1988). Therefore, it is not important to calibrate which decision-making method is better, but it is useful to detect causes of divergence in order to narrow a gap, or to combine aspects of both intuition and rationality.

In summary, although the MCDM model is simple and static, it is a useful and valuable tool that helps decision-makers enhance their level of understanding, and detect the relevant reasons behind objective results. The overall scores deriving from the model analysis should not be taken as defining the answer to the problem but should be used to generate discussion of the problem and for learning (Belton, 1990). In this way, decision-makers may improve a set of criteria, adjust weighting and scoring, and subsequently carry out sensitivity analysis. That would lead to improving their decision-making. After examining the results, if the decision-makers cannot differentiate which alternative is superior, they may use both in a detailed study using some other decision-making tools. The main purpose for using either MCDM or intuition is to prioritise the choices and narrow the scope of the analysis.

These two decision tools still have drawbacks with regard to the inability to capture inter-relationships among criteria and other variables and reflect dynamic effects. Decision-making may be poor where decisions have delayed, indirect, non-linear and multiple feedback effects among them (Paich & Sterman, 1993).

A data warehouse and Extranet banking can fulfil the bank's mission and contain cogent and different aspects in terms of benefits, marketing and diffusion processes. Therefore, both are further elaborated using a system dynamics analysis, which is suitable to represent a dynamic approach to problems and interrelationships among

variables (Coyle, 1996; Wolstenholme, 1994). A further analysis starting in the next chapter allows decision-makers to explore factors and exert operational policies in order to exploit more advantages from the two technologies.

CHAPTER 8

GENERAL MODEL OF THE DIFFUSION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) USING SYSTEM DYNAMICS

8.1 Introduction

Since 1983, the banking Industry in Thailand has introduced and implemented numerous information and communication technologies (ICT). ICT investment commencing with the highly popular ATM transaction services has led to the advent of electronic banking in Thailand (The Siam Commercial Bank PCL, 1996a).

ICT adoption is initiated generally through equipment purchases and subsequent relevant software applications and peripherals requirements. Currently, bank executives have to make crucial decisions in regard to adopting new technologies, maximising their utility, and finding ways to promote those adopted, as well as mitigating the degree of seriousness of problems deriving from technologies, and integrating those technologies into business performances. Technological adoption and

diffusion become a routine practice for decision-makers due to the rapid rate of technological evolution and intense competition in the banking industry.

Chapter 7 reports technology adoption of the Siam Commercial Bank PCL. The study revealed two predominant technologies of the bank: a data warehouse and Extranet banking. Before proceeding to develop the diffusion models of these two technologies, this chapter presents a generic conceptual model of ICT diffusion. The model captures key variables, detects constraints and proves propositions for strategic policies in order to provide a guideline on how to diffuse technologies productively. It also gives answers for the research questions 3 to 4, "*what is a requisite group model of ICT diffusion and what are the requisite policies for adoption and diffusion of ICT for the bank*".

This chapter consists of two main sections. The first section presents the development of a model of ICT diffusion based on qualitative system dynamics approach starting from: describing problems; identifying actors, goals and decision; capturing process structure of the bank; defining organisational boundaries; and analysing feedback loops. Section two aims at quantifying the qualitative model of ICT diffusion using quantitative system dynamics approach. The results provide insight of the relationship between variables that can be used for policy analysis in order to increase the rate of technology diffusion more effectively.

It is noted that diffusion, in this study, did not deal with technology spreading across different banks. Rather it dealt with how the specific technology spread among the users (internal and external) of the bank.

8.2 A Model of ICT Diffusion based on Qualitative System Dynamics

A model of ICT diffusion was developed based on qualitative and quantitative system dynamics using a feedback loop technique. This technique identifies feedback structures based on a 'reference mode behaviour' (Wolstenholme, 1994). According to previous research, a reference mode of technology diffusion normally follows the s-curve (Brancheau & Wetherbe, 1990; Quaddus, 1995; Rogers, 1983).

Qualitative system dynamic analysis consists of problem description, identification of actors, goals and decisions, classification of a process structure, organisation boundaries and influence diagrams (Wolstenholme, 1994).

8.2.1 Problem Description

The first stage for system dynamics analysis is to clarify problems that an organisation has confronted. According to the ICT usage of the bank previously explored in Chapter 6, various types of technologies (e.g. a data warehouse, Intranet system, Extranet banking, ATM) are currently employed to service customers and facilitate work processes. Although these ICT create many advantages, the bank is still confronting many critical problems such as rapid obsolescence of adopted technologies, selection of inappropriate technologies, lack of capable employees, high costs of technologies, low productive usage of those adopted, and low acceptance from staff and customers. These problems obstruct the technology diffusion of the bank. Therefore, the model of ICT diffusion aims at providing ways to increase the rate of technology diffusion and to mitigate levels of seriousness of the problems.

8.2.2 Actors, Goals and Decisions

Actors involved in the technology diffusion issue are the Siam Commercial Bank PCL (i.e. SCB), vendors, competitors, customers and bank staff. Each actor differs in his/her objectives and decision-making issues. The details are indicated in Table 8.1.

Table 8.1. Actors, Goals and Decisions

Actors	Goals	Decision
The SCB (The technology group)	<ol style="list-style-type: none"> 1. Gaining opportunities from technologies 2. Diffusing technologies extensively. 3. Minimising risks, technological problems 	<ol style="list-style-type: none"> 1. Negotiation with vendors 2. Technology adoption (i.e. selection) 3. Technology implementation 4. Technology diffusion (e.g. training, promoting)
Vendors	Sales enhancement	Negotiation (e.g. types of technologies, price, conditions)
Competitors	<ol style="list-style-type: none"> 1. Retaining competitive advantages 2. Protecting market share 	<ol style="list-style-type: none"> 1. Technology competition 2. Technology imitation
Customers	Maximising satisfaction	Accepting/ Rejecting technology usage
Staff	Maximising benefits from technologies (e.g. convenience, knowledge, promotion)	<ol style="list-style-type: none"> 1. Learning how to use technology 2. Accepting/ Rejecting technology usage

Sources: (The Siam Commercial Bank PCL, 1995; The Siam Commercial Bank's executives, personal communication, December 15-20, 1996).

1. **SCB.** The SCB technology group consists of four departments: *systems engineering, technology and process engineering, business relations, and applied technology office* (see Figure 8.1). People in this group are responsible for adopting, implementing and diffusing technologies. The SCB acts as a change agent; therefore, its objectives and decisions are different from those of its staff. The goals of the SCB are to gain opportunities from technologies, diffuse them extensively, and minimise risks and technological problems. Staff in the technology group have full knowledge of technologies and have a close relationship with top executive management.

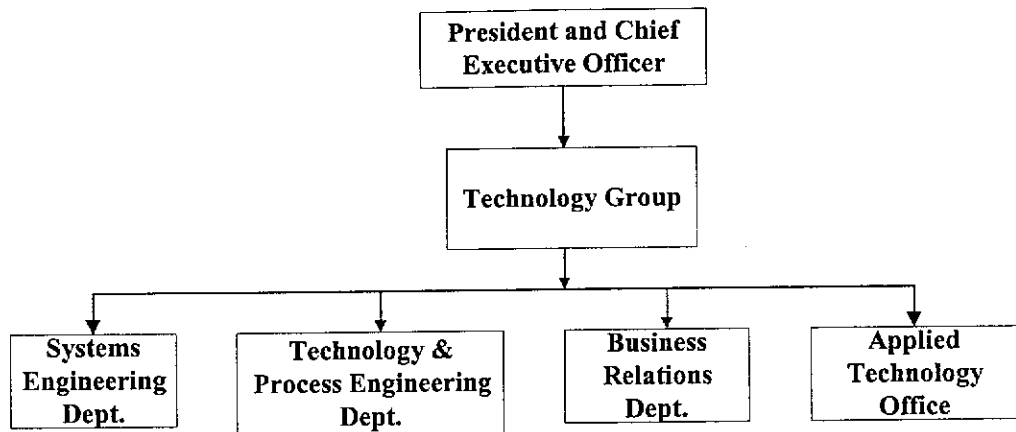


Figure 8.1. The SCB Technology Group

2. **Vendors.** Vendors are persons who supply technological applications to the bank. Their main objective is sales enhancement by offering appropriate conditions to the bank.
3. **Competitors.** Competitors are other banks in the banking industry. The objectives of competitors are to protect their market share and retain their competitive advantage. Competitiveness is one of the factors that force the bank to adopt new technologies to compete with rivals. For large banks, competition for technological leadership is a policy employed to defend their position whereas small banks are inclined to invest in only small and affordable technology by imitating only successfully proven technologies to support staff and facilitate work processes (The Siam Commercial Bank PCL, 1995).
4. **Customer.** Customers use or are going to use technologies provided by the bank. Customers employ technology to gain maximised benefits or satisfaction from technology usage. Their main decision is whether to adopt or reject use of ICT.
5. **Staff.** Staff are end-users of the bank's technologies. Staff are separated from the SCB (i.e. the technology group) because of different roles and

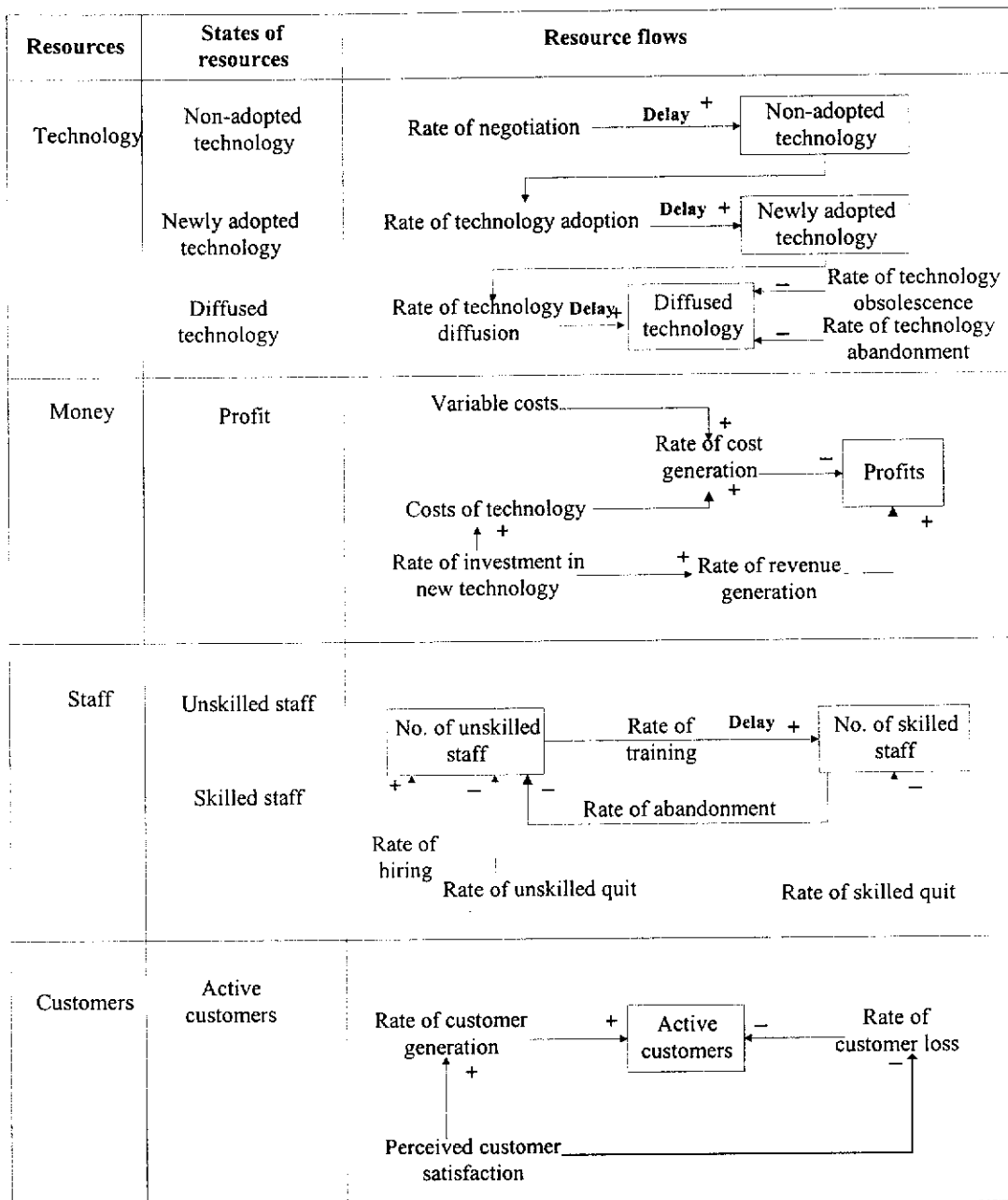
objectives. Each member considers how to maximise benefits from technologies not only for an organisation but also for his or her own sake.

8.2.3 Process Structure of the SCB

According to Wolstenholme (1994), a process structure is to convert resources between states. A resource is a stock that accumulates the resource, which is relevant to the problem of concern or the purpose of the model such as staff, money and technological problems. An inflow or outflow of rate variables regulates the resource. For example, the rate of training increases the number of knowledge workers whereas the rate of staff quitting decreases the number of knowledge workers. A resource can be changed into different states. For example, unskilled workers are transformed into knowledge workers after they obtain sufficient training.

The process structure of the Siam Commercial Bank PCL with respect to ICT adoption and diffusion consists of four types of resources: technology, money, staff, and customers (see Table 8.2).

Table 8.2. The SCB Process Structure



1. **Technology.** Technology is divided into three states: non-adopted technology, newly adopted technology, and diffused technology. Staff of the technology group search for appropriate non-adopted technologies to support work processes or to fulfil requirements of the bank. Technologies at this phase include available and prospective technologies proposed by technological vendors or suppliers. Costs, amount of technology investment and risk are driven by negotiating strategy between the bank and vendors (Auer, 1993). At this state, it takes some time for the bank to adopt

technologies (e.g. negotiation, feasibility study and approval time). The relationship between the rate of negotiation and technology at a market phase is positive.

Non-adopted technology will be turned into newly adopted technology (i.e. investment in technology) under the control of a rate of technology adoption. An increase in the rate of technology adoption affects positively on the amount of the newly adopted technology.

Once new technology is adopted, the bank tries to diffuse it organisation-wide or to customers (Fichman & Kemerer, 1994). Diffused technology is regulated positively by the rate of technology diffusion and negatively by the rate of technology obsolescence (Quaddus, 1996) and the rate of technology abandonment (Tognazzini, 1996) because people normally switch to use more efficient technology. The diffusion process is also a time consuming process.

2. **Money.** Money is represented by profit. A rate of cost generation depletes profit whereas the rate of revenue generation accumulates it. The rate of cost generation comprises the cost of technologies, which are controlled by the rate of investment in new technology and variable costs (e.g. training costs, equipment, maintenance, overheads, and costs for resolving technological problems). Investment in new technology provides opportunities to increase the rate of revenue generation (Wolstenholme, 1994).
3. **Staff.** Staff comprise unskilled and skilled staff. Unskilled staff are positively controlled by a rate of hiring and negatively controlled by a rate of unskilled workers quitting. Unskilled staff are transformed into skilled staff (with a delay) via the rate of training. The numbers of skilled staff declines by the rate of skilled staff quitting and the rate of technology abandonment. The rate of technology abandonment feeds skilled staff back as unskilled staff, but at a lower rate. Generally, former skilled staff are able to learn faster than unskilled staff because information technology allows people to increase learning ability and create a common background (Croft,

1995). That is, once one technology is learnt, others can be learnt more quickly.

4. **Customers.** It is expected that new technology will bring about more active customers. Active customers are increased by the rate of customer generation and decreased by the rate of customer loss. Both rates are regulated mainly from perceived customer satisfaction.

8.2.4 Organisational Boundaries

Once the process structure of the system has been identified, organisational boundaries are defined to clarify which organisations or people control each rate variable in a process. It is useful to set up organisational boundaries because making decisions or exerting policies to improve the process structure may require integrated control strategies from each organisation (Wolstenholme, 1994).

This study defines organisational boundaries with regard to technology adoption and diffusion of the bank into five sectors: the SCB, staff, vendors, customers and competitors. The relationships of each sector in organisational boundaries are illustrated in Figure 8.2 (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996).

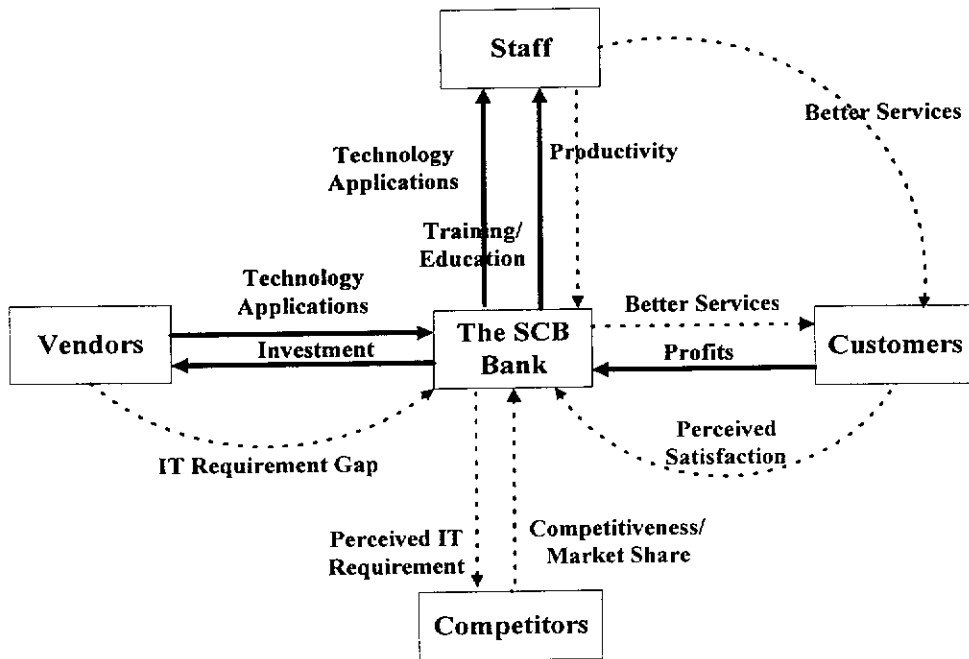


Figure 8.2. Organisational Boundaries

1. **The SCB.** The bank invests in new technologies from vendors or technology suppliers because it realises there is a gap between existing technologies in the bank and available technologies in a market, and considers that new technology may fulfil its business objectives. New adopted technology is diffused to staff and customers in terms of better services. The SCB also provides training or educational programs to support technology usage.
2. **Vendors.** Vendors supply technological applications, and provide after sales services and support (e.g. training, service and maintenance). Levels of technical support and other services depend on success in negotiation (Auer, 1993).
3. **Competitors.** Competition forces the SCB to adopt new technology in order to retain market share. On the other hand, technology investment by the bank also affects its competitors. However, this sector finally was omitted from the model analysis because of difficulty in obtaining information from other banks at the same time that the main research uses one bank as a case

study. Trust is a sensitive issue in conducting research in this most competitive area.

4. **Customers.** If customers perceive satisfaction from new adopted technology, the numbers of active customers and activities will increase leading to increasing in profit. Concurrently, an increase in profit influences the bank to introduce new technologies or upgrade existing technologies.
5. **Staff.** The bank diffuses adopted technology applications and provides training or educational programs to staff. The prospective outcomes from staff are improved productivity (Grover, Teng, Segars, & Fiedler, 1998) and the provision of better services to customers and enhanced ability to adopt subsequent new technologies.

8.2.5 Feedback Loops

The qualitative system dynamics begins with creating an influence diagram to identify information feedback loops. The analysis of feedback loops facilitates understanding of how processes, organisational boundaries, delays, information, and strategies of systems interact to create system behaviour. There are two types of feedback loops, positive and negative. A positive feedback loop reinforces change that leads to instability of a system whereas a negative feedback loop or controlling helps a system adjust undesirable changes to a balance or desired norm (Coyle, 1996; Kornbluh & Little, 1976; Stevenson, 1993).

Information on technology diffusion deriving from literature reviews in Chapter 4 reveal relationships among variables. These variables and their relationships were used as a guideline for interviewing and developing questionnaires. The big picture of technology diffusion is shown in Figure 8.3.

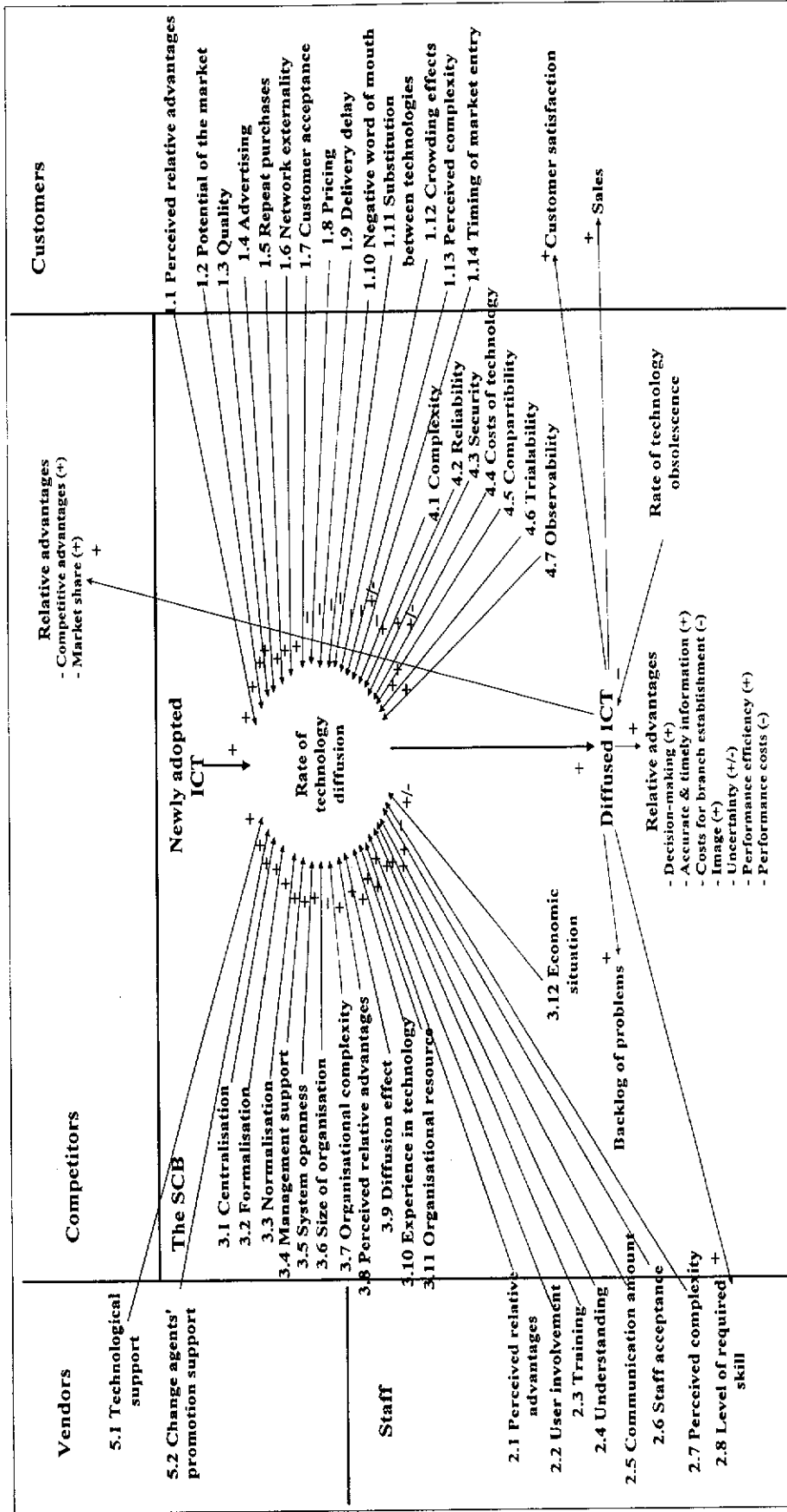


Figure 8.3. Variables of Diffusion of Information and Communication Technologies (ICT) from Literature

According to Figure 8.3, factors that influence the rate of technology diffusion were divided into five groups. First, if technology is employed to service “customers” directly, factors such as perceived relative advantage, potential of the market, quality, advertising, repeating purchases, network externality and customer acceptance impact positively on technology diffusion. On the other hand, delivery delays, negative word of mouth, substitution between technologies, and price exert negative impacts on it. Second, “staff” also accelerates or decelerates the degree of technological diffusion. Thus, factors such as perceived relative advantages, user involvement, understanding communication amount, acceptance and ease of use have to be taken into consideration. Third, “organisational” factors such as management support, experience in technology, centralisation and formalisation increase the rate of technology diffusion. Fourth, properties of “technology” itself promote and demote the rate of technology diffusion. Technology with less complexity, reliability, security, low-costs, compatibility, trialability and observability is more preferable to adopt and implement. Fifth, technical support from “vendors” also boost the rate of technology diffusion. The details of these factors, relationships and references are presented in Appendix 8.1.

Diffused technology also impacts on other factors. For example, diffused ICT creates relative advantages, depending on the properties of each technology, such as improved decision-making, providing accurate and timely information, increased performance efficiency, decreased costs for performance efficiency and increased image. Advantages such as competitive advantages and market share affect the bank’s competitors. Technologies that service customers directly such as ATMs, smart cards, and Extranet banking bring about customer satisfaction leading to increased sales in terms of fees and incomes. Yet, technology diffusion also accumulates a backlog of problems and requires skilled workers (Appendix 8.1).

All the variables were adjusted based on information from the bank. The ICT model divided organisation boundaries into four sub-sectors: the bank (i.e. technology group), bank staff, customers, and vendors. It emphasises four resources (i.e. technology, profits, staff, and customers), and captures the main feedback loops, positive and negative, of the system (Figure 8.4).

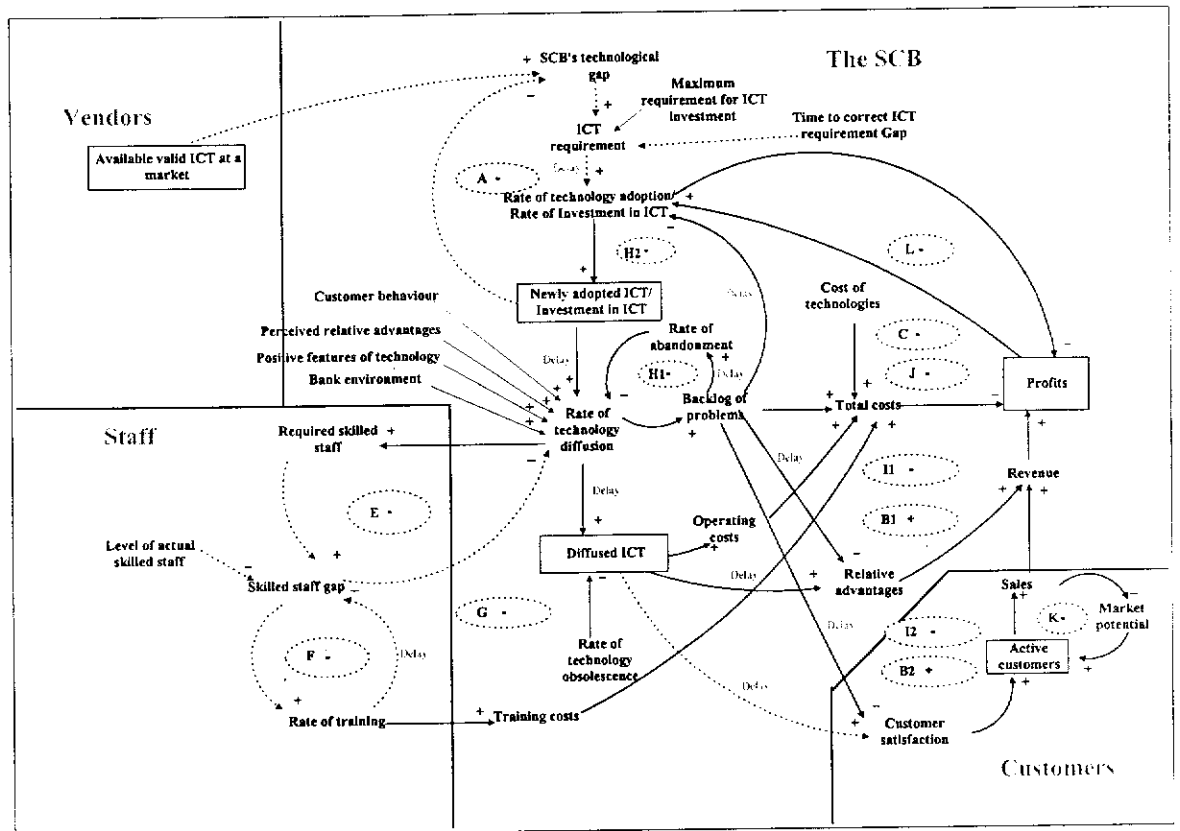


Figure 8.4. The Influence Diagram of the Information and Communication Technologies (ICT) Diffusion Model

Figure 8.4 shows the holistic view of the feedback loops of the ICT diffusion model. The details of each loop are described as follows:

ICT requirement (negative feedback loop A: Figure 8.5). Available technology in a market always attracts an organisation to acquire it. Technological requirements of the Siam Commercial Bank PCL are inspired by a gap between “available valid ICT” at a market and a level of “newly adopted ICT or investment in ICT”. According to Figure 8.5, the bank narrows its “technological gap” by increasing technological investment. However, the technology requirement is controlled by “maximum requirement for ICT investment” (The Siam Commercial Bank’s executives, personal communication, December 15-20, 1996).

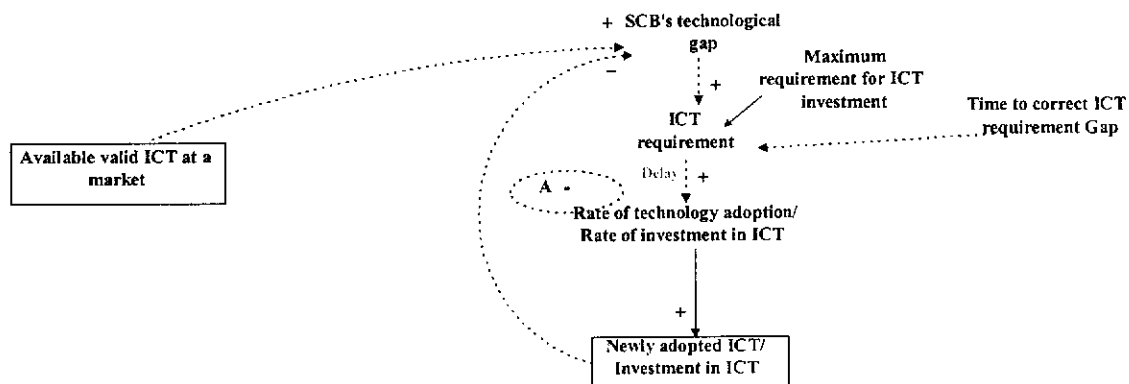


Figure 8.5. ICT Requirement (Negative Feedback Loop A)

Relative advantages and customer satisfaction (positive feedback loops B1, and B2: Figure 8.6). “Investment in new technology” activates the bank to diffuse technology in order to maximise “relative advantages”. The relationship between “newly adopted ICT” and “diffused ICT” is positive (see Figure 8.6) because normally, increasing returns deriving from technology adoption (e.g. learning ability, economies of scales, infrastructure technologies, and network externalities) is a primary factor that drives technology diffusion (Caskey & Sellon, 1996; Fichman & Kemerer, 1994). Other factors that drive the “rate of technology diffusion” are “customer behaviours”, “perceived relative advantages”, “features of technology”, and “bank environments” (see Figure 8.3 and Appendix 8.1). After a time delay the stock of “diffused ICT” brings about “relative advantages” which depend on technological properties. For example, the main relative advantages of a data warehouse are improved decision-making and mass customisation whereas Extranet banking provide cost saving for branch establishment and a decrease in physical transactions at bank counters (Jenkins & McKenzie, 1997; Kelly, 1994). “Relative advantages” will provide “profits”, that subsequently induce additional technological investment (Wolstenholme, 1994). Technology diffusion is a time consuming process; therefore, it takes time (delay) for the bank to diffuse technology and ultimately gain profits.

“Customer satisfaction” is a vital factor for generating “active customers”, which leads to accelerating “sales” and then positively impacts on "profits". The loop is then completed through the variables of loop B1 (Figure 8.6).

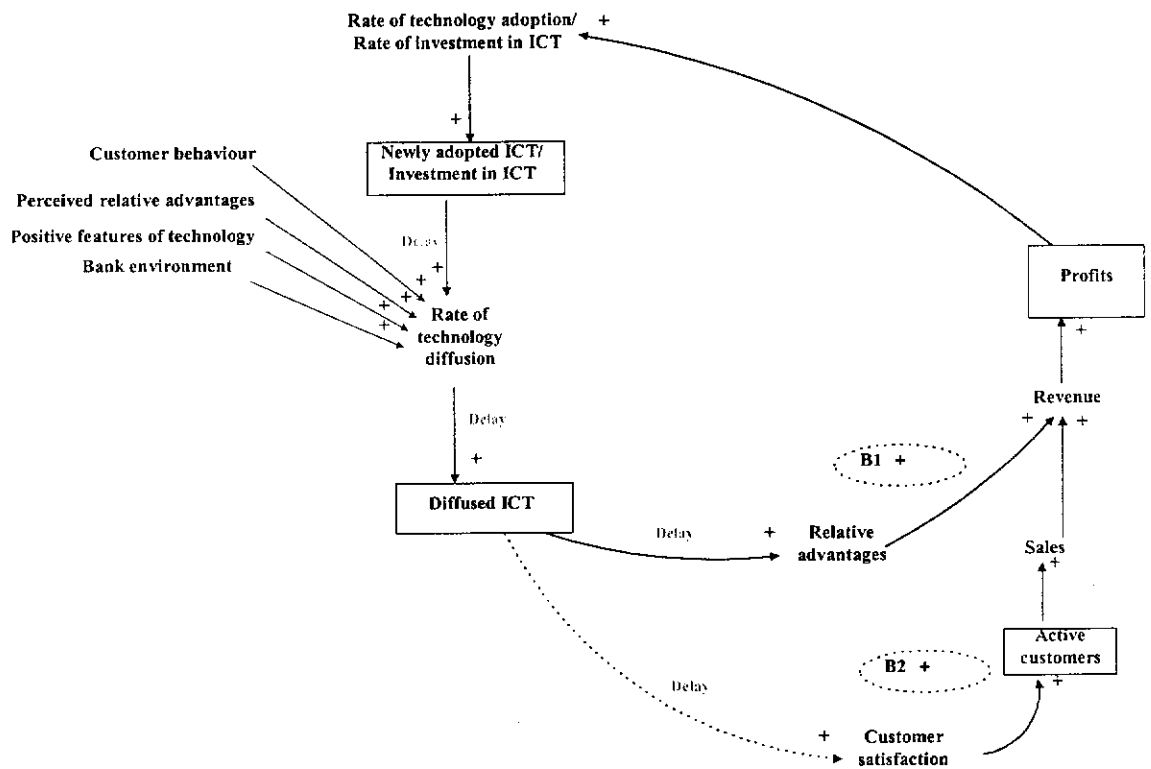


Figure 8.6. Relative Advantages and Customer Satisfaction (Positive Feedback Loops B1 and B2)

Costs (negative feedback loop C: Figure 8.7). Massive expenditure such as “costs of technology” and “operational costs” is accommodated throughout the processes of adopting and diffusing new technology (Takac & Singh, 1992; Tomatzky & Klein, 1982). Certainly, the costs reduce prospective “profits”(Figure 8.7).

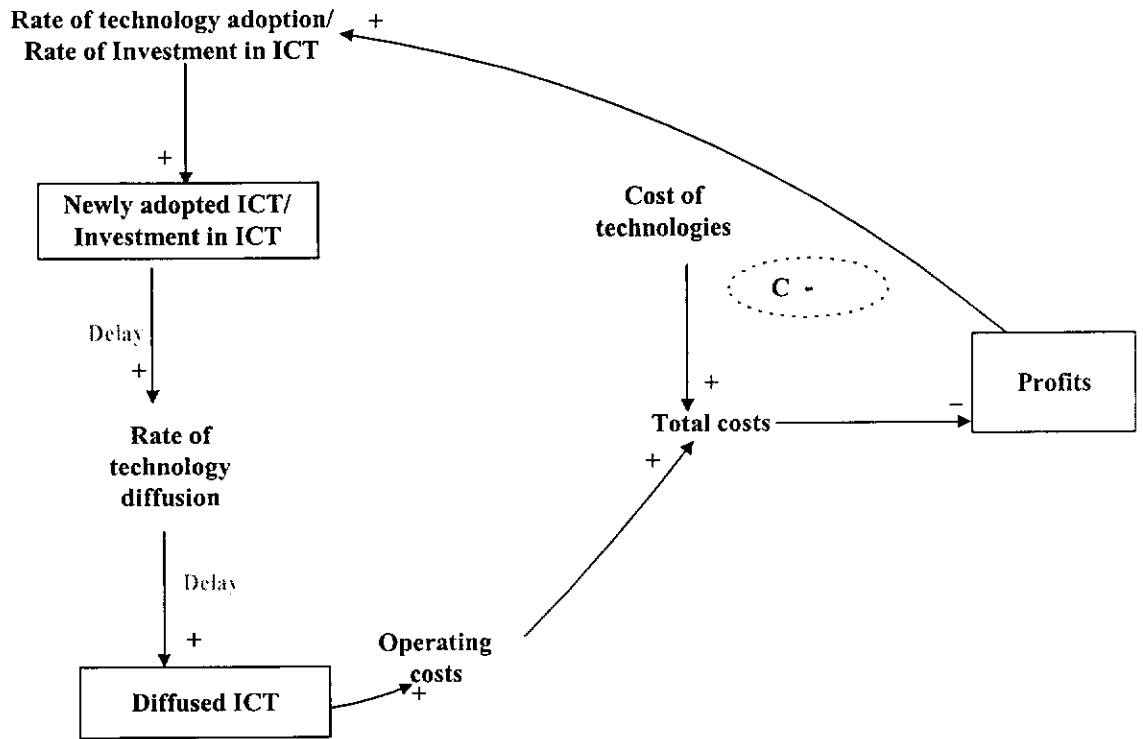


Figure 8.7 Costs (Negative Feedback Loop C)

Training (negative feedback loops E and F: Figure 8.8). New technology usage requires an increase in the number of “required skilled staff” (Bezdek & Jones, 1990). At the same time, sufficient “levels of actual skilled staff” is indispensable to assure successful diffusion (Kwon & Zmud, 1987; Madu, 1989). Failing to upgrade levels of skilled staff widens the gap between the “actual skilled staff” and “required skilled staff”. Therefore, providing “training” is necessary to fill the gap (Figure 8.8).

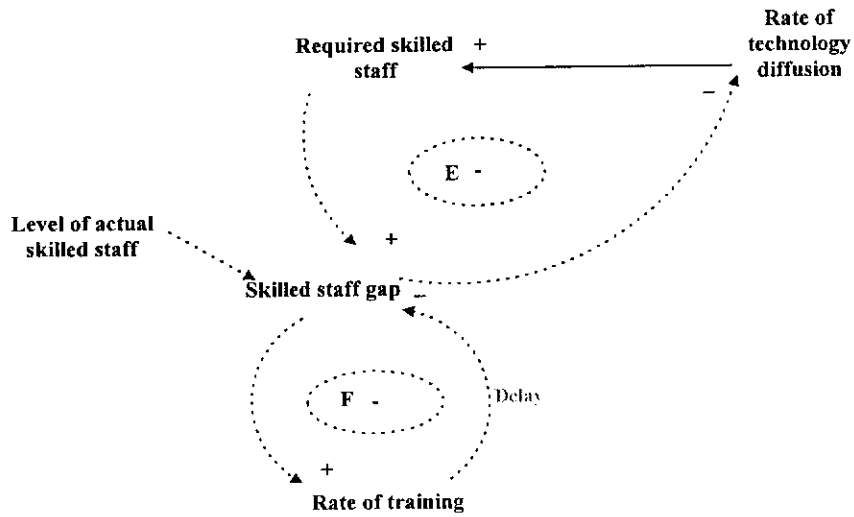


Figure 8.8. Training (Negative Feedback Loops E and F)

Training costs (*negative feedback loop G: Figure 8.9*). Fulfilling quality and quantity of skilled staff via training results in increasing “training costs” (Farr & Sullivan, 1996; Goff, 1999), and subsequently decreasing “profits” (Figure 8.9).

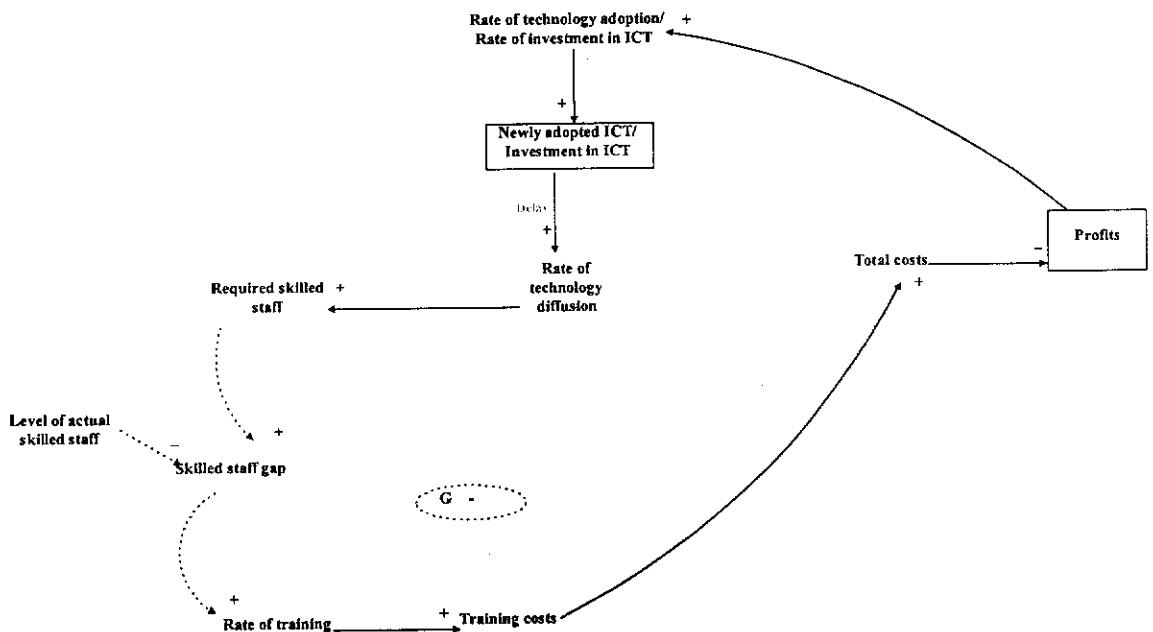


Figure 8.9. Training Costs (Negative Feedback Loop G)

A backlog of problems (negative feedback loops H1 and H2: Figure 8.10). Once technology is integrated in work performances and services, “a backlog of problems” begins to accumulate (Saeed, 1990). For example, a data warehouse also has the potential to provide incorrect data, and difficulty in access and processing. On the other hand, Extranet banking still has problems in regard to difficulty in connecting, sluggish response in transferring data, and downed servers. (The Siam Commercial Bank's staff, 1998b; 1998d). If end users or customers are annoyed or disappointed, they will abandon that technology use. The bank may also hesitate to adopt additional technologies (Figure 8.10).

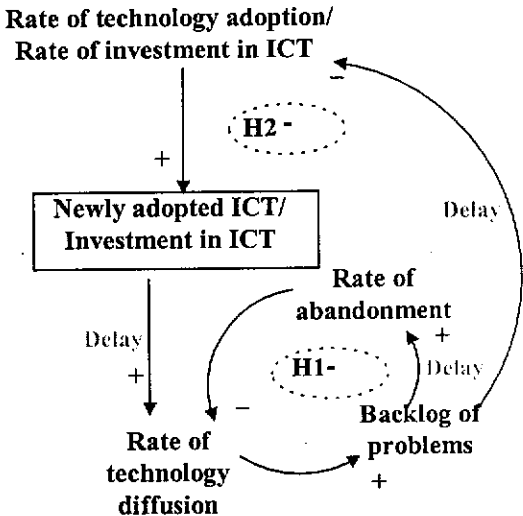


Figure 8.10. A Backlog of Problems (Negative Feedback Loops H1 and H2)

Impacts from a backlog of problems (*negative feedback loops I1 and I2: Figure 8.11*). “A backlog of problems” exerts negative impacts on both “relative advantages” (loop B1) and “customer satisfaction” (loop B2). These impacts may completely or partially offset the positive gains from previous feedback loops (Loop B1 and B2) (see Figure 8.11).

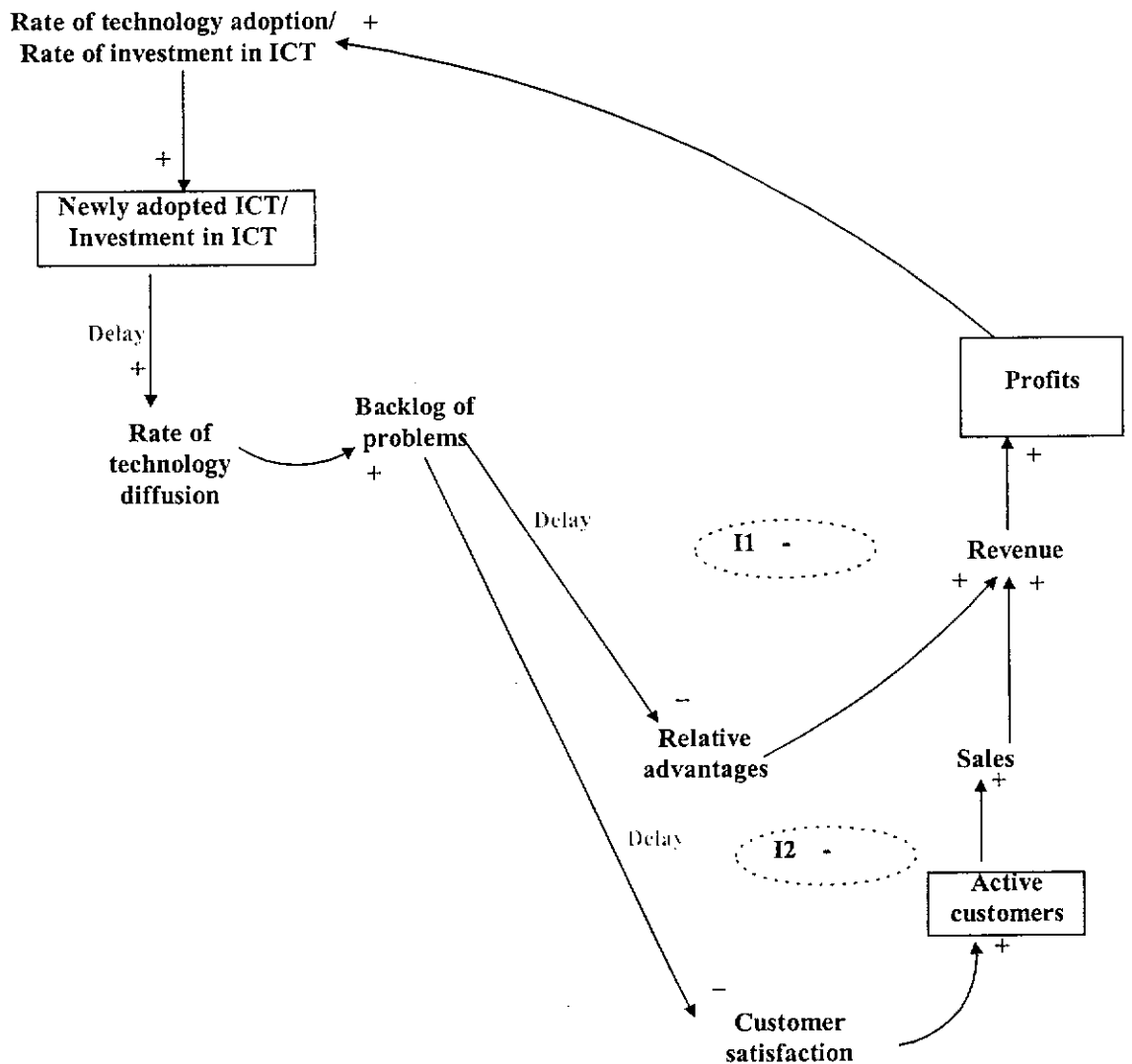


Figure 8.11. Impacts from a Backlog of Problems (Negative Feedback Loops I1 and I2)

Total costs (*negative feedback loop J: Figure 8.12*). Technological development leads to a positive relationship with various related costs (Madu, Kuei, & Madu, 1991). Apart from “costs of technology” and “operating costs”, various costs (e.g.

“training” and “costs from a backlog of problems”) continue to accumulate with the diffusion process (Figure 8.12).

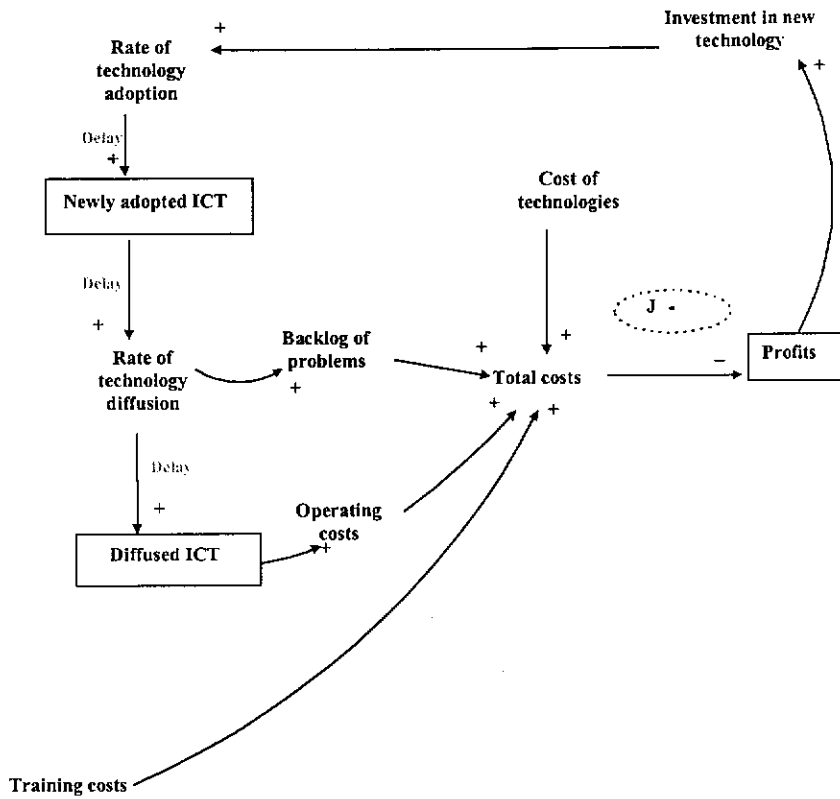


Figure 8.12. Total Costs (Negative Feedback Loop J)

Potential market (Negative feedback loop K: Figure 8.13). Market potential is one general aspects that affect technology diffusion (Maier, 1995). Substantial market potential inspires for technology adoption and diffusion. For example, although the economic crisis in Thailand impact severely on an automotive market, manufacturers and IT vendors still invest on managing information technology systems because of a huge market potential (Piszczalski, 1999). Market potential also hinders the diffusion process because the numbers of “active customers” cannot be beyond the “potential market”, which is limited by population, income and numbers of business (Figure 8.13).

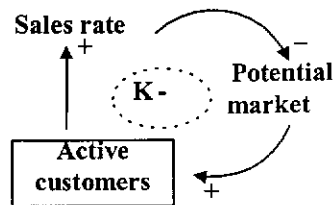


Figure 8.13. Potential Market (Negative Feedback Loop K)

Technological investment and profits (negative feedback loop L: Figure 8.14). Spending on technological investment not only brings many advantages but also decreases profits (Takac & Singh, 1992; The Siam Commercial Bank's staff, 1998c). The bank has to find the balance between “investment in technology” and “profits” in order to arrive at the desirable level of technological expenditure because excessive investment has the potential to decrease its profits (Figure 8.14).

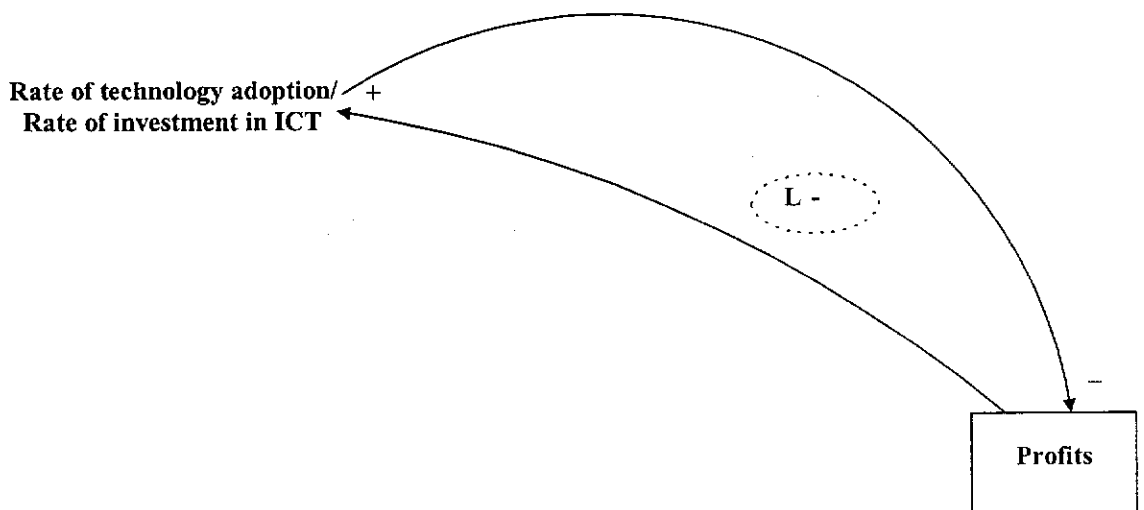


Figure 8.14. Technological Investment and Profits (Negative Feedback Loop L)

8.3 A Model of ICT Diffusion Based on Quantitative System Dynamics Approach

The qualitative conceptual model identified by the above feedback loops was quantified and simulated using *ithink* software (Richmond, Peterson, & Charyk, 1994). Each feedback was added to the simulation until the whole system was complete. This incremental technique enhances understanding in terms of the impacts of each feedback

loop, detecting errors and tracing the logical concepts. The results from simulation provided a complete model of diffusion of information and communication technologies (ICT) and answered for issues that can be used for policy analyses to enhance a rate of technology diffusion. The model of ICT diffusion is presented in Appendix 8.2.

It may be mentioned here that this and all subsequent models dealt with most of the variables captured during the data collection/interview process. However exact relationship of the variables have been made parsimonious in line with the understanding and concern of the bank executive.

8.3.1 List of Variables of ICT

The variables of the model were initially derived from the literature review, the interview data from bank executives and the questionnaires of Extranet banking and data warehouse. According to the initial data, a level of actual performance is set at 0 for low and 7 for high actual performance. A number for the actual performance of each issue is transformed to a value on a 0 to 1 scale for *ithink* simulation. The transformation process begins with setting 7 to 1. Then, the other values are calculated relatively from the initial setting. For example, supposing that the actual performance equals 6, the 0 to 1 scale equals $((6/7) \times 1)$ or 0.857. Table 8.3 illustrates the list of all variables used for model analysis.

Table 8.3. Lists of Variables of ICT

Name	Initial Data	Value used in <i>ithink</i> model
Adoption and diffusion		
1.1 Percentage of a backlog of problems		0.10% per year
1.2 Resolve problem fraction	.80 %	0.80
1.3 Rate of technology abandonment	2-3 %	0.03 per year
1.4 Propensity to invest	10%	0.10
1.5 Customer behaviour fraction	*Level of actual performance = 4.62	0.66
1.6 Perceived relative advantages	*Level of actual performance = 5.32	0.76
1.7 Positive features of technology	*Level of actual performance = 5.46	0.78
1.8 Bank environments	*Level of actual performance = 5.74	0.82
Customer behaviour		
2.1 Customer perceived satisfaction	Level of actual performance = 5	0.70
2.2 Number of prospective customers (Potential market)		2500
2.3 Active customer		Initial number = 1000
Staff		
3.1 Unskilled staff		5,000
3.2 Skilled staff		1
3.3 Unskilled quit fraction		0.05
3.4 Skilled quit fraction		0.01
3.5 Level of understanding	Level of actual performance = 4.2	0.60
Relative advantages		
4.1 Average relative advantage		**baht 250 per Diffused Unit
4.2 Sale price		**Unit price = baht 150
Cost		
5.1 Average costs of technology		Change in investment in new technology
5.2 Training costs		**baht 200 per rate of training
5.3. Operating & maintenance costs		**baht 110 per rate of ICT diffusion
5.4 Costs from backlog of problems		**baht 150 per backlog of problems
5.5 Minimum investment	2 million per year	** baht 167,000 per month
Time		
6.1 Time to correct technological gap		2 month
6.2 Time for customisation		2 month
6.3 Time for training staff		6 month
6.5 Economic life of technology	3 up to 5 year	60 month

Sources: (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996; The Siam Commercial Bank's staff, 1998c; 1998d; 1998e)

Note: * Average value between a data warehouse and Extranet banking
 ** Data from Extranet banking

8.3.2 A Baseline Model of ICT Diffusion

Initially, the feedback loops were simulated incrementally from loop A to loop C in order to identify the behaviours of significant variables such as rate of technology diffusion, diffused technology, and profit. These simulation results up to loop C were considered baseline results because costs and benefits from technology are basically taken into consideration whenever an organisation requires new technology (Nambisan & Wang, 1999; Sahal, 1977). The baseline results were used to compare with other results derived from subsequent incremental simulation.

Feedback loops of the baseline model were transformed into simulation diagrams using *ithink* software. The details of the model both in the form of feedback loops and the simulation diagrams are illustrated in Figure 8.15.

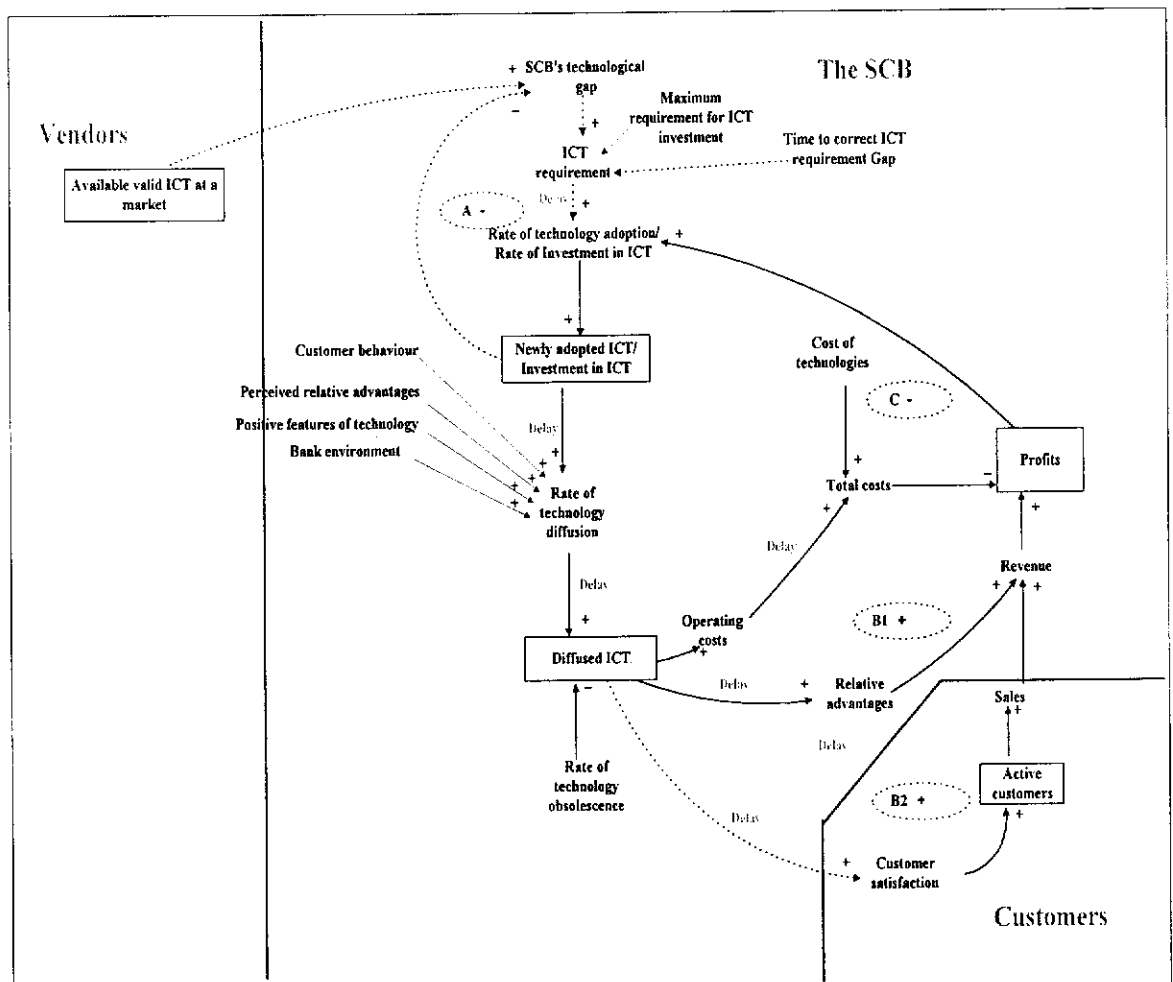


Figure 8.15. A Baseline Model of ICT Diffusion (A: Feedback Loops)

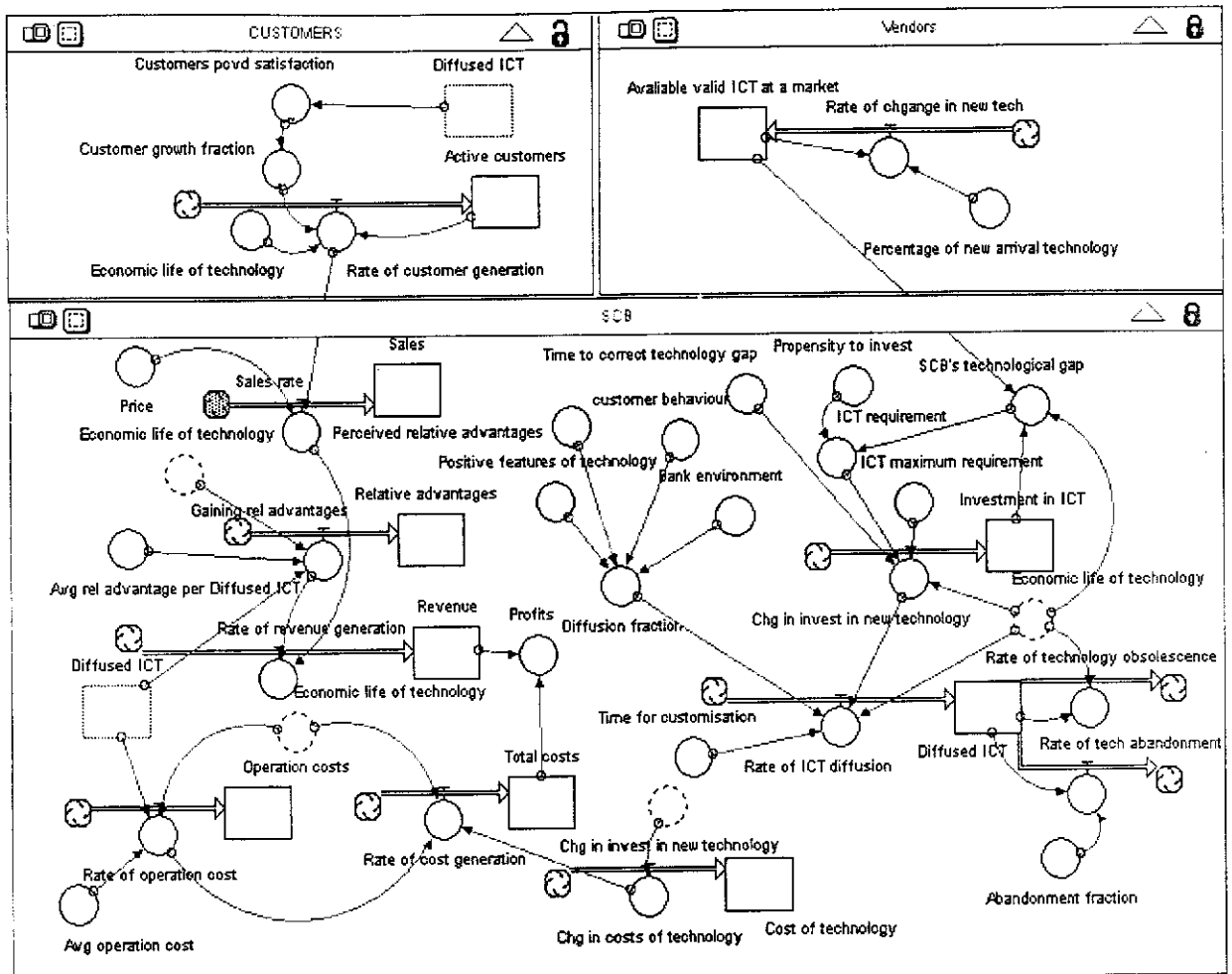


Figure 8.15. A Baseline Model of ICT Diffusion (Cont.) (B: Simulation Diagram)

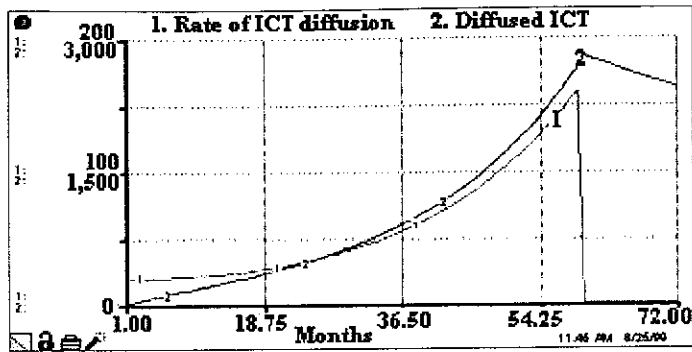
According to Figure 8.15, the system boundaries of the baseline model comprise vendors, the technology group of the bank (SCB) and customers. Initially, the bank acquires information and communication technologies (ICT) that are available in a market to facilitate work processes and customers. Although it is tempting to adopt inadequate technologies, the rate of technological investment is constrained by factors such as “propensity to invest”, and “the maximum ICT requirement” (i.e. technological expenditure), which come from the technological policy of the bank. In general, it takes some time for the bank to adopt technology. This delay arises from time for research, negotiation and approval.

The adopted technology is diffused to customers and staff in an organisation. The rate of technology diffusion depends on the factor such as perceived relative

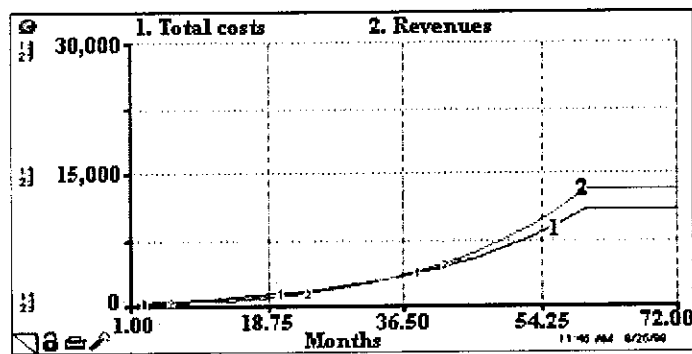
advantages, features of technology, readiness of organisational environments, and receptive customers (Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989; Rogers, 1983; Thompson, 1987; Waema & Walsham, 1990; Wynekoop, Senn, & Conger, 1992). Technological diffusion arises with time delays (e.g. time for customisation).

The diffused technology brings about “relative advantages” depending on its properties, decrease time for work processes, improvement of decision-making, cost savings for instance. Furthermore, technologies such as Extranet banking, credits cards, and smart cards can create direct revenues from “sales”. The two main benefits from the diffused technology after deducting from its costs (e.g. “costs of technology” and “operation costs”) provide ultimate “profits” to the bank.

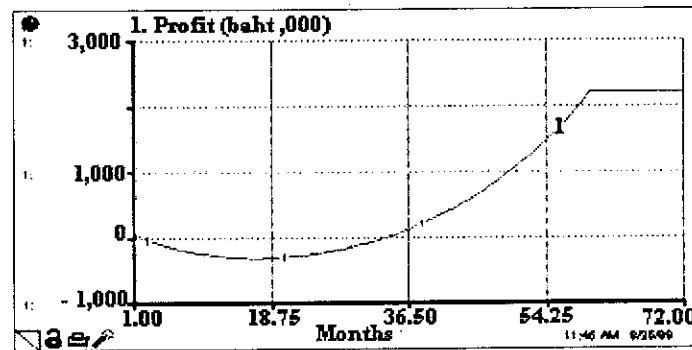
The simulation diagram was simulated focusing on four variables: the rate of technology diffusion, diffused ICT, a break-even point, and profits. The rate of technology diffusion increases until the technology is obsolete. The diffused ICT has a s-shape curve, which implies that the technology is gradually diffusing at the first stage, increasing rapidly after taking off, and diminishing after technological obsolescence or absorbing the potential market (Figure 8.16 a). The break-even point of technology happens at the 34th month (Figure 8.16 b). The bank obtains profit of baht 2,201,000 from the technology within 60 months (Figure 8.16 c).



a. Diffused ICT



b. Total Revenues and Total Costs



c. Profits

Figure 8.16. A Baseline Model of ICT Diffusion (Feedback Loops A, B1, B2, and C)

The baseline model of ICT diffusion was further developed to investigate various propositions derived from literature reviews in order to confirm the results from previous studies and identify important variables that increase the rate of technology diffusion. The model detects the results of the following research questions.

- Q1. How does “training support” impact on technology diffusion?
- Q2. How does “backlog of problems” impact on technology diffusion?
- Q3. How does “market potential” affect technology diffusion?
- Q4. To what extent does “investment in new technology” affect “economic returns on investment”?
- Q5. To what extent does the bank harvest “economic gains” from “investment in new technology”?

8.3.3 The Impact of “Training Support” on Technology Diffusion

Apart from technical features, important factors influencing the success and failure of technological implementation are organisational aspects such as training, top management support, interactions during implementation, user involvement, and motivated and capable users’ attitudes (Kwon & Zmud, 1987; Manross & Rice, 1986). Since innovation can succeed only if end users have a full understanding of the technology, training is considered as a vital policy to provide knowledge, reduce levels of resistance, create skilled human resources and increase managerial potential (Madu, 1989). Generally, technology diffusion changes positively with the level of training support. When technology is diffused, it creates learning environments that convince more end users to attend training. More trained staff and active staff further enhance diffusion rate (Quaddus, 1996).

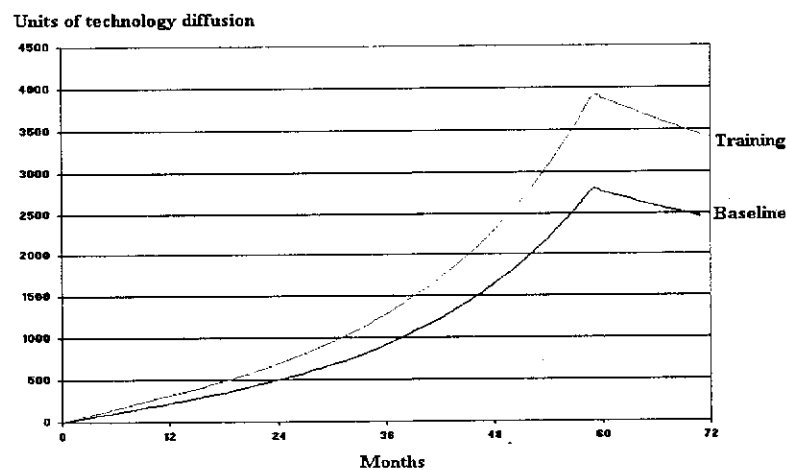
Therefore, the propositions regarding training support are:

Prop1a: Training support increases diffused ICT.

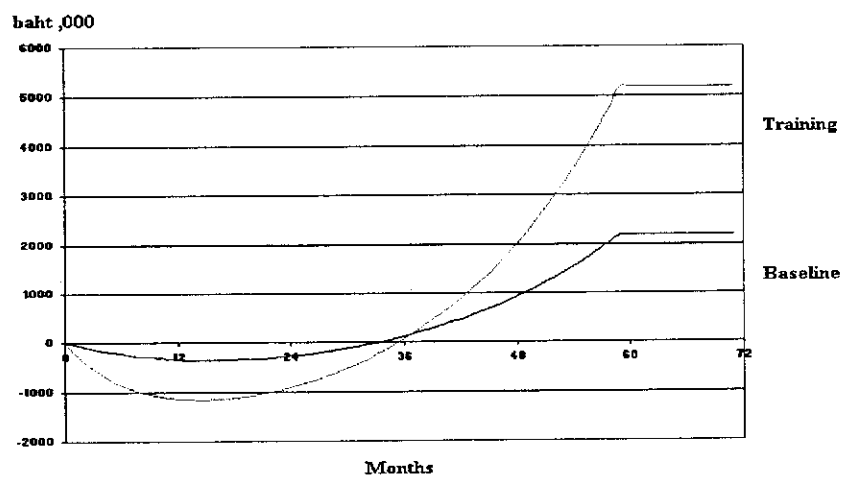
Prop1b: Training support increases profits (i.e. relative advantages and sales).

It is noted that no formal statistic tool is used to investigate the propositions. The investigation is done visually based on the derived graphs from the system dynamics model in the context of the SCB model (Abdel-Hamid, 1988; Forrester, 1992; Richardson & Pugh, 1981).

Loops E, F and G (training and training costs) in Figures 8.8 and 8.9 are added to the baseline simulation for the purpose of capturing the impacts of training support which is set up to bridge the gap of insufficient technical skills. The derived results are then compared with those of the baseline (Figure 8.16).



a. Diffused ICT



b. Profits

Figure 8.17. Impacts of Training Support on Technology Diffusion

According to Figure 8.17a, the rate of technology diffusion supported by training is higher than the baseline for the whole period of time. Additionally, despite an increase in training costs, the bank still gains more profits (Figure 8.17b). Therefore, it can be concluded that “training support” is a vital factor that impacts positively on technology diffusion. The two propositions are supported. That is, training support increases diffused technology and profits.

8.3.4 The Impact of “Backlog of Problems” on Technology Diffusion

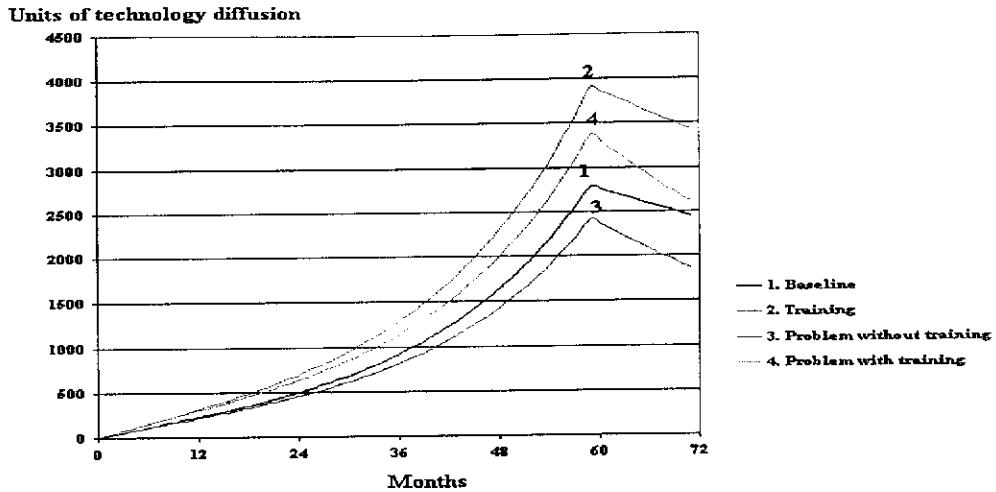
Solving work problems and reducing uncertainty in problem solving are two main reasons for adopting information technology. However, whenever technology is diffused, a backlog of unsolved problems associated with the technology itself and the organisational aspects of adopters are created (Foschini, 1989; Gozlu, 1994; Rogers, 1983). Generally, technology not only brings about a good return on investment but also gives rise to problems (e.g. abused information, business frauds, insecurity and unreliability, and increasing demand for higher capacity of hardware and software) (Global Banking Intelligence Corp., 1996). Therefore, if an organisation fails to solve the backlog of problems, it may create one kind of uncertainty in the minds of adopters leading to demoting further adoption and simultaneously promoting existing adopters to abandon technology use (Rogers, 1983; Saeed, 1990).

Thus, given the “backlog of problems” factor, the suggested propositions are:

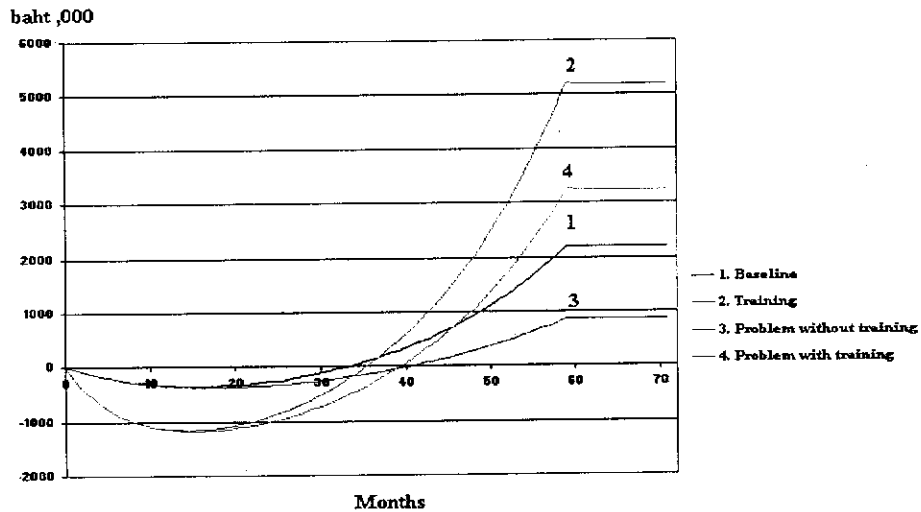
Prop2a: A backlog of problems decreases diffused technology.

Prop2b: A backlog of problems decreases profits.

As can be seen in Figure 8.4, a backlog of unsolved problems directly affects rates of technology adoption and diffusion, consumes costs for resolving problems and possibly reverses relative advantages and customer satisfaction from positive to negative outcomes. The entire set of feedback loops (from Loop A to Loop J) are then simulated to detect the impacts of the backlog of problems.



a. Diffused ICT



b. Profits

Figure 8.18. Impacts of a Backlog of Problems on Technology Diffusion

According to Figure 8.18a, a backlog of problems, without training support, decreases diffused technology. The percentage of a backlog of problems was set at 10 per cent per year. Although the technology developers perceived that a backlog of problems that the bank currently confronted was low (The Siam Commercial Bank's staff, 1998c; 1998d), but based on the bank staff's perception, it was high (The Siam Commercial Bank's staff, 1998e). Figure 8.18b reveals that profits do decrease because of the impacts of a backlog of problems.

Given the training factor and a backlog of problems, the diffused technology and profits are still higher than those from the baseline because of the more powerful influences of training support.

The end results provided the answer for the research question of “*how does a backlog of problems impact on technology diffusion*” and supported the two propositions. That is a backlog of problems exerts negative impacts on diffused technology and profits.

8.3.5 The Impact of “Potential Market” on Technology Diffusion

Previous research indicates that early adoption of new IT applications leads to long-term competitive advantages (e.g. market share and income) (Dos Santos & Peffers, 1995). However, an organisation may hesitate to become involved in, or may postpone full implementation of a particular technology because of an obscure actual demand or market potential of a product deriving from technology use (P. Jirapinyo, personal Communication, December 19, 1996).

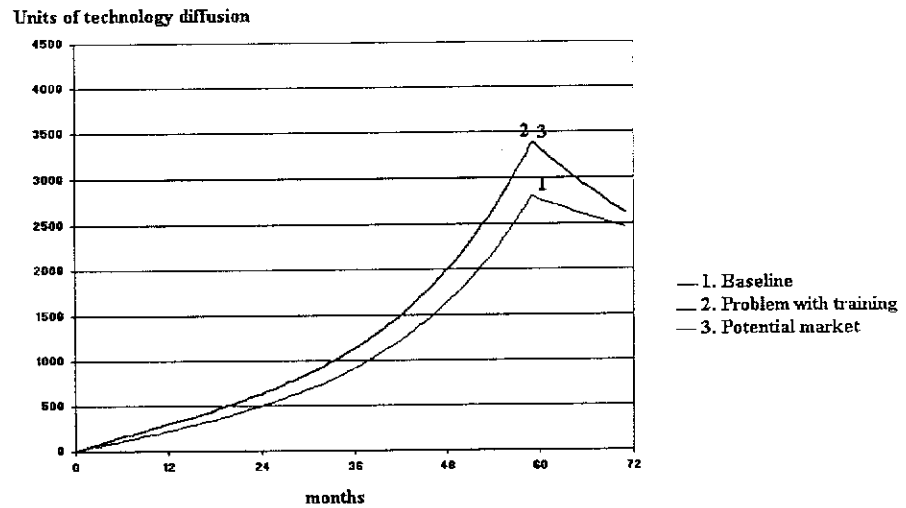
Potential market is physically reduced by sales in a period and increased by a flow coming from new potential customers and customers who repurchase (Maier, 1996; 1998). Yet, in reality, it is difficult to know the potential market of a particular product because many potential customers or users may decide to wait for it to attain some initial success before entering the market. This delay occurs because early adopters will see few benefits from the product until it is widely used. A wait-and-see attitude of prospective customers may cause insufficient demand to launch the product successfully (Caskey & Sellon, 1996). Additionally, in a dynamic environment, short product life cycles, a sharp decline in prices and time to market also affect potential market (Maier, 1995).

In effect, even where technology can be successfully diffused, economic gains are limited by potential market size. Therefore, the suggested proposition is:

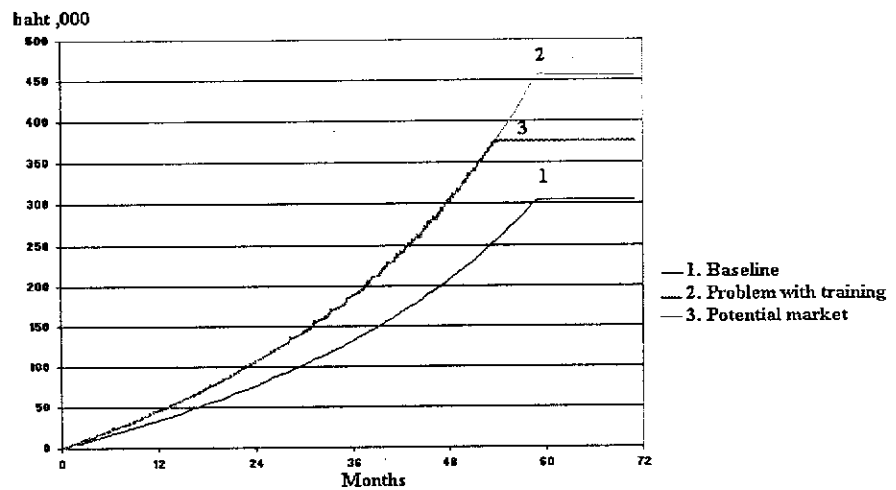
Prop3: Despite successful diffusion potential market size inhibits sales.

The feedback loop K in Figure 8.13 (potential market) is added in order to observe the influence of potential market on sales. As can be seen from Figure 8.19a and b, although the diffused technology is similar to those of previous simulations (e.g.

problem with training scenario), sales increase until the potential market is completely absorbed. It can be concluded that technology cannot increase sales beyond potential market, although it can be successfully diffused. Therefore, the proposition is supported.



a. Diffused ICT



b. Sales

Figure 8.19. Impacts of Market Potential on Sales

8.3.6 The Effect of “Investment in New Technology” on “Economic Returns on Investment”

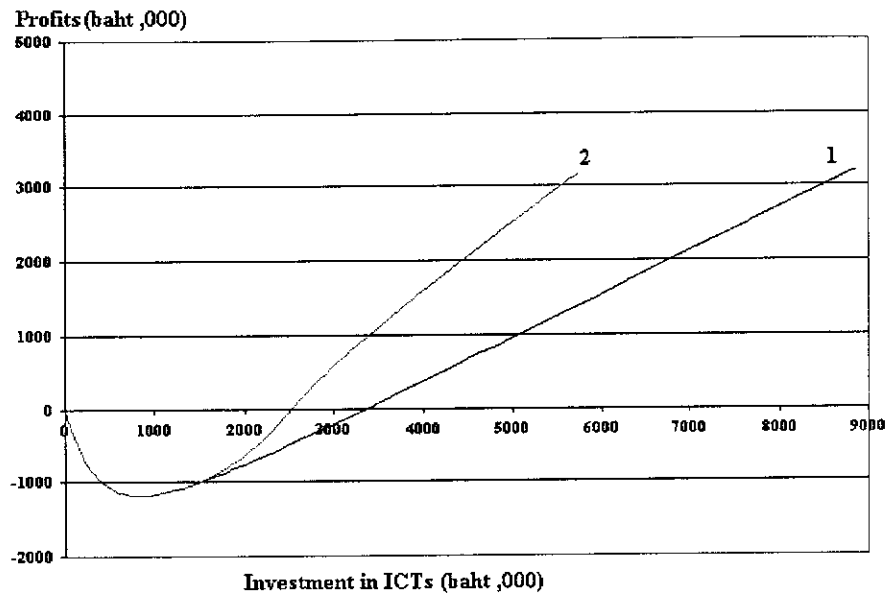
In the recent past in Thailand, massive technological investment was not considered a serious issue due to the economic prosperity of the country. However, currently,

there are increasing concerns regarding technological adoption and the overall gains in return for such investment because high investment not only brings many advantages but it also decreases profits (Takac & Singh, 1992; The Siam Commercial Bank's executives, personal communication, December 15-20, 1996). Additionally, excessive emphasis on technological aspects may persuade people to spend time and effort dealing with the technology instead of dedicating themselves to their actual work performance.

Investment in new technology to eliminate a technological gap or catch up with technological evolution cannot be infinitely increased because technology expenditure relates directly to profits of an organisation. It is important that an organisation has to determine a balance between desired investment in new technology and economic returns from such investment. Therefore the suggested proposition is:

Prop4: The bank gains higher economic returns on investment from controlled technology expenditure than that from uncontrolled.

Loop L in Figure 8.14 (technological investment and profits) was added to the simulation to observe the impacts of technological investment of the bank based on the amount of its profits. The maximum requirement of ICT investment was changed from the fix rate (i.e. baht 900,000 per month) to the minimum investment (baht 167,000) plus 9 per cent of profits derived from the technology (The Siam Commercial Bank's executives, personal communication, December 15-20, 1996).



1. Uncontrolled technological expenditure
2. Controlled technological expenditure

Figure 8.20. Impacts on Profits of Investment in Technology

According to Figure 8.20, with the same amount of technological investment, profits derived from controlled technology expenditure are higher than those without controlled technology expenditure. Proposition 4 is therefore supported.

8.3.7 “Economic Gains” for “Investment in New Technology”

In general, a positive relationship between relative advantages and technological adoption has been found (Kwon & Zmud, 1987; Rogers, 1983). However, economic gains from technological investment cannot be obtained synchronously. First, when new technologies are introduced, their potential may not be exploited fully because quite a few technologies are implemented on a trial-and-error basis (Gagnon & Toulouse, 1996). Second, during the initial stages, advantages of technologies cannot be obtained or even precisely determined, whereas short run costs are readily available (Gerwin, 1988). Third, technological investment requires an adaptation and learning process to combine environment, organisation, team, task and technology. Once the misalignments of these factors are corrected and end users eventually adopt, economic returns increase (Applegate, 1992).

Consequently, technologies have to be substantially invested together with minimum sufficient usage then advantages from the technology can be harvested. The proposition relating to this research question is:

Prop5: Economic gains can be obtained after a new technology has been substantially invested.

The simulation results of comparing investment in new technology with profits in Figure 8.20 also reveals that the bank begins to obtain positive profits after it has spent at least baht 2,500,000 for technological investment. That is the bank cannot gain any profits from its technological investment at the low level of investment. Profits increase after the bank has spent substantial money for technology investment. Proposition 5 is therefore supported.

8.4 Model Validation

As previously mentioned in Chapter 5, a model can be validated based on the philosophical concepts of the pragmatist which defines a valid model as one of many possible ways to explain a real system. This means that a model is valid if it is sufficiently useful for desired purposes and satisfies users. Model validation can also be justified through its development of a gradual process of "confidence building". (Barlas, 1996). This confidence arises from satisfaction of the model structure, its general behaviour characteristics, and its ability to generate accepted consequences (Forrester & Senge, 1980; Kornbluh & Little, 1976; Wolstenholme, 1994).

The diffusion model of ICT was justified as a valid model because it was useful and developed based on the "confidence building" process. First, the model aims at helping the case study bank (i.e. the Siam Commercial Bank PCL) find ways to diffuse technologies more productively. It identified factors that affect the diffusion process such as, training, a backlog of problems, market potential, and volume of investment. The bank executives accepted that if the bank promotes factors that create positive impacts and concurrently eliminates the negative one, technology can be diffused more quickly and effectively. This implies that the model is useful and adequate to respond for the purposes of the bank.

Second, the ICT diffusion model was gradually developed to assure confidence to satisfy users. The process of building confidence into the model followed these steps.

1. The model development was initiated from identifying variables in regard to technology diffusion from in depth literature reviews. The identified factors were used to develop a conceptual framework using the qualitative system dynamics approach. This framework (see Figure 8.3) helps users understand a holistic picture of the system behaviours.
2. The ICT model identified the system boundaries, roles of inter-related actors both inside and outside the bank who may influence the diffusion process, or may be affected by the process. It also captured a process structure and the interactions between each factor. These provide the fundamental background for users to comprehend the system and highlight problems of concern.
3. After building the conceptual framework of ICT diffusion, data were collected from the case study bank in order to customise the conceptual model to reality based on the real perceptions of people. At this stage, the theoretical framework (Figure 8.3) was adjusted for practical proposes (Figure 8.4).
4. The adjusted model was then simulated using the data from the bank in order to observe the behavioural patterns and quantify the values of variables of interest (e.g. a pattern of technological diffusion, rate of the technology diffusion, diffused technology, break-even point, and economic returns on investment).
5. Results from the model analysis were tested with the findings from previous literature reviews and reality in order to investigate various propositions and confirm the validity of the model. The model was further verified by bank experts to confirm its validity or to get comments for model revision.
6. The general model of ICT diffusion is probably obscure for users to understand because each technology contains unique properties, benefits, features, and a diffusion process. Therefore, this model was further analysed

by dividing it into sub-models of a data warehouse and Extranet banking which will be presented in Chapters 9 and 10. These two sub-models were analysed to detect their diffusion processes and test for leveraged strategic policies that enhance the rate of technological diffusion. The results enhance the levels of understanding, confirm their usefulness with regards to helping the bank find ways to diffuse the technologies productively, and verify the consistencies between specific technologies and ICT in general.

7. The experts again tested the outcomes from the two models emphasising policy analyses in order to validate the models based on their perception, knowledge, experience, additional information and intuition. Their acceptance confirms the validity of the models whereas their recommendations were used to revise the models to enhance confidence in model building and use.

Apart from the usefulness and confidence building process, the model of ICT diffusion was further tested and validated based on the formal criteria comprising the three major stages of structure validity, behaviour validity, and tests of policy implications (Barlas, 1996; Forrester & Senge, 1980). The definitions of each test were already explained in Table 5.3.

8.4.1 Structure Validity Tests

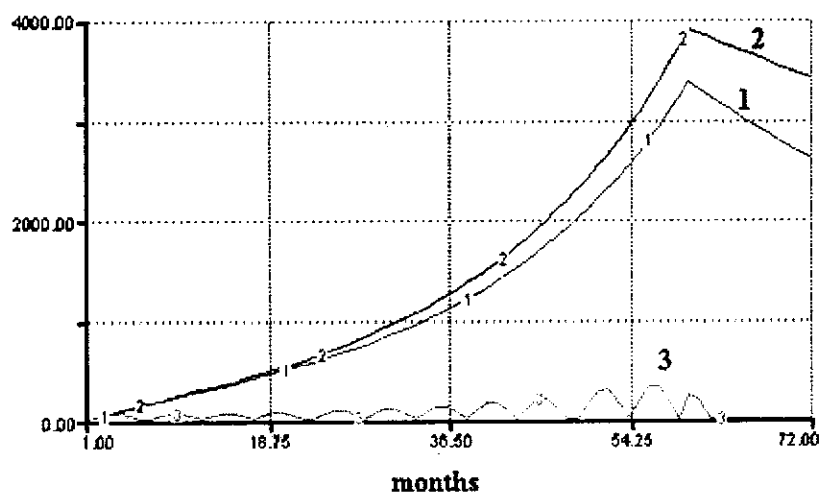
The structure validity tests were used to assess the structure and parameters of the ICT diffusion model directly without examining relationships between structure and behaviour. The model was verified based on the following tests.

1. **Structure verification.** Equations of the models were mainly identified based on common acceptance in the real systems. For example “sales” equals “numbers of customers” multiplied by a “unit price”. The others were detected from literature reviews. According to previous research, the rate of technological diffusion is determined by factors such as organisational environments, perceived relative advantages, positive features of technology, and customer behaviour. Therefore, the equation for “a diffusion fraction” was taken as the average value of these four factors.

2. **Parameter verification.** All the parameters, both conceptual and numeric, were identified from the literature review (details in Appendix 8.1) and customised through questionnaires and interview data from bank respondents.

3. **Extreme conditions.** Extreme tests were always conducted on the selected parameters during the model testing in order to observe the patterns of outcomes, compare them with a real system, and trace the reasons behind those outcomes. For example, the parameter of “percentage of a backlog of problems” was assigned as 10, 0, and 100 per cent per year in order to see its impact on “diffused ICT”. The results in Figure 8.21 reveal that, if technology is error free, the bank is able to gain more diffused technology. On the other hand, highly problematic technology creates low and fluctuated diffused ICT. The fluctuation arises because whenever technology is adopted and diffused, the problems from that technology drive people to abandon technological use.

Units of technology diffusion



1. Percentage of a backlog of problems = 10% per year
2. Percentage of a backlog of problems = 0% per year
3. Percentage of a backlog of problems = 100% per year

Figure 8.21. Extreme Test of the Impact of a Backlog of Problems on Diffused Technology

4. **Boundary adequacy.** The ICT model accommodated all appropriate relevant system boundaries into the model including the technology group of the bank, customers, staff, and vendors. The interactions of these four system boundaries were described in Figure 8.2.
5. **Dimensional consistency.** The model was carefully checked for the consistence of dimensions between stock and flow variables, and units of measurement in transformation variables from one resource to others.
6. **Turing test.** This study conducted a Turing test by proposing the outcomes of the model to five bank staff who are experts in technological issues in order to ask them to compare the model findings with those of the real system based on their experience and knowledge. Following are the results from the Turing test derived from the five experts (The Siam Commercial Bank's executives, 1999).
 - They agreed that training support is the important factor to drive technology diffusion whereas a backlog of problems obstructs it. They commented that the high percentage of backlogs of problems perceived by users was more reliable than the low perceptions by technology developers. Therefore, the ICT model was then revised afterward by changing the percentage of a backlog of problems from 3 to 10 per cent per year.
 - Technology diffusion is restricted to potential markets. However, the market potential for many technologies is still high but the bank has to find ways to attract prospective customers. For example, the bank plans to evolve Extranet banking to Internet banking, incorporate the usage of smart cards with student identification cards, and install user-friendly software applications to extract data from the bank data warehouse.
 - They agreed that technological investment should be in an appropriate proportion of expected returns because massive investment does not always provide highly promising outcomes. However, it is hard for the bank to know the balance between the two. At present, the bank has spent baht 900 million for technological investment, or 9-10 per cent of total expenditure. They also agreed that the bank has to invest substantially

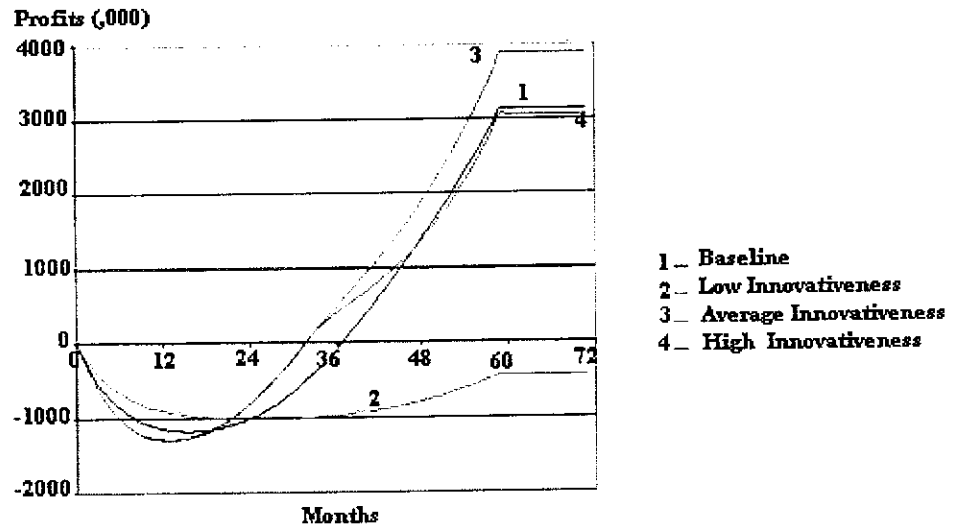
before gaining returns on the investment. However, the returns on investment are contingent upon types of technology and are not necessarily in the form of monetary returns. For example, the bank has invested heavily on a data warehouse and spent a large sum of money to solve the Y2K problem although they are as yet to provide substantial returns because it is a must for the sustainable growth of the bank in the future.

8.4.2 Behaviour Validity Tests

The behaviour validity test was conducted to measure how accurately a model can reproduce major behaviour patterns exhibited in a real system. The behaviour validity tests comprise a behaviour-reproduction test, behaviour-anomaly test, and behaviour-sensitivity.

1. **Behaviour reproduction.** The ICT model passed the behaviour reproduction test because it generates the behaviour in accordance with the real system such as the s-shape of the behavioural pattern of diffused ICT. Furthermore, although the ICT models were developed using different values of data (e.g. percentages of a backlog of problems, sales, relative advantages and costs), the behavioural patterns of interested variables are the same. For example, the present ICT model (using bank information) reproduced the same behaviours of all observed variables similar to those of the ICT model at an early stage of development (using the data mostly from literature reviews) (Quaddus & Intrapairot, 1998).
2. **Behaviour sensitivity.** Behaviour sensitivity can be experimented on any interested variables by assigning different values, analysing and visualising their impacts on those variables. Figure 8.22 illustrates the impacts of the level of bank innovativeness on profits. The sensitivity analyses were conducted under four scenarios of baseline, low, average, and high innovativeness. The sensitivity analysis reported that if insufficient money is spent on technological investment (low innovative), the investment is insubstantial to provide economic returns on investment whereas if the investment is increased, the bank may gain higher returns compared to the baseline. However, if the bank is

attempting to be a highly innovative leader by spending excessive money on technological investment, the economic returns may not increase in the same proportion as the increase in investment.

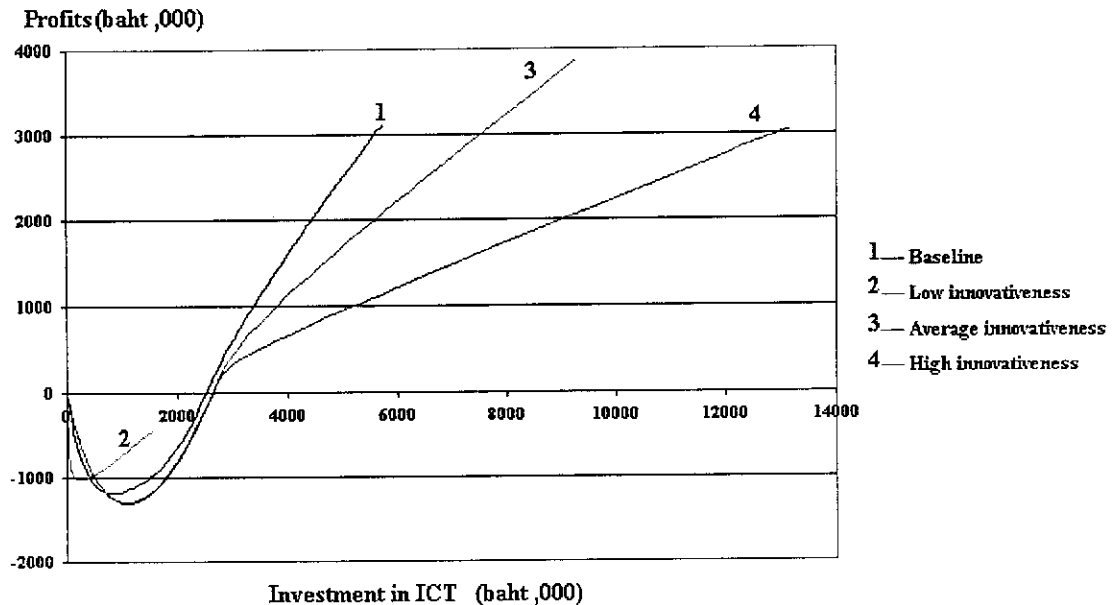


1. Baseline: Propensity to invest = 0.10 and percentage of spending profit on investment = 0.09
2. Propensity to invest = 0.01 and percentage of spending profit on investment = 0.01
3. Propensity to invest = 0.20 and percentage of spending profit on investment = 0.20
4. Propensity to invest = 0.50 and percentage of spending profit on investment = 0.50

Figure 8.22. Behaviour Sensitivity Test: Impacts of Level of Innovativeness on Profits

3. **Behaviour anomaly:** The ICT model attempted to detect anomalous features of model behaviour. Anomalies may conflict with the behaviour of the real system but are useful as a warning sign for users to prevent unexpected outcomes. The results in Figure 8.22 also indicated anomaly of the system behaviour because usually people intuitively perceive that a highly innovative organisation will gain large profits from technological investment. The results from Figure 2.23 further remind users that emphasising only profits may not be sufficient. They have to have a balance between technological investment and its economic returns. Although, profits from the scenario of “average innovativeness” are higher than those from the “baseline” scenario, the

investment under this scenario is higher also. Taking the economic life of technology, market potential, and other bank constraints into account, “the baseline scenario” can become a good option.



1. Baseline: Propensity to invest = 0.10 and percentage of spending profit on investment = 0.09
2. Propensity to invest = 0.01 and percentage of spending profit on investment = 0.01
3. Propensity to invest = 0.20 and percentage of spending profit on investment = 0.20
4. Propensity to invest = 0.50 and percentage of spending profit on investment = 0.50

Figure 8.23 Behaviour Anomaly Test: Impacts of Level of Innovativeness on Profits

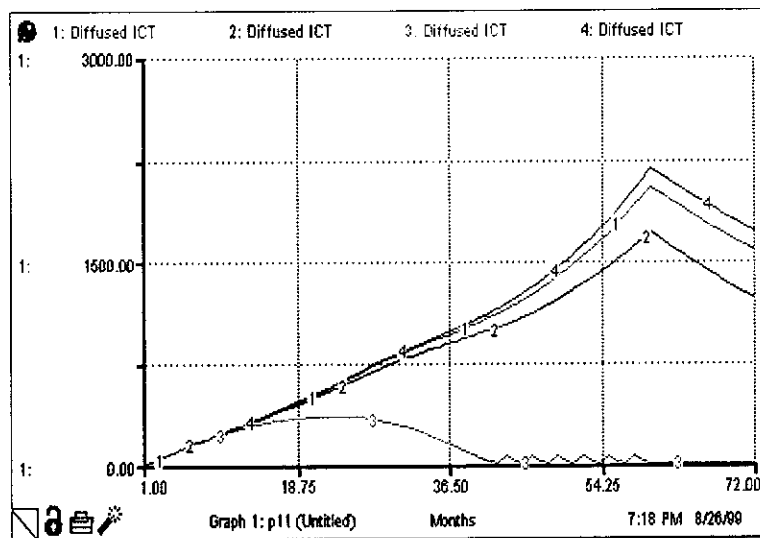
8.4.3 Policy Implication Tests

Policy implication tests were used to verify if the prediction from the ICT model in responding to policy changes corresponds with responses of a real system. The study employed two tests: changed-behaviour-prediction test and policy-sensitivity test.

1. **Changed-behaviour prediction.** The ICT model provided the correct predictions from the changing policies. For example, an increase in training support positively exerts leveraged impact on increasing the rate of technology

diffusion and economic gains.

2. **Policy sensitivity.** The ICT model allows users to test for policy sensitivity in any interested variables apart from those presented in this chapter in order to reveal the impacts of exerted policies and detect the risk from using those policies. The policy sensitivity is useful for the bank as a learning tool before implementing policies in the real system. The bank may try to increase the rate of technology diffusion by putting an emphasis on solving problems occurring during the diffusion process. If the bank does this it can be observed from the policy sensitivity analysis that this policy is not effective because the diffused technology does not increase substantially although the bank can solve the problems. However, if the bank neglects this policy by ignoring the problems accumulating during a diffusion process, technology may not be diffused in the long run (see Figure 8.24).



1. Baseline: Percentage of resolved problems = 0.80
2. Percentage of resolved problems = 0.50
3. Percentage of resolved problems = 0.00
4. Percentage of resolved problems = 1

Figure 8.24. Policy Sensitivity Test: Percentage of Resolved Problems on Profits

In effect, the model of ICT diffusion is valid not only because of its usefulness and its development based on the confidence-building process but also because of enough confidence in meeting the requirements of validity tests including structure validity,

behaviour validity, and tests of policy implications.

8.5 Requisite Group Model of ICT Diffusion, and Requisite Policies for Adoption and Diffusion: Research Questions 3 and 4

The requisite group model of ICT diffusion was initially developed by defining all the related issues of technology diffusion including problem definition, actors, process structures of the bank, and organisational boundaries to help decision-makers understand the problems and related issues of technology diffusion. Then, factors that may impact on the rate of technology diffusion were detected from the literature review to provide a holistic view of the system behaviour (Figure 8.3). However, only important variables perceived by the respondents of the bank were taken to develop the influence diagram (Figure 8.4) based on the qualitative system dynamics approach. The influence diagram illustrating the inter-relationships among variables was then quantified based on the quantitative system dynamics approach using data from the bank. The results from the ICT diffusion model revealed that the ICT diffusion follows the s-curve (Figure 8.16a) and reported important factors that impact on technology diffusion. Firstly, training support increases diffused technology and economic gains whereas a backlog of problems reduces them. Second, despite successful diffusion, the market potential limits economic returns from technological investment. Third, it is vital to balance the desired technology investment against its prospective returns because excessive investment does not assure highly lucrative outcomes. Fourth, substantial technology investment is a prerequisite for gaining returns on the investment.

The model of ICT diffusion developed based on the above process provided the answer for the third research question, “*what is a requisite group model of ICT diffusion?*” The model was justified as a requisite group model (Phillips, 1988) because it provides enough information for a group of decision-makers in the bank to understand the problems and make appropriate decisions to diffuse ICT productively. The requisite policies for adoption and diffusion of ICT for the bank, that is, the fourth research question, are “training support”, “a backlog of problem”, “market potential”, and a “level of investment”. These strategic policy factors can be employed to enhance the level of technology diffusion.

The requisite group model of ICT diffusion enables bank officials to understand the present state and constraints of technology diffusion, and then apply the model to particular technologies. Since each technology may have unique properties, the model of ICT diffusion will be elaborated highlighting two different diffusion processes of a data warehouse and Extranet banking. A data warehouse is diffused to end-users in an organisation whereas Extranet banking is assimilated to bank customers. The diffusion models of the two technologies will provide more understanding and clearer answers for the third and fourth research questions.

8.6 Summary

This chapter presented the model analyses of diffusion of information and communication technologies (ICT) using system dynamics methodology and the data from the Siam Commercial Bank. The ICT model investigated the following issues. First, training support has the potential to accelerate the rate of technology diffusion and economic gains whereas a backlog of problems hinders them. Second, market potential constrains an increase in economic returns although technology is successfully diffused. Third, it is important to determine the balance between the desired investment in new technology and its prospective outcomes because massive investment in new technology does not always bring a good return on that investment. Fourth, economic gains from new technology are obtained after an organisation has spent substantial resources on technology investment.

This model enables bank officials to better understand the present state and constraints of technology adoption and diffusion. This can be further used for policy analysis and forward planning to mitigate the constraints and re-design the system behaviours. Since existing and potential banking technologies are abundant, the model can be initially used to gain holistic understanding before applying any particular technologies or tailoring for specific organisations.

Apart from interview data, this proposed general model of ICT diffusion was based on the qualitative system dynamics approach and includes numerous variables based on the literature review. However, in reality, relatively few variables are taken into account by bank staff. Additionally, complete data are hard to obtain due to their physical properties (e.g. implicit, intangible and unclassified). Therefore, in the subsequent chapters this

general model will be elaborated into two specific technologies: data warehousing technology and Extranet banking and use only variables that the bank has considered in order to improve the model to fit with reality.

CHAPTER 9

ANALYSIS I : DIFFUSION OF A DATA WAREHOUSE AT SCB

9.1 Introduction

This chapter presents the model analysis of data warehousing technology using system dynamics methodology. A data warehouse was taken into detailed analysis because not only has the Siam Commercial Bank PCL invested massively in it but also because it was the technology most preferred by the sample group's intuitions.

A data warehouse, an analytical database providing massive information for competitiveness and decision support (Poe, Klauer, & Brobst, 1998), is a "hot" technology that many organisations are anxious to invest in order to make maximum use of their data. Since the critical success factors of this technology come from intensity of usage, technology diffusion is indispensable.

The Siam Commercial Bank PCL has introduced and implemented a data warehouse based on a customer management system since 1995, and expected completion in 1998. However, actual implementation was completed in 1999. The bank aims at using the data warehouse for decision-making support, enhancing effectiveness in

customer services, and utilising customers' data to gain competitive advantages from its rivals.

The bank executives perceived intuitively that a data warehouse was the most preferred technology that may fulfil the bank's mission of being "*the best managed bank [in Thailand] with sustainable excellent performance*". However, the information from current users showed a low rate of diffusion. For example, of the anticipated 200 users, only 54 revealed that they actually used it (The Siam Commercial Bank's staff, 1998b). Furthermore, factors that may hinder the diffusion of a data warehouse still exist. These include: lack of comprehensive understanding of the technology; insufficient training and assistance from IT people; receiving incorrect, incomplete and non-updated data; difficulty and time consuming for accessing and processing; and inconvenience of use due to the restrictions necessitated by the security system (The Siam Commercial Bank's staff, 1998b; 1998e).

This chapter presents a system dynamics (SD) model using the case of data warehouse diffusion. The model of diffusion of a data warehouse provides clear answers for the third and fourth research questions (*i.e. a requisite group model of ICT diffusion and requisite policies for adoption and diffusion of ICT for the bank*) by customising ICT to specific technology. The model undertaken was system dynamics because of its rigorous properties in capturing inter-relationships among variables and in handling dynamic aspects of the system behaviour. It was also developed based on the concept of decision support systems in order that decision-makers are able to use it as a learning tool to perform their strategic policy analysis. They may improve their decision-making processes via running sensitivity analyses, visualising the impacts of their decisions, detecting effective policies, and applying the model to other issues or scenarios using massive information from data warehousing technology.

This chapter is organised as follows. The first part presents general background of a data warehouse at the SCB. A conceptual model of data warehouse diffusion was formulated using the qualitative SD approach in the second part. Then, the conceptual model was quantified using the quantitative SD approach. Sensitivity

analysis was then undertaken to observe the impacts of dominant variables. The quantitative model in the third part was divided into two sub-models: a priceless model and an estimated price model. Finally, strategic policies were tested and simulated to detect the most leveraged ones that might speed up the rate of technology diffusion and thus accelerate economic returns on investment.

9.2 Methods of Data Collection

This study employed four methods of data collection including observations, interviews, questionnaires, and documents. Initially, a conceptual model of diffusion of data warehouse was developed based on extensive literature reviews. The model was used as a guide for data collection. It was then modified based on the data from the bank to adapt it to the specific case situation (validation). The details of data collection presented in Table 9.1 were already explained in Chapter 5.

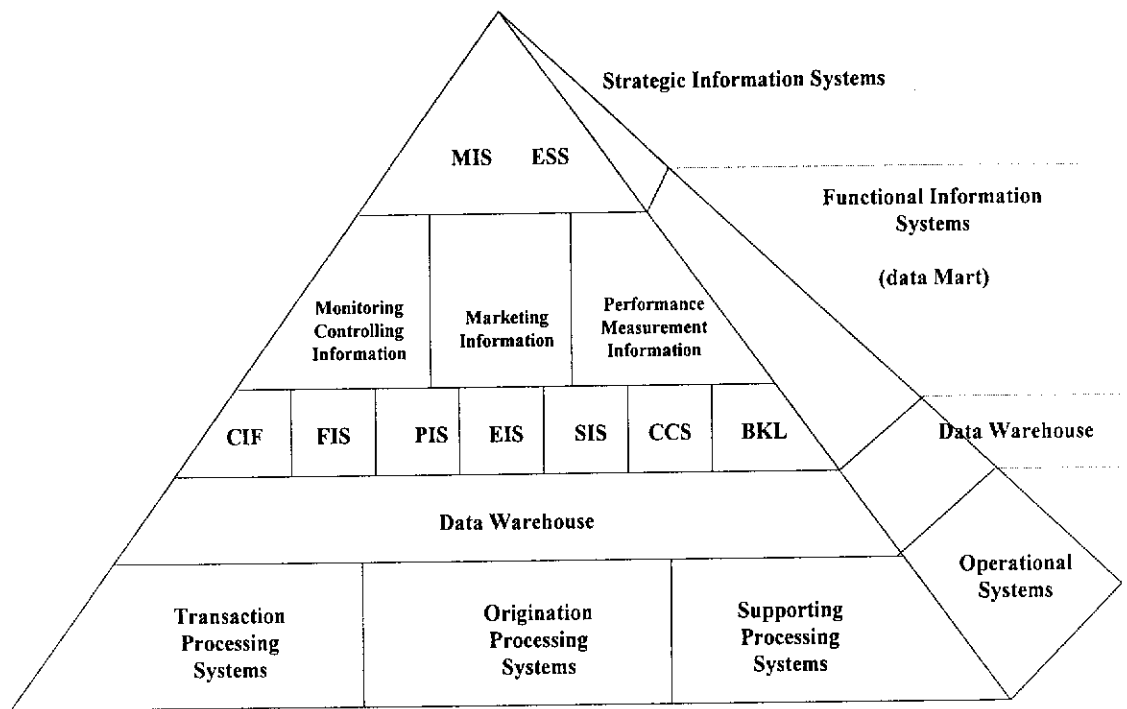
Table 9.1. Data Collection

Topic	No. of respondents	Method of data collection	Name of questionnaire/ interview	Purposes
1. Data warehouse	10 (people in charge)	Questionnaire, interview & document	"Data Warehouse"	- General background - Variables regarding the data warehouse
2. Prospective users of data warehouse	389 out of 500	Questionnaire	"Technology and Bank Staff"	Information regarding prospective users of the data warehouse
3. Data warehouse users	54 out of 200	Questionnaire & interview	"Data Warehouse Users"	Information regarding the perception of data warehouse users.
4. Policy analyses	16 (executives)	Questionnaire & Interview	"Policy Analysis"	Variables for policy analyses
5. Model validation	5 (executives)	Interview	"Model Validation"	Verifying the models

9.3 General Background

The Siam Commercial Bank PCL Indicates the importance of the data warehouse because data used for decision-making is vital for business performance. Additionally, the concept of a data warehouse accords with the vision of Dr. Olan Chaiprawat, the former president of the bank, who replaced the banking management system from account base to customer base (i.e. a Customer Management System-CMS). He believes that CMS supported by information from data warehousing technology will service customers more effectively than the traditional system. Apart from effectiveness in banking services, the bank may utilise customers' data (e.g. details and customer behaviours) for decision-making purposes, leading to gaining competitive advantages over its rivals.

At present, the bank employs many information systems to serve customers and facilitate internal management. The conceptual information technology of the bank is divided into four levels, operational systems, data warehouse, functional information systems, and strategic information systems (See Figure 9.1) (The Siam Commercial Bank PCL, 1995; 1997a; The Siam Commercial Bank's Staff, 1998c).



CIF = Customer Information System Facilities FIS = Financial Information Systems
 PIS = Personnel Information Systems EIS = External Information Systems
 SIS = Security Information Systems CCS = Credit Card Systems
 BKL = Blacklist Systems

Figure 9.1 Conceptual IT Structure of the Siam Commercial Bank

Source: (The Siam Commercial Bank PCL, 1997a)

- Operational systems are information systems, combining three sub systems, transaction, origination and supporting processing systems, and aimed at providing information to facilitate customer services and operational works with high efficiency. First, transaction-processing systems provide accurate and rapid data to serve numerous customers through deposit account systems, ATM, Tele Banking and loan systems. Second, origination-processing systems provide sufficient information within a short time for routine decision-making with respect to banking services including opening accounts and credit approval. Third, supporting processing systems support

internal banking management in order to furnish customers with data exchange such as electronic clearing systems and Intranet.

2. Data warehouse integrates all data from banking operational environments and many disparate bank databases to support Customer Management Systems (CMS) and provides data for versatile purposes in the future, especially marketing and strategic planning. Through its use, many advantages are anticipated, such as improved internal banking processes (paperless), minimised costs and time, increased sales through effective customer segmentation, targets and product strategies, more effective decision-making and capturing of business opportunities. These are expected to increase competitive advantages and sustainable growth. Once a data warehouse is fully implemented, bank officials around the country may access and analyse their required data directly by themselves without waiting for data and assistance from the head office. However, at present, only authorised users have access to the data warehouse due to the perceived need of the preservation of the bank's traditional image in terms of customer ethical issues and treatment of confidential information.
3. Functional information systems- combining monitoring and controlling, marketing, and performance information system- are the information systems that provide support for functional purposes. The monitoring and controlling information system provides data to control and monitor different types of jobs including clearing system (CLS) and financial information system (FIS). Marketing information system is employed to gain benefits from marketing. Performance information system provides data to measure performance or efficiency of customers, staff and services.
4. Strategic information systems are information systems that use data for decision-making and analysis such as Management Information Systems (MIS) and Executive Support Systems (ESS).

9.3.1 Clients of Data Warehouse

Clients of data warehousing technology come from specific users of this technology rather than general bank customers. Since clients are used as a proxy variable to indicate a rate of technology diffusion, the study divides clients into two states, prospective and current clients. The former are bank officials who are going to use the data warehouse in the future whereas the latter are the ones who were using it during the data collection phase of this study.

9.3.1.1 Prospective Clients

The "*Technology and Bank Staff*" questionnaire (Appendix 5.4) was distributed to the bank staff at the head office and branches. The respondent rate was 79.8 % (203 from the head office and 186 from the branches). This questionnaire aimed to detect the level of actual performance of presently available technologies based on bank staff's perceptions because they may be prospective clients of the data warehouse in the future. The weighting ranged from 1 to 7, whereby 7 indicated perfect performance for each issue. The levels of actual performance of banking technologies are indicated in Table 9.2 and Figure 9.2.

Table 9.2. Level of Actual Performance of Banking Technologies

Issues	Level of actual performance		
	Head office	Branches	Total
Understanding regarding banking technologies	4.32	4.16	4.24
Technological training from the bank	3.39	3.36	3.38
Acceptance in new technology	6.00	5.43	5.73
Technologies are easy to use	4.91	4.66	4.79
Satisfaction in using technology	5.77	5.41	5.60
Technological support from IT people	4.03	3.73	3.89
Technology provides advantages to you	6.05	5.61	5.84
Technology provides advantages to the bank	6.28	5.88	6.09
Involvement with IT people when the bank brings in new technologies	3.69	3.64	3.66
Understanding about a data warehouse	3.40	2.93	3.18
Acceptance in using a data warehouse	4.91	4.10	4.53
Satisfaction in using a data warehouse	5.28	4.52	4.92
A data warehouse provides advantages to the bank	5.62	4.79	5.23
A data warehouse provides advantages to you	5.43	4.61	5.04

Source: Data derived from "Technology and Bank staff" questionnaire, January 1998

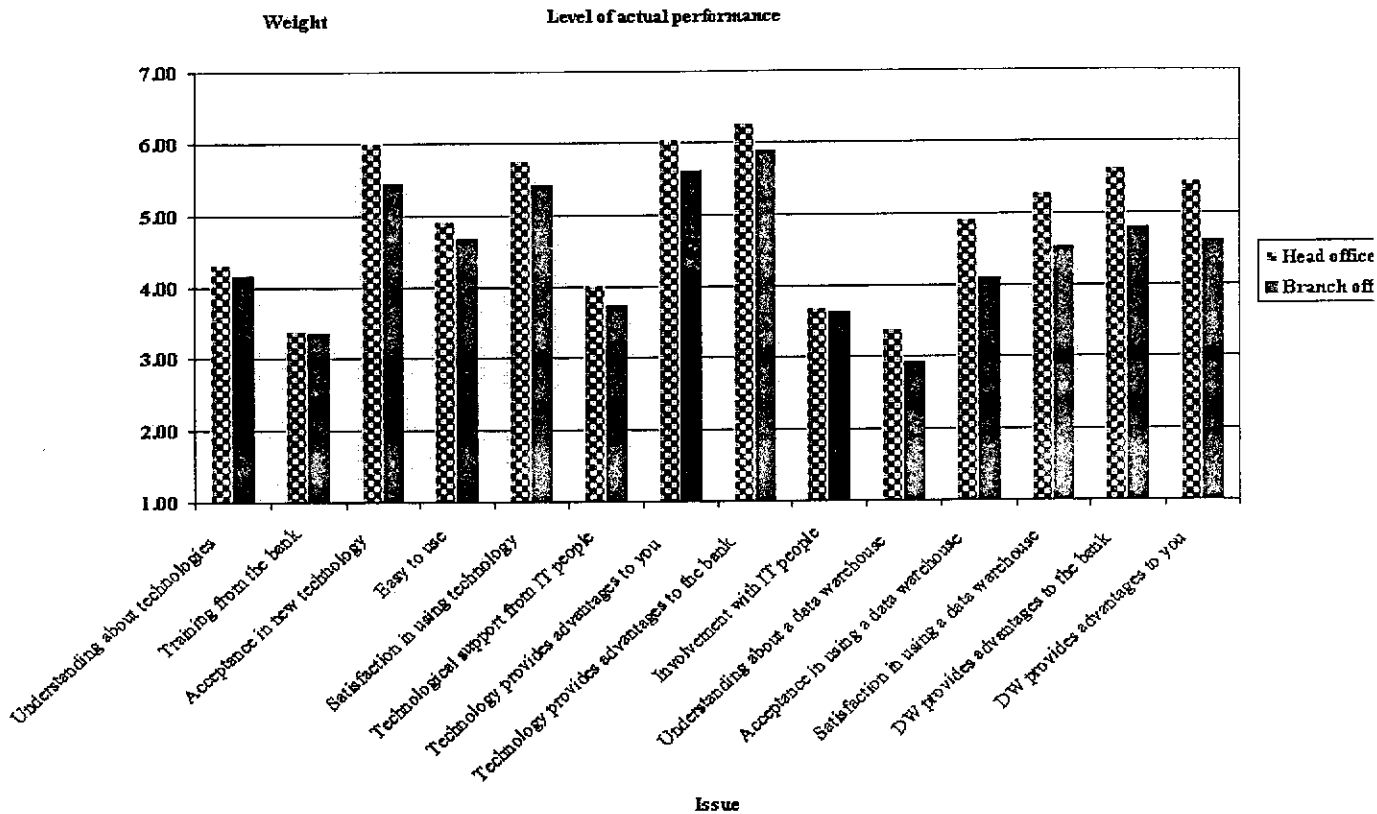


Figure 9.2. Level of Actual Performance of Banking Technologies

According to the above results, bank officials perceived that technologies provided advantages to the bank (6.09) and to themselves as well (5.84). Therefore, levels of acceptance of new technology and satisfaction in using technologies were high (5.73, and 5.60, respectively). Bank staff also perceived that the bank and themselves would gain advantages from the data warehouse (5.23 and 5.04). The results further identified that the level of understanding and knowledge about the data warehouse was still low (3.18). Bank staff perceptions indicated that there was insufficient technological training provided by the bank (3.38), that there were few chances to become involved with IT people when the bank adopts new technologies (3.66), and that sufficient technological support was lacking (3.89).

The comparison of levels of actual performance of banking technologies between bank staff at the head office and those at the branches (Figure 9.2) revealed that the

officials at the head offices were in better positions regarding technological issues than those from the branches.

It can be observed also from the questionnaire's results that some bank staff, especially ones from the branches, still did not comprehend a data warehouse. About 2.3 % of the respondents did not provide any answers with regard to data warehouse questions.

9.3.1.2 Current Clients

The "*Data Warehouse Users*" questionnaire (Appendix 5.5) was additionally developed to capture information about current users of the data warehouse due to insufficient data of current numbers of usage, perceptions of users and advantages from the data warehouse. The questionnaire was distributed to 23 departments which anticipating using this technology. The bank believed that there were 200 bank staff using this technology, as at January 1998.

There were two main obstacles in data collection using the "*Data Warehouse Users*" questionnaire. First, many target respondents did not know whether or not they were actually using the data warehouse because of many available databases in the bank. This implied that the data warehouse has not well advertised enterprise-wide. Second, the names of respondents were listed from the information provided by the Intranet system of the bank. After distribution, there were many phone calls complaining about incorrect names and positions. This indicated that updating information is a crucial task to gain advantages from databases and the data warehouse.

9.3.2 Level of Actual Performance of Data Warehouse

Data from the current clients revealed the real numbers of people who use this technology or think they are using it and, also the perceptions of current users as to the level of actual performance of the data warehouse. Although 200 bank staff were expected to be current clients only 54 people use the data warehouse. According to Table 9.3 and Figure 9.3, the current users accepted to use the data warehouse (5.50) and were satisfied in using it (5.41). They realised that the data warehouse provided

advantages for the bank (5.36) and for themselves (5.23). However, satisfaction as to the levels of training about the data warehouse by the bank and technical support from IT people was low (2.03 and 3.50 respectively). This may result in a low level of understanding about this technology (3.46) and negatively influence perceptions regarding ease of use (3.76).

Table 9.3. Level of Actual Performance of Data Warehouse

Issues	Level of actual performance
Training regarding a data warehouse from the bank	2.03
Data in a data warehouse meet your requirements	4.03
A data warehouse is easy to use	3.76
Problems occurring in using a data warehouse	4.78
Technical support from IT people	3.50
Understanding regarding a data warehouse	3.46
Acceptance in using a data warehouse in your work	5.50
Satisfaction in using a data warehouse	5.41
A data warehouse provides advantages to you	5.23
A data warehouse provides advantages to your organisation	5.36

Source: Data derived from “*Data Warehouse Users*” questionnaire, January 1998

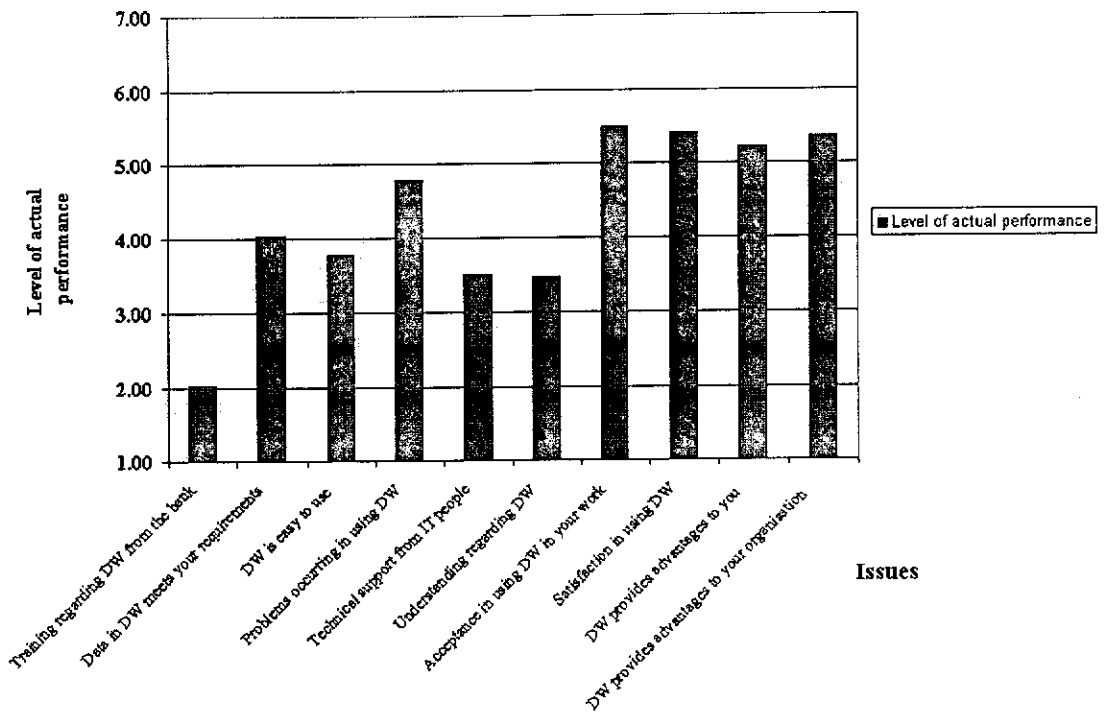


Figure 9.3. Level of Actual Performance of Data Warehouse

9.3.3 Relative Advantages from Data Warehouse

Despite many advantages expected from using a data warehouse, people in charge of this technology insufficiently indicated the explicit benefits due to the following three main reasons. First, IT people are only developers but not users. Second, many benefits are implicit and hard to quantify. Third, the data warehouse has not been completely implemented yet. Using the “*Data Warehouse Users*” questionnaire, current users perceived that the data warehouse provided the following benefits (Table 9.4 and Figure 9.4): accurate and timely information (82.14% of the responses); more effective decision-making (69.64%); improved access to information for loan underwriting (66.07%); increased performance efficiency (66.07%); improved access to information for internal management (58.93%); and improved access to information for strategic planning (55.36%).

Table 9.4. Relative Advantages from a Data Warehouse

Relative advantages	Number of responses	Per cent of responses
More accurate and timely information	46	82.14
More effective decision making	39	69.64
Improved access to information for loan underwriting	37	66.07
Increased performance efficiency	37	66.07
Improved access to information for internal management	33	58.93
Improved access to information for strategic planning	31	55.36
Capitalised on business opportunity	21	37.50
Mass customisation	16	28.57
Cost saving	0 8	14.29
Increased competitive advantage	0 7	12.50
Increased market share	0 5	8.93
Increased sales	0 3	5.36

Source: Data derived from "Data Warehouse Users" questionnaire, January 1998

Relative advantages from data warehouse

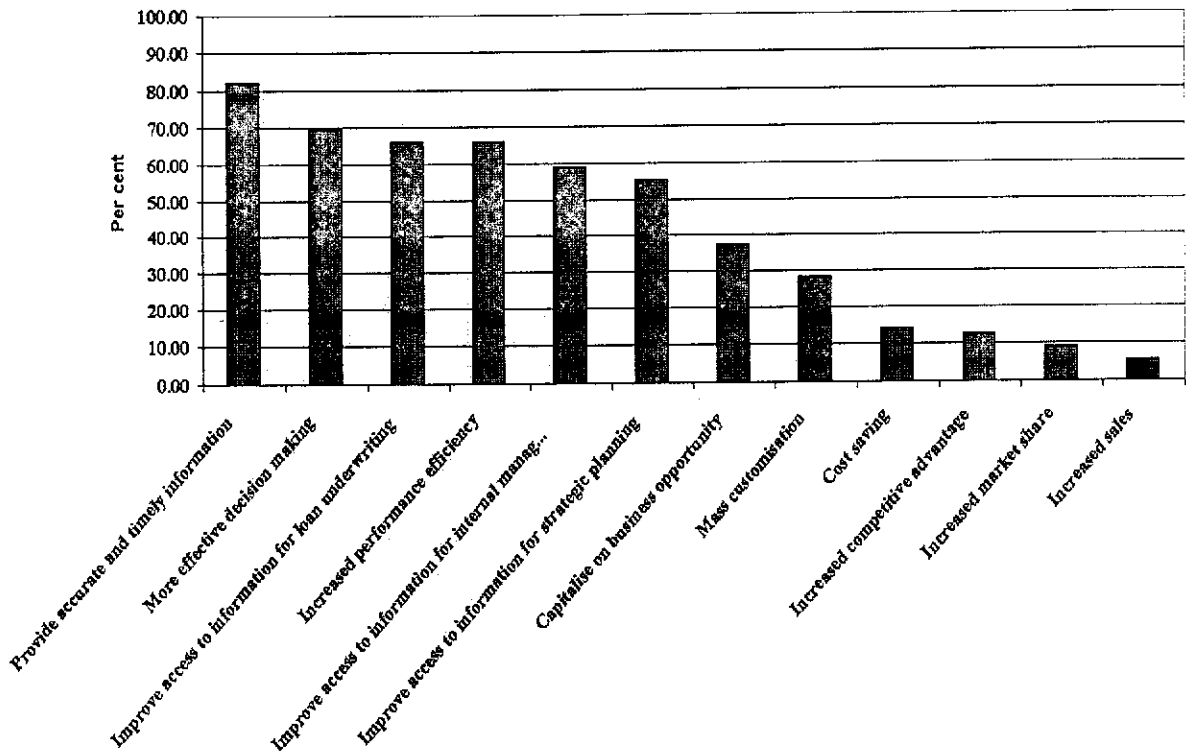


Figure 9.4. Relative Advantages from Data Warehouse

9.3.4 Problems in Using Data Warehouse

The following are problems that the users have confronted in using data warehousing technology (The Siam Commercial Bank's staff, 1998b; 1998c).

1. **Data warehouse concept.** Users revealed that they still lacked comprehensive understanding about the data warehouse (e.g. what is a data warehouse and what benefits can be gained from its usage).
2. **Technological support.** Training, advertising, user manuals and assistance from IT people was still insufficient. Respondents complained that they did not even know which departments were responsible for the data warehouse.
3. **Data issue.** Quite a few respondents commented that the data warehouse sometimes provides incorrect, incomplete and non-updated data. Data from

the data warehouse are inconsistent with other banks' databases and all bank products have not been put in the same database. Some complained that they could not get historical data or required data.

4. **Hardware issue.** Users reported that it was difficult to access the data warehouse and that its processing was complicated and slow. The system broke down quite often and when problems occurred, they could not be solved right away. They considered that the capacity of hardware was limited and network systems sometimes could not transfer data.
5. **Security issue.** The security system required that users have many passwords, change them quite often, and key log off every page, leading to inconvenience in using the data warehouse. It can be inferred from the questionnaire results that although the bank tries to protect itself from unauthorised users by assigning passwords, this can be bypassed and staff can still access data warehouse by borrowing passwords from their peers.

9.4 Model Analysis Using Qualitative System Dynamics Approach

The development of the conceptual model was based on the qualitative system dynamics approach (Wolstenholme, 1994). The model was divided into four stages: 1) basic concept, 2) present state, 3) identified constraints and 4) redesign of strategic policies. The basic concept depicted the main simple aspects of data warehousing technology in order to promote better understanding and communication with bank executives who do not have any background in system dynamics. The other three stages were developed based on the previous systems dynamics research (Coyle, 1996; Wolstenholme, 1994) using the data capturing from the bank staff and literature reviews.

9.4.1 Basic Concept

The basic conceptual model of the data warehouse (DW) is presented in Figure 9.5. The bank has invested in the data warehouse to gain relative advantages. The identified

advantages are accurate and timely information, more effective decision-making, increased performance efficiency, improved access to information (for loan underwriting, for internal management and for strategic planning), capitalised on business opportunities and mass customisation. These benefits prompt the bank to enlarge its technological investment. However, concurrently, the bank is confronted with constraints, either from the technology or its own readiness (e.g. levels of knowledge of bank staff, limitations of technology, and insufficient support from vendors). The constraints drain relative advantages and widen the gap between the desired and actual advantages, leading to a decrease in additional investment.

Two main loops (positive and negative) were depicted. The variables in the negative loop presented impediments to the bank in obtaining high leverage from its investment.

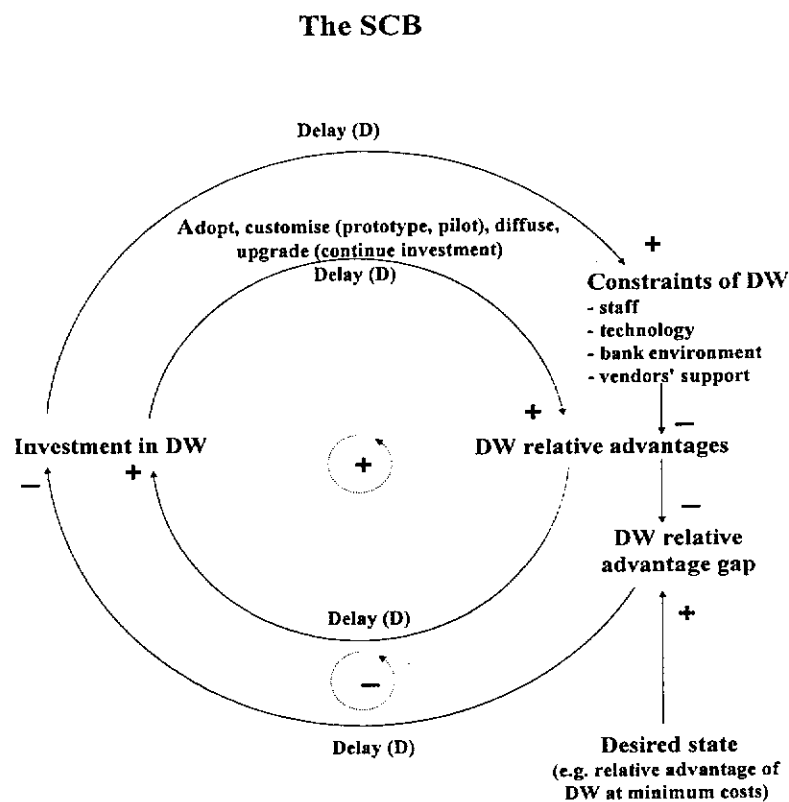


Figure 9.5. The Basic Conceptual Model of Data Warehouse

9.4.2 Present State of Data Warehouse

This stage defined organisational boundaries with regard to the diffusion of data warehouse of the bank into three sub-sectors: the bank- technology group as an agent of

change, bank staff, and vendors, and captured four feedback loops: A1, B, C, and E (as illustrated in Figure 9.6).

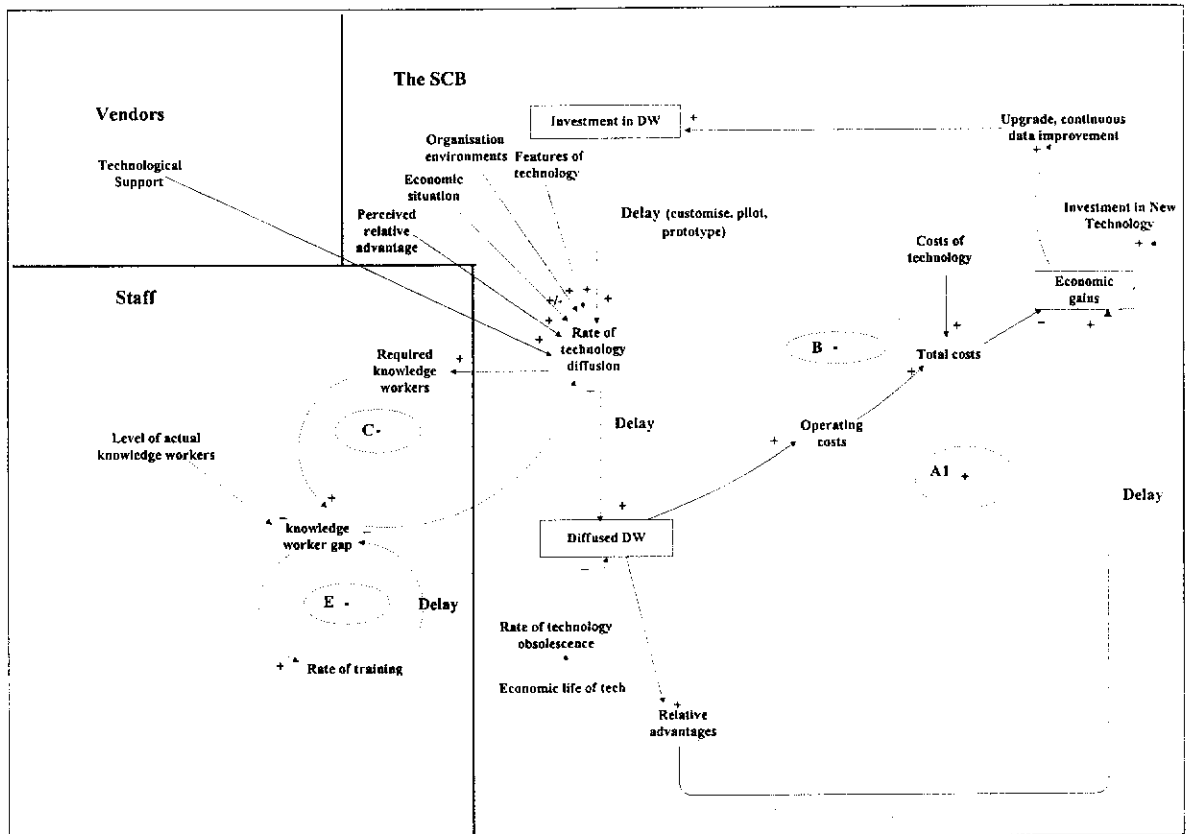


Figure 9.6. Conceptual Model: The Present State of Data Warehouse (DW)

Positive feedback loop A1. This loop works as follows. “Investment in DW” impels the bank to enhance the usage of this technology throughout the organisation. According to Fichman and Kemerer (1994), increasing returns due to technology adoption is an important factor that drives technology diffusion. Therefore, the relationship between “investment in DW” and “rate of technology diffusion” is positive, after some delay to realise the returns. In turn, it increases the stock of “diffused DW”. As previously explained, the rate of technology diffusion is contingent upon factors such as perceived relative advantages, technological support, economic situations, organisational environments and features of technology. Therefore, increased DW diffusion will increase the “relative advantages” of the bank (Gagnon & Toulouse, 1996; Herbig & Day, 1992; Manross & Rice, 1986; Preece, 1989).

The current users of the bank perceived that relative advantages from the data warehouse were accurate and timely information; more effective decision-making; improved access to information for loan underwriting, strategic planning, internal management; and increased performance efficiency (The Siam Commercial Bank's staff, 1998b). All these will add to the economic benefit of the bank. "Relative advantages" will then increase "economic gains", that subsequently induce additional technological investment (Wolstenholme, 1994). The diffusion process is a time consuming process; therefore, it takes time (delay) for the bank to diffuse technology and obtain economic gains.

It can be concluded from the feedback loop A1 that the more that the data warehousing technology is diffused, the more relative advantages and economic gains are obtained.

Negative feedback loop B. The cost of building a data warehouse is enormous and its diffusion process consumes excessive resources for purchase and operation (O'Sullivan, 1996; The Siam Commercial Bank's staff, 1998c). Costs of the data warehouse thus lessen the prospective "economic gains" from this technology. Negative feedback loop B indicates that costs from a data warehouse will decrease the expected returns from the previous loop.

Negative feedback loops C and E. Generally, diffusing information technologies demands an increase in the number of "required knowledge workers" (Bezdek & Jones, 1990). However, successful diffusion occurs when an organisation has sufficient "actual knowledge workers" and technical skills (Kwon & Zmud, 1987; Madu, 1989). The increased "required knowledge workers" subsequently widens the gap between the actual level of knowledge workers and those required. Since the gap hinders the diffusion process, the bank has to provide "training" or educational programs to bridge it (Madu, 1989; Manross & Rice, 1986).

Negative feedback loops C and E indicate that the bank has to balance the number of actual and required knowledge workers and provide appropriate training in order to compensate for insufficient knowledge workers.

9.4.3 Identified Constraints of Data Warehouse Diffusion

The present state of the conceptual model was expanded to identify the constraints. This state incorporated the customer sub-sector, and captured additional feedback loops: A2, F, G1, G2, H, I, and J (Figure 9.7).

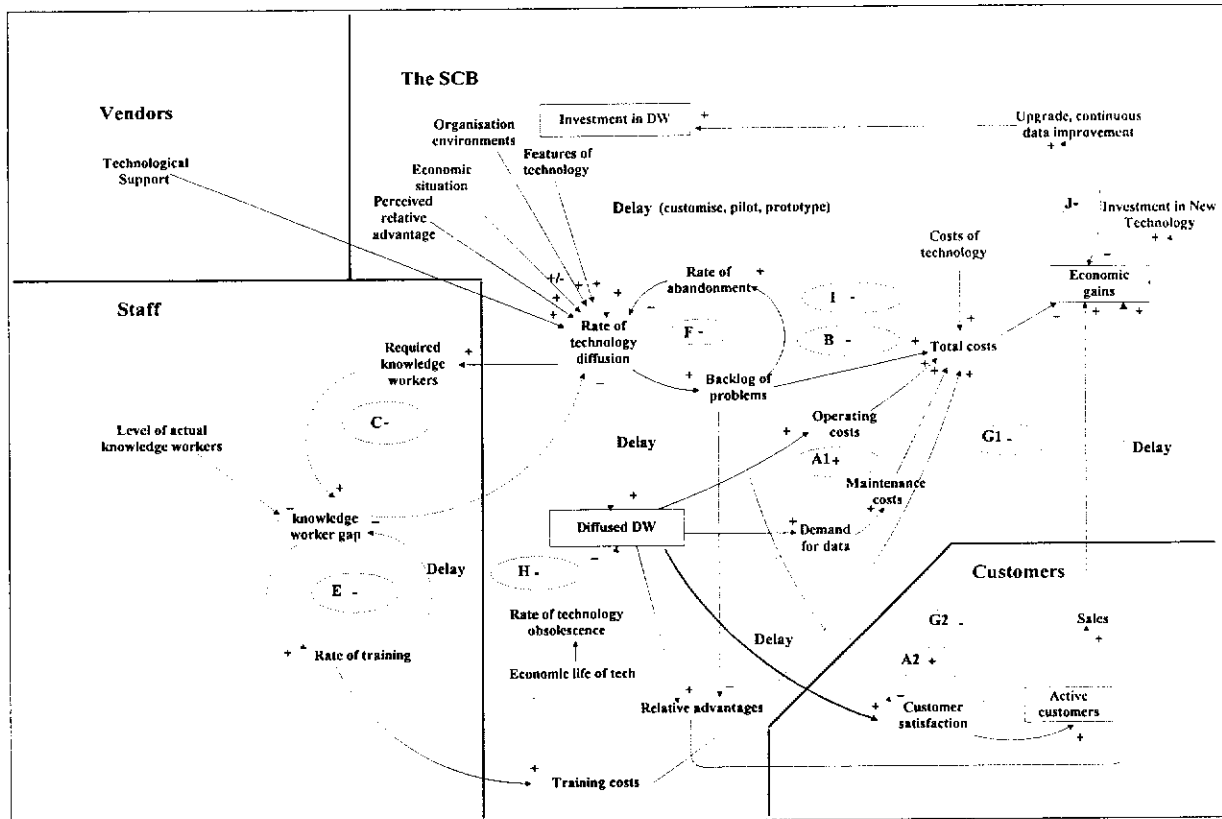


Figure 9. 7. Conceptual Model: The Constraints of Data Warehouse (DW)

Positive feedback loop A2. Although currently the bank does not highlight the direct effects of the data warehouse on bank customers, considered optimistically, the diffused data warehouse ultimately promotes “customer satisfaction” through tailoring services for individual customers’ needs (Kelly, 1994). That leads to an increase in “active customers” and “sales”, which then impacts the "economic gains" positively. The loop is then completed through the elements of loop A1.

Negative feedback loop F. The data warehouse also has the potential to increase “the backlog of problems” (e.g. providing incorrect, incomplete and non-updated

data, difficulty in access and processing, inconvenience in use) (The Siam Commercial Bank's staff, 1998b). These problems may increase the "rate of abandonment" of that technology and subsequently dampen the diffusion process.

Negative feedback loops G1 and G2. Once problems from technology are accumulated, they exert negative impacts on both relative advantages (Loop A1) and customer satisfaction (Loop A2).

Negative feedback loop H. Upgrading the quality and quantity of knowledge workers via training results in increasing "training costs" and thus decreases "economic gains" (Farr & Sullivan, 1996; Goff, 1999).

Negative feedback loop I. According to Madu, Kuei and Madu (1991), development of IT leads to a positive relationship with various related costs. The more the technology is diffused the higher and more various are the costs involved (i.e. training costs, operating costs, maintenance costs and costs from the backlog of problems).

Negative feedback loop J. Currently, there are increasing concerns regarding technology adoption and the overall gains in return for such investment, because high investment not only brings many advantages but also decreases profits (Takac & Singh, 1992; The Siam Commercial Bank's staff, 1998e). The variables in this loop indicate that excessive technological investment has the potential to decrease economic gains of the organisation.

9.4.4 Redesign of Strategic Policies

The strategic policies to diffuse data warehousing technology involve endogenous factors such as staff and bank environments. The bank considers bank staff as the direct clients of this technology. The actual customers of the bank are not taken into account because the mutual impacts are not concurrently conceived.

These policies comprise levels of training support, co-operation between information technology (IT) departments and knowledge workers, decreased perceived complexity, increased perceived relative advantages, top management support, increased positive

features of technology, and decreased training delays (The Siam Commercial Bank's executives, 1998).

1. **Training support.** Bank staff recommended that the bank provide knowledge regarding the data warehouse via user manuals or an Intranet system of the bank since staff are unable to attend every training program. Additionally, they considered that the bank should freely allow any bank staff interested in learning and getting information to access the data warehouse, because gaining relative advantages and increasing customer satisfaction rely very much on understanding and substantial effective usage (The Siam Commercial Bank's staff, 1998b).
2. **Co-operation between IT and users.** Since data warehousing technology is perceived as complicated, requiring versatile knowledge and tailor-made tools, end users tend to depend heavily upon IT people (The Siam Commercial Bank's staff, 1998c). Therefore, technological assistance, involvement in technological development, full understanding of users' requirements, close communication and follow-up are essential to IT staff.
3. **Decreased perceived complexity.** Currently, the data warehouse appears difficult to use. The bank tried to decrease these perceived difficulties by installing user friendly software applications to extract required data, perform queries and create reports. Additionally, a data catalogue is designed to illustrate available data in order that users can index data that might meet their requirements. It is believed that once end-users know how to get access to their required data easily, they will use the data warehouse regularly and develop their learning skills to maximise advantages from the available data (The Siam Commercial Bank's staff, 1998c).
4. **Increased perceived relative advantages.** If users feel that they gain relative advantages from the data warehouse in terms of convenience, efficiency and workload reduction, they would be pleased to use it voluntarily instead of compulsorily (Gagnon & Toulouse, 1996; Manross & Rice, 1986; Rogers, 1983; Wynekoop et al., 1992; among many others).

5. **Top management support.** Given the hierarchical nature of Thai society, and the conservative culture of the bank, top management support and direction is vital in convincing bank staff to increase efficiency of technology use (The Siam Commercial Bank's staff, 1998b; 1998c).
6. **Increased positive features of technology.** As previously mentioned, bank staff are still confronted with many technological issues in the data warehouse. First, problems regarding data integrity, incompleteness, redundancy and non-updated data are hard to avoid due to many database legacies. Second, the response time to retrieve, extract or transfer data is slow due to traffic jams in limited communication lines. Third, high security to protect the system from misuse by unauthorised people may reduce the convenience of usage or increase the complexity of the system. Thus, increased positive features of the technology (e.g. increased reliability, decreased response time and intensified security without added complexity) are vital for diffusing the data warehouse (The Siam Commercial Bank's staff, 1998b; 1998c). Positive features of technology will decrease the backlog of problems and create user-friendly circumstances in using technology, leading to a positive impact on customer satisfaction, and also a decrease in technology abandonment.
7. **Decreased training delays.** The bank provided training programs ranging in length from 1 day to 1 week. However, in practice, the training process may take a longer time due to a number of reasons. For example, on the one hand, it is difficult to bring together most staff who work in branch offices around the country for training because of the high costs, staff workloads and insufficient facilities. Setting suitable programs for them is also difficult because staff differ in technological backgrounds, require divergent types of information, and undertake differing job responsibilities. On the other hand, not only do the people in charge of technology have excessive routine workloads, but also too few of them have complete and comprehensive knowledge of the data warehouse. These hinder them in the effective provision of a wide range of training for the whole target group within minimum time. Consequently, although actual training time is short, time for

preparation and waiting for the trainers' availability is longer than expected. The training delays may impact on technology diffusion (The Siam Commercial Bank's staff, 1998b; 1998c). Therefore, the training delays may impact on technology diffusion.

The model was then redesigned by exerting the strategic variables into the defined constraints (Figure 9.8).

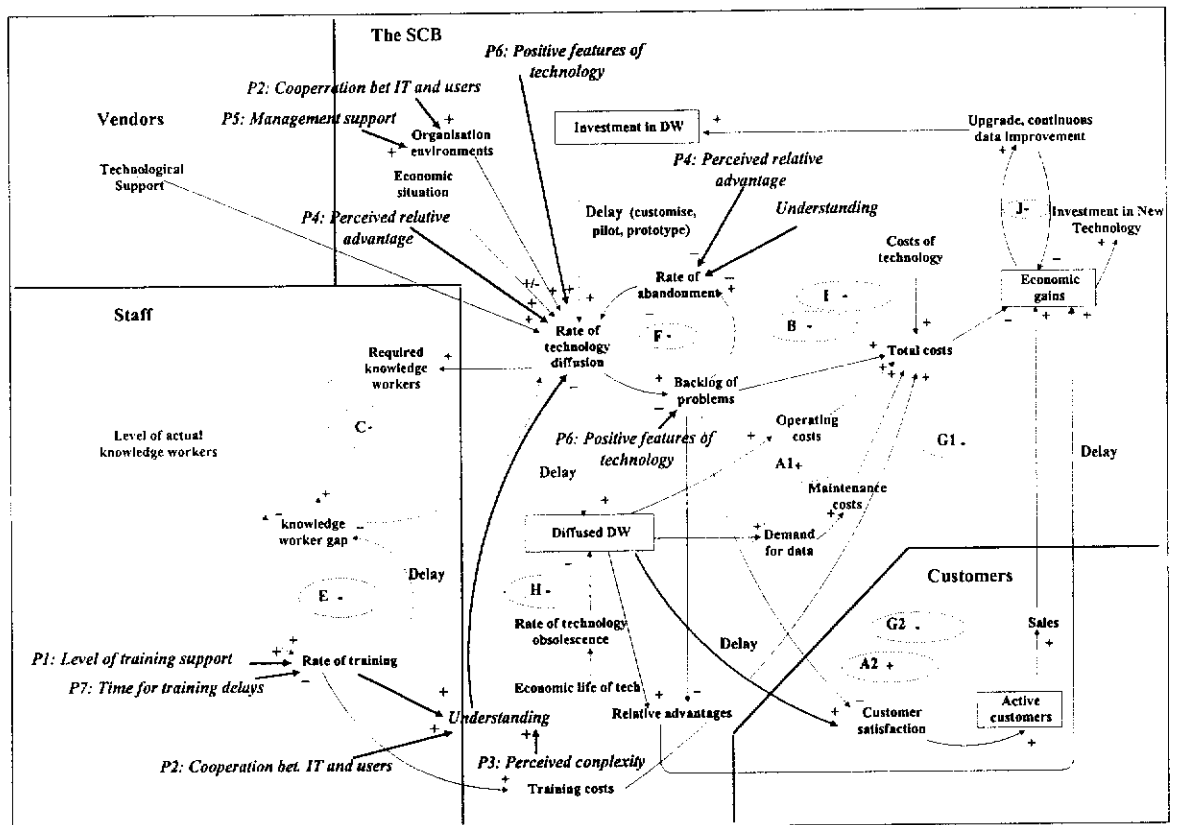


Figure 9.8. Redesigned Strategic Policies of Data Warehouse

The seven strategic policies mentioned were exerted with an expectation that they might enhance technology diffusion and successively have a positive impact on economic gains. The level of understanding was increased by the rate of training, *co-operation between IT people and users* and *decrease in perceived complexity*. The training rate is driven from providing high level of training support and eliminating obstructs in training in order to decrease *time for training delays*. If users, who are supported by sufficient and effective training, gain *understanding* about the technology and positively *perceive relative advantages* in using it, the rate of technology abandonment will decrease and

then the rate of technology diffusion will accumulate. *Positive features of technology* not only resolve the backlog of problems but also increase percentage of usage. Strategic policies such as *perceived relative advantages, co-operation between IT and users* and *management support* also support an increase in percentage of usage leading to increased diffused technology.

However, the qualitative system dynamics (Figure 9.8) lacks the capability to produce the final outcomes of each or combined variables precisely and conclusively, because a variable or strategic policy not only produces intended impacts in one loop but also creates negative unintended impacts on other loops. The positive and negative impacts may cancel out each other, or one may have more influence than the others. For example, if the bank promotes the training support policy, increased positive economic gains both from sales and other relative advantages may be expected. However, tracing through the total feedback loops in the model, this policy would increase training costs, promote demand for sophisticated and various data, and accumulate the backlog of problems. These lead to decreasing staff and customer satisfaction and ultimately reduced economic gains.

As qualitative system dynamics fails to visualise the holistic impacts of interactive feedback loops, the qualitative system dynamics analysis was quantified and simulated according to the quantitative system dynamics approach.

9.5 Model Analysis Using Quantitative System Dynamics Approach

While qualitative system dynamics exposes the first-degree impacts of the policies, it fails to analyse the higher degree impacts of interacting feedback loops. Therefore, the qualitative system dynamics analysis and these strategic policies were simulated and quantified based on the quantitative system dynamics approach to detect the most effective policy that helps the bank diffuse this technology productively. The model analysis was divided into two sub-models: a price-less model and an estimated price model. Sensitivity analysis was also carried out to identify the influential variables.

9.5.1 List of Variables of Data Warehouse

The variables from this study initially derived from literature reviews. Then, data from interviewing key persons and questionnaires were collected to obtain data specific to the Siam Commercial Bank PCL. Table 9.5 illustrates the list of variables of the data warehouse from both personal interviews and questionnaires.

Table 9.5. Lists of Data Warehouse Variables

Name	Initial Data	Value used in <i>think</i> simulation
Adoption and diffusion		
1.1 Rate of investment	Baht 10 million per year.	10 million
1.2 Total investment in technology	Baht 30-50 million	Initial value for investment in DW 50 million Cost of technology = baht 50 million
1.3 Rate of technology diffusion	Number of regular users per month	From simulation
1.4 Diffused data warehouse	Numbers of users = 54, from 23 departments	Initial number of unskilled workers = 54
1.5 Investment in new technology/ year	Baht 500 – 1,000 million 9% of the bank expenditure	0.09 per year
1.6 Backlog of problems (Level of problems occurring in using DW)	12 % per year	0.12 per year
1.7 Resolve problem fraction	0.80	0.80
1.8 Rate of technology abandonment	3% per year	0.03 per year
Features of technology		
2.1 Reliability	Level of actual performance = 5.00	0.71*
2.2. Security	Level of actual performance = 5.57	0.80*
2.3 Ease of use	Level of actual performance = 4.50	0.64*
2.4 Observability	Level of actual performance = 4.29	0.61*
2.5 Quick response time	Level of actual performance = 4.00	0.57*
Bank environments		
3.1 Management support	Level of actual performance = 6.14	0.88*
3.2 Co-operation between IT and users	Level of actual performance = 4.48	0.64*
Customer behaviour		
4.1 Customer acceptance	Level of actual performance = 4.00	0.57*
Staff		
5.1 Required knowledge workers	6,000	6,000
5.2 Level of actual knowledge workers	200	200
5.3 Level of technical training from the bank	Level of actual performance = 3.00	0.43*
5.4 Level of understanding in using technology	Level of actual performance = 2.57	0.37*
5.5 Staff acceptance	Level of actual performance = 3.57	0.51*
5.6 Perceived complexity	Level of actual performance = 3.14	0.45*
5.7 Perceived relative advantages	Level of actual performance = 4.48	0.64*

Name	Initial data	Value used in <i>ithink</i> simulation
Relative advantages		
6.1. Provides accurate and timely information	Level of actual performance = 6.25	0.89*
6.2 More effective decision making	Level of actual performance = 6.50	0.93*
6.3 Improves access to information for loan underwriting	Level of actual performance = 4.50	0.64*
6.4 Increased performance efficiency	Level of actual performance = 4.25	0.61*
6.5 Improves access to information for strategic planning	Level of actual performance = 5.25	0.75*
Cost		
7.1 Costs of technology	Baht 50 million	Baht 50 million
7.2 Training costs	Baht 1,000	Baht 1,000
7.3. Operating/ Maintenance costs	Baht 10 million /year	Baht 10 million /year
7.4 Costs from backlog of problems	Baht 600	Baht 600
Time		
8.1 Time for approval	Less than 1 month	1
8.2 Time for customisation	6 months	6
8.3 Time for prototype/pilot project	Months	12
8.4 Time for training staff	From 1 week to 1 year	12
8.5 Economic life of technology	3 up to 4 years	60 months
Marketing		
9.1 Advertising	Level of actual performance = 4.14	0.59*
9.2 Positive word of mouth	Level of actual performance = 4.71	0.67*
Vendors		
10.1 Technical support	Level of actual performance = 3.54	0.51*
10.2 Promotion effort	Level of actual performance = 5.43	0.78*

Note * Level of actual performance was converted to 0-1 scale

9.5.2 Model Analysis 1: A Price-Less Model

The *price-less model* is defined as a model that highlights only the process of technology diffusion without dealing with variables related to costs and benefits of this technology (Intrapairot & Quaddus, 1999a). Costs and benefits of the data warehouse were not taken into account due to the following reasons.

1. Costs of the data warehouse are combined with other costs of technologies in the bank. For example, the bank buys computer hardware not only for specific use of the data warehouse but for other operational systems as well. Similarly, operational costs, maintenance costs and costs from resolving the backlog of problems are mingled with costs of other databases and computer systems of the bank. Therefore, although the top executive managers were

pleased to provide these kinds of data, they did not know the precise figures involved. On the other hand, persons in charge hesitated to give data because it was hard even for them to itemise the specific costs spent only for the data warehouse and because they were inclined to treat all the organisational data confidentially.

2. Given this confidentiality, the only data made available to this research was that the bank has spent about baht 30-50 million on the cost of technology and baht 10 million per year on operation and maintenance.
3. Benefits from the data warehouse are implicit and hard to quantify due to the features of the technology itself and its as yet incomplete implementation. The only data available was the perceptions of the end users that this technology provided benefits for them.
4. Bank executives seemed to be interested in benefits in kind from the technology, such as supporting an organisation's learning concepts, gaining opportunities in the future, and maintaining a high profile as innovative leaders rather than merely in monetary benefits. Furthermore, although the technological investment seems expensive it is trivial when compared with the overall profits of the bank. Therefore, the bank is willing to spend money to trial any promising technology because if it works successfully, the bank may benefit in the long run or otherwise just simply gain positive experience in learning new technologies and developing human resources (The Siam Commercial Bank's staff, 1998e).

Thus, in order to make the model realistic and not manipulate the data, a *price-less model* was initially developed for the purpose of investigating the outcomes of the inter-relationships among variables such as the rate of technology diffusion, diffused data warehouse, staff as technology clients, and training.

The price-less model incorporated only two system boundaries, the bank and its staff (Figure 9.9). The model analysis carried out three simulations, beginning with capturing two main feedback loops relating to training (Loops C and E) in

Simulation 1. Then, the backlog of problems (Loop F) and economic life of technology were added in Simulations 2 and 3. The full model is presented in Appendix 9.1.

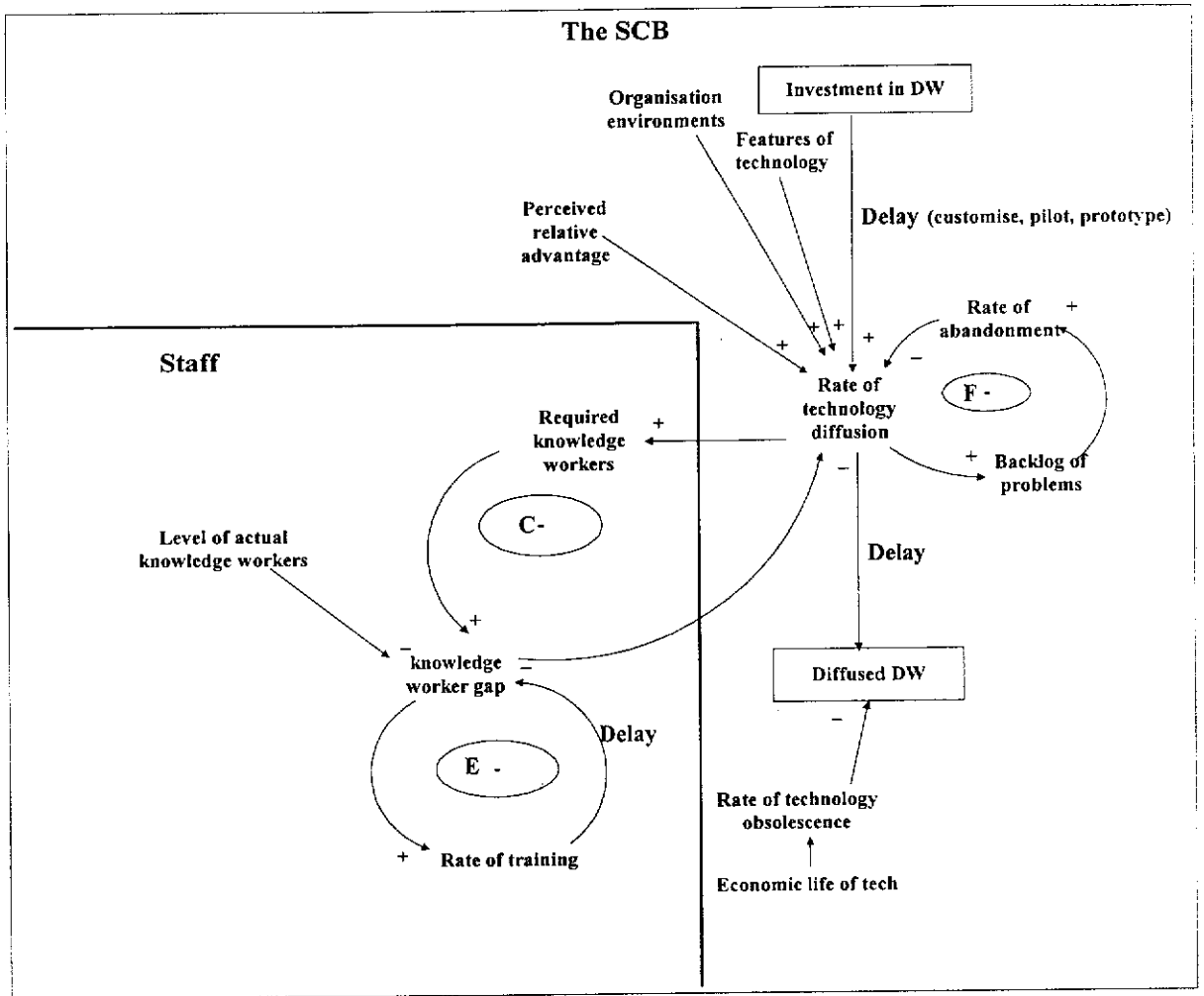


Figure 9.9. Influence Diagram of a Price-less Model

Simulation 1- Training as Transforming Device for Technology Diffusion

The influence diagrams in Figure 9.9 and the data derived from interviews and questionnaires were transformed to a simulation diagram in Figure 9.10 using *ithink* software (Richmond, Peterson, & Charyk, 1994).

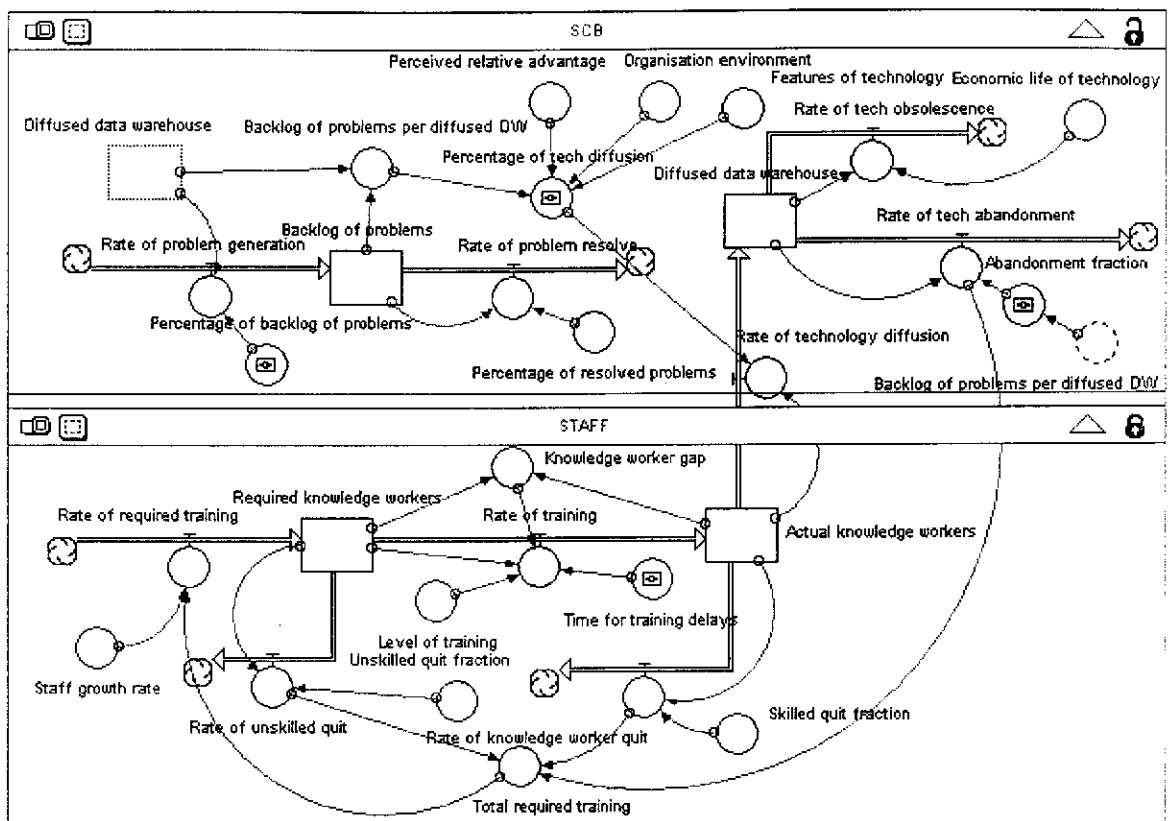


Figure 9.10. Simulation Model of the Price-less Model

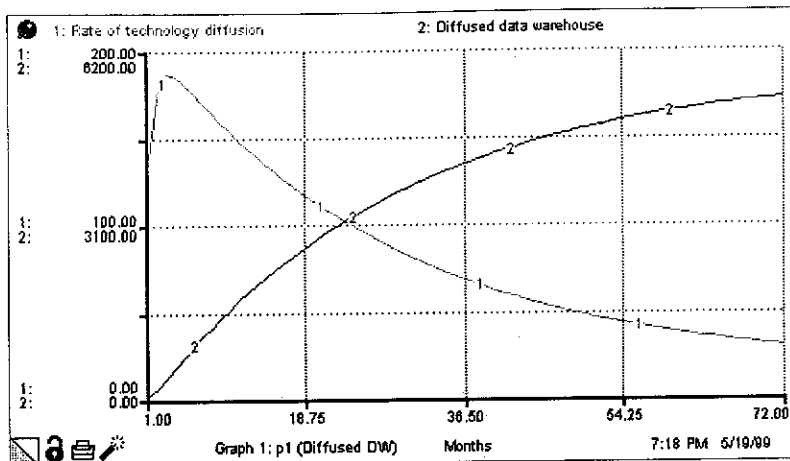
As shown in Figure 9.10 the diffusion process began with the objective of transforming unskilled workers or “required knowledge workers” to “actual knowledge workers” via “a rate of training”. After training the “actual knowledge workers” were considered as a proxy variable for “diffused data warehouse” if they used the technology regularly. This simulation model captured three main variables.

1. **Required knowledge workers.** The initial number of required knowledge workers was set at 6,000. The bank ideally aims to diffuse the data warehouse to almost all of the bank staff, approximately 13,000, yet not all are expected to use it. Therefore, the analysis assumed that only half of them were required clients (The Siam Commercial Bank's staff, 1998c).
2. **Actual knowledge workers.** There were 200 knowledge workers from 23 departments using the technology. Thus, the initial number of knowledge workers was set at 200. “Required knowledge workers” who attend training

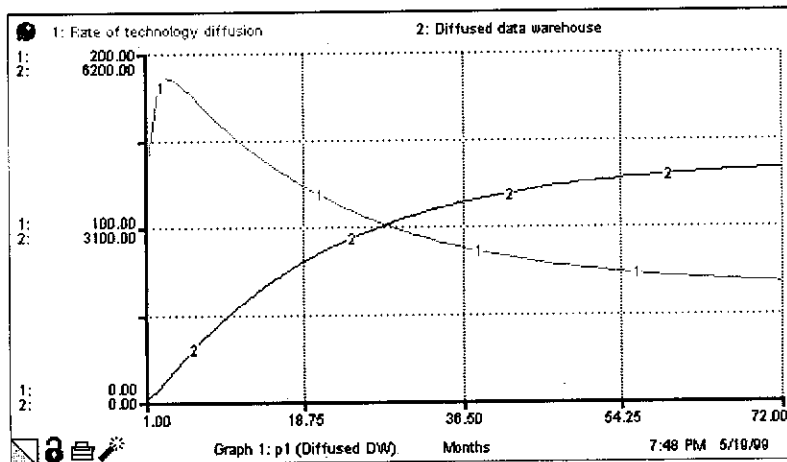
courses would be accumulated as “actual knowledge workers”. The rate of training was determined by two main variables: “levels of training” and “training delays”. The level of training from the bank was a low 0.40. Furthermore, since bank officials differed in background, experience and job responsibility, it took time to provide training for them. The analysis used 12 months as the period for training delays (The Siam Commercial Bank's staff, 1998c; 1998e).

3. **Diffused data warehouse.** Knowledge workers were considered as “diffused data warehouse” if they were regular users. According to the questionnaire data, only 54 knowledge workers out of the expected 200 currently used the technology (The Siam Commercial Bank's staff, 1998b). Parameters that impact on the rate of technology diffusion were “features of technology”, “organisation environments” and “perceived relative advantages”. The variable of “technical support from vendors” was omitted because the data warehouse was developed in-house with little support from vendors. Although the variable termed “economic situations” was perceived as an important factor, it was excluded because the bank staff could not quantify its value.

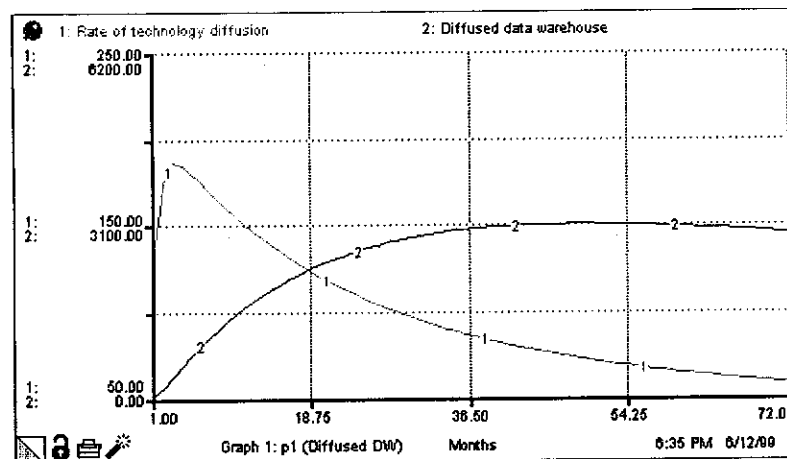
The results in Figure 9.11 revealed that data warehousing technology was diffused rapidly during the first five periods. Then the rate of technology diffusion diminished. The rate of technology diffusion remained low. Although the diffusion process was compulsory as directed by bank executives, the bank was not actually ready for diffusing the technology because of the low level of training (0.40), low perceived relative advantages (0.64) and time delays for training (12 months). The simulation 1 revealed that the bank accrued only 5,123 users for diffused technology out of the diffusion target of 6,254 users within 60 time periods, due to leakage (i.e. numbers of people quitting the bank, neglecting usage after training, and abandoning it after a short period of time).



a. Simulation 1: Training as Transforming Device for Technology Diffusion



b. Simulation 2: Adding the Backlog of Problems



c. Simulation 3: Adding Economic Life of Technology

Figure 9.11. Diffused Data Warehouse from the Price-less Model

Simulation 2: Adding the Backlog of Problems

The backlog of problems (Loop F in Figure 9.9) was added to the simulation. According to developers of the data warehouse, the percentage of the backlog of problems was 12 per cent per year (The Siam Commercial Bank's staff, 1998c). The result in Figure 9.11b revealed that the diffused data warehouse was lower than that of Figure 9.11a of Simulation 1 because the impact from the backlog of problems lead to an increased rate of technology abandonment and decreased percentage of technology diffusion.

Simulation 3: Adding Economic Life of Technology

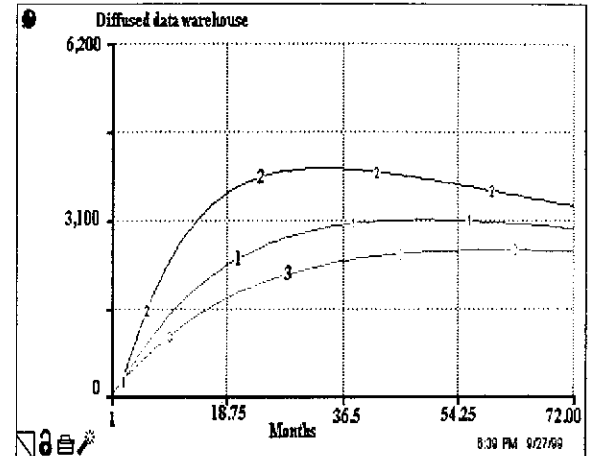
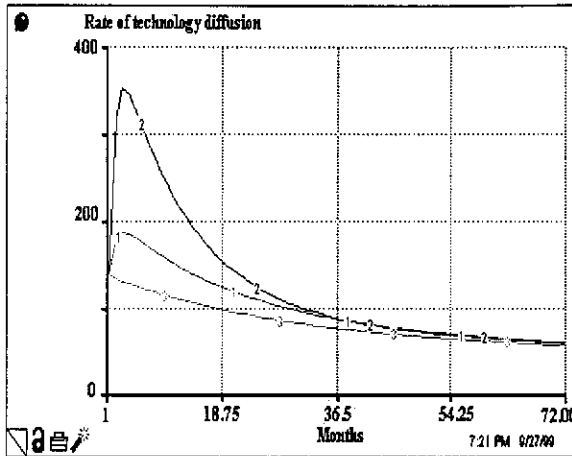
All technologies become obsolete after a time (Quaddus, 1996). The rate of technology obsolescence impacts on technology diffusion especially when that time is close to the economic life of the technology. The economic life of the data warehouse was anticipated at five years (The Siam Commercial Bank's staff, 1998c). The result in Figure 9.11c revealed that the diffused data warehouse decreased dramatically when the time became closer to its economic life (60 months). Apart from technology abandonment, technology obsolescence also drains the diffused technology because technology is insufficient or no longer fulfils users' requirements.

9.5.3 Sensitivity Analysis

Sensitivity analyses were undertaken in order to observe the impacts of variables on the diffused technology. Four variables, including training delays, percentage of the backlog of problems, percentage of resolved problems, and percentage of technology abandonment were considered as possibly impacting on the diffusion process. The sensitivity analyses provide some expected and unexpected results, which the bank executives can use for policy planning.

Sensitivity Analysis 1: Training Delays

According to the previous strategic policy analysis, a decrease in training delays may substantially boost the rate of technology diffusion in the initial periods.



a: Rate of Technology Diffusion

b: Diffused Data Warehouse

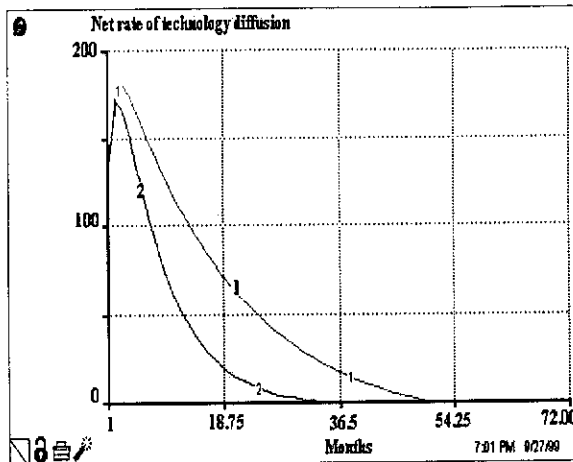
1. Baseline: Time for training = 12 months
2. Time for training = 6 months
3. Time for training = 18 months

Figure 9.12. Comparison of Diffused Data Warehouse using Different Training Delays

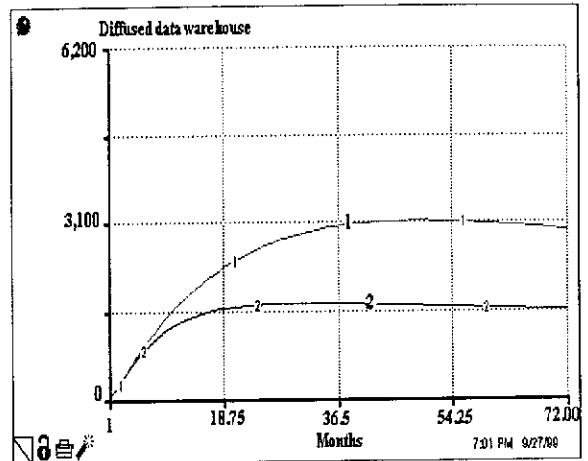
The simulation in Figure 9.12 indicated that the level of technology diffusion was contingent upon training delays initially. However, with time the users gain enough expertise and the eventual diffusion is not significantly different due to the different training time. This provides an important message to the planners of the bank.

Sensitivity Analysis 2: Percentage of the Backlog of Problems

The backlog of problems such as incorrect and non-updated data, difficulty in accessing and processing, and slow speed of response time, may lead to reluctance in using the technology.



a: Net Rate of Technology Diffusion



b: Diffused Data Warehouse

1. Baseline: percentage of the backlog of problems = 12% per year
2. Percentage of the backlog of problems based on users' perceptions = 68% per year

Figure 9.13. Comparison of Diffused Data Warehouse using Different Percentage of the Backlog of Problems

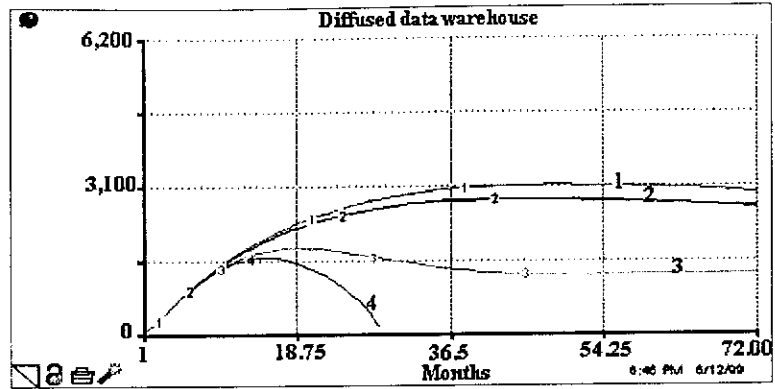
Based on the data from the technology developers, the percentage of the backlog of problems was 12 per cent per year, which was used as a baseline simulation (The Siam Commercial Bank's staff, 1998c). However, according to users in the bank, perceptions of the level of problems occurring in using the data warehouse were rather high, at 4.78 out of 7 (i.e. 68%) (The Siam Commercial Bank's staff, 1998b). Therefore, data from the two sources were simulated in order to observe the impact of percentage of the backlog of the problems. The results in Figure 9.13 revealed that the high percentage of the backlog of problems significantly impacts the diffused data warehouse and the net rate of technology diffusion (i.e. the rate of technology diffusion minus the rate of technology abandonment and the rate of technology obsolescence).

Sensitivity Analysis 3: Percentage of Resolved Problems

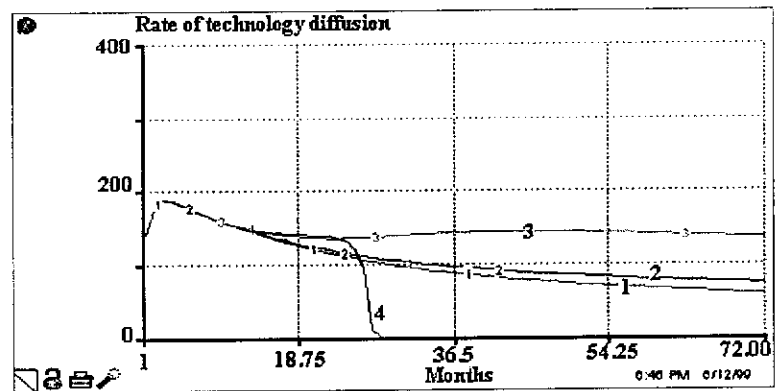
When problems are accumulating, an organisation has to find ways to resolve them in order to retain users' satisfaction and prevent further negative consequences. According to the bank's technology developers, they were confident that they could solve all the

problems within a short time, the expected percentage of resolved problems being approximately 0.8 (solve the problems with some delays) to 1 (The Siam Commercial Bank's staff, 1998c). However, users still complain about the low percentage of resolved problems or delay times for problem solving (The Siam Commercial Bank's staff, 1998b).

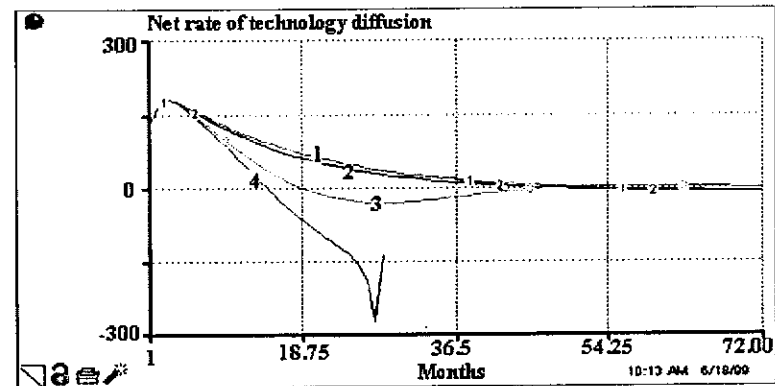
The simulation was undertaken using four percentages of resolved problems: 0.8, 0.5, 0.1 and 0. The results from simulations in Figure 9.14a confirmed that percentage of resolved problems affected the diffused data warehouse significantly because the unsolved problems increased the backlog of problems. According to Figures 9.14b and c, although the rates of technology diffusion increased, the net rate of technology diffusion decreased because of high abandonment of technology use. Particularly if an organisation cannot solve the problems (i.e. the percentage of resolved problems is 0), the diffused data warehouse and the rate of technology diffusion (Figures 9.14 a and b) equals 0 at the period 28 because they are drained by the high rate of technology abandonment.



a: Diffused data warehouse



b: Rate of Technology Diffusion



c: Net rate of Technology Diffusion

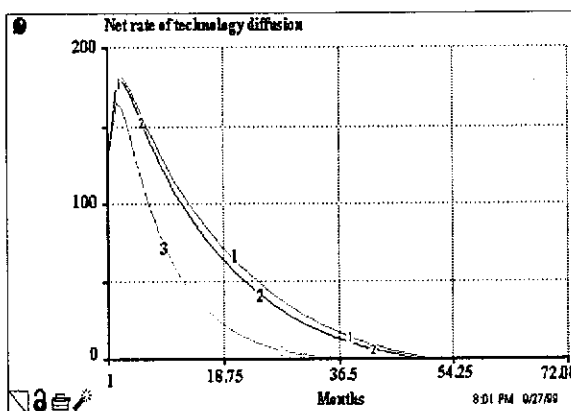
1. Baseline: Percentage of resolved problems = 0.8
2. Percentage of resolved problems = 0.5
3. Percentage of resolved problems = 0.1
4. Percentage of resolved problems = 0.0

Figure 9.14. Comparison of Diffused Data Warehouse using Different Resolution of Problems

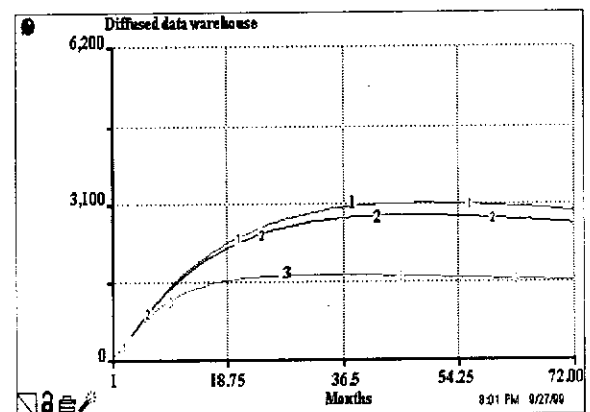
Sensitivity Analysis 4: Percentage of Technology Abandonment

Technology will not be diffused productively unless users apply their knowledge from training to their routine workloads. Therefore, not only the provision of a wide range of training but also increasing percentage of usage is vital to boost the technology diffusion. However, technology abandonment occurs commonly because of unease in technology use, or technology obsolescence. Since technology abandonment drains diffused technology, the bank must prevent it by reducing the percentage of technology abandonment by such means as providing retraining, or enforcing regular usage by staff.

Since the data collection was undertaken during the initial stage of technological development, the users might have been unsure as to whether or not they were actually using the technology. Additionally, the bank did not have time to control and monitor usage after training. Although trained people numbered 200, only 54 considered that they actually used this technology. That was reflected in the high percentage of technology abandonment (i.e. 73 %). This percentage may be decreased without difficulty if knowledge workers gain more understanding and are compelled to use the technology regularly. Once the percentage of technology abandonment is decreasing, the technology will be diffused more effectively.



a: Net rate of Technology Diffusion



b: Diffused Data Warehouse

1. Baseline: percentage of technology abandonment = 3 % per year
2. Percentage of technology abandonment = 10 % per year
3. Percentage of technology abandonment = 73 % per year

Figure 9.15. Comparison of Diffused Data Warehouse using Different Percentages of Technology Abandonment

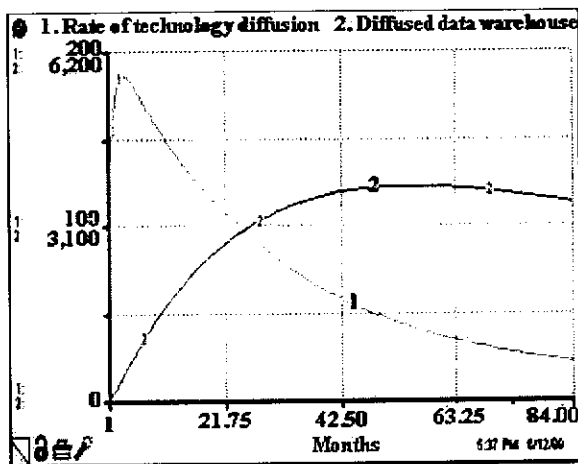
Inferring from other technologies of the bank, the percentage of technology abandonment was set at 3 per cent per year for a baseline simulation. It can be observed from the sensitivity analyses in Figure 9.15 that the higher the percentage of technology abandonment, the less technology can be diffused. At the early period of a diffusing process, differences between diffused technology based on different percentages of technology abandonment were small. However, in the long run, the differences were distinctive.

As can be seen from the sensitivity analyses, the four factors, *training delays*, *percentage of the backlog of problems*, *percentage of resolved problems*, and *percentage of technology abandonment* exert an influence on the level of technology diffusion. Therefore, strategic policies should be formulated in order to change these factors in positive directions to increase the rate of technology diffusion and diffused technology.

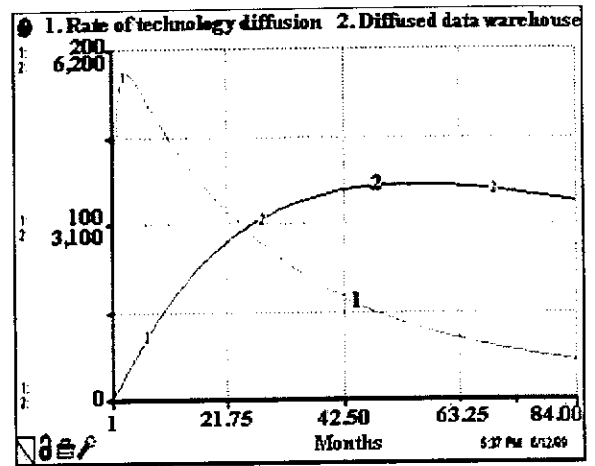
9.5.4 Model Analysis 2: An Estimated Price Model

An estimated price model was expanded from *the price-less model* by adding variables relating to costs and benefits. This model analysis was undertaken based on the influence diagram in Figure 9.7 using the available data as well as estimated data in order to provide prospective results for a monetary aspect. Although the model employed many estimated data, it may allow people to test scenarios at low costs by adjusting information that they think is more appropriate.

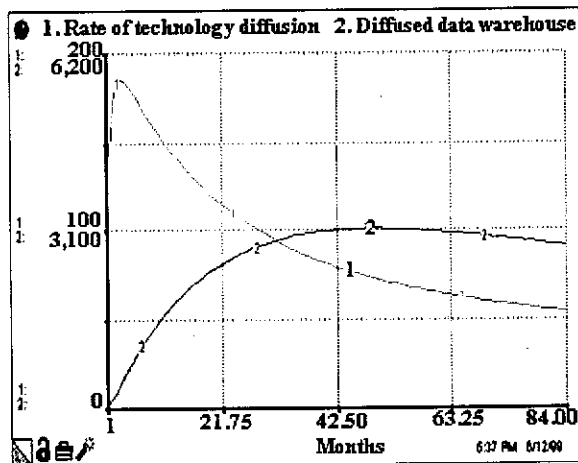
The model analysis employed an additional technique by accumulating feedback loops based on qualitative analysis, for the purpose of making the model easy to understand and facilitating the observation of impacts among the loops and tracing for errors when unexpected behaviour occurs. All the results from simulations highlighting the rate of technology diffusion, diffused data warehouse, and economic gains are compared in Figures 9.16 and 9.17. (The full model is presented in Appendix 9.2). These two figures must be read together to understand the impact of different simulations.



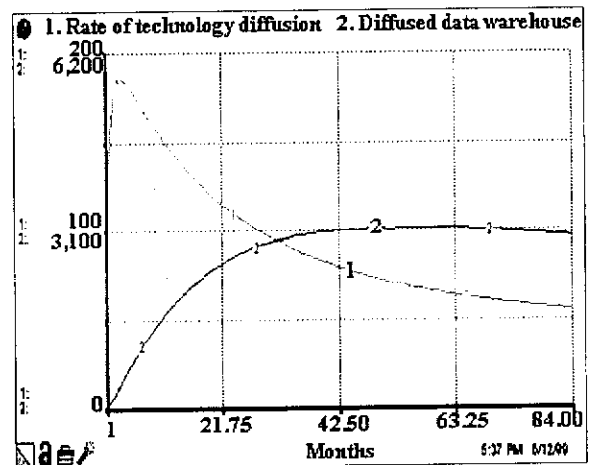
a. Simulation 1: Adding Cost-Benefit



b. Simulation 2: Adding Customers



c. Simulation 3: Adding the Backlog of Problems



d. Simulation 4: Adding Investment in Technology

Figure 9.16. Comparison of the Estimated Price Model

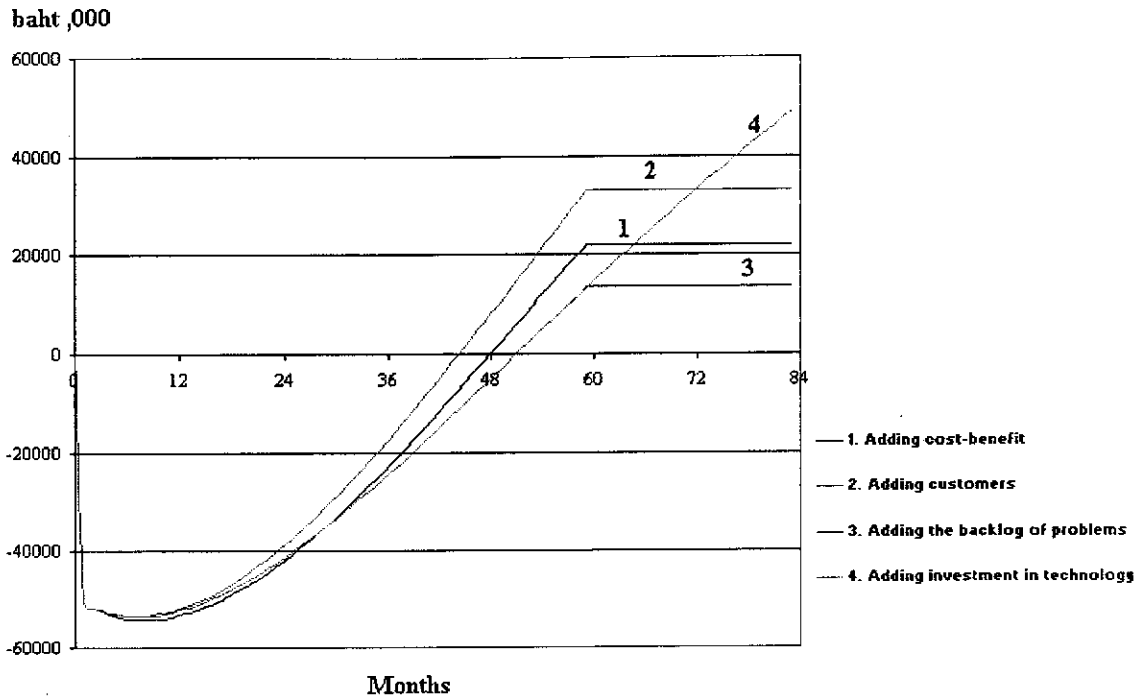


Figure 9.17. Comparison of Economic Gains from *the Estimated Price Model*

Simulation 1: Adding cost-benefit

This simulation expanded from the Simulation 1 of *the price-less model* by adding three main feedback loops, including relative advantages (Loop A1), costs (Loop B) and training costs (Loop H) (see Figure 9.7).

The bank users perceived that the relative advantages of the data warehouse were the provision of accurate and timely information, effective decision-making, improved access to information for loan underwriting, increasing performance efficiently and information for strategic planning (The Siam Commercial Bank's staff, 1998b). The rate of gaining relative advantage was calculated by multiplying the number of users (i.e. diffused data warehouse) with the level of actual performance of each relative advantage and with average revenue (baht 200). The benefits were constrained by the economic life of technology (60 months).

Costs comprise the cost of technology and operational costs. The bank has invested approximately baht 50 million in the technology, and has spent baht 10 million on maintenance and operational costs. Training costs are expenditures on training the

bank staff. These expenditures are varied, based on the rate of training and the average training cost which was set at baht 1,000 per person.

The results indicated that the rate of technology diffusion increases dramatically during the first five months and then diminishes. The bank can create 3,716 knowledge workers who regularly use the data warehouse (i.e. diffused data warehouse) within 60 periods (see Figure 9.16a).

Simulation 2: Adding customers

Customers (Loop A2) were taken into consideration because the data warehouse is to be ultimately employed for customer satisfaction which in turn may lead to an increase in the customer base. The idea behind this simulation is that the knowledge workers who use the data warehouse regularly (i.e. diffused data warehouse) will utilise their knowledge in serving customers, thereby creating more customer satisfaction. This will lead to an increase in the actual level of perceived satisfaction of customers. The more the satisfaction is perceived, the potentially higher the customer growth (the bank normally aims at gaining a 20 per cent growth rate).

Supposing that there are 10,000 initial active customers, the potential market that the bank aims to achieve within the economic life of the technology was set at 10 times the former (i.e.100,000). Each customer brings benefits to the bank in terms of fees and interest. Therefore, the sales rate was calculated by multiplying the rate of change in customers with an average price (baht 1,000). In effect, the bank gains advantages in terms of sales until the potential market is saturated or before the technology is obsolete.

The results from Simulation 2 revealed that the rate of technology diffusion and diffused data warehouse were similar to those of *Simulation 1- adding cost-benefit model-* (see Figures 9.16a, b). However, the economic gains (i.e. the difference between revenues and costs) from Simulation 2 were higher than those of Simulation 1 (Figure 9.17) because of additional benefits from customers.

Simulation 3: Adding the backlog of problems

The backlog of problems (Loop F) was added to the Simulation 2 model. The backlog of problems increases the rate of technology abandonment, decreases percentage of usage, decreases customers' perceived satisfaction and enlarges costs. At present, the percentage of the backlog of problems was 12% per year, with average cost of resolving the problems at baht 600. This cost was estimated with reference to the information of Extranet banking of the Siam Commercial Bank.

The results revealed that the rate of technology diffusion, diffused data warehouse and economic gains were lower than those of *Simulation 2- adding customers-* (see Figures 9.16b, c and 9.17).

Simulation 4: Adding investment in technology

This simulation took investment in technology (Loop J) into account. According to Loop J in Figure 9.7, economic gains are expended in continuous improvement of the technology. Yet, this increases costs and subsequently reduces the economic gains.

The results from the simulation (Figures 9.16c, d and 9.17) indicated that the rate of technology diffusion, diffused data warehouse, and economic gains were higher than those of Simulation 3 because spending in economic gains for continuous improvement of the technology may extend its economic life far beyond 60 months. That may provide more benefits to the bank in the long run.

However, investment in the data warehouse in order to improve and catch up with technological evolution should not be infinitely increased because although technological improvement is able to increase an economic life of technology, technological expenditure directly decreases economic gains of an organisation.

Figure 9.18 depicts two feedback loops of technological investment. The positive feedback loop A indicates that continuous improvement expands the economic life of technology that may lead to a decrease in the rate of technology obsolescence and an increase in economic gains. On the other hand, the negative feedback loop B reveals that at the same time technological investment increases over all costs leading to

decreases in economic gains. The bank, therefore, has to find a balance between the technological investment and economic gains because excessive spending may not always result in higher returns on the investment.

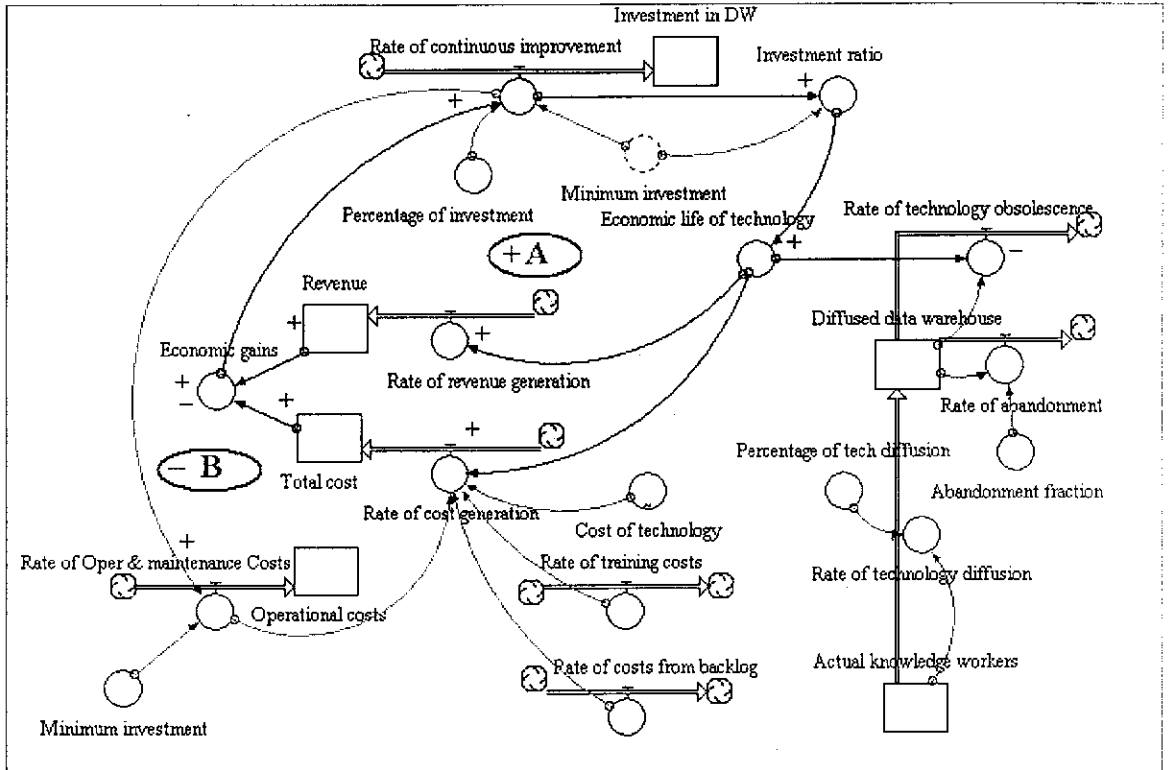
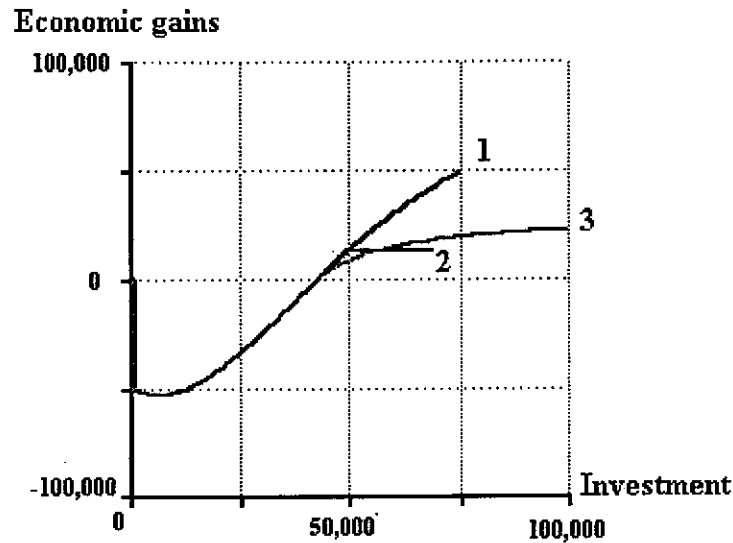


Figure 9.18. Simulation Model of Investment in Technology and Economic Gains

The sensitivity analysis using three different percentage points of investment indicates different ultimate economic gains (See Figure 9.19).



1. Baseline: Percentage of investment = 0.09 of economic gains
2. Percentage of investment = 0.00 of economic gains
3. Percentage of investment = 0.80 of economic gains

Figure 9.19. Impacts on Economic gains of Investment in Data Warehouse

Currently, the bank has a technological plan to spend 9 per cent of its profits on technology investment (The Siam Commercial Bank's executives, 1998). According to Figure 9.19, the economic gains based on this investment policy is illustrated in scenario 1. If the bank decreases the percentage of investment to 0, by spending only minimum investment, the economic gains from scenario 2 is lower than the first one. However, if the bank spends heavily on technology investment (i.e. 80 per cent of economic gains) the ultimate economic gains from the investment is also low.

9.6 Policy Analysis

The simulation model and sensitivity analyses based on system dynamics analysis provide the present state and constraints of the technology. Once the behaviour of the systems are detected the decision-makers can try to use strategic policies in order to improve the systems' behaviour and increase the technology diffusion that may result in economic gains from the technology.

The bank officials put forward the main strategic policies that they felt were important to increase the rate of technology diffusion. These include *increased levels of training support, co-operation between IT people and users, decreased perceived complexity, increased perceived relative advantages, top management support, increased positive features of technology, and decreased training delays*. They also identified a level of actual performance for each policy (Table 9.6). The level of actual performance was the level of current perception of each issue. The lowest weight (1) indicated the lowest performance whereas the highest (7) was the desired performance. Since, the actual performance of each strategic policy based on the developers' perception is different from that of the users' the average values between the two groups were used. The level of performance (1 to 7) was then transformed to a zero to 1 scale value in order to make it suitable for simulation by *ithink* software.

Table 9.6. List of Strategic Policies of Data Warehouse

Policy	Level of actual performance (Average Weight- 1 low and 7 high)	Level of desired performance (Average Weight- 1 low and 7 high)	Value used in <i>ithink</i> (Average Weight- 0 low and 1 high)
1. Increased levels of training	2.67 (users) 3.00 (developers) 2.84 (average)	7	From 0.40 to 1.00
2. Increased co-operation between IT people and users	3.50 (users) 5.43 (developers) 4.47 (average)	7	From 0.64 to 1.00
3. Decreased perceived complexity (Make it easy to use)	3.24 (users) 3.14 (developers) 3.19 (average)	7	From 0.46 to 1.00
4. Increased perceived relative advantages	5.29 (users) 3.71 (developers) 4.50 (average)	7	From 0.64 to 1.00
5. Increased management support	6.14	7	From 0.88 to 1.00
6. Increased positive features of technology	4.67	7	From 0.67 to 1.00
7. Decreased time for training delays	12 months	6 months	From 12 to 6

Sources: (The Siam Commercial Bank's executives, 1998; The Siam Commercial Bank's staff, 1998b; 1998c)

The seven strategic policies were exerted with the expectation that they may enhance technology diffusion and successively have a positive impact on economic gains. The policy analysis used the simulation in Figure 9.16d as a baseline model.

All the policies were simulated to detect a policy that provides a strong impact in increasing the technology diffusion, aiding the bank in gaining the diffused data warehouse within a shorter time before the technology is obsolete. The end results of each policy were compared in Table 9.7 and Figures 9.20 and 9.21.

Table 9.7 Comparison of the Impacts from Exerting Strategic Policies

Policy	Diffused data warehouse (within 84 months)	Break-even point of time of return on investment	Economic gains within 84 months (baht ,000)
1. Baseline simulation	2,973	51	49,565
2. Increased level of training	3,487	32	102,028
3. Increased co-operation between IT people and users	3,591	45	74,667
4. Decreased perceived complexity (Make it easy to use)	3,970	44	87,179
5. Increased perceived relative advantages	3,975	43	87,824
6. Increased management support	2,975	51	49,945
7. Increased positive features of technology	3,777	44	81,447
8. Decreased time for training delays	3,409	36	91,304
9. All policies	3,798	23	144,902

Diffused data warehouse (persons)

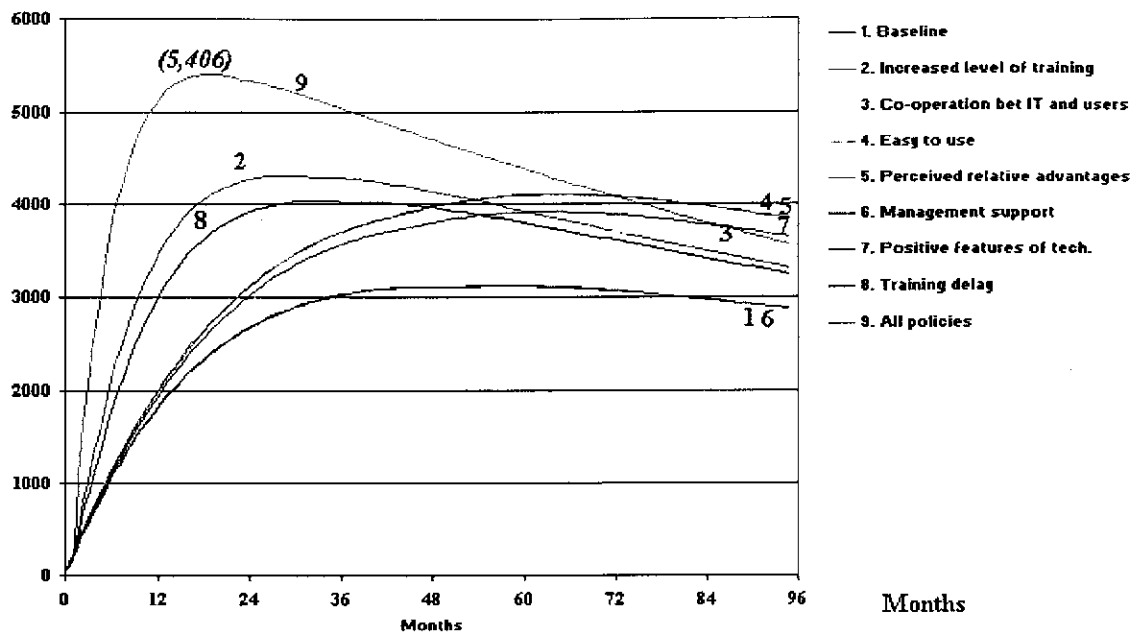


Figure 9.20. Comparison of Diffused Data Warehouse among Different Policies

baht 1,000

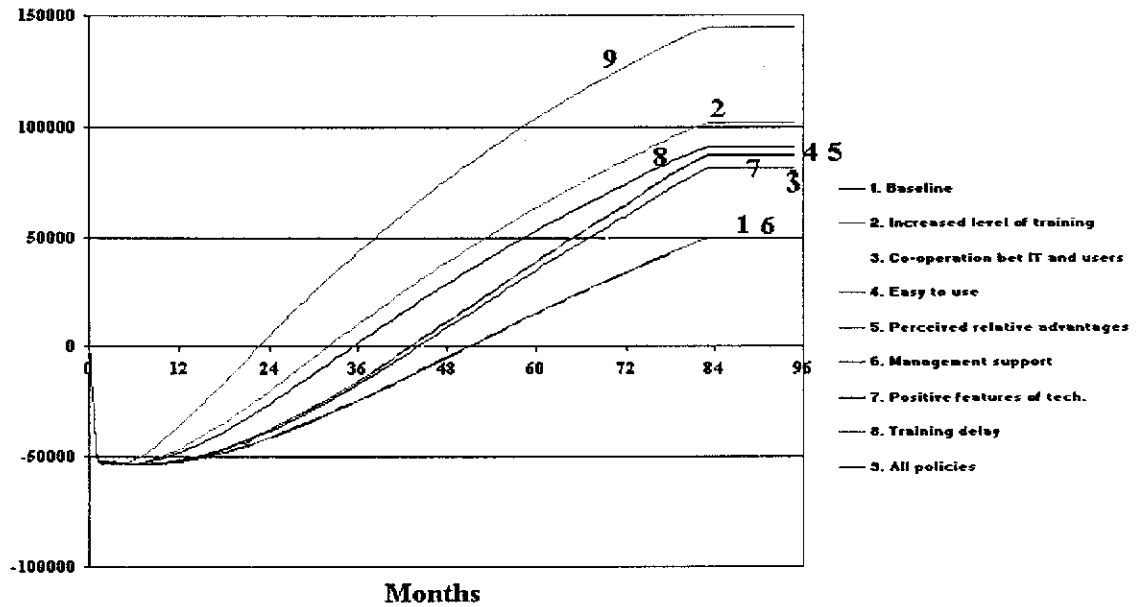


Figure 9.21. Comparison of Economic Gains among Different Policies

The results revealed that the leveraged strategic policies for increased technology diffusion and economic gains were increasing levels of training, decreasing training delays, decreasing perceived complexity (make it easy to use), increasing perceived

relative advantages, increasing positive features of technology, and increasing co-operation between IT people and users. However the policy of increased management support did not exert significant impact on diffused data warehouse because the current performance of this policy was already very high (i.e. 6.14 out of 7).

While each policy enhanced a diffused data warehouse, none of the policies individually could absorb the target technology diffusion (6,254) within 84 months. If the bank combines all the policies effectively, it may ideally gain more diffused technology (5,406) at period 19. Figure 9.20 also revealed that diffused data warehouse diminished when the time was close to the economic life of the technology (the economic life of technology is expanded from 60 to 84 months, if the bank spends substantial continuous investment on technology).

If the bank combines all policies and undertakes them effectively, the break-even point from this technology will decrease from more than 51 months to 23 months, and increase the economic gains (i.e. profits) from minus 49 million to 144 million within 7 years (Table 9.7 and Figure 9.21). According to the data from the validation phase, the bank experts revealed that it is feasible to combine all the policies. For example, the bank always provides training and educational programs to end-users with high support from IT people. The time for training delays is expected to be only six months. The investment in user-friendly software applications and the continuous improvement of hardware may help end-users extract reliable information from the data warehouse easily and quickly that leads to an increase in their perceived relative advantages (The Siam Commercial Bank's executives, 1999).

9.6.1 Using DSS for Strategic Policy Analysis

The systems dynamics based decision support system is defined as a decision-making tool that incorporates system dynamics models into decision support system concepts and characteristics. Initially, system dynamics models are developed by a modeller to detect problems, relationships between variables, constraints, and potential strategic policies to solve the problems. Then, the models are proposed to business people in an organisation, for experimentation based on their own

knowledge via user-friendly interfaces and supportive tools in order to solve problems or improve decisions.

The model of data warehouse diffusion was compatible with the DSS characteristics of Licker (1997).

1. **Supporting managerial decision-makers.** The model was developed to support decision-makers in strategic policy analyses for one of the large banks in Thailand. The bank provided full support backup in terms of data, facilities and co-operation.
2. **Supporting semi-structured decision situations.** This model simplified difficult decision-making issues relating to the topic of how to productively diffuse the data warehouse for the bank. The qualitative SD model provides influence diagrams to capture relationships of variables from many system boundaries within the bank. The influence diagrams allow decision-makers to understand problems and constraints of the system before forwarding ways to solve the problems.
3. **Extending managers' capabilities.** The model enhances the strength of decision-makers by extending their capabilities in bringing their own business knowledge, experience and intuition to test the model via running simulation or conducting sensitivity analyses. From that, they are able to combine simulation outcomes with their own insight to freely make their judgements.
4. **Evolving over time.** Quantitative system dynamics helps decision-makers visualise impacts from their decisions and compare the decisions with the reality within a short time. Continuous improvement makes the model closer to reality because as they become familiar with the subject matter and make more decisions, the SD model becomes more reliable and the outcomes from their decisions become more appropriate.
5. **Easy to use interfaces and graphical capabilities.** The model using *ithink* software (Richmond et al., 1994) provides users friendly interfaces and

graphical capabilities (e.g. tables, figures, and graphs), making it easy to use and reflecting the impact of factors of interest.

6. **Interactive.** The model allows decision-makers to check on validity or reasonableness by running simulation to obtain end results and to compare with reality. This will enhance their level of understanding, and detect relevant reasons behind objective results. The results may be used to catalyse discussion of the problem, and for learning that leads to improving their decision-making and consensus. Furthermore, testing for shocks or unexpected outcomes or running a simulation before real implementation protects an organisation from potential risks derived from wrong decisions.

Figure 9.22 shows the DSS for the diffusion of data warehouse. It is observed that prospective decision-makers are able to analyse the system boundaries that accommodate the interaction between three groups (i.e. staff, customers and the bank). By simply clicking the button “run”, the model will be simulated and final results of any factor of interest will be provided under a specified scenario within a few seconds. The simulation results can be visualised via tables, graphs and numeric displays. Decision-makers are able to change variables or data based on their business knowledge, experience or information that they think better fits different test scenarios, assumptions, perceptions and policies, by simply using “slider bars” and then visualising the final outcomes. The model, therefore, may save an organisation from wasting time, effort and resources from “blind decisions”, and improve their decision-making processes, promoting their learning and proficiency.

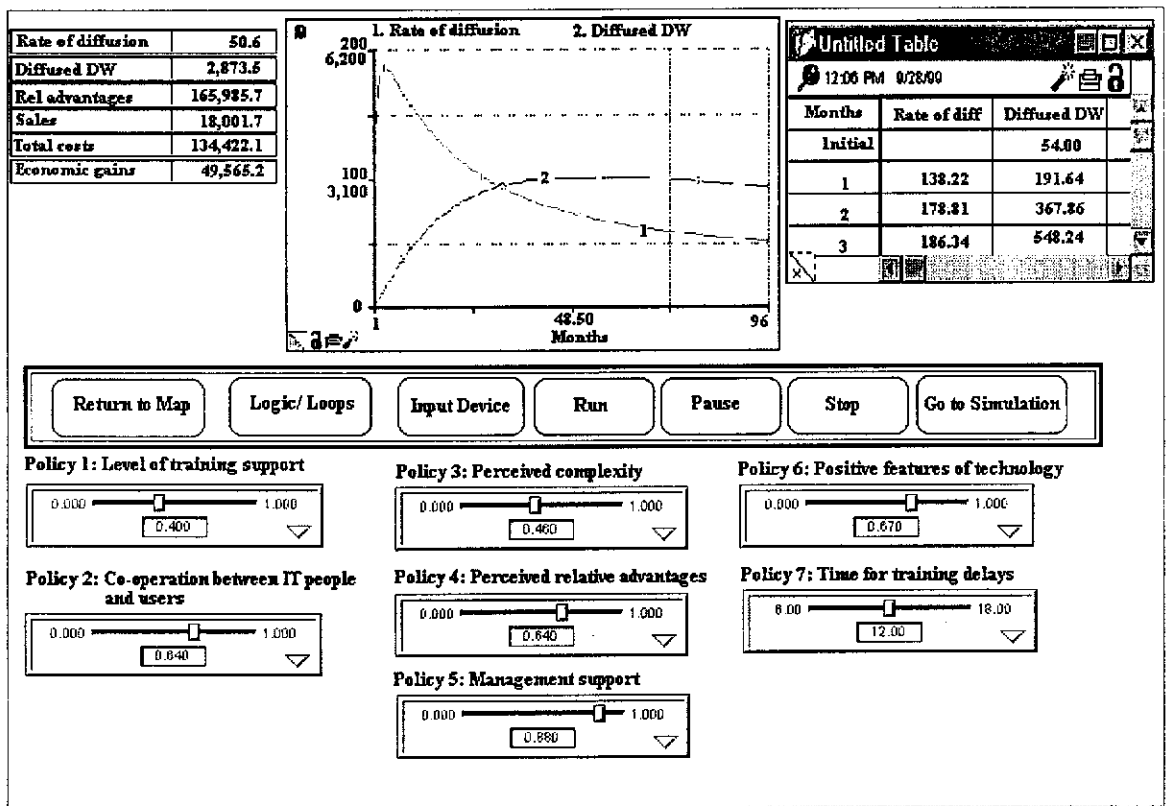
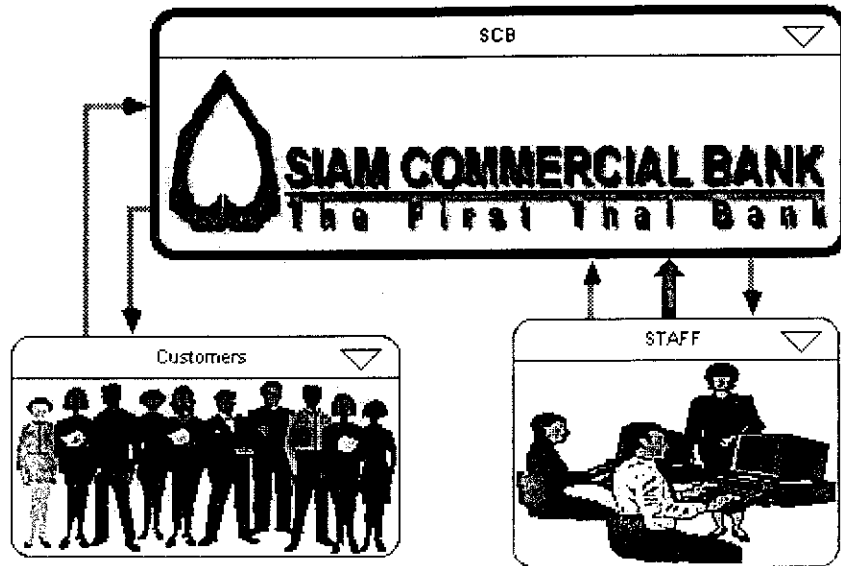


Figure 9.22. User Interfaces of System Dynamics Based Decision Support System

9.7 Model Validation

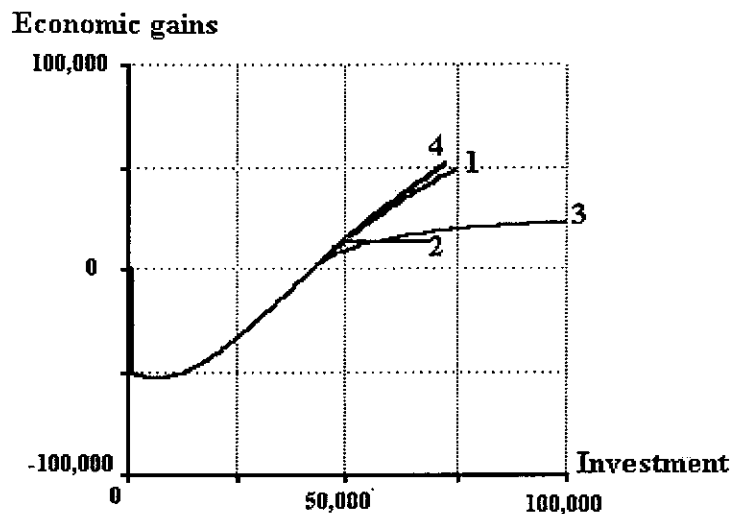
The diffusion models of a data warehouse (both the price-less model and the estimated price model) were validated in the same ways as the ICT diffusion model. These models proved sufficiently useful for the desired purpose of helping the bank diffuse data warehousing technology more efficiently and were developed through a gradual process of "confidence building". The models were further verified using the formal criteria comprising the three major stages of structure validity, behaviour validity, and tests of policy implications (Barlas, 1996; Forrester & Senge, 1980). In this section, the model validation concentrates only on the Turing test with regard to sensitivity analyses and tests of policy implication.

The Turing test was conducted by proposing the diffusion models to five experts in technological issues of the bank. They made a comparison between the models' outcomes and those of the real system based on their experience and knowledge (The Siam Commercial Bank's executives, 1999). The following are some of the ideas and comments from the experts.

1. They agreed that training is an important factor for diffusing the data warehouse. The bank tries to find useful training tools to help the bank staff develop their self-learning using web technology because using a manual is not a suitable tool to aid learning due to a limitation of time and staff workload. Training delays may occur because of the workload of both trainers and users.
2. They agreed that a backlog of problem is a hindrance for a diffusion process. According to Figure 9.13, the high percentage of backlog of problems perceived from end users was more acceptable than the low perception of developers because users had less capability to extract data from the data warehouse than developers.
3. They agreed with the sensitivity analysis in Figure 9.14 that the degrees of resolution of problems may affect the data warehouse diffusion. If problems occur the bank has the potential to resolve these, technology can be diffused

without difficulty. Once the problems are beyond its ability to resolve them, users will abandon technological usage.

4. They explained that users might abandon technology because the data warehouse required creative thinking to get the full benefits of the technology. However, sometimes, inappropriate staff attend training (e.g. people who are available at a time of training or do not perceive relative advantages from the technology). These staff will use the technology for a short time. When they are confronted with obstacles or dissatisfaction they may stop using it. In addition, technology abandonment occurs because the trained staff are transferred to work in different departments and they cannot apply their knowledge from the training to new duties.
5. They accepted that excessive investment impacts negatively on economic gains. The sensitivity analysis in Figure 9.19 was therefore acceptable. However, one expert commented that the baseline scenario using 9 per cent of economic gains was too high. He would like to see the outcome from the percentage of investment equal 0.05 of economic gains. Thus, after the validation phase the fourth scenario was simulated based on his comment. Figure 9.23 shows that the end result of the percentage of investment equals five per cent of economic gains and was better than that of the baseline result. That is, the bank can obtain higher economic gains from its lower investment.



1. Baseline: Percentage of investment = 0.09 of economic gains
2. Percentage of investment = 0.00 of economic gains
3. Percentage of investment = 0.80 of economic gains
4. Percentage of investment = 0.05 of economic gains

Figure 9. 23. Impacts on Economic gains of Investment in Data Warehouse

6. They commented that the number of the target of technological diffusion represented by skilled workers regularly use technology setting at 6,000 and this is too high. They expected a figure of 3,000. However, the models have not been revised because the diffused data warehouse at the baseline was already close to the target (i.e. 3,039) (see Figure 9.11 c).
7. They accepted that the break-even point of the data warehouse diffusion without strategic policies to enhance the rate of technology occurred at 4 years. If the bank combines strategic policies, the bank possibly speeds up the break-even point from 4 to 2 years (see Figure 9.21). However, they could not verify the amount of economic gains from the data warehouse.
8. All the proposed policies including *increasing levels of training, decreasing training delays, making technology ease of use, increasing perceived relative advantages, increasing positive features of technology, and increasing co-operation between IT people and users* were acceptable.

In conclusion, the diffusion models of the data warehouse were valid because the bank users perceived them as useful models providing insights on how to diffuse the technology more effectively. They were developed based on the confidence-building process starting from qualitative analyses, sensitivity analyses, and policy analyses. They were also tested for structure validity, behaviour validity, and tests of policy implications. The bank executives who have expertise in banking technologies finally verified the models. All sensitivities analyses and policies analysis were supported.

9.8 Requisite Group Model of Diffusion of Data Warehouse, and Requisite Policies for Adoption and Diffusion: Research Questions 3 and 4

The requisite group model of data warehouse diffusion was additionally conducted to support the answers of the third and fourth research questions in Chapter 8 (i.e. what is a requisite group model of ICT diffusion, and what are the requisite policies for adoption and diffusion of ICT for the bank?). This model of data warehouse diffusion, which highlights the diffusion process within internal-organisation was justified as a requisite group model (Phillips, 1988) because it provides enough information for decision-makers in the bank to understand the system behaviour of the technology in order to make appropriate decisions for productive diffusion.

The models (i.e. the price-less and the estimated price model) were developed by defining the present state, and its constraints of the technology. Then, factors that may impact on the rate of technology diffusion were detected from the literature reviews to provide the holistic view of the system behaviour (Figure 8.3). However, the variables were customised to the perception of the bank respondents to develop the influence diagram (Figure 9.7) based on the qualitative system dynamics approach. The influence diagram providing understanding of the inter-relationships among variables was then quantified based on the quantitative system dynamics approach using data from the bank. The results showed that the data warehouse diffusion also follows the s-curve (Figure 9.11). The sensitivity analyses revealed that training delays, percentage of the backlog of problems, percentage of resolved problems,

and percentage of technology abandonment were important factors that impact on the technology diffusion.

The requisite policies for adoption and diffusion of data warehouse were identified during the stage of redesigned strategic policies (Figure 9.8) and then quantified using quantitative system dynamics methodology. The leverage policies were: *increasing levels of training, decreasing training delays, making technology ease of use, increasing perceived relative advantages, increasing positive features of technology, and increasing co-operation between IT people and users, whereas increasing management support was a low impact policy.* If all policies are effectively integrated, the bank will feasibly decrease time for technology diffusion and absorb a more diffused data warehouse.

9.9 Summary

This chapter presents a model of technology diffusion of data warehouse using the system dynamics based decision support system approach. The model demonstrates ways to develop a requisite model of diffusion of a data warehouse.

A qualitative system dynamics approach was initially employed to identify the present state and detect constraints of this technology. The qualitative model provides holistic perspectives, yet it may not suffice for analyses of the impacts of interaction between the feedback loops. A quantitative system dynamics approach was therefore elaborated.

The price-less model was initially simulated highlighting the diffusion process without manipulating variables of costs and benefits due to restrictions on data collection. The model provided insights on how to diffuse the data warehouse to the bank staff via training. *The estimated price model* was then expanded from *the price-less model* using estimated data for costs and benefits. The feedback loops were additionally simulated to detect the complete quantitative system dynamics model of the data warehouse.

The model provided insights on how to diffuse the data warehouse to the bank staff via training and other policies. The requisite policies for successful adoption and

diffusion were: *increasing levels of training, decreasing training delays, decreasing perceived complexity, increasing perceived relative advantages, increasing positive features of technology, and increasing co-operation between IT people and users.* Since top executives of the bank already give full support for technological development, the policy of *increasing management support* was not the high impact policy. If the bank undertakes all policies effectively, it may dramatically decrease time for technology diffusion and substantially absorb more diffused technology.

Since the model was developed based on the system dynamics decision support system decision-makers are able to use it to test all the policies by themselves by using user-friendly tools provided to bridge the requirement gap between modellers and decision-makers. That is, although the model was developed using rich data (e.g. literature reviews, interviews and questionnaires), employing complex tools (e.g. influence diagrams, mathematics equations and simulations) and consuming considerable time, it presents decision-makers with easy interfaces such as control tools, maps, figures, graphs and tables.

In the next chapter, the model of Extranet banking will be presented. The process of Extranet diffusion puts emphasis on bank customers rather than the bank staff, because the bank provides Extranet banking not only to facilitate customers directly but also expects benefits from technological usage.

CHAPTER 10

ANALYSIS II: DIFFUSION OF EXTRANET BANKING AT SCB

10.1 Introduction

Banks employ Internet/Extranet banking which is one type of popular banking technology, to furnish their customers with remote banking transaction capacity via web technology. Thailand has introduced Internet banking in the form of Extranet banking, which requires customers to subscribe for this service. Once a bank adopts this technology, effective diffusion to customers is necessary in order to absorb a potential market and obtain returns on investment.

This chapter proposes a model analysis of Extranet banking using a system dynamics approach. This model was additionally undertaken because although a data warehouse was intuitively perceived as the most preferred technology, the results from the MCDM analysis identified that Extranet banking was superior to the data warehouse. The model also provides the answers for the third and fourth research questions, “*what is a requisite group model of ICT diffusion?*”, and “*what are the requisite policies for adoption and diffusion of ICT for the bank?*” However, the

diffusion process of this technology is more related to bank customers rather than bank staff.

The first part of this chapter informs fundamental background of Extranet banking at the Siam Commercial Bank PCL. The model of Extranet banking was developed in the second part using both qualitative and quantitative system dynamics approaches. It depicted variables, their relationships and feedback loops under three sub-system boundaries of the bank (i.e. the technology group), staff and customers. The feedback loops were quantified to reflect the patterns of technological diffusion and its economics gains. The strategic policies were then tested to detect for leverages that may enhance effectiveness in technological diffusion.

10.2 Methods of Data Collection

This study employed the same methods of data collection used to conduct the diffusion model of data warehousing technology: observations, interviews, questionnaires, and documents. The data of Extranet banking came from three sources: people in charge of the technology, prospective customers, and executives in the bank.

Initially, bank staff were interviewed and completed the “*Extranet Banking*” questionnaire in order to detect issues or problems that the bank has confronted so far with regard to this technology. Subsequently, the “*Prospective Customers of Internet/Extranet Banking*” questionnaires aimed at verifying the perceptions of bank staff towards Extranet banking were distributed to 119 respondents. These respondents have the potential to be customers of this technology as they have a high educational level (54.62% bachelor degree, and 39.50 % master and doctorate degrees of all respondents), and important positions in private and public organisations. Executives from the technology group were asked for opinions and recommendations for strategic policies that may enhance the diffusion process. Finally, the completed model of Extranet banking was proposed to the experts of the bank for model validation and revision. The details of data collection have already been explained in Chapter 5 and are presented again in Table 10.1.

Table 10. 1. Data Collection

Topic	No. of respondents	Method of data collection	Name of questionnaire/ interview	Purposes
1. Extranet banking (SCB Cash Management)	5 (people in charge)	Questionnaire & interviews & document	" <i>Extranet Banking</i> "	Variables regarding Extranet banking
2. Prospective customers of Extranet banking	119 out of 140	Questionnaire & interview	" <i>Prospective Customers of Internet/ Extranet Banking</i> "	Information regarding prospective customers (potential market)
3. Policy analyses	16 (executives)	Questionnaire & Interview	" <i>Policy Analysis</i> "	Variables for policy analyses
4. Model Validation	5 (executives)	Interview	" <i>Model Validation</i> "	Verifying the models

10.3 General Background

Extranet banking is one of the electronic banking services that banks aim to be an information bank between the bank and customer offices. It employed web technology to transfer services and information via electronic device (i.e. personal computers, telephones and modems). With this technology, customers are able to receive information rapidly and accurately without physically visiting the bank.

The Extranet banking technology of the Siam Commercial Bank PCL was implemented in August 1996, evolving from *INFO-BANKING*, which operated under the DOS environment for the Windows environment (Lamunpan, 1996). With this technology, customers are allowed access to bank databases to carry out their banking transactions for 24 hours a day, examine account balances, request and download bank statements to their personal computers, and transfer money between accounts held under the same name branches ("Home banking via Internet," 1996). The bank calls the Extranet banking service *SCB Cash Management*. At the beginning of 1998, there were approximately 2,000 subscribers paying subscription fees based on service options, with a maximum rate of baht 1,800 per year. There are

two main services provided: financial administration data (e.g. balance checking, account transferring, transferring to a third party, bank statement enquiry, bill payment and stopping payment), and business data (e.g. currency exchange rates, stock exchange, interest rates, financial information and economic information) (The Siam Commercial Bank's staff, 1998d).

In this study, the main issues of Extranet banking were identified from two sources of information: bank staff, who are in charge of this technology and prospective customers.

Initially, an average number of business transactions with a bank via different channels were examined using the “*Prospective Customers of Internet/ Extranet Banking*” questionnaire. As can be seen in Table 10.2, each respondent performs his/her business transactions with banks on average 7 to 8 times per month. The respondents mainly use ATM machines and visit banks physically (i.e. 3.87 and 2.79 times per month, respectively). Nevertheless, usage of Internet/Extranet banking is low (i.e. 0.27 time per month).

Table 10. 2. Numbers of Business Transactions with a Bank per Month

Method of transaction	Numbers of business transaction per month/ person
Bank in person	2.79
Using ATM machines	3.87
Using telephone banking	0.87
Using Internet/Extranet Banking	0.27
Total	7.80

Source: Data derived from “*Prospective Customers of Internet/ Extranet Banking*” questionnaire, January 1998

The main issues examined from the two sources of data (i.e. bank staff and prospective customers) were as follows.

1. **Potential market.** The bank staff felt confident that Extranet banking could be diffused to absorb a potential market without difficulty. Direct sales

focusing only on customers from corporate business enterprises was employed as a marketing strategy to gain 10,000 customers within 5 years. The bank has not expanded this technology to retail customers due to three main reasons. Firstly, this technology will compete with other bank services (i.e. *TELE-BANKING*) which it aims to mainly serve retail bank customers. Secondly, if the bank provides this service to retail customers, the hardware and the security systems have to be upgraded or expanded. Third, the subscription fee is considered too expensive for retail customers to afford.

Information from prospective customers revealed that Thai people still prefer to go to their banks physically or to use ATM machines. Preference for an Internet/Extranet access is low. According to Table 10.3, approximately 49.68 per cent of bank transactions have been undertaken via ATM machines and 35.78 per cent via personal visits. The transaction via electronic banking is low, with 11.10 per cent via telephone banking and 3.45 per cent via Internet/Extranet banking (as of January 1998).

Table 10. 3. Methods of Business Transaction with a Bank

Method of transaction	Number of transaction per month					
	Bangkok		Chiang Mai		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Bank in person	258	35.93	74	35.24	332	35.78
Using ATM machines	332	46.24	129	61.43	461	49.68
Using telephone banking	96	13.37	7	3.33	103	11.10
Using Internet/Extranet Banking	32	4.46	0	0.00	32	3.45
Total	718	100.00	210	100.00	928	100.00

Source: Data derived from "*Prospective Customers of Internet/ Extranet Banking*" questionnaire, January 1998

The respondents came from the top socio-economic groups in Thai society (e.g. education and career positions) and yet actual use of electronic banking by this group was low. In contrast, the respondents intention and inclination

in using Internet/Extranet banking was high. Further data (Table 10.4) indicated that the respondents were going to use it (38.66 per cent) or may use it in the future (17.65 per cent).

Table 10. 4. Plan to Use Internet/Extranet Banking in the Future

Plan to use Internet banking	Bangkok		Chiang Mai		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Yes	25	38.46	21	38.89	46	38.66
No	20	30.77	20	37.04	40	33.61
Maybe	13	20.00	8	14.81	21	17.65
Don't know	7	10.77	5	9.26	12	10.08
Total	65	100.00	54	100.00	119	100.00

Source: Data derived from "*Prospective Customers of Internet/ Extranet Banking*" questionnaire, January 1998

2. **Insufficient skills.** The bank has insufficient salespersons, who have both information technology (IT) and business knowledge needed to demonstrate the Extranet banking service to prospective customers. Concurrently, customers of this technology should also have knowledge of both. Thus, prospective customers hesitated to use Extranet banking because they (13.94% of the respondents) felt that they had deficient knowledge of computer technology (See Table 10.5).

Table 10. 5. Reasons for Not Using Internet/Extranet Banking by Prospective Customers

Reasons	Bangkok		Chiang Mai		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Not necessary	24	25.53	33	28.95	57	27.40
Lack of equipment (e.g. computer, modem)	26	27.66	26	22.81	52	25.00
Do not know that the bank provides this service	26	27.66	26	22.81	52	25.00
Insufficient computer knowledge	9	9.57	20	17.54	29	13.94
Uncertain about security systems	9	9.57	9	7.89	18	8.65
Total	94	100.00	114	100.00	208	100.00

Source: Data derived from "Prospective Customers of Internet/ Extranet Banking" questionnaire, January 1998

3. **Costs for usage.** The bank perception is that customers are hesitant in using this technology because they have to outlay an initial investment themselves (e.g. for personal computers and modems). This perception is consistent with the information from prospective users. According to Table 10.5, respondents (25 per cent) indicated that they did not have sufficient computer facilities to connect with their banks and were not willing to invest their own money for this. Many respondents also commented that the use of Internet or e-mail from their offices, especially in the public sector, is still restricted. Some executives still perceive that computer facilities are too expensive to allow for normal usage, and limit the quantity of usage to save costs, protect security and keep the confidentiality of organisations.

4. **Reliability and security.** The bank has high confidence in the reliability and security of Extranet banking due to the many intensively protective procedures available to prevent its technology from errors and business fraud. Yet, the security issue is one of the main concerns that deter potential customers from using this technology. Potential customers (8.65 per cent) revealed that they do not trust Extranet banking. Some added comments that even though ATM has been implemented for a long time, errors still occur. In fact, they are obliged to use certain technology, such as ATM, only because their organisations transfer salaries to an ATM system. A voluntary usage of technology, especially high technology such as Internet/Extranet banking, is far beyond their interests.
5. **Infrastructure.** According to bank information, diffusion of this technology is also contingent upon infrastructure such as telephone lines and speed of modems. Congestion of telephone lines, low speed of modems, and high costs in using telephones may hinder the rate of technology diffusion.

Based on prospective customers' perceptions (Table 10.5), the other two reasons for not using Internet/Extranet banking were that it was not required and the lack of information. Firstly, 27.40 per cent of respondents felt that Extranet banking was beyond their requirements because of their own low levels of business transactions. The usage of the technology in Chiang Mai (i.e. the second largest city in Thailand) is zero. This may be because clients felt that if they used Extranet banking, they would be charged for long distance calls, which would be much more expensive than going to banks or dropping in to ATM machines. Secondly, 25 per cent of respondents revealed that they did not know that Internet/Extranet banking was currently available. This is because banks prefer to provide this technology to corporate enterprises rather than to retail customers. Therefore, the banks have not spent much money on advertising such services.

Based on the two sources of information, the market potential of Internet/Extranet banking sounds promising due to two main reasons. Firstly, current non-adopters of this technology are clearly available in plenty. Secondly, the propensity to use this technology among people with the capability and affordability is high (more than 50

per cent). However, the rate of technology diffusion may not burgeon out. Bank staff revealed that an interest in this technology is dropping partly due to the economic crisis in Thailand. Before July 1997, many organisations were 'technologically oriented'. They adopted technologies not only to gain benefits but also to reflect a good image and social status. Taking the above into consideration, innovative expensive technologies could be easily accepted in the future without difficulty in terms of organisational expenditures. However, at present, because of the current economic situation, even a subscription fee of baht 1,800 (i.e. AUD \$ 90) per year is considered an extravagant expenditure (The Siam Commercial Bank's staff, 1998d).

10.4 Model Analysis Using Qualitative System Dynamics Approach

The derived information was initially analysed based on the qualitative system dynamics approach (Coyle, 1996; Wolstenholme, 1994). Figure 10.1 illustrates the influence diagram of Extranet banking, which depicts variables, system boundaries, and relationships among variables and feedback loops.

The system boundary of Extranet banking was divided into three sub-systems (i.e. the SCB, staff and customers). The SCB is defined as departments that are responsible for technical support and business policies of this technology. Staff comprises people who are responsible to provide services using Extranet banking to customers. As at January 1998, there were 8 officials available to do so. The organisation in charge had a plan to train staff from branch offices by dividing them into 10 groups, with 500 people per group, in order to enhance their knowledge and capability to sell the technology to customers. Customers are subscribers to this technology. There were 2,000 subscribers. The bank expected to gain another 10,000 customers within 5 years, or an increase of 600 customers per year. However, these two figures appear inconsistent because if customers were to increase by 600 per year, within five years there would only be 5,000 customers (including the current customers). Therefore, the analysis used 600 customers per year as the target rate of technology diffusion and 10,000 as a potential market of this technology.

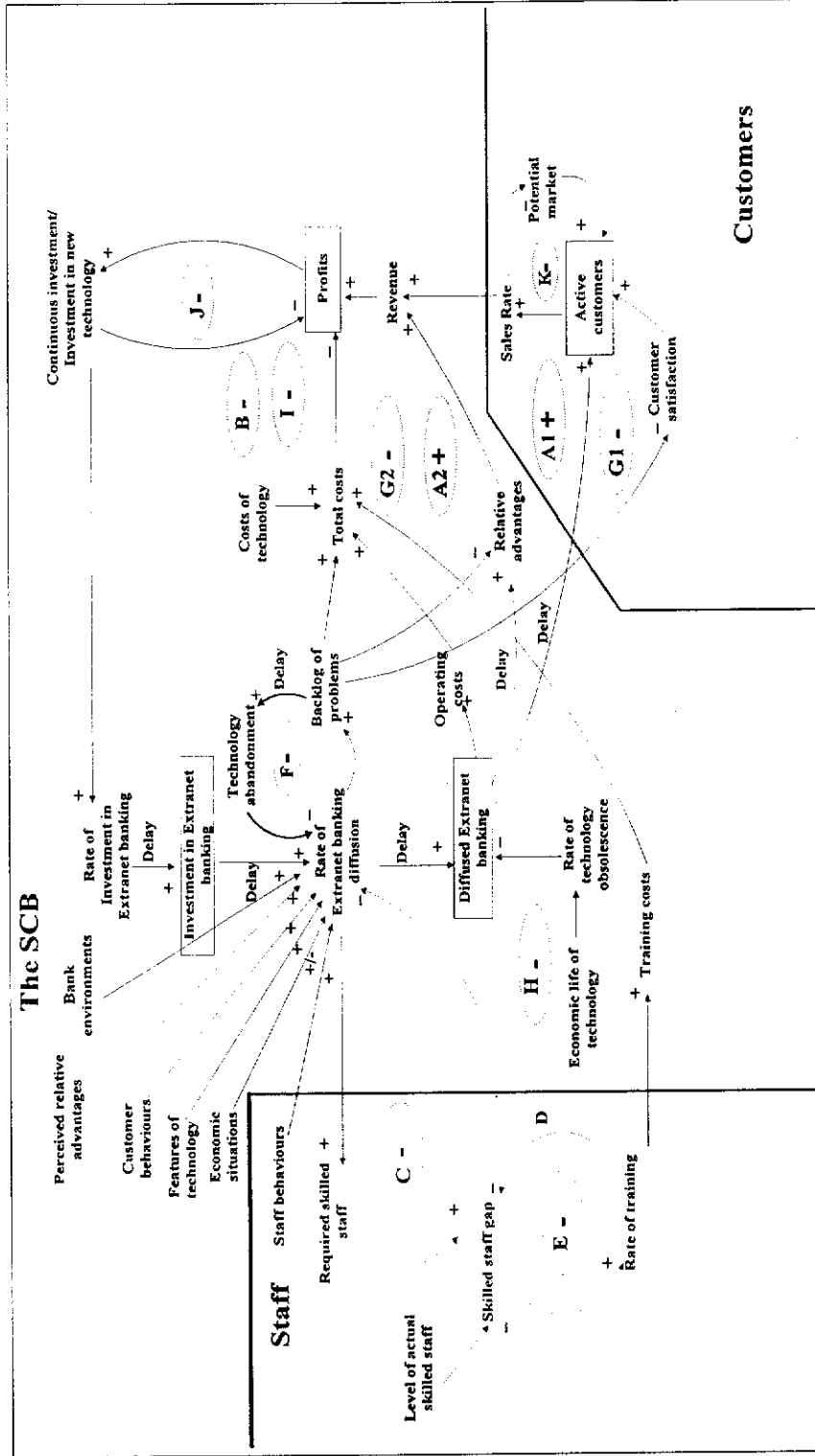


Figure 10.1. The Influence Diagram of Extranet Banking

10.4.1 Influence Diagram

The influence diagram of this technology comprises 12 feedback loops.

Positive feedback loop A1. “Investment in Extranet banking” impels the bank to diffuse this technology to customers in order to obtain anticipated returns from the investment. Factors that drive the “rate of technology diffusion” are “perceived relative advantages”, “customer behaviours”, “economic situations”, “bank environments” and “features of technology” (Gagnon & Toulouse, 1996; Herbig & Day, 1992; among many others).

The bank diffuses this technology by selling *the SCB Cash Management* service to customers. “Active customers” bring about an increase in “sales”, “revenue” (e.g. subscription fees and service fees) and “profits”. Ultimately “profits” subsequently induce additional technological investment. In general, the diffusion process is a time consuming process; therefore, time delays occur during the diffusion process as well as receipt of profits.

Positive feedback loop A2. Apart from sales, “diffused Extranet banking” also increases other “relative advantages”. The explicit relative advantage is internal performance cost saving due to a decrease in physical visits to bank counters by customers. Sales and cost savings lead to increases in revenue and profits respectively. Eventually, profits encourage additional technological investment (The Siam Commercial Bank's staff, 1998d). The feedback loops A1 and A2 are positive. That is, the more Extranet banking is diffused, the more increases in “sales”, “relative advantages” and “profits” can be obtained.

Negative feedback loop B. The bank spends resources for the provision of Extranet banking such as costs of technology, operating and maintenance costs. These costs decrease profits.

Negative feedback loops C and E. Diffusing Extranet banking, similar to other information technologies, requires an increase in the number of skilled staff to look after customers (Bezdek & Jones, 1990). The difference between skilled staff

available and those still required widens the “skilled staff gap”, and impels the bank to provide “training” or educational programs to fill it.

Negative feedback loop F. Extranet banking also has the potential to increase a backlog of problems. At present, a department in charge has to send staff to fix customers’ problems at the rate of 2-3 cases per day. Most problems come from the difficulty in connecting to the bank, sluggish response in transferring data and downed servers. A backlog of problems results in increased rate of technology abandonment, and subsequently decreases the rate of technology diffusion (The Siam Commercial Bank’s staff, 1998d).

Negative feedback loops G1 and G2. Problems from technology usage may exert negative impacts on customer satisfaction, leading to the decrease in active customers and thus relative advantages.

Negative feedback loop H. Providing training programs to upgrade the quality and quantity of skilled staff results in increasing costs and decreasing profits (Farr & Sullivan, 1996; Goff, 1999).

Negative feedback loop I. The more the technology is diffused the higher and more various are the costs involved, from initial costs in feedback loop B such as training costs, and costs to resolve problems (Madu, Kuei, & Madu, 1991).

Negative feedback loop J. Profits from this technology induce the bank to additional investment and upgrading of the technology. Conversely, such investment may reduce the profits of the bank (Takac & Singh, 1992).

Negative feedback loop K. Since Extranet banking relates directly to customers, the market potential is important to indicate the future level of sales and anticipated relative advantages. The bank is able to increase sales, however, once the market is completely saturated, sales and profits decrease.

10.5 Model Analysis Using Quantitative System Dynamics Approach

Although the qualitative model provides holistic perspectives, it may not suffice for analyses of the impacts of interaction between the feedback loops. The model of Extranet banking was then elaborated based on a quantitative system dynamics approach (see details in Appendix 10.1).

10.5.1 List of Variables of Extranet Banking

Table 10.6 illustrates the list of variables of Extranet banking deriving from both personal interviews and the questionnaires. The level of actual performance (i.e. the level of current perceptions of staff) towards each issue was identified using a 1 to 7 scale. The lowest score (1) indicates the lowest performance. On the other hand, the highest one (7) determines the level of desired performance. The level of actual performance (1 to 7) was converted to a zero to 1 scale value in order to facilitate simulation using *ithink* software.

Table 10. 6. Lists of Variables of Extranet Banking (EB)

Name	Initial Data	Value used in <i>ithink</i> simulation
Adoption and diffusion		
1.1 Rate of investment in IB	Baht 2 million per year.	Baht 166,666
1.2 Total investment in technology	Baht 20 million. The project started 1 Aug 1996.	Initial value for investment in IB = baht 20 million Cost of technology = baht 20 million
1.3 Rate of IB diffusion	Numbers of subscribers = 600/year or 50/month. No of transactions/month = 80,000 Amount of fees/month = Baht 550,000	Numbers of subscribers = 50 person/month.
1.4 Diffused IB	Current number of subscribers = 2,000	2, 000
1.5 Investment in new technology/ year	Baht 500 – 1,000 million 9% of the bank expenditure	
1.6 Backlog of problem	Number of problems 3 cases/day	Problem fraction = 0.0015 percent per month
1.7 Rate of technology abandonment	2- 3 %	0.03 per year
1.8 Economic situation	Economic growth = -3-3.5 %	
Features of technology		
2.1 Reliability	Level of actual performance = 7	1.00*
2.2. Security	Level of actual performance = 7	1.00*
2.3 Easy to use	Level of actual performance = 6	0.85*
2.4 Compatibility with existing systems	Level of actual performance = 6	0.85*
2.5 Triability	Level of actual performance = 6	0.85*
2.6 Observability	Level of actual performance = 6	0.85*
Bank environments		
3.1 Formalisation	Level of actual performance = 7	1.00*
3.2 Centralisation	Level of actual performance = 7	1.00*
3.3. Size of organisation	Level of actual performance = 6	0.85*
3.4 Management support	Level of actual performance = 7	0.85*
3.5 Organisational resources	Level of actual performance = 5	0.71*
3.6 Co-operation between IT and users	Level of actual performance = 7	1.00*
3.7 Experience in technology	Level of actual performance = 6	0.85*
Customer behaviour		
4.1 Customer acceptance	Level of actual performance = 6	0.85*
4.2 Customer satisfaction	Level of actual performance = 7	1.00*
4.4 Perceived complexity	Level of actual performance = 4	0.57*
4.5 Perceived relative advantages	Level of actual performance = 4	0.57*
Staff		
5.1 Required skilled staff	500 people for 1 0 groups	5,000 (adjusted to 1,000 after validation phase)
5.2 Level of actual skill	Level of actual performance = 3	0.42*
5.3 Level of technical training from the bank	Level of actual performance = 5	0.71*
5.4 Level of understanding in using technology	Level of actual performance = 5	0.71*

Name	Initial Data	Value used in <i>ithink</i> simulation
5.5 Staff acceptance	Level of actual performance = 5	0.71*
5.6 Perceived complexity	Level of actual performance = 4	0.57*
5.7 perceived relative advantages	Level of actual performance = 6	0.85*
Relative advantages	Decrease internal performance cost because customers do not go to the bank counters (20,000 * 15 baht/month)	Baht 150/ Diffused IB
6.1 Cost saving		
6.2 Increased sales	- Revenue from sales = baht 6,000,000 /year - Number of customers =2000 - Number of transaction = 80,000/month	- No. of transaction/month = 40 - Avg. fee per transaction =6.25 baht
6.3 Increased market share	Level of actual performance = 6	0.85*
6.4 Competitive advantage	Level of actual performance = 6	0.85*
6.5 Image	Level of actual performance = 7	1.00*
6.6 Capitalise on business opportunity	Level of actual performance = 6	0.85*
6.7 Decreased costs for branch establishment	Level of actual performance = 6	0.85*
Cost		
7.1 Costs of technology	Baht 20 million	Baht 20,000,000
7.2 Training costs	Baht 200,000 /year	Baht 16,666/month
7.3. Operating costs	11* 20,000/month	Baht 110/Diffused IB
7.4 Costs from backlog of problems	Costs from resolving backlog of problems and maintenance costs = baht 400,000/year	Baht 150/Diffused IB
7.5 Maintenance costs		Baht 50/ Diffused IB
7.5 Expense on sales promotion	Baht 200,000/year	Baht 16,666/ month
Time		
8.1 Time for customisation	12 months	1 month
8.2 Time for training staff	1 week	1 month
8.3 Time for gaining customer satisfaction	2 weeks to 1 month after offering by salespersons	1 month
8.4 Economic life of technology	3 up to 5 year	60 months
Marketing		
9.1 Advertisement	Level of actual performance = 4	0.57*
9.2 Positive word of mouth	Level of actual performance = 6	0.85*
9.3 Timing of market entry	Level of actual performance = 6	0.85*
9.4 Price	Level of actual performance = 6	0.85*
9.5 Potential market	Level of actual performance = 6	0.85*
9.6 Number of prospective customers	10,000	10,000

Note * Level of actual performance was converted to 0-1 scale

10.5.2 Model Analysis

Parts of the derived data were scattered, unrelated and conflicted with each other. Inconsistent data are common due to the fact that people in charge can give only piecemeal data, rather than holistic data about the system. Examples of conflicting data are as following.

“The bank wants to increase the customer base by 600 people per year within 5 years.”

“The economic life of this technology is 3 to 5 years.”

“The potential market of this technology is about 10,000.”

“The revenue target is 20 per cent increase per year.”

“The bank invests in this technology baht 2 million per year.”

“The bank will train staff, 10 groups with 500 people per group.”

The above data is inconsistent. First, if the bank increases by 600 customers per year it will take 16 years to absorb the potential market (10,000 customers) but the economic life of this technology is only 3-5 years. Second, the revenue target of the bank is 20 per cent per year. However, the bank cannot achieve the target because an increase in 600 customers per year means that the rate of increase in customers is decreasing from 30 per cent for the first year to 12 per cent per year at the end of the fifth year. Third, the bank spends baht 2 million per year for investment in this technology and intends to provide massive training. However, the interviewees did not identify that this amount of investment and trained staff could help the bank to increase the target revenue of 20% per year.

Therefore, an incremental approach was employed to develop a quantitative system dynamics model to find a complete model at the present state and to validate consistency among the data. The model was then used as a baseline model in order to explore strategic policies to detect leverage points that may increase the rate of technology diffusion and profits and promote “system learning” (Senge, 1992). The results from four simulations- focusing on the rate of technology diffusion, time to gain 5,000 customers, numbers of subscribers, and profits within 60 months- are presented in Table 10.7.

Table 10. 7. Comparison of Simulation Results using an Incremental Approach

	Rate of technology diffusion (within 60 months)	Time to acquire 5000 customers (months)	Diffused Extranet banking (Numbers of customers) within 60 months	Profits within 60 months (1,000 baht)
Base run 1 (Using a diffusion target)	42	129	3,665	19,939
Base run 2 (Using a growth rate of diffusion)	28-57	83 (only 4,685)	3,502	16,799
Base run 3 (Adding training)	28-104	65	4,593	21,327
Base run 4 (Adding a backlog of problems)	28-91	73	4,092	18,761

10.5.2.1 Base Run 1: Using a Diffusion Target

The first simulation used a target of the bank endeavouring to diffuse this technology to 600 subscribers per year (i.e. 50 per month) as a rate of technology diffusion. The simulation aimed to use the interview data without any attempt to link the variables. That is, there is no linkage between investment in technology and technology diffusion, between investment in technology and profits, and between staff and technology diffusion.

The results of this simulation revealed that the rate of technological diffusion was 42 subscribers per month and took the bank to gain 5,000 customers 129 months. The bank obtained 19 million baht within 60 months. However, the results did not accord with reality because the economic life of this technology is projected at up to 84 months (the economic life of technology is expanded from 60 to 84 months, if the bank spends substantial continuous investment on technology).

10.5.2.2 Base Run 2: Using a Growth Rate of Diffusion

This simulation was undertaken using the current customers (2,000 customers) as diffused technology with a 20% per year growth rate of diffusion instead of highlighting a constant customer target (i.e. 50 subscribers per month). The rate of technology investment, the rate of technology diffusion, and profits were linked.

The rate of technology diffusion increased from 42 subscribers for the whole 60 months in *Base run 1* to a range between 28 and 57 customers per month. The bank gained the highest number of subscribers (4,685), within 83 months because of leakage such as technology abandonment and technology obsolescence, and would have 3,502 subscribers within 60 months. The bank can gain 16 million baht from technology investment.

10.5.2.3 Base Run 3: Adding Training

This simulation inserted a staff sector into the previous simulation. The assumption under this simulation is that if the bank has more skilled staff, the rate of technology diffusion should increase because of higher acceptance from customers, and improved staff behaviour in terms of better understanding in technology use, more acceptance and a decrease in perceived complexity. The two factors from customers and staff will accelerate the rate of technology diffusion. The accelerator factor was calculated from the derived data by supposing that the current accelerator factor was 1. According to Table 10.7, training increased the rate of technology diffusion from 57 to 104 customers per month. The bank gained 5,000 customers within 65 months and obtained 21 million baht within 60 months.

10.5.2.4 Base Run 4: Adding a Backlog of Problems

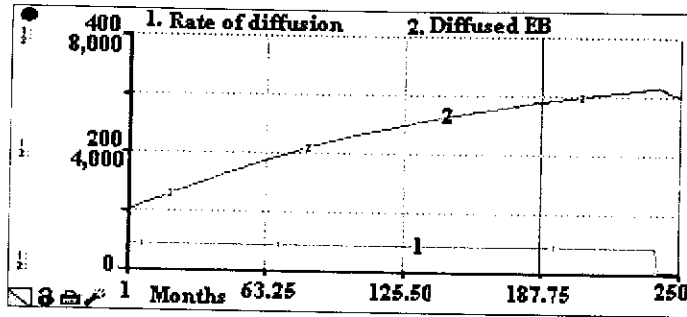
The data from interviewing bank officials indicated that the rate of technology abandonment of Extranet banking was 2-3 per cent per year. Additionally, the bank had to send staff to solve customers' problems, averaging three cases a day. Therefore, *base run 4* exerted impacts from a backlog of problems on the rate of technology diffusion and the rate of technology abandonment. The basic assumption is that the more customers perceive problems in technology usage, the more they

abandon it, and the harder the task for the bank staff to convince new customers to use it. There were two main changes in this simulation. That is, a backlog of problems decreases the rate of technology diffusion but increases the rate of technology abandonment.

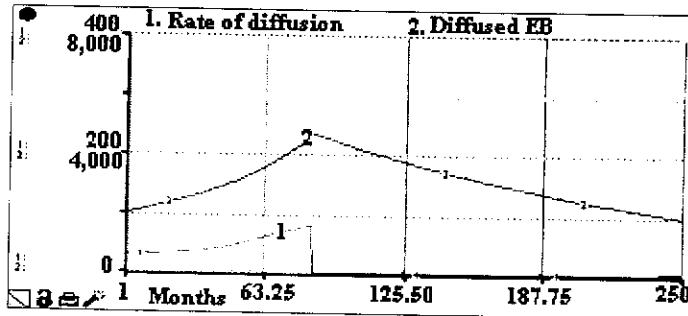
A backlog of problems decreased the rate of technology diffusion from 104 to 91 persons per month. Furthermore, the bank took a longer time to gain 5,000 customers (from 65 to 73 months), absorbed fewer prospective customers (from 4,593 to 4,092 people within 60 months), and received less profit (from 21 to 18 million baht).

The comparison of each simulation is illustrated in Figure 10.2. The rate of technology diffusion from *base run 1* is constant at 42 customers per month. The rate of technology diffusion increases up to 57 in *base run 2* because of the growth rate of technology diffusion that the bank tries to achieve, and the relationships between technological investment, technology diffusion and profits. Training (*base run 3*) enhances the rate of technology diffusion whereas a backlog of problems (*base run 4*) decreases it. Note that in Figures 10.2 b, c and d the rate of diffusion drops suddenly after time period 84, which has been set as the economic life of Extranet banking.

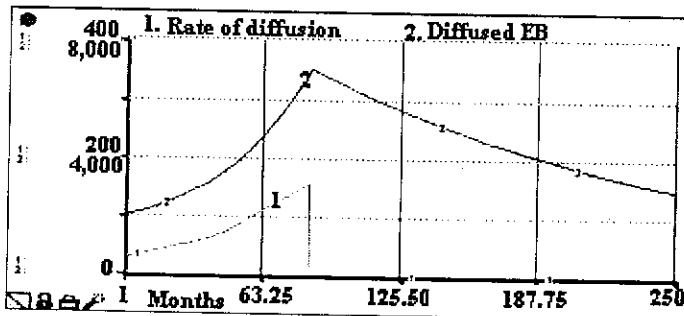
The patterns of diffused Extranet banking follow an s-curve, with different slopes however. According to Figure 10.2b, the diffused technology gradually increases up to period 84 and then diminishes due to abandonment of technology and the economic life of the technology. The bank, therefore, cannot absorb the market potential (10,000) before technology is obsolete. Once the bank provides training (Figure 10.2c.), diffused technology increases more rapidly compared to that of the previous scenario leading to absorbing more customers from the potential market. Yet, when the problems are accommodated (Figure 10.2d.), the slope of the diffused technology is more elastic than that of the *base run 3*. That is, the bank takes a longer time (i.e. 73 months) to gain 5,000 customers and absorbs less market potential.



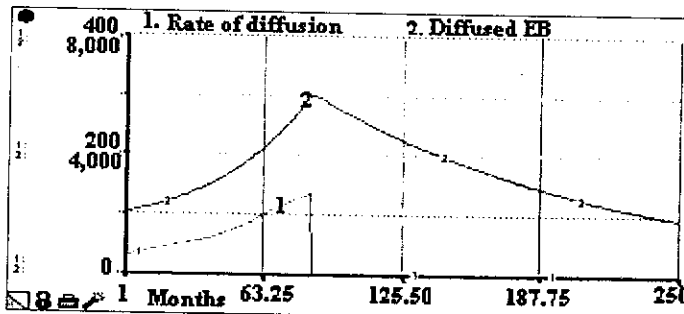
a. Base run 1: using a diffusion target



b. Base run 2: using a growth rate of diffusion



c. Base run 3: adding training



d. Base run 4: adding a backlog of problems

Figure 10. 2. Comparison of the Rate of Technology Diffusion and Diffused Extranet Banking between Different Scenarios

10.6 Policy Analysis for Extranet Banking

The policy analysis aims to observe impacts of strategic policies and detect the leverage policies that may increase the rate of technology diffusion of Extranet banking and profits from use of this technology.

The bank executives identified the seven strategic policies and people in charge of Extranet banking identified a level of current perception (i.e. actual performance) of each policy using the 1-7 scale (i.e. lowest to desired performance). The perception toward actual performance of each strategic policy of development, from prospective staff and customers may differ and so the average values were used. Then, the level of performance (1 to 7) was transformed to a zero to 1 scale for simulation (see Table 10.8).

1. **Increased levels of training.** People in charge of Extranet banking believed that if the bank increases the level of training, this technology can be diffused faster, leading to an increase in profits because sufficient skilled staff are able to convince prospective customers to adopt the technology. They also can support existing customers more efficiently that may prevent customers from technology abandonment (The Siam Commercial Bank's staff, 1998d).
2. **Increased co-operation between IT people and users.** According to Table 10.5, although Extranet banking is a user-friendly technology, prospective customers still lack confident in using it because of worrying about their insufficient computer knowledge and uncertainty about security systems (Extranet banking prospective customers, 1998). Technological assistance and close communication when customers have problems may help the bank diffuse this technology more productively.
3. **Decreased perceived complexity.** Actually, Extranet banking is not complicated technology for people who use Internet regularly because of its user-friendly interfaces. However, for most Thai people, perceived complexity is still high because the Internet is still new (Extranet banking prospective customers, 1998). Furthermore, bank staff need combined

technological expertise and business knowledge to convince customers of the advantages of Extranet banking during sales enforcement. At the same time, users need to have both skills to make full use of it. Therefore, making technology easy to use is vital for the success of technological diffusion. The bank tries to decrease the perceived difficulties by facilitating the usage with user-friendly tools, demonstration, and attempting to change the technology to Internet banking (The Siam Commercial Bank's executives, 1999). In the future, when Internet usage is common and more available, the perceived complexity of Extranet banking may decrease because users are able to develop their learning skills and easily apply their knowledge to maximise advantages from the technology.

4. **Increased perceived relative advantages.** Prospective customers perceived that Extranet banking was beyond their necessity compared to costs (e.g. subscription fees and fundamental investment in computers and modems) (Extranet banking prospective customers, 1998). At present, the bank plans to increase perceived relative advantages of this technology by evolving Extranet into Internet banking, and incorporating electronic commerce into this technology. Electronic commerce will allow existing customers to do business with each other using the Extranet banking as a medium for trade and financial transactions (The Siam Commercial Bank's executives, 1999).
5. **Increased management support.** The bank staff indicated that an important factor in driving technology development is support from top executive managers (The Siam Commercial Bank's staff, 1998b; 1998d).
6. **Increased positive features of technology.** Positive features of Extranet banking such as security, reliability, quick response time, and accessibility are important for the success of its diffusion.
7. **Marketing strategies.** Since Extranet banking serves customers directly, marketing strategies are vital to increase the rate of technology diffusion and profits. According to Table 10.5, twenty five percent of the respondents revealed that they did not know the availability of this technology. Thus,

increasing promotional advertising may lead to increases in the rate of technology diffusion (Bee, 1988; Feichtinger, 1992).

Table 10. 8. List of Strategic Policies of Extranet Banking

Policy	Level of actual performance (Average Weight-1 low and 7 high)	Level of desired performance (Average Weight-1 low and 7 high)	Value used in <i>ithink</i> (Average Weight-0 low and 1 high)
1. Increased levels of training	3.38 (prospective staff) 5.00 (developers) 4.19 (average)	7	From 0.60 to 1.00
2. Increased co-operation between IT people and users	3.89 (prospective staff) 7.00 (developers) 5.45 (average)	7	From 0.78 to 1.00
3. Decreased perceived complexity (Make it easy to use)	4.00 (prospective staff) 4.00 (developers) 4.00 (average)	7	From 0.57 to 1.00
4. Increased perceived relative advantages	4.00 (prospective customers) 6.00 (developers) 5.00 (average)	7	From 0.71 to 1.00
5. Increased management support	6.00	7	From 0.86 to 1.00
6. Increased positive features of technology	6.33	7	From 0.90 to 1.00
7. Increased advertising	4.00	7	From 0.57 to 1.00

Sources: (The Siam Commercial Bank's executives, 1998; The Siam Commercial Bank's staff, 1998d; 1998e)

Each strategic policy was additionally simulated from the baseline model (*the base run 4*) in order to find leveraged policy that may increase the rate of technology diffusion. The end results of each policy were compared in Table 10.9. The comparison patterns of diffused technology and the rates of technology diffusion from different policies are also illustrated in Figures 10.3 and 10.4.

Table 10. 9. Comparison of the Impacts of Exerting Strategic Policies

Policy	Rate of technology diffusion (within 60 months)	Diffused Extranet banking (within 60 months)	Break-even point of time of return on investment (months)	Profits within 60 months (1,000 Baht)
1. Baseline simulation	28-91	4092	37	18,761
2. Increased levels of training	28-95	4263	37	19,849
3. Increased co-operation between IT people and users	34-142	5189	35	23,988
4. Decreased perceived complexity (Make it easy to use)	40-185	6110	34	28,224
5. Increased perceived relative advantages	31-119	4702	36	21,681
6. Increased management support	30-104	4373	37	20,127
7. Increased positive features of technology	29-136	5670	34	26,470
8. Increased promotional advertising	31-113	4579	37	20,772
9. All policies	64-521	11166	28	70,342

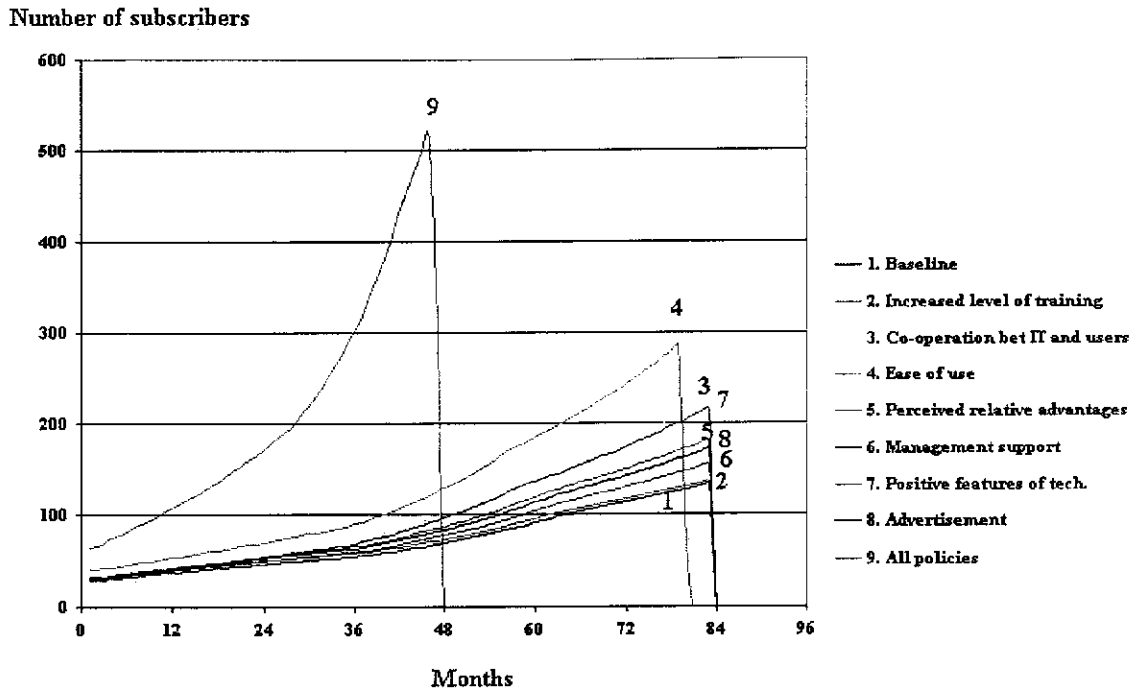


Figure 10.3. Comparison of Rate of Technology Diffusion from Different Policies

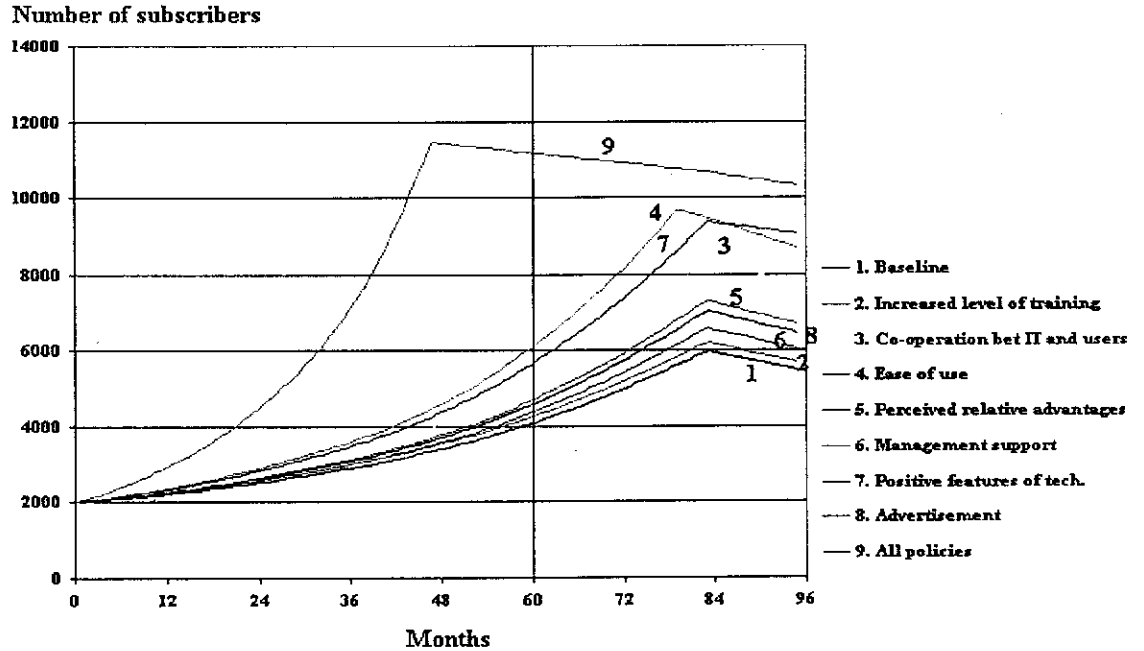


Figure 10.4. Comparison of Diffused Extranet Banking from Different Policies

Leverage policies are the policies that gain higher subscribers or absorb the potential market within the shortest time due to the limitation of the economic life of

technology (60 months). As a matter of fact, the model was simulated using the economic life of technology of a minimum of 60 months and a maximum of 84 months depending upon adequate continuous improvement and investment. However, Table 10.9 presents the outcomes up to period 60, because of a high evolution of information and communication technology.

Decreased perceived complexity (6,110 subscribers), increased positive features of technology (5,670), increased co-operation between IT people and users (5,189), increased perceived relative advantages (4,702), and increased promotional advertising (4,579) are five main policies that may drive the rate of technology diffusion. However, *increased level of training* and *increased management support* do not provide a strong impact on technology diffusion. This is because affect of the increase in the number of trained staff does not directly result in diffused Extranet banking and the bank executives have already given full support for this technology.

If the bank combines all the policies and undertakes them effectively, ideal technology diffusion will increase from 4,092 to 11,166 subscribers. The bank experts revealed that it is possible to combine the proposed policies. Currently, the bank tries to evolve the Extranet banking to Internet banking to make the technology much easier to use. The bank also plans to combine electronic commerce with this technology to offer additional relative advantages to customers. Continuous technology improvement, co-operation between IT people and users, training support, and management support are normal practices of the bank. However, the bank places an emphasis on promoting the image of the bank rather than on a particular technology. The promotional advertising of Extranet banking can be applied to informal advertising such as word of mouth (The Siam Commercial Bank's executives, 1999).

Figure 10.5 illustrates the comparison among profits based on each strategic policy. Those fore-mentioned policies (i.e. *decreasing perceived complexity, positive features of technology, co-operation between IT people and users, increasing perceived relative advantages, and increasing advertising*) may increase profits of the bank. Ideally, if the bank combines all the policies, the profits may increase from

baht 18 million within 60 months to baht 70 million. The break-even point of return on investment may decrease from 37 months to 28 months.

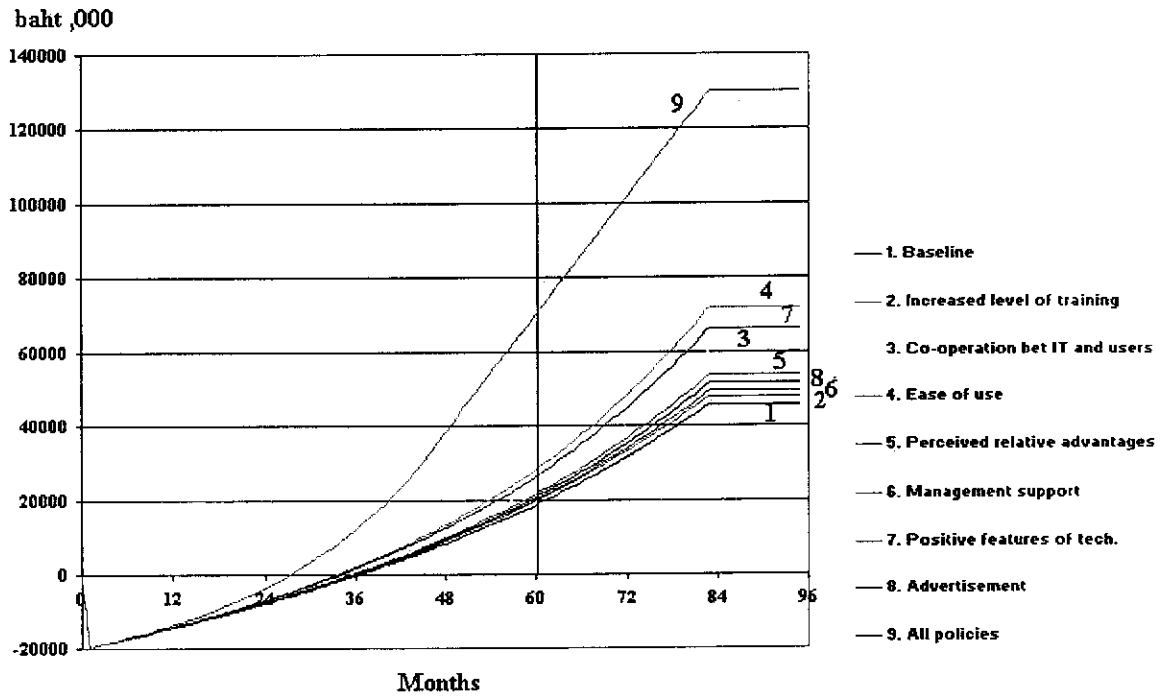


Figure 10.5. Comparison among Profits from Different Policies

It can be observed from the model analyses using cases of Extranet banking and the data warehouse that some strategic policies exert high impacts on the diffusion process of the both technologies; but others affect on particular technologies only. The following are issues emerging from the results of policy analyses of both technologies.

There are three important points where the leveraged policies of Extranet banking and the data warehouse (Chapter 9) either agree or differ.

First, strategic policies such as *increased positive features of technology*, *decreased perceived complexity*, and *perceived relative advantages* are leveraged policies for the data warehouse and Extranet banking because both technologies are perceived as incomplete, complicated, implicit-advantage technologies. Users perceive that the data warehouse still provides incorrect/non-updated data, is difficult to use, and they are unsure about expected advantages. Customers of Extranet banking are also

uncertain about security, are confronted with difficulties in accessing and transferring data, and are unsure about benefits from usage (Extranet banking prospective customers, 1998; The Siam Commercial Bank's staff, 1998b; 1998e).

Second, strategic policies that impact greatly on a data warehouse diffusion may not be important for Extranet banking. For example, *increasing level of training* is the leveraged policy of a data warehouse because the numbers of diffused data warehouse was represented by the numbers of knowledge workers who use the technology regularly. That is, increasing the level of training means directly increasing the numbers of diffused technology. On the other hand, diffused Extranet banking was represented by the numbers of subscribers of the technology. Increasing the level of training is a process to create the numbers of skilled workers to sell and support the technology. This may affect diffused technology indirectly.

Third, Extranet banking is a commercial technology and not sufficiently informative for prospective customers (Extranet banking prospective customers, 1998). Therefore, highlighting marketing strategies such as promotional advertising has substantial impacts on its diffusion process. The data warehouse, however, has been developed to serve internal work processes and its availability is widely promoted. Thus, this strategic policy was not taken into account for the policy analysis of a data warehouse.

10.7 Model Validation

The diffusion model of Extranet banking was verified based on the core confidence-building tests in the same way as validation of the ICT model. Therefore, the model validation of the Extranet banking puts emphasis only on the Turing test and tests of policy implication.

The model of Extranet banking was validated by the five executives with expertise in the technology of the bank. The experts agreed with the outcomes from the model analysis; yet many parts of the model were revised based on their recommendations. The details of the model validation based on the bank experts are as follows.

1. They agreed that the break-even point of the technology is approximately three years and can be reduced within two years if the bank exerts appropriate policies to enhance the rate of technology diffusion. However, they cannot explicitly identify profits from the technology.
2. They did not agree with the process of training. According to the previous data provided by people in charge of this technology, the bank planned to train 5,000 bank officials around the country by dividing the training into 10 groups. The experts revealed that the bank has not implemented the training plan and the numbers of required skilled staff set at 5,000 is exaggerated. Therefore, after the validation phase, the model was revised by changing the numbers of required staff from 5,000 to 1,000. A time delay for training was set at 12 months because although the training time is short, the process in providing training is long. Many factors obstruct the provision such as the readiness of trainers, the facilities at branch offices, and inappropriateness in communication infrastructure to sell the technology around the country. The results from the improved model indicated that although the values of concerned variables such as the rate of technology diffusion, diffused technology, and profits were changing from the previous analyses (Intrapairot, Quaddus, & Kummerow, 1999), the behavioural patterns of these variables were similar.
3. They felt that *increasing positive features of technology, decreasing perceived complexity; increasing co-operation between IT people and users* are not quite important because Extranet banking is not difficult to use. However, the information from the prospective users revealed that they perceived the technology as difficult and insufficiently reliable. Actually, the information from the current uses of Extranet banking can reveal the levels of actual performance of the technology. Unfortunately, staff in charge of the technology who distributed the questionnaires to their customers for the protection of bank confidentiality have not returned the questionnaires. In the future, the bank can use the information from the

current subscribers to retest the policies in order to fill gaps between the perceptions of prospective uses and those of the developers.

4. *Increasing perceived relative advantages* is an important policy. At present, the bank tries to add some advantages for users such as planning to combine electronic commerce with Extranet banking. This service will provide customers with more advantages and convenience from cross selling among subscribers of the technology and from using the bank facilities for information and financial transaction. In addition, the Extranet banking will be evolved into Internet banking in order that customers can gain more benefits from ease of use and access to the bank system.
5. Although *promotional advertising* is an important policy to speed up the rate of technology diffusion, it is hard to increase the promotional advertising specific for Extranet banking. Normally, the bank does not have a plan to promote bank products or services individually but emphasises the bank image. They suggested that this policy could be conducted informally using positive word of mouth or demonstrations.

The model of Extranet banking was valid due to its usefulness in helping the bank diffuse the technology efficiently and its process in building confidence into the model. The model also passed validity testing using the formal criteria for model validation.

10.8 Requisite Group Model of Diffusion of Extranet Banking, and Requisite Policies for Adoption and Diffusion: Research Questions 3 and 4

The model of diffusion of Extranet banking was a requisite group model (Phillips, 1988) that was conducted to help decision-makers in the bank understand the system behaviour of the technology and subsequently make appropriate decisions to diffuse it productively. The model was developed to additionally support the answers for the

third and fourth research questions in Chapter 8 but highlighting the diffusion process via bank customers instead of via the internal-organisation.

The model was initially developed using the influence diagram (Figure 10.1) to illustrate the inter-relationships among variables. Then, the variables were simulated based on quantitative system dynamic approach. The results confirmed that the diffusion of Extranet banking also follows the s-curve (Figure 10.2). The analysis of requisite policies for technology adoption and diffusion revealed that the leveraged policies were: *making technology ease of use, increasing positive features of technology, increasing co-operation between IT people and users, increasing perceived relative advantages, and increasing promotional advertising*. On the other hand, *increasing management support, and increasing level of training* did not exert a high impact on technology diffusion. If the bank combines these requisite policies, it will absorb more customers of the technology within a shorter time.

10.9 Summary

Currently the level of acceptance in using Extranet banking in Thailand is not high. It is however believed that adopters of this technology will increase in the long run in the same way as those who use ATM machines.

The model of Extranet banking provides the answers for the requisite model and policies of ICT diffusion highlighting that this technology and its diffusion process is related directly to customers. The analysis of the model pointed out that making the technology easy to use, increasing positive features of technology, co-operation between IT people and users, and increasing perceived relative advantages are the main issues that the bank should consider. Additionally, since this technology is employed to service customers, marketing such as promotional advertising is necessary to boost the rate of technology diffusion in order to absorb the market potential before the technology becomes obsolete, due to the limitations of its economic life.

The proposed Extranet banking model is however constrained by limitations, in that it may not be a suitable vehicle for accurate predictions because of the potential

unreliability of information gathered. This incompleteness of data is due to a variety of reasons, in the main based on the “human factor”. For example, inconsistencies in data derived from the fact that bank staff responsible for validating data were unable to devote sufficient time or interest to it because of other demands of work. Data were also scattered and potentially biased because of respondents’ varying perceptions. Finally, not all parts of the data, especially costs and benefits, could be recorded or classified because of the properties of data (e.g. un-categorisation, implicitly and un-quantification), and confidentiality. Therefore, if an organisation requires an accurate forecasting model, provision of accurate information and full co-operation between the model analyst and stakeholders of the organisation are a must. Nevertheless, at the least, this model analysis may be useful as a basic guideline for promoting the learning and understanding of the people involved. That is, bank staff are able to “play” with it by adding more variables (e.g. economic situation, competitors), changing the relationships between variables, as well as adding other strategic policies as they see fit.

A summary of the entire research, main findings of the study, study limitations and recommendations, implications and future research will be presented in the following chapter.

CHAPTER 11

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

11.1 Introduction

The first part of this chapter identifies if the Thai baking Industry is able to use information and communication technology (ICT) at a level for competitive advantages. Next, the chapter recapitulates the entire research and highlights the main findings discovered from previous chapters. Other pertinent issues revealed during the study including study limitations and implications for future research, are identified and recommendations suggested.

11.2 Using ICT as a Lever for Competitive Advantage: Research Question 5

Information and communication technologies (ICT) are widely used for three main purposes: to service customers with convenient services and differentiated products or services; to accelerate work processes and improve work performance beyond human capability; and to aid decision-making and strategic planning (The Siam

Commercial Bank PCL, 1995). It is believed that if organisations attain these aims, technology may help them to compete with competitors, retain and increase market share, sales and profits. However, no research has been conducted to identify that the Thai banking industry can gain competitive advantages from technological investment.

The objective of this section is to uncover the answer for the fifth research question *“can information and communication technologies be used as levers of competitive advantage for the banking industry in Thailand, and if so, why and how?”* The answer was analysed from data collected from two main sources: interviews and documents. People who have technological knowledge from four commercial banks were interviewed including 1) Krung Thai bank representing a large bank, 2) Thai Military Bank representing a medium-sized bank, and 3) Bank of Asia and Siam City Bank representing a small-sized bank. Documents consist of information from publications, annual reports, and information from the Internet. Content analysis was employed for data treatment.

The information revealed that the Thai commercial banks agreed that they are able to use information and communication technologies as a lever for competitive advantage. Technologies can be used to create competitive advantages both internally and externally. The banks internally employ technologies to facilitate work processes, improve work performances and assist better decision-making. At the same time, technologies differentiate products, create value added, and facilitate services that will attract external customers (C. Kangwanpong, personal communication, June 22, 1999.). Each commercial bank employs technologies that suit its business vision and objectives. The Thai banking industry can be divided into four groups: large banks, medium-sized banks, small banks, and branches of foreign banks (The Siam Commercial Bank PCL, 1995).

11.2.1 Technology Usage in the Large Banks

The large commercial banks such as Bangkok Bank, Thai Farmers Bank, Krung Thai Bank, and the Siam Commercial Bank employ various kinds of technologies due to

sufficient resources in terms of monetary funds and skilled workers. The main core characteristics for technology uses of the large banks are as follows.

The large banks have clear visions to use technology for competitive advantage. They aim at being a technological leader and deploy technologies to gain competitive advantages in terms of market share and profit. For example, Bangkok Bank, which is the largest Thai bank, has a vision of being a quality full-service bank and becoming one of the leading international banks in Asia. To attain this aim, the bank emphasises human resources, technology, and operational efficiency. Technology is viewed as an important integral part of the bank and is continuously developed to maintain the bank's position as a leader in banking technology (Bangkok Bank Public Company Limited, 1998). Krung Thai Bank makes a commitment to invest in information technology and staff training in order to be ready for changes in the work system and to strengthen the bank's competitiveness (Krung Thai Bank, 1999). Thai Farmer Bank perceives that service differentiation and the ability to provide efficient high quality service are critical factors for retaining a competitive advantage and ensure future success. Therefore, a huge investment has been made in computer technology emphasising a "re-engineer" program (Thai Farmer Bank Public Company Limited, 1999b). The Siam Commercial Bank has long adopted policies to invest in technology to respond to customers' requirements and still places strong emphasis on technological developments to be a leader in finance and banking technology and adapt to economic fluctuations and business competition (Banking technology information, 1999b).

Large banks have continuously developed technology and spent heavily on technological investment, despite the economic crisis. Bangkok Bank, for example during the economic recession, had to postpone many important projects including building a new head office, but technological projects still proceeded such as completion of a computer centre worth more than US\$25 million (Banking Technology Report, 1999). The bank will also spend approximately US\$ 400-500 million over the next five years on technological improvements (Bangkok Bank, Public Company Limited, 1999b).

The technological investment of each bank is well planned and managed. Technological investment is prepared to make ready for future growth in areas such as technological infrastructure, computer centres, network systems and re-engineering programs. Bangkok Bank has developed technologies to provide more service channels, upgrade communication network, improve a number of internal operations for better efficiency, improve information in the data warehouse system, upgrade the web technology system, and solve the Y2K problem (Bangkok Bank Public Company Limited, 1998; 1999a). Recently, the bank completed a computer centre to support and ensure uninterrupted customer services and banking work processes (Banking Technology Report, 1999). Krung Thai Bank, despite being confronted with budget constraints, still continues technological development to be ready for the future (e.g. a new computer centre and the Y2K project) (Informatic, 1998b). Thai Farmers Bank puts emphasis on "re-engineering" bank operations to improve customer services and operational efficiency. With this program, the bank is able to reduce customer waiting time with less staff, shorten the loan approval process, and improve efficiency of the payment process and collections ("Re-engineering in Thailand," 1997; Thai Farmer Bank Public Company Limited, 1999a). The Siam Commercial Bank has applied web technology in conjunction with the development of data systems (a data warehouse) for both internal and external use (e.g. Intranet and Extranet).

The development of technology of the large banks has been developed together with investment in human resources because advantages from technology depend on the utilisation of human beings. Therefore, training and educational programs are highlighted. The Siam Commercial Bank, for instance, started developing the "learning organisation" concept in 1995. In 1996 the bank spent funds for personnel development in order to create skilled personnel to serve customers ("SCB sees new concept," 1996).

The large banks attempt to pioneer promising and advanced technology in order to be an innovative leader searching for new business opportunities. Krung Thai proudly provides an on-line ticket-less booking system (T. Simasathien, personal communication, June 25, 1999). Currently, Thai Farmers Bank and the Siam

Commercial Bank are both interested in launching electronic commerce due to a huge market potential (Banking technology information, 1999b; Informatic, 1998c; Thai Farmer Bank Public Company Limited, 1999b).

11.2.2 Technology Usage in the Middle-Sized Banks

The middle-sized banks such as Bank of Ayudhya and Thai Military bank are more careful in adopting new technology. They tend to adopt departmental systems rather than integrated systems or follow technologies that are successfully implemented by the large banks because of limitations in resources and skilled personnel. Technology is mainly adopted to aid work processes (The Siam Commercial Bank PCL, 1995).

The Thai Military Bank agrees that technology can be used as to achieve competitive advantages. Although the bank went from the tenth to the sixth position in the banking industry in Thailand without improving technology, but to retain this position and to gain sustainable growth, technology development is indispensable. Therefore, the bank has spent substantial resources on technological development emphasising a quality branch program and a business process improvement or redesign (BPR) program. These two programs help the bank improve the quality of the branch offices with regard to servicing customers more efficiently, improving decision-making and strategic planning using information from the branches, and expanding the numbers of branches without increasing the number of staff. Being a middle-sized bank, the bank is more cautious in adopting new technology because of limitations in resources. The bank adopts fundamental technologies that are necessary to facilitate work processes and increase customer satisfaction. Advanced technologies will be adopted in accordance with the bank's vision and objectives or following the success stories of pioneer banks. On the positive side being a middle-sized bank allows the bank to gain benefits from economies of scales from investments and to be able to control technological development projects (C. Kangwanpong, personal communication, June 22, 1999.).

11.2.3 Technology Usage in Small Banks

In general, small banks gradually develop only the very successful technology and employ only affordable technology in order to facilitate work processes and support personnel development (The Siam Commercial Bank PCL, 1995).

The small-sized banks also agree that technological investment is an important part of achieving competitive advantages. For example, Siam City Bank indicates that information technology plays an important role because of the high competitive nature of the banking business. Therefore, the bank perceives the importance of human capital and technological development as a prerequisite for the delivery of quality products and services to satisfy customers (Siam City Bank, 1999a; 1999b; Technology group: Siam City Bank, personal communication, June 22, 1999). Bank of Asia has developed technology together with re-engineering for three years in order to achieve the vision of becoming the best Thai financial service centre with a record of innovation and a reputation for professionalism (Bank of Asia Public Company Limited, 1999). The technology development helps the bank to increase branches from 90 to 110 branches but employees decreased from 3000 to less than 2500 in 1998 (Informatic, 1998a; Public relation department of Bank of Asia, personal communication, June 22, 1999). Bangkok Metropolitan Bank emphasises technology, both hardware and software, and personnel development in order to create efficiency in management and enhance customer satisfaction that may lead to retaining the growth rate of the bank (Bangkok Metropolitan Bank Public Co. Ltd., 1995; 1999).

The small banks invest in fundamental technologies (e.g. ATMs, tele-banking, ATM, network systems, account system), and technologies that they can afford and help them fulfil their objectives. Metropolitan Bank places an emphasis on information management systems such as Financial Management Information system and Customer Information Systems (Bangkok Metropolitan Bank Public Co. Ltd., 1995). Siam City Bank invests in well-proven successful technologies such as VISA card and Visa electron and emphasises solving urgent technological problems of the Y2K (Siam City Bank, 1999a; Technology group: Siam City Bank, personal

communication, June 22, 1999). The Bank of Asia invests heavily on the development of the retail bank system by transforming branch offices to be a fully integrated system to support every bank system and function (Informatic, 1998a; Public relation department of Bank of Asia, personal communication, June 22, 1999). Thai Danu Bank launches Smart cards in conjunction with student cards in order to encourage students to use technology in their daily lives (Banking technology information, 1999c). Nakornthon Bank is interested in PC banking, Debit card, telephone banking, and electronic commerce (Nakornthon Bank Public Co., Ltd., 1999).

11.2.4 Technology Usage in Branches of Foreign Banks

Branches of foreign banks adopt technological systems and policies from their parent banks. Normally, they employ more advanced technologies than those of the small banks. For example, Citybank Bangkok branch adopts technology that is designed to a global standard and incorporates the latest technology to meet customers' requirement in order to fulfil the mission of being the best Thai financial service centre with a reputation for innovation, professionalism and doing the right thing for customers (Citybank, 1999).

The results from the study revealed that information and communication technologies (ICT) can be used to achieve competitive advantages for the banking industry in Thailand because technologies help them gain or maintain competitive advantages in terms of market share and survival in an intensely competitive environment. Each bank develops and adopts technology individually depending on its vision, objectives, business size, and availability of resources. Generally, the banks try to cope with technologies or services that other banks have such as ATMs, Tele-banking, home banking services, Internet homepage, and computer centres and may use technology as a competitive weapon. However, at present, many banks are attempting to help each other in order to protect themselves from foreign banks. Thus, the Banking IT Club was established as a centre for the Thai commercial banks to exchange technological information, promote continuous co-operation for technological policies, assistance, and research, increase efficiency in work

performance, and increase capability for competition of Thai financial institutes as a whole (Banking technology information, 1999a).

11.3 Summary

This study was conducted under information systems research domain. The main objective of the study was to develop suitable models for information and communication technologies (ICT) adoption and diffusion in the banking industry in Thailand using two decision-making tools: multiple criteria decision-making (MCDM) and system dynamics (SD).

The models were designed to detect the inter-relationships between variables of technology adoption and diffusion, identify problems, test requisite and operational policies for the bank and provide the answers to the following research questions.

- Q1. What is the current status regarding information and communication technologies (ICT) of the bank?
- Q2. What constitutes a requisite group model of ICT adoption?
- Q3. What constitutes a requisite group model of ICT diffusion?
- Q4. What are the requisite policies of the bank for adoption and diffusion of ICT?
- Q5. Can information and communication technologies be used as levers of competitive advantage for the banking industry in Thailand, and if so, why and how?

The results of the study provide three main contributions.

First, on the conceptual side, the study shows how two well known modelling approaches, MCDM and SD, could be combined effectively. Initially, MCDM was suitably employed for static approaches by selecting the most preferable choice among various alternatives. SD was subsequently employed for detail analyses of the selected choice by capturing inter-relational and dynamic effects among variables in order to detect behavioural patterns of the problems of concern.

Second, on the application side, the study shows how MCDM and SD could be used to develop a requisite group model of ICT adoption and diffusion for a major bank in Thailand, for policy analysis and forward planning.

Third, the models were developed as a decision support tool. With user friendly devices, decision-makers may improve their decision-making processes by running sensitivity analyses, applying the models based on their available information, intuition, and experience, testing for high impact policies, visualising their decision outcomes, and modifying the models to other relevant issues or scenarios.

This study was conducted using two research methodologies: system development research and case study. System development or engineering research is a research method transforming conceptual ideas in people's minds to actual practical outcomes. The case study is a focused investigation of hypothesised relationships in a selected organisation. Based on system development research, the ICT adoption and diffusion models were developed starting from conceptual models using data from literature reviews and respondents' perceptions, and then evolved to user-friendly models that can be put to practical use for decision-making in an organisation. The case of the Siam Commercial Bank PCL was employed in order to customise generic models to fit specific cases using real information, obstacles, and perceptions.

The research consisted of five stages: identifying problems, constructing a conceptual framework, developing system architecture, testing and validation, and conducting policy experiments. Data was collected from various sources including observations, interviews, questionnaires, and documents. All information was interpreted by a content analysis and used for model development, MCDM and SD.

11.4 Major Findings

The major findings providing answers for the identified research questions are outlined below.

11.4.1 Current Status of ICT Usage in the Siam Commercial Bank PCL (Research Question 1)

The Siam Commercial Bank PCL was the first commercial bank in Thailand and is recognised as one of the four largest banks. The bank aims to achieve the mission of being the best managed bank with sustainable and excellent performance. To this end, the bank maintains competitiveness through teamwork using a “learning organisation” concept, develops skilled staff to ensure high quality of work, and employs technologies to support decision-making, management, and customers’ requirements.

The bank currently employs various types of technologies including ATMs, EFTPOS, smart cards, databases, a data warehouse, video conferencing, Intranet system, Extranet banking, and network systems. These technologies are designed to improve banking services, fulfil customers’ requirements, increase efficiency in working processes, provide accurate and timely information for decision-making, increase business opportunities, retain competitive advantages, eliminate re-work and redundancy, reduce operational costs, and maintain the good image of an innovative leader in the field.

However, the bank still confronts problems relating to technology adoption and diffusion. Predominant problems faced are rapid obsolescence, selecting inappropriate technologies, under-productive technology usage, lack of skilled employees, high costs of technologies, under-expected performance from technologies, receiving incorrect information, and insufficient acceptance in some technologies from bank staff and customers.

11.4.2 A Requisite Group Model of ICT Adoption (Research Question 2)

The MCDM technique was employed for technology evaluation and selection. The model development consisted of three stages: structuring a problem; eliciting information and values; and evaluation.

The first stage was to identify the objectives that the bank are aiming to attain. Then, all potential alternatives were identified for evaluation under a set of specific criteria. The five technological alternatives that the bank uses to fulfil its objective of being the best managed and performed bank are: smart cards; a data warehouse; video-conferencing; Internet/Extranet banking; and EFTPOS. Each of these alternatives was evaluated using the same criteria. High level criteria consisted of relative advantages, features of technology, bank environments, customer behaviour, and economic situation of the nation. Each high level criterion was sub-divided into low level criteria, including specific issues detailed from the main criteria. During the second stage, respondents were asked to weigh the level of importance of each criterion and then score all the alternatives against the specified criteria. The last stage evaluated the alternatives and conducted sensitivity analysis using the V.I.S.A. software. Results from the MCDM analysis revealed that the preferred technology was Extranet banking and the second alternative was a data warehouse.

However, the analytical results differed from the results derived from intuitive judgements of the same respondents, namely that a data warehouse was superior to Extranet banking. The divergent outcomes may have resulted from differing ways of using available information, differences in conscious awareness between intuitive and rational decision-making, using the same criteria to evaluate different technologies, different perceptions between surface and deep structures, and the impacts of time delays.

In effect, the proposed model of ICT adoption helps decision-makers to increase their level of understanding and solving of problems, compares the rational results with their intuition, detects possible relevant reasons behind objective results, and allows them to improve their decision-making by adjusting weighting and scoring, and conducting sensitivity analyses.

11.4.3 A Requisite Group Model of ICT Diffusion (Research Question 3)

Using MCDM may not be sufficient for technology diffusion because MCDM is not capable of clarifying the inter-relationships between criteria and variables, and

reflecting dynamic effects. Therefore, additional models of technology diffusion were developed based on the system dynamics approach.

The MCDM analysis identified two predominant technologies of the bank: Extranet banking and the data warehouse. Therefore, this research divided the diffusion models into three sub diffusion models: the generic conceptual model of information and communication technologies (ICT); the model of data warehousing technology; and the model of Extranet banking.

11.4.3.1 A Model of Diffusion of Information and Communication Technologies (ICT)

A generic model of diffusion of information and communication technologies (ICT) was developed based on the qualitative and quantitative system dynamics approach using a feedback loop technique accommodating the four system boundaries of the technology group of the bank (i.e. SCB), vendors, customers and staff. The qualitative conceptual model was quantified using the *ithink* software by adding each feedback loop to the simulation until the whole system was complete. The results from the ICT diffusion model revealed the following issues.

- Training support has the potential to accelerate diffused technology and economic gains.
- A backlog of problems hinders the rate of technology diffusion and economic gains.
- Although technology is successfully diffused, economic returns from investment are constrained by the market potential.
- It is important for the bank to balance the desired technology investment against its prospective outcomes, because massive investment does not always bring a good return on that investment.
- Economic gains from new technology are obtained only after the bank has spent substantial resources on technology investment.

This ICT diffusion model enables bank officials to understand the present state as well as constraints of technology diffusion in order to apply the model to particular technologies. The main findings can be used for development of strategic policies to enhance the level of diffused technology, minimise constraints and improve the system behaviours.

11.4.3.2 A Model of Diffusion of a Data Warehouse (DW)

A data warehouse is a central analytical database that has been extracted, standardised and integrated from various operational and management databases of the organisation to enhance competitiveness and decision support. The Siam Commercial Bank PCL has invested extensively in a data warehouse project for the purpose of obtaining accurate timely data to support decision-making and management.

The model of diffusion of a data warehouse was initially developed based on a qualitative system dynamics approach to identify the present state, detect constraints, and illustrate holistic perspectives of a data warehouse. A quantitative system dynamics approach was employed to quantify the values of dominant variables and to visualise the impacts of interaction between feedback loops and variables.

The data warehouse model was divided into two scenarios: a price-less model and an estimated price model. The *price-less model* was simulated using variables relating to diffusing and training processes. This model provided insights into diffusing the data warehouse to the bank staff via training, and revealed important variables affecting the rate of technology diffusion such as: training delays; percentage of resolution of problems, percentage of technology abandonment; and the backlog of problems.

The estimated price model was expanded from *the price-less model* using estimated costs and benefits to observe the rate of technology diffusion, diffused data warehouse, and economic gains. The results revealed that an increase in customers brings about an increase in economic gains. However, the backlog of problems decreases both diffused data warehouse and economic gains. The bank may receive more benefits in the long run if it spends part of its economic gains in technology

investment because continuous improvement may extend the economic life of the technology.

11.4.3.3 A Model of Diffusion of Extranet Banking

Banks employ Internet/Extranet banking to cater for customers using personal computers for remote banking transactions. At the time this research was conducted, the Extranet banking system of the bank had already been completely implemented, and had approximately 2,000 subscribers. In this study, information elicited from prospective users indicated clearly that this technology has the potential to expand in the future. There are high numbers of current non-users and high propensity for them to become users if the bank decreases costs of usage, ensures the reliability and security of the system, improves infrastructure and increases promotional advertising.

The model of diffusion of Extranet banking depicted variables, their relationships and feedback loops under three sub-system boundaries of the SCB, staff and customers. The model then was simulated using an incremental technique to verify consistency among the data.

The simulation results revealed patterns of diffused Extranet banking which follow the s-curve, with differing slopes. If the bank provides training, the slope of diffused technology is more inelastic because technology is diffused more rapidly. However, if the backlog of problems is taken into account, the slope of the diffused technology curve is elastic because the technology is only gradually diffused and the bank takes a longer time to absorb its market potential.

In conclusion, the three models of technology diffusion were developed using user-friendly tools to assist decision-makers who may be inadequately prepared in technological knowledge. By these means, decision-makers may bring their business knowledge to bear in testing different scenarios, assumptions, perceptions and policies, and in turn observe the final outcomes. That would help them to decrease wasted time, effort and resources. It would also help support their decision-making processes, and promote their learning and understanding.

11.4.4 The Requisite Policies for Adoption and Diffusion of ICT for the Bank (Research Question 4)

The policy for technology adoption involves the selection of technology, which best fits with identified criteria. However, the best selection does not always guarantee the successful implementation or diffusion or ensure a good return on investment.

This policy analysis for technology diffusion aims at observing impacts of strategic policies and finding the leveraged ones. Strategic policies, proposed by bank executives, were tested and simulated to detect the most leveraged ones that would help the bank increase the rate of diffusion of selected technology and accelerate economic returns.

Given the nature of data warehousing technology, the success of its diffusion is dependent upon the quantity and quality of knowledge workers' usage of the technology. Therefore, leveraged policies are those that enhance the learning process of users and promote willingness to use the technology. High impact policies are *increasing levels of training support, decreasing time for training delays, decreasing perceived complexity, increasing perceived relative advantages, increasing positive features of technology, and increasing co-operation between IT people and users.*

On the other hand, leveraged policies of Extranet banking are those that help the bank absorb potential bank customers within the shortest time. The high impact policies of Extranet banking are similar to those of the data warehouse, such as *making the technology easy to use, increasing positive features of technology, co-operation between IT people and users, and increasing perceived relative advantages.* This is because prospective customers still perceive that both technologies are not sufficiently reliable, not easy to use, and have no real benefits. The leveraged policies for the two technologies may differ. For example, *increasing level of training* is less important for Extranet banking because skilled workers do not directly represent the numbers of technology diffusion as those of a data warehouse but only helps the bank to sell and support the technology. Nevertheless, since Extranet banking is used directly to assist customers, *increasing promotional advertising* is an important policy that may boost the rate of technology diffusion and economic gains.

11.4.5 Using Information and Communication Technologies as a Lever of Competitive Advantage for the Banking Industry in Thailand (Research Question 5)

Unfortunately, the detailed answers for this research question could not be identified because of insufficient data and the limitations of the research methodologies employed. Using one main case study and developing the models in closed co-operation for solving problems of a particular bank prevented the opportunity of gaining in-depth information from the other banks. However, information was collected via interviews, documents, and results have been presented earlier in section 11.2. This research question still needs more information to produce in-depth answers. The detailed answers could be identified using a survey research.

11.5 Implication for the Models of ICT Adoption and Diffusion

The implications derived from the proposed model development of adoption and diffusion of information and communication technologies (ICT) are advanced in order to make recommendations for the Siam Commercial Bank, and general policy makers.

11.5.1 Implication for the Bank

The implications for the Siam Commercial Bank are as follows:

11.5.1.1 Using MCDM as a Decision-Making Tool

The proposed model of technology adoption based on MCDM analysis demonstrated an easy procedure to select the best alternatives from various conflicting criteria. Using the MCDM tool supported with software applications such as V.I.S.A. may help bank staff evaluate technological alternatives more efficiently and effectively as compared to the traditional method. First, MCDM is a suitable tool for technological evaluation. Second, MCDM software applications are inexpensive and available in the market. Third, the software applications are easy to learn and use within a short

time. Fourth, outcomes from an MCDM analysis can be compared with the intuition or experience of decision-makers and provides insight into differences. Fifth, MCDM allows decision-makers to conduct sensitivity analysis to test for different scenarios and conditions of problems. Sixth, MCDM mitigates conflicts and promotes consensus of group decision-making by identifying reasons of outcomes. Finally, an MCDM analysis is applicable to other issues in regard to choice selection or alternative evaluations.

11.5.1.2 Using System Dynamics as a Decision-Making Tool

System dynamics (SD) is more difficult to learn and use compared with MCDM. However, it is more useful in terms of being more applicable in solving various problems, and reflects reality more close. Using system dynamics as a decision-making tool for problem solving helps the bank perceive holistic and dynamic aspects of a problem rather than a static snapshot. Decision-makers are able to accommodate more variables, interrelationships among variables, and time delays in problem solving, and then by simulating relevant variables, test policies that be may used as a warning sign to detect unintended outcomes, and generally improve system behaviour.

11.5.1.3 Recommendations based on the Proposed Model of ICT Diffusion

The model of ICT diffusion was proposed for application to any particular technologies. The model analysis revealed that training, a backlog of problems, and market potential, impacted on technology diffusion and subsequently on economic gains.

Therefore, it is vital for the bank itself to provide training because the nature of the Thai education system does not sufficiently support the concept of self-learning. Because of this background, people seem to need guidelines to aid learning. Apart from direct training, encouraging self-learning via on the job training may help bank staff to adapt themselves to learn and use technology.

Generally, the bank is able to compel staff to use technology. However, if technology serves bank customers directly, it must be tested to be error free before launching to

the public market. Otherwise problems from technology and delay time for resolving problems may create negative word-of-mouth feedback that leads to a decrease in technology diffusion.

For some technologies, the bank must provide promotional advertising to speed up technology use, because each technology has a limited economic life. If technology completely absorbs a potential market before its obsolescence, the bank will gain benefits from the full capacity of that technology. However, once the technology has already absorbed the potential market, its economic gains are limited.

Decision-makers of the bank can modify the ICT diffusion model by adjusting or adding appropriate information and assumptions. Using the model will help the bank to gain more understanding about the system, test for preferable outcomes without costs, and apply the proposed model to other technologies.

11.5.1.4 Recommendations based on the Model of Diffusion of Data Warehouse

The information from data collection reveals that many bank officials lack understanding about the data warehouse and how to use it. According to observation during data collection, some data had not been updated, leading to confusion and unreliability in using the data. Many participants did not agree that the data warehouse is a good project but they did not openly reveal their negative perceptions because the project was a firm directive of the bank executives.

The model of the data warehouse detected the following problems: the bank has to emphasise the quantity and quality of usage by bank staff by decreasing training delays; the bank must increase positive features of technology; the bank must provide training support; the bank must decrease perceived complexity; and finally the bank must enhance co-operation between IT people and users.

11.5.1.5 Recommendation based on the Model of Diffusion of Extranet Banking

According to data from prospective customers and research observations, Extranet banking by the bank appears to be outperforming other technologies especially if the bank assures customers in the security and reliability of the system, clarify real

benefits, and enhances its promotional advertising. The important policies that the banks should take into consideration to absorb prospective subscribers and increase profits are: increasing positive features of technology; promoting co-operation between IT people and users; making the technology easy to use; adding relative advantages; and increasing promotional advertising.

11.5.1.6 Downsizing Business Performance

The model of ICT diffusion also pointed out that economic returns from any one technology are obtained only after the bank has spent substantial investment on it. However, economic gains may not increase positively in the same proportion with technological investment. Therefore, technological investment has to be in balance with expected benefits from technology because excessive investment consumes both monetary and human resources.

If the bank is willing to spend massively on technology investment, the bank has to cut down other expenses, and exploit the full capacity of technology. Downsizing work processes could achieve that. Based on observation and comparison of business performance between Australian and Thai banks, the Australian banks are able to provide bank transactions with one staff and one computer at a bank counter close to customers' communities. For ordinary Australian bank offices, there are only 3-4 bank officials at a front counter and a few staff at the back office to service their customers. In contrast, Thai banks accommodate many staff both at the front and back offices. Therefore, although it may not be an acceptable recommendation to replace human beings with computer technologies in Thailand, if the bank aims at being an innovative leader, downsizing should be a possible way that helps the bank to survive in a highly competitive market.

11.5.2 Implication for Policy Makers

The following implications are recommended for policy makers.

- Policy makers are able to use simple technique such as MCDM analysis to help their decision-making with regard to choice selection. The results from rational analysis will be used to support their intuition and experience to

detect causes of differences and these may improve problem solving and promote learning.

- Apart from the static approach, policy analysis should capture the dynamic aspects and accommodate many key variables at the same time. Policies should be tested using a simulation analysis because it provides prospective outcomes at low cost and without disturbing the real system.
- Policy makers should have versatile abilities in combining information, technological proficiency, and business knowledge. They have to know how to detect information from massive amounts of data and how to verify the data. They have to use computer technology that can aid decision-making processes or policy planning by selecting tools that are suitable for any type of problem. Finally, they have to bring their business experience and knowledge using the right tools, and information to make appropriate decisions.
- It can be observed from the decision-making processes in Thai society that there are gaps between decision-makers, technological people, and ordinary staff. First, business people lack computer capability to aid their decision-making whereas computer experts are unable to use their expertise to solve business problems. Second, Thai decision-makers rarely use computers for decision-making not only due to insufficient computer knowledge but also due to their lack of typing skills. Normally, clerical works are assigned to clerks due to the social hierarchy in the society. These two skills are essential for policy-makers to practise in order to synergy advantages from technology and their own knowledge and experience.

11.6 Study Limitations

The limitations of this research are restricted to the following issues:

- The proposed models are suitable for aided learning and visualising patterns of outcomes such as diffused technology, and profits. However, they may not provide accurate forecasting because of the potential incompleteness of

information obtained. The incompleteness (e.g. redundancy, inconsistency, and biased data) occurred due to many reasons. First, bank staff were unable to devote sufficient time or interest to verify data. Second, they could not reveal all information due to constraints of confidentiality of the organisation. Third, some data could not be recorded or classified because of their specific properties, such as scatter, non-categorisation, and non-quantification.

- The model development lacked the full involvement of stakeholders due to three reasons. Firstly, the research was conducted mainly in Australia but used a Thai case study. The co-operation occurred during the data collection phase. Closed communication was difficult because of costs and the full workload of bank staff. Secondly, the model development was too complicated and time consuming for stakeholders to pay attention and understand. Thirdly, the issue of technology adoption and diffusion was initiated as a problem by the researcher. The bank may not consider this as a serious problem when compared to problems impacting from the Thai economic crisis.
- The models were developed according to the available information deriving from interviews and questionnaires. The researcher proposed some additional assumptions based on literature review and understanding of the national character because it was hard to involve with stakeholders. However, stakeholders verified the completed models to confirm their validity.
- Apart from model development, the interview and questionnaire data were manually analysed because the study aimed at using data for model development for which it was not suitable to employ computer or statistical tools.

In conclusion, if the bank requires an accurate forecasting model, provision of accurate information and full co-operation between the model analyst and stakeholders is a must. Nevertheless, these model analyses are useful as basic

guidelines for promoting the learning and understanding of the people involved by allowing bank staff to test the models based on information, assumptions, and other strategic policies as they see fit.

11.7 Future Research

The knowledge gained from conducting the research relating to MCDM and SD areas can be further developed and expanded to deal with many prospects.

- The generic model of ICT adoption and diffusion can be applied to any particular technology in any organisation. The interesting technologies that are worthwhile to investigate are smart cards, EFTPOS, and electronic commerce.

Smart card projects have been researched and implemented as pilot projects by the Siam Commercial Bank and other banks in Thailand. However, the projects are stuck between full implementation and a “wait and see” policy because of uncertainty of the success of technology diffusion. Although, the properties of smart cards seem similar to ATM cards, some differences may inhibit the rate of diffusion. For example, in many instances people feel more confident in carrying cash rather than cards. They also prefer credit cards to debit cards (i.e. smart cards) because credit cards reflect high social status of cardholders. EFTPOS is also an interesting field to be investigated because using EFTPOS in replacement of cash transactions is common in Australia but has not yet gained popularity in Thailand. At present, electronic commerce is of interest to many people. The model of this technology can be expanded from Extranet banking by adding system boundary of suppliers and issues of security.

Tracing the detailed characteristics of each technology may reveal different patterns of technology diffusion and different policies to increase the rate of technology diffusion, and economic gains. Further research in regard to technology diffusion is a fascinating prospect.

- Such research can be also expanded by using other decision-making methods (e.g. the Analytical Hierarchy Process- AHP), or employing other software

applications (e.g. Expert Choice, HIVIEW), or involving GSS environmental settings (e.g. network GSS, decision conferencing).

Research combining the three areas of GSS, MCDM and SD is a fruitful area to be developed. Initially, this research aimed at combining these three decision-making areas. However, the scope was finally confined to MCDM and SD because of three main obstacles: availability of GSS facilities; language of computer interfaces; and differing natures of an organisational culture. Thai executives prefer verbal communication to computers.

If obstacles are solved, research based on these various techniques will provide considerable knowledge of decision analysis because this exploits the best capability of each technique. GSS is a valuable tool for data acquisition of group decision-making. MCDM is the best selection tool to prioritise choices, and SD is suitable for detail and policy analyses.

- It is also worthwhile to investigate the comparison between work performance in a banking system, such as between Australia and Thailand, in the use of computers to replace humans in the workplace, and a cost comparison between human resources and computers.
- It would be interesting to conduct longitudinal research because the long-term study would indicate the real impacts of MCDM-SD applications, whether they contribute to the success of decision-making in an organisation or not. Otherwise, it seems the MCDM-SD process can be an experiment where model analysts undertake their tasks but there is no real intention for practical implementation.
- The knowledge and theories grounded in one culture may not apply in other cultures. The cultural differences in decision-making styles result in conflict in working operations, especially in joint-venture organisations. A comparison using MCDM-SD applications in different cultures is thus of great interest.

11.8 Conclusion

“A study on the adoption and diffusion of information and communication technologies in the banking industry in Thailand using multiple-criteria based system dynamics approach” is the research combining two study areas of information systems: multiple criteria decision-making and system dynamics. It was conducted using two research methodologies: system development and a case study of the Siam Commercial Bank PCL. The data were collected from observations, interviews, questionnaires and documents for development of the model.

The model analysis was divided into four models. The model of ICT adoption provided ways to select the best alternative that fulfilled the mission of the bank. The model was developed using MCDM as a decision-making tool with the V.I.S.A. software. Result from the MCDM analysis revealed that Extranet banking was the most preferred technology.

The model of ICT diffusion aimed at providing a generic model of technology diffusion that could be applied to any particular technology. Results revealed that the dominant variables that may impact on diffusion of technology are training, a backlog of problems, and market potential. The findings also revealed that the bank has to find a balance between technology investment and economic returns from investment. Furthermore, economic returns are obtained only after spending substantially on technology investment.

Additionally, the model of diffusion data warehouse was developed because bank staff intuited that this technology would help the bank attain its objectives. The model of data warehouse highlighted the necessity of quality and quantity of knowledge workers. Therefore, training support is an important factor to diffuse this technology.

The model of diffusion of Extranet banking revealed that the success of this technology comes from the customers of the technology. Therefore, the important factors are decreasing perceived problems from the technology and promotional advertising.

The policy analyses of the three technologies confirm that the core important policies that increase technology diffusion and economic gains are *increasing positive features of technology, increasing levels of training support, decreasing perceived complexity, increased perceived relative advantages* and *increasing co-operation between IT people and users*. If technology facilitates customers directly, marketing strategy such as advertising is vital.

All the findings have implications for the bank; however, these findings could be applied to other banks and general policy makers in various business enterprises. The limitations of the study and implications for future research have been presented for the benefit of future researchers.

REFERENCES*

- AAP. (1997, August 23-24). No more lunch money with smart card. *The weekend Australian*, pp. 5.
- Abdel-Hamid, T. K. (1988). Understanding the "90% syndrome" in software project management: A simulation-based case study. *The Journal of Systems and Software*, 8, 319-330.
- Abdel-Hamid, T. K. (1989a). The dynamics of software project staffing: A system dynamics based simulation approach. *IEEE Transactions on Software Engineering*, 15(2), 109-119.
- Abdel-Hamid, T. K. (1989b). A study of staff turnover, acquisition, and assimilation and their impact on software development cost and schedule. *Journal of Management Information Systems*, 16(1), 21-40.
- Abdel-Hamid, T. K. (1990). On the utility of historical project statistics for costs and schedule estimation: Results from a simulation-based case study. *Journal of Systems Software*, 13, 71-82.
- Abdel-Hamid, T. K., & Madnick, S. E. (1987). On the portability of quantitative software estimation models. *Information & Management*, 13, 1-10.
- Ackermann, F., & Eden, C. (1994). Issues in computer and non-computer supported GDSSs. *Decision Support Systems*, 12, 381-390.
- Ackoff, R. L. (1971). Towards a system of systems concepts. *Management Science*, 17(11), 105-112.
- Advantage Group Limited. (1996). *What does EFTPOS mean to You?* [Online]. Available: <http://www.advgroup.co.nz/textonly/mean.htm> [1996, December 4].
- Agarwal, R., Higgins, C., & Tanniru, M. R. (1991). Technology diffusion in a centralised MIS environment: Experiences at carrier. *Information and Management*, 20(1), 61-70.
- Ahire, S. L., & Rana, D. S. (1995). Selection of TQM pilot projects using an MCDM approach. *International Journal of Quality and Reliability Management*, 12(1), 61-81.

* Note: American Psychological Association (APA) style (American Psychological Association. (1994). *Publication manual of the American Psychological Association*. (4 ed.). Washington: American Psychological Association).

- Akkermans, H. (1995). Developing a logistics strategy through participative business modelling. *International Journal of Operations and Production Management*, 15(11), 100-112.
- Alavi, M. (1993). An assessment of electronic meeting systems in a corporate setting. *Information & Management*, 25, 175-182.
- Allen, C. (1995). Get smart. *Bank Management*, 71(2), 58-62.
- Alter, S. (1996). *Information systems: A management perspective*. (2 ed.). Menlo Park, California: Benjamin/Cummings Pub. Co.
- Amoroso, D. (1993). *Decision-making using Lotus 1-2-3: Building quality applications*. New York: Mitchell: McGraw-Hill.
- Andersen, D. F., & Richardson, G. P. (1997). Scripts for group model building. *System Dynamics Review*, 13(2), 107-129.
- Andersen, D. F., Richardson, G. P., & Vennix, J. A. M. (1997). Group model building: Adding more science to the craft. *System Dynamics Review*, 13(2), 187-201.
- Anderson, E. G. J., & Joglekar, N. R. (1996). *Modelling the dynamics of innovation at the firm level*. Paper presented at the 1996 System Dynamics Conference, Cambridge, Massachusetts.
- Antunes, C. H., Almeida, L. A., Lopes, V., & Climaco, J. N. (1994). A decision support system dedicated to discrete multiple criteria problems. *Decision Support Systems*, 12, 327-335.
- Applegate, L. D. (1992). *A case study in the assimilation of technology support for teams*. New York: Van Nostrand Reinhold.
- Arthur Anderson and Co. (1989). *Trends and issues in retail financial services technology: Case study-Australia*. Lafferty Publications (Australia) Ltd.
- Atkinson, D. J. (1995). *Decision analysis* (Overhead for Instructors). Perth, Western Australia: School of Information Systems, Curtin University of Technology.
- Atkinson, D. J. (1996). *A study of perceptions of individual participants of a client group undertaking a series of meetings supported by a group support system (GSS)*. Unpublished Doctoral dissertation, Curtin University of Technology, Perth, Western Australia.
- Atkinson, D. J., & Lewis, F. (1994). *MeetingWare*. Perth, Western Australia: School of Information Systems, Curtin University of Technology.
- Atkinson, D. J., & Marshall, P. H. (1990). A comparison of group decision support systems approaches illustrated via LSE decision conferencing and Meetingware. *ASOR Bulletin*, 9(3), 12-28.

- Auer, J. (1993). Negotiating a better deal with vendors: Tips on managing the acquisition process. *Information-Systems-Management*, 10(4), 66-68.
- Bangkok Bank Public Company Limited. (1998). *A self-sufficient economy, Annual Report*.
- Bangkok Bank Public Company Limited. (1999a). *Office banking* [Online]. Available: http://www.bbl.co.th/services/serv_offbanking.htm [1999, April 23].
- Bangkok Bank Public Company Limited. (1999b). *Vision of Bangkok Bank* [Online]. Available: http://www.bbl.co.th/aboutus/about_vision.htm [1999, April 23].
- Bangkok Metropolitan Bank Public Co. Ltd. (1995). *Annual report 1995*. Bangkok.
- Bangkok Metropolitan Bank Public Co. Ltd. (1999). *About Bangkok Metropolitan Bank*. Bangkok Metropolitan Bank [Online]. Available: http://www.bmb.co.th/index_about_history.htm [1999, April 24].
- Bank International Indonesia. (1996). *Best commercial bank: Rewarding strength, strategy and growth*. Bank International Indonesia [Online]. Available: http://www.bii.co.id/english/about_bii/reading_room/asiamoney.htm [1996, October 15].
- Bank of Asia Public Company Limited. (1999). *Vision to action*. Bank of Asia Public Company Limited [Online]. Available: <http://www.boa.co.th/vision.htm> [1999, April 24].
- Bank of Thailand. (1998, November 19). *History and responsibilities of the Bank of Thailand* [Online]. Available: <http://www.bot.or.th/govnr/public/history/rol&respon-e.htm>.
- Bank of Thailand. (1999, June 22). *Statistics of Financial Indications* [Online]. Available: http://www.bot.or.th/fsupv/public/fin_data/menu.htm.
- Banking technology information. (1999a). Banking IT club established to jointly develop high technology. *Money and Banking*, 18(206), 150-151.
- Banking technology information. (1999b). SCB launches three projects to provide E-commerce through the web. *Money and Banking*, 18(204), 149-150.
- Banking technology information. (1999c). Thai Danu promotes smart cards, eyeing to promote high tech kids. *Money and Banking*, 18(202), 152-153.
- Banking Technology Report. (1999). A visit to one of the most high technology computer centre of Bangkok. *Money and Banking*, 18(204), 154-156.
- Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review*, 12(3), 183-210.

- Barras, R. (1994). Interactive innovation in financial and business services: The vanguard of the service revolution. In E. Rhodes & D. Wield (Eds.), *Implementing new technologies* (pp. 106-120). Cornwall, London: Blackwell.
- Baumol, W. J. (1967). *Business behaviour, value and growth*. New York: Brace & World.
- Bayar, V. (1998). Information and communications technology in science. *OECD Observer*, 213, 9-12.
- Bee, E. R. (1988). How to improve economic development advertising: Lessons from the diffusion of innovations. *Economic Development Review*, 6(2), 47-52.
- Belton, V. (1984). The use of a simple multiple-criteria model to assist in selection from a shortlist. In S. French (Ed.), *Reading in Decision Analysis* (pp. 124-138). London: Chapman and Hall.
- Belton, V. (1986). A comparison of the analytic hierarchy process and a simple multi-attribute value function. *European Journal of Operational Research*, 26, 7-21.
- Belton, V. (1990). *Multiple criteria decision analysis- Practically the only way to choose* (Working paper 90/10). Birmingham: University of Strathclyde.
- Belton, V., & Vickers, S. P. (1989). V.I.S.A. - VIM for MCDA. In A. G. Lockett & G. Islei (Eds.), *Improving decision making in organisation* (pp. 287-304). Berlin: Springer-Vorlage.
- Belton, V. (1995). *V.I.S.A. for windows: User guide*. Glasgow: Visual Thinking International Limited.
- Bezdek, R. H., & Jones, J. D. (1990). Economic growth, technological change, and employment requirements for scientists and engineers. *Technological Forecasting and Social Change*, 38, 375-391.
- Bhatnagar, S. C. (1994). Is technology transfer the answer? In K. Duncan & K. Krueger (Eds.), *The IFIP, 13 th World Computer Congress 94* (Vol. 3, pp. 453-455). Amsterdam: Elsevier Science B.V. (North-Holland).
- Blackler, F., & Brown, C. (1985). Evaluation and the impact of information technologies on people in organisations. *Human Relations*, 38(3), 213-231.
- Bogetoft, P., & Pruzan, P. (1991). *Planning with multiple criteria: Investigation, communication, choice*. Amsterdam: Elsevier Science Publishers.
- Boucher, T. O., & MacStravic, E. L. (1991). Multiattribute evaluation within a present value: Framework and its relation to the analytic hierarchy process. *Engineering Economist*, 37(1), 1-32.

- Bowonder, B., Miyake, T., & Linstone, H. A. (1994). The Japanese institutional mechanisms for industrial growth: A systems perspective- Part II. *Technological Forecasting and Social Change*, 47, 309-344.
- Brancheau, J. C., & Wetherbe, J. C. (1990). The adoption of spreadsheet software: Testing innovation diffusion theory in the context of end-user computing. *Information system research*, 1(2), 115-143.
- Buchanan, J. T. (1997). A naive approach for solving MCDM problems: The GUESS method. *Journal of the Operational Research*, 48, 202-206.
- Bui, T., & Loebbecke, C. (1996). Supporting cognitive feedback using system dynamics: A demand model of the global system of mobile telecommunication. *Decision Support Systems*, 17(2), 83-98.
- Bui, T. X. (1987). *Co-Op: A group decision support system for cooperative multiple criteria group decision-making*. Berlin: Springer-Vorlage.
- Bunyamanee, S., & Nivatupumin, C. (1998). *The year they sunk the baht* [Online]. Available: <http://www.bkkpost.samart.co.th/n...chive/ecoreview97/review9704.html>. [1998, January 14].
- Buongiorno, J. (1996). Forest sector modelling: A synthesis of econometrics, mathematical programming, and system dynamics methods. *International Journal of Forecasting*, 12(3), 329-343.
- Burn, J. M. (1995). The new cultural revolution: The impact of EDI on Asia. *Journal of Global Information Management*, 3(4), 16-23.
- Butler Group. (1997a). *Brio Technology: The keys to the data warehouse: Access tools for end users desktop data access* [Online]. Available: <http://www.butlergroup.co.uk/manguide/dwuk1096/brio.htm>. [1997, February 9].
- Butler Group. (1997b). *Business case for data warehousing strategies and technologies* [Online]. Available: <http://www.butlergroup.co.uk/manguide/dwuk1096/s1.htm>. [1997, February 24].
- Buzzacchi, L., Colombo, M. G., & Mariotti, S. (1995). Technological regimes and innovation in services: The case of the Italian banking industry. *Research Policy*, 24(1), 151-168.
- Carter, W. K. (1992). To invest in new technology or not? New tools for making decision. *Journal of accountancy*, May, 58-64.
- Caskey, J. P., & Sellon, G. H. (1996). Is the debit card revolution finally here? In P. O'Hara (Ed.), *A book of readings on the financial system* (6 ed., pp. 79-95). Perth: Curtin University of Technology.

- Cervantes, M. (1997). Diffusing technology to industry. *OECD Observer*, Aug/Sep207, 20-23.
- Chambers, M. R. (1991). Planning for technological substitution and change. *International Journal of Production Economics*, 25(1-3), 191-200.
- Checkland, P. (1995). Model validation in soft systems practice. *Systems Research*, 12(1), 47-54.
- Chen, R. (1985). The trained user as a systems analyst. *Journal of Systems Management*, 36(7), 38-40.
- Chowdhury, S., & Sahu, K. C. (1992). A system dynamics model for the Indian oil and gas exploration/exploitation industry. *Technological Forecasting and Social Change*, 42, 63-83.
- Citybank. (1999). *Citybank: Bangkok Branch* [Online]. Available: <http://www.citibank.com/thailand/> [1999, August 22].
- Clark, D. L. (1993). Choosing platform automation isn't for the fainthearted. *ABA Banking Journal*, 85(1), 56-60.
- Cooper, R. B., & Zmud, R. W. (1990). Information technology implementation research: A technological diffusion approach. *Management Science*, 36(2), 123-139.
- Coyle, R. G. (1996). *System dynamics modelling: A practical approach*. London: Chapman & Hall.
- Croft, B. (1995). Opening windows to the world. *Communication World*, 12(11), 16-19.
- Currid, C. (1993, May 3). Technology takes centre stage in a changing business world. *InfoWorld*, 15, 62.
- Davies, M. A. P. (1994). A multicriteria decision model application for managing group decisions. *Journal of the Operational Research Society*, 45(1), 47-58.
- Davis, A., & O' Donnell, J. (1997). Modelling complex problems: system dynamics and performance measurement. *Management Accounting London*, 75(5), 18-20.
- De Castro, J. O., & Schulze, W. S. (1995). The transfer of technology to less developed countries: A model from the perspective of the technology recipient. *The Journal of High Technology Management Research*, 6(1), 113-126.
- De Geus, A. P. (1992). Modelling to predict or to learn? *European Journal of Operational Research*, 59, 1-5.

- Dennis, A. R., Nunamaker, J. F., & Vogel, D. R. (1991). A comparative of laboratory and field research in the study of electronic meeting systems. *Journal of Management Information Systems*, 7(3), 107-135.
- Department of Local Administration. (1999, February 1). *Statistic of Thai population* (1999) [Online]. Available: http://www.dola.go.th/stat/stat_txt.htm.
- Desai, C., Wright, G., & Fletcher, K. (1998). Barriers to successful implementation of database marketing: A cross-industry study. *International Journal of Information Management*, 18(4), 265-276.
- DeSanctis, G., & Gallupe, R. B. (1987). A foundation for the study of group decision support systems. *Management Science*, 33, 589-609.
- Dillon, N. (1997). Videoconferencing boosts productivity. *Computerworld*, 31(40), 39-41.
- Dillon, N. (1998). Staying in touch via video. *Computerworld*, 32(41), 51.
- Dos Santos, B. L., & Peffers, K. (1995). Rewards to investors in innovative information technology applications: First movers and early followers in ATMs. *Organisation Science*, 6(3), 241-259.
- Dunham, R. B., & Pierce, J. L. (1989). *Management*. Glenview, Ill.: Scott, Foresman.
- Dvorak, J. C. (1997). Not-so-smart money. *PC/Computing*, 10(1), 57.
- Dyer, J. S., Fishburn, P. C., Steuer, R. E., Wallenius, & Zionts, S. (1992). Multiple criteria decision-making, multiattribute utility theory: The next ten years. *Management Science*, 38(5), 645-655.
- Dyner, I., Smith, R. A., & Pena, G. E. (1995). System dynamics modelling for residential energy efficiency analysis and management. *Journal of the Operational Research Society*, 46, 163-173.
- Earl, M. J. (1987). *Information systems strategy formulation*. Chichester: John Wiley & Sons Ltd.
- Eden, C. (1994a). Cognitive mapping and problem structuring for system dynamics model building. *System Dynamics Review*, 10(2-3), 257-276.
- Eden, C. (1994b). *On evaluating the performance of "wide-band" GDSS's*. University of Strathclyde, Glasgow, Scotland.
- Edwards, W. (1977). How to use multiattribute utility measurement for social decision making. *IEEE Transactions on Systems, Man, and Cybernetics*, 7(5), 326-340.
- Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management reviews*, 14(4), 532-550.

- Eom, H. B. (1989). The current state of multiple criteria decision support systems. *Human Systems Management*, 8(2), 113-119.
- Eom, S. B., & Min, H. (1992). The changing role of multiple criteria in decision support systems. *Human Systems Management*, 11(3), 137-144.
- Eom, S. B., Lee, S. M., & Kim, J. K. (1993). The intellectual structure of decision support systems. *Decision Support Systems*, 10, 19-35.
- Erdener, C. B., & Dunn, C. P. (1990). Content analysis. In A. S. Huff (Ed.), *Mapping strategic thought* (pp. 291-300). Chichester: John Wiley & Sons.
- Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching by a project of the American Educational Research Association* (3 ed., pp. 119-161). New York: MacMillan.
- Extranet banking prospective customers. (1998). [Prospective Customers of Internet/ Extranet Banking questionnaire and interview]. Unpublished raw data.
- Farr, J. V., & Sullivan, J. F. (1996). Rethinking training in the 1990s. *Journal of Management in Engineering*, 12(3), 29-33.
- Federal Bureau of Consumer Affairs. (1995). *A cashless society?: Electronic banking and the consumer*. Canberra: Australian Govt. Publishing Service.
- Feichtinger, G. (1992). Hopf Bifurcation in an advertising diffusion model. *Journal of Economic Behaviour and Organisation*, 17(3), 401-411.
- Fichman, R. G., & Kemerer, C. F. (1994). Toward a theory of adoption and diffusion of software process innovations. In L. Levine (Ed.), *The IFIP TC8: Diffusion, transfer and implementation of information technology* (pp. 23-30). Pittsburgh, PA: North-Holland.
- Fink, D. (1998). Guidelines for the successful adoption of information technology in small and medium enterprises. *International Journal of Information Management*, 18(4), 243-253.
- Fink, D., & Kazakoff, K. (1997). Getting IT right. *Australian Accountant*, 67(10), 50-52.
- Fletcher, K., & Wright, G. (1997). Strategic and organisational determinants of information system sophistication: An analysis of the uptake of database marketing in the financial services industry. *European Journal of Information Systems*, 6(3), 141-154.
- Forrester, J. W. (1992). Policies, decisions and information sources for modelling. *European Journal of Operational Research*, 59(42-63).

- Forrester, J. W. (1994). *Learning through system dynamics as preparation for the 21st century* [Online]. Available: <http://www.rtpnet.org/~gotwals/stella/sdg/sdprep21.txt> [1998, January 16].
- Forrester, J. W., & Senge, P. M. (1980). Tests for building confidence in system dynamics models. *TIMS Studies in the Management Sciences*, 14, 209-228.
- Forsgren, R. (1989). Increasing mail survey response rates: Methods for small business researchers. *Journal of Small Business Management*, 27(4), 61-66.
- Forsyth, D. R. (1990). *Group dynamics*. Pacific Grove, CA: Thomson Information.
- Foschini, S. (1989). Development and use of system dynamics models as tools for strategic planning of flexible assembly systems. In P. M. Milling & E. O. K. Zahn (Eds.), *Computer-based management of complex systems* (pp. 89-96). Berlin: Springer-Verlag.
- Franz, L. S., Reeves, G. R., & Gozalez, J. J. (1986). An interactive approach to multiple objective multiple decision maker problems. In Y. Sawaragi, K. Inoue, & H. Nakayama (Eds.), *Toward interactive and intelligent decision support systems* (pp. 172-182). Berlin: Springer-Vorlage.
- Fried, L. (1993). Advanced information technology use: A survey of multinational corporations. *Information Systems Management*, 10(2), 7-14.
- Fryer, B. (1995). Meeting your customers halfway. *PC World*, 13(11), 31-32.
- Gagnon, Y. C., & Toulouse, J. M. (1996). The behaviour of business managers when adopting new technologies. *Technological Forecasting and Social Change*, 52, 59-74.
- Galliers, R. D. (1990). Choosing appropriate information systems research approaches: A revised taxonomy. In H. E. Nissen, H. K. Hirschheim, & R. Klein (Eds.), *The information system research arena of the 90's: Challenges, perceptions and alternative approaches. IFIP TC8 WG8.2 Working Conference* (pp. 155-173.). Copenhagen, Denmark: Elsevier Science B.V. (North-Holland).
- Ganesh, J., & Kumar, V. (1996). Capturing the cross-national learning effect: An analysis of an industrial technology diffusion. *Journal of the Academy of Marketing Science*, 24(4), 328-337.
- Ganesh, J., Kumar, V., & Subramaniam, V. (1997). Learning effect in multinational diffusion of consumer durable: An exploratory investigation. *Journal of the Academy of Marketing Science*, 25(3), 214-228.
- Gear, T., & Read, M. (1989). *On-line group decision support*. Berlin: Springer-Vorlage.

- Geisler, E. (1992). Managing information technologies in small business: Some practical lessons and guidelines. *Journal of General Management*, 18(1), 74-81.
- Gerwin, D. (1988). A theory of innovation processes for computer-aided manufacturing technology. *IEEE Transactions on Engineering Management*, 35(2), 90-100.
- Gibson, S. (1994). Videoconferencing is coming to a desktop near you. *PC Week*, 11, 73.
- Gibson, S. (1999, March 29). Videoconferencing still shy of adoption. *PC Week*, 16, 130.
- Global Banking Intelligence Corp. (1996). *Technology investment in banking* [Online]. Available: <http://www.globalbanking.com/tech.htm> [1996, July 15].
- Gluck, F. W. (1994). The CEO as venture capitalist: An interview with W. Brian Author of the Santa Fe Institute. *McKinsey-Quarterly*, 90-92.
- Goff, L. (1999, Jan 25). Training Takes Time, But Pays Off. *Computerworld*, NA1.
- Goodwin, P., & Wright, G. (1993). *Decision analysis for management judgement*. Chichester: John Wiley & Sons.
- Gozlu, S. (1994). Transfer of information technology to a developing environment: The Turkish case. In K. Duncan & K. Krueger (Eds.), *The IFIP, 13 th World Computer Congress 94* (Vol. 3, pp. 465-470). Amsterdam: Elsevier Science B.V. (North-Holland).
- Graham, A. K., Morecroft, J. D. W., Senge, P. M., & Sterman, J. D. (1992). Model-supported case studies for management education. *European Journal of Operation Research*, 59, 151-166.
- Grover, V., Teng, J., Segars, A. H., & Fiedler, K. (1998). The influence of information technology diffusion and business process change on perceived productivity: The IS executive's perspective. *Information and Management*, 34(3), 141-159.
- Guba, E. G. (1990). The alternative paradigm dialog. In E. C. Guba (Ed.), *The paradigm dialog* (pp. 17-27). Newbury Park, CA: Sage.
- Guglielmo, C. (1996). Here come the super-ATMs. *Fortune*, 134(7), 232-234.
- Gupta, Y. P., & Gupta, M. C. (1990). A process model to study the impact of role variables on turnover intentions of information systems personnel. *Computers in Industry*, 15(3), 211-238.
- Hackathorn, R. (1995). Data warehousing energises your enterprise. *Datamation*, 41 (2), 38-42.

- Hackett, G. R. (1994). Investment in technology- the service sector sinkhole? In E. Rhodes & D. Wield (Eds.), *Implementing new technologies: Innovation and the management of technology* (2 ed., pp. 21-30). Oxford: NCC Blackwell Inc.
- Hannan, T. H., & McDowell, J. M. (1990). The impact of technology adoption on market structure. *Review of Economics and Statistics*, 72(1), 164-168.
- Harker, P. T. (1989). *The art and science of decision-making: The analytic hierarchy process*: University of Pennsylvania.
- Harris, R., & Davison, R. (1999). Anxiety and involvement: Cultural dimensions of attitudes toward computers in developing societies. *Journal of Global Information Management*, 7(1), 26-38.
- Hathaiseri, R. (1998). Thailand economic crisis: Problem, impacts and trends. *Chulalongkorn review*, 10(38), 1-33.
- Heidenberger, K., & Flessa, S. (1993). A system dynamics model for AIDS policy support in Tanzania. *European Journal of Operational Research*, 70(2), 167-176.
- Henerson, M. E., Morris, L. L., & Fitz-Gibbon, C. T. (1987). *How to measure attitudes*. Newbury Park, CA: Sage.
- Herbig, P. A., & Day, R. L. (1992). Customer acceptance: The key to successful introductions of innovations. *Marketing Intelligence and Planning*, 10(1), 4-15.
- Hicks, J. O. (1993). *Management information systems*. (3 ed.). St.Paul, Minneapolis: West Publishing Company.
- Hogan, C. (1993). How to get more out of videoconference meetings: A socio-technical approach: Experience at Curtin University of Technology. *Training & Management Development Methods*, 7, 5.01-5.16.
- Hogan, M. (1999). Internet banking gets real. *PC/Computing*, 12(2), 198.
- Hollander, S. (1987). *Classical economics*. London: Samuel Hollander.
- Holloway, N. (1997). Cassandras confounded. *Far-Eastern-Economic-Review*, 160(25), 62-63.
- Home banking via Internet*. (1996). The Nation [Online]. Available: <http://www.scb.co.th/scb-bus-news/n060296-1.html> [1996, October 14].
- Hong, I. Y. B. (1989). Computerised group decision support for managerial choice/judgement tasks through facilitate preference formulation and utilisation. *Dissertation Abstracts International*, 50(08), 2565.

- Hong, I. Y. B. (1992). Designing a GDSS for supporting managerial choices and judgements: A MCDM perspective. *Decision Support System Transactions*, 181-194.
- Horrock, C. (1996). *Making the warehouse work* [Online]. Available: <http://www.computerworld.com/search/html/9606/960624DW1SL96dw10.html> [1996, September 16].
- Howells, J. R. (1995). Going global: The use of ICT networks in research and development. *Research Policy*, 24(2), 169-184.
- Huff, S. L., & Munro, M. C. (1985). Information technology assessment and adoption: A field study. *MIS Quarterly*, December, 327-339.
- Hutchinson, S. E., & Sawyer, S. C. (1996). *Computers and information systems*. (5 ed.). Chicago: Irwin.
- Hwang, C. L., & Lin, M. J. (1987). Group decision making under multiple criteria methods and application. In M. Beckmann & W. Krelle (Eds.), *Lecture notes in economics and mathematical systems*. Berlin: Springer-Vorlage.
- Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). Electronic data interchange and small organisations: Adoption and impact of technology. *MIS Quarterly*, 19(4), 465-485.
- Informatic. (1998a). Bank of Asia uses IT to supplement their operations: New 'high tech' bank image unveiled. *Money and Banking*, 17(190), 153-156.
- Informatic. (1998b). Krung Thai computer centre. *Money and Banking*, 17(196), 158-160.
- Informatic. (1998c). Thai Farmers Bank to use IT to improve its services in preparation of e-commerce in October. *Money and Banking*, 17(196), 155-156.
- Inmon, W. H., & Hackathorn, R. D. (1994). *Using the data warehouse*. New York: John Willey & Sons.
- Internet banking (1999, April 10). *The Economist (US)*, 351, 70.
- Intrapairot, A., & Quaddus, M. (1998). Adoption and diffusion of data warehousing technology: A system dynamic approach. *Proceedings of the 16th International Conference of the System Dynamics Society [CD-ROM], Quebec City, Canada*.
- Intrapairot, A., & Quaddus, M. (1999a). A system dynamics (SD) based decision support system (DSS) for strategic policy analysis: A case study of data warehouse diffusion. *Proceedings of the 1999 International Society for Decision Support System [CD-ROM], Melbourne, Australia*.

- Intrapairot, A., & Quaddus, M. (1999b). Technology adoption in the banking industry in Thailand: Intuition versus MCDM analysis. In D. Despotis & C. Zopounidis (Eds.), *The 5th International Conference of the Decision Sciences Institute* (pp. 1316-1319). Athens, Greece.
- Intrapairot, A., Quaddus, M., & Kummerow, M. (1999). A system dynamics approach to the diffusion of Intranet banking: A case study from Thailand. *Proceedings of the 17th International Conference of the System Dynamics Society* [CD-ROM], Wellington, New Zealand.
- Iz, P. H. (1992). Two multiple criteria group decision support systems based on mathematical programming and ranking methods. *European Journal of Operational Research*, 61, 245-253.
- Iz, P. H., & Gardiner, L. R. (1993). Analysis of multiple criteria decision support systems for co-operative groups. *Group Decision and Negotiation*, 2, 61-79.
- Janis, I. (1972). *Victims of groupthink*. Boston: Houghton-Mifflin.
- Jelassi, M. T., & Beauclair, R. A. (1987). An integrated framework for group decision support systems design. *Information & Management*, 13, 143-153.
- Jenkins, E., & McKenzie, H. (1997). *Cashless society- Are we ready?* [Online]. Available: <http://www.webaustralia.com.au/magazine/articles/it2.htm> [1997, June 23].
- Jirapinyo, P. (1996). The SCB banking technology. (Available from the Business Relations Department, The Siam Commercial Bank PCL, Thailand).
- Johnstone, B. (1999, May 3). Really smart card. *Forbes*, pp. 198-200.
- Jones, C. (1991). Qualitative interviewing. In G. Allen & C. Skinner (Eds.), *Handbook for research students in the social science* (pp. 203-214). London: Farnar Press.
- Jordan, J. L. (1996). *The functions and future of retail banking* [Online]. Available: <http://www.clev.frb.org/ccca/jj100196.htm> [1996, February 12].
- Kahneman, D., & Tversky, A. (1982). On the study of statistical intuitions. *Cognition*, 11, 123-141.
- Keen, P. G. W., & Scott, M. S. (1978). *Decision support systems: An organisation perspective*. Reading, Mass: Addison-Wesley.
- Keeney, R. L. (1982). Decision analysis: An overview. *Operations research*, 30, 803-838.
- Keleman, K. S., & Lewis, L. F. (1990). Experiences with GDSS development: Lab and field studies. *Journal of Information Science Principles & Practice*, 16 (3), 195-205.

- Kelly, S. (1994). *Data Warehousing: The route to mass customisation*. Chichester: John Wiley & Sons.
- Kemerer, C., F. (1998). Progress, obstacles, and opportunities in software engineering economics. *Communications of the ACM*, 41(8), 63-66.
- Kenneally, C. (1997, June 9). Swedes banking on Intranet: Sparbanken's Channel One is bridge to paperless transactions. *PC Week*, 14, 39-40.
- Kersell, M. (1994). Consumer comfort brightens industry's future. *Info Canada*, 19 (2), 1-34.
- Khorramshahgol, R., Azani, H., & Gousty, Y. (1988). An integrated approach to project evaluation and selection. *IEEE Transactions on Engineering Management*, 35(4), 265-270.
- Kim, D. H., & Juhn, J. H. (1996). *Dynamics of networks: System dynamics model for network externality and critical mass* [Online]. Available: <http://soback.kornet.nm.kr/~sddhkim/96dyn.html> [1997, July 25].
- Kivel, G., & Rubin, I. (1996a). *Case study: Security First Network Bank*. The Tower Group [Online]. Available: http://www.towergroup.com/pages/notes/v10/v10_010R.htm [1997, February 13].
- Kivel, G., & Rubin, I. (1996b). *Establishing an internet-based banking service* [Online]. Available: http://www.towergroup.com/pages/notes/v10/v10_015R.htm. [1997, February 13].
- Korhonen, P. (1992). Multiple criteria decision support: The state of research and future directions. *Computers and Operations Research*, 19(7), 549-551.
- Korhonen, P., Moskowitz, H., & Wallenius, J. (1992). Multiple criteria decision support : A review. *European Journal of Operational Research*, 63, 361-375.
- Kornbluh, M., & Little, D. (1976). The nature of computer simulation model. *Technological Forecasting and Social Change*, 9, 3-26.
- Kouzelis, A. (1987). On the determinants of ATM performance. *European Journal of Operational Research*, 30(1), 89-94.
- Krippendorff, K. (1980). *Content analysis: An introduction to its methodology*. Beverly Hills, CA: Sage.
- Krung Thai Bank. (1999). *About KTB vision or strategy* [Online]. Available: http://www.ktb.co.th/english/about/index_about_vision.htm [1999, August 23].
- Kwon, T. H., & Zmud, R. W. (1987). Unifying the fragmented models of information system implementation. In R. J. Boland & R. A. Hirschheim

- (Eds.), *Critical issues in information systems research* (pp. 227-251). New York: John Wiley.
- Lai, V. S., & Guynes, J., L. (1997). An assessment of the influence of organisational characteristics on information technology adoption decision: A discriminative approach. *IEEE-Transactions on Engineering Management*, 44(2), 146-157.
- Lambert, B. (1996). *Data warehousing fundamentals: What you need to know to succeeded* [Online]. Available: <http://www.data-warehouse.com/resource/articles/lamb8.htm>. [1997, February 24].
- Lamunpan. (1996). SCB Cash Management. *SCB Technologies*, 1(4), 7-11.
- Lane, D. C. (1992). Modelling as learning: A consultancy methodology for enhancing learning in management terms. In J. D. W. Morecroft & J. D. Sterman (Eds.), *Modelling for learning organisations* (pp. 85-117). Portland, OR: Productivity Press.
- Lane, D. C., & Oliva, R. (1998). The greater whole: Towards a synthesis of system dynamics and soft systems methodology. *European Journal of Operational Research*, 107(1), 214-235.
- Langen, D. (1989). An (interactive) decision support system for bank asset liability management. *Decision Support Systems*, 5(4), 389-401.
- Larsen, E. R., Ackere, A. v., & Warren, K. (1997). The growth of service and the service of growth: Using system dynamics to understand service quality and capital allocation. *Decision Support Systems*, 19, 271-287.
- Leedy, P. D. (1993). *Practical research planning and design*. (5 ed.). New York: Macmillan Publishing Company.
- Liberatore, M. J., & Breem, D. (1997). Adoption and implementation of digital-imaging technology in the banking and insurance industry. *IEEE Transactions on Engineering Management*, 44(4), 367-377.
- Licker, P. S. (1997). *Management information systems: A strategic leadership approach*. Fort Worth, TX: The Dryden Press.
- Limayem, M. (1992). *Automating decision guidance: Design and impacts in a group decision support environment*. Unpublished Doctoral dissertation, University of Minnesota, Minnesota.
- Llewellyn, M. (1998). Smart cards - let 'em roll. *Australian Banker*, 112(1), 30-22.
- Loh, L., & Venkatraman, N. (1992). Diffusion of information technology outsourcing: Influence sources and the kodak effect. *Information Systems Research*, 3(4), 334-359.

- Lunsford, J., Brewer, H. B., & Brennan, P. J. (1994). Community banking: tapping technology's potential. *Bank Management*, 70(4), 34-39.
- Madu, C. N. (1989). Transferring technology to developing countries: Critical factors for success. *Long Range Planning*, 22(4), 115-124.
- Madu, C. N., Kuei, C., & Madu, A. N. (1991). Setting priorities for the IT industry in Taiwan: A Delphi study. *Long Range Planning*, 24(5), 105-118.
- Mahan, J. S. (1997). Banking on the Internet at Security First Network Bank. *Journal of Retail Banking Services*, 18(3), 23-27.
- Maier, F. H. (1995). Innovation diffusion models for decision support in strategic management. In T. Shimada & K. Saeed (Eds.), *1995 International System Dynamics Conference* (Vol. 2, pp. 656-665). Tokyo, Japan: The System Dynamics Society.
- Maier, F. H. (1996). Substitution among successive product generations: An almost neglected problem in innovation diffusion models. In G. P. Richardson & J. D. Sterman (Eds.), *Proceedings of the 1996 International System Dynamics Conference* (Vol. 2, pp. 345-348). Cambridge, Mass.
- Maier, F. H. (1998). New product diffusion models for decision support in innovation management. *System Dynamics Review*, 14(4), 285-308.
- Makos, R. (1995). Decision support: Harnessing the value of information. *Bank Management*, 71(5), 73-75.
- Makridakis, S., & Wheelwright, S. C. (1989a). *Forecasting methods for management*. New York: John Wiley & Sons, Inc.
- Makridakis, S., & Wheelwright, S. C. (1989b). Integrating judgmental and quantitative methods. In S. Makridakis & S. C. Wheelwright (Eds.), *Forecasting methods for management* (pp. 311-317). New York: John Wiley & Sons, Inc.
- Malakooti, B. (1986). An MCDM model to solve the glass industry energy problem. *IIE Transactions*, 18(4), 374-379.
- Manross, G. G., & Rice, R. E. (1986). Don't hang up: Organisational diffusion of the intelligent telephone. *Information & Management*, 10, 161-175.
- Marin, J. (1998). Say goodbye to bankers' hours. *Management Review*, 87(1), 33-37.
- Marleau, D. (1997). *Knowledge for development*. Canadian International Development Agency [Online]. Available: http://www.acid-cida.gc.ca/cida_ind.nsf/0e258f35e6cd1eb28525662d0057b6fe/ec2ac611ad3a44cd852564bf007a6f06?OpenDocument [1999, April 26].

- Martinsons, M. G. (1995). Knowledge-based systems leverage human resource management expertise. *International Journal of Manpower*, 16(2), 17-34.
- Martinsons, M. G., & Chong, P. K. C. (1999). The influence of human factors and specialist involvement on information systems success. *Human Relations*, 52(1), 123-152.
- Massey, A. P., & Clapper, D. L. (1995). Element finding: The impact of a group support system on a crucial phase of sense making. *Journal of Management Information Systems*, 11(4), 149-176.
- McKenna, C. K. (1980). *Quantitative methods for public decision-making*. New York: McGraw-Hill Book.
- Milling, P. M. (1996). Modelling innovation processes for decision support and management simulation. *System Dynamics Review*, 12(3), 211-234.
- Minkes, A. L. (1987). *The entrepreneurial manager: Decisions, goals and business ideas*. Harmondsworth, England: Penguin Book.
- Mittermier, R. T., Hsia, P., & Yeh, R. T. (1987). Alternatives to overcome the communication problem of formal requirements analysis. In B. Galliers (Ed.), *Information analysis: Selected readings* (pp. 153-165). Sydney: Addison-Wesley Publishing Company.
- Mohanty, R. P., & Venkataraman, S. (1993). Use of the analytic hierarchy process for selecting automated manufacturing systems. *International Journal of Operations and Production Management*, 13(8), 45-57.
- Mollaghasemi, M., Pet, E. J., & Gupta, U. (1995). A multiple criteria buy versus lease analysis for government contracts. *IEEE Transactions on Engineering Management*, 42(3), 278-287.
- Monroe, A. (1996). Banking on the Internet: Much talk, little action. *Investment Dealers Digest*, 62(23), 20-22.
- Moore, G. A. (1995, November 6). The right, and the wrong, time to buy. *Computerworld*, 29, 37.
- Moore, G. A. (1998). The Gorilla Game for CIOs. *CIO*, 11(17), 52-53.
- Morecroft, J. D. W. (1988). System dynamics and microworlds for policymakers. *European Journal of Operational Research*, 35, 301-320.
- Morecroft, J. D. W. (1992). Executive knowledge, models and learning. In J. D. W. Morecroft & J. D. Sterman (Eds.), *Modelling for learning organisations* (pp. 1-27). Portland, OR: Productivity Press.

- Morecroft, J. D. W., Jarsen, E. R., Lomi, A., & Ginsberg, A. (1995). The dynamics of resource sharing: A metaphorical model. *System Dynamics Review*, 11(4), 289-309.
- Morecroft, J. D. W., & Van der Heijden, K. A. J. M. (1992). Modelling the oil producers- Capturing oil industry knowledge in a behavioural simulation model. *European Journal of Operational Research*, 59, 102-122.
- Moretti, M. (1998, 20-21May). *A strategy for the revival of Thailand's financial sector*. Paper presented at the Thailand's Dynamic Recovery and Competitiveness, UNCC, Bangkok.
- Moser, C. A., & Kalton, G. (1986). *Survey methods in social investigation*. Aldershot, England: Gower.
- Muhammad, T. K. (1996). Toward a cashless society: Smart cards offer an alternative to paper money. *Black Enterprise*, 26(11), 58.
- Mustafa, A., & Goh, M. (1996). Multi-criterion models for higher education administration. *Omega*, 24(2), 167-178.
- Mysior, A., Shuman, J., & Linstone, H. (1984). *Electronic funds transfer technology assessment: A retrospective look*. New York: Elsevier Science Publishing Co., Inc.
- Nakornthon Bank Public Co., Ltd. (1999). *Electronic banking services* [Online]. Available: http://www.ntb.co.th/index_nav.html [1999, August 22].
- Nambisan, S., & Wang, Y. M. (1999). Roadblocks to web technology adoption? *Communications of the ACM*, 42(1), 98-101.
- Nazareth, D. L. (1993). Integrating MCDM and DSS: Barriers and counter strategies. *Infor*, 31(1), 1-15.
- Nevis, E. C., DiBella, A. J., & Gould, J. M. (1995). Understanding organisations as learning systems. *Sloan Management Review*, Winter, 73-85.
- Norton, J. J., Reed, C., & Walden, I. (1995). *Cross-border electronic banking: Challenges and opportunities*. London: Lloyd's of London Press Ltd.
- Nunamaker, J. F., Chen, M., & Purdin, T. D. M. (1990-91). System development in information systems research. *Journal of Management Information Systems*, 7(3), 89-106.
- Nunamaker, J. F., Dennis, A. R., Valacich, J. S., Vogel, D. R., & George, J. F. (1991). Electronic meeting systems to support group work. *Communications of the ACM*, 34(7), 41-61.
- Nunamaker, J. F., Dennis, A. R., Valacich, J. S., Vogel, D. R., & George, J. F. (1993). Group support systems research: Experience from the lab and field. In

- L. M. Jessup & J. S. Valacich (Eds.), *Group support systems: New perspectives* (pp. 146-168). New York: Macmillan.
- O'Brien, J. A. (1996). *Management information systems: Managing information technology in the networked enterprise*. (3 ed.). Chicago: Irwin.
- Odedra-Straub, M. (1994). The myths and illusions of technology transfer. In K. Duncan & K. Krueger (Eds.), *The IFIP 13 th World Computer Congress* (pp. 463-464). Amsterdam: Elsevier Science B.V. (North-Holland).
- Oliver, I., & Langford, K. (1987). Myths of demons and users: Evident and analysis of negative perceptions of users. In R. Galliers (Ed.), *Information analysis: Selected readings* (pp. 113-123). Sydney: Addison-Wesley Publishing Company.
- Opel, W. (1993). The potential of systems dynamics in research administration. *SRA Journal*, 25(1), 5-16.
- Orenstein, A., F. (1998). Internet banking. *Bank systems and technology*, 35(2), 24-30.
- Orr, B. (1998). The end of the beginning. *ABA Banking Journal*, 90(5), 82.
- O'Sullivan, O. (1996). Data warehousing - without the warehouse. *ABA Banking Journal*, 88(12), 42-45.
- O'Sullivan, O. (1997). Tellers play TV anchor. *ABA Banking Journal*, 89(7), 55-58.
- Ozernoy, V. M. (1992). Choosing the "best" multiple criteria decision-making method. *Infor*, 30(2), 159-171.
- Paich, M., & Sterman, J. D. (1993). Boom, bust, and failures to learn in experimental markets. *Management Science*, 39(12), 1439-1458.
- Papaconstantinou, G., Sakurai, N., & Wyckoff, A. (1998). Domestic and international product-embodied R&D diffusion. *Research Policy*, 27(3), 301-314.
- Parthasarathy, M., & Bhattacharjee, A. (1998). Understanding post-adoption behaviour in the context of online services. *Information Systems Research*, 9(4), 362-379.
- Patter, M. Q. (1990). *Qualitative evaluation and research*. Newbury Park, CA: Sage.
- Pennings, J. M., & Harianto, F. (1992). The diffusion of technological innovation in the commercial banking industry. *Strategic Management Journal*, 13(1), 29-46.
- Pentium. (1996a). Applied technology office. *SCB Technologies*, 1(2), 6-7.
- Pentium. (1996b). Video conferencing. *SCB Technologies*, 1(8), 6-7.

- Pervan, G. P. (1994). A case for more case study research in group support systems. In B. C. Glasson, I. T. Hawryszkiewicz, B. A. Underwood, & R. A. Weber (Eds.), *The IFIP TC8 Conference on Business Process Re-engineering: Information system opportunities and challenges* (pp. 485-495). Gold Coast Queensland, Australia.
- Peterson, S. (1992). Software for model building and simulation: An illustration of design philosophy. *European Journal of Operation Research*, 59, 197-202.
- Phananiramai, M. (1995). Thailand national report: Employment situation, problems and policy. *TDR Quarterly Review*, 10(3), 11-15.
- Phillips, L. D. (1988). Requisite decision modelling: A case study. In S. French (Ed.), *Reading in decision analysis*. London: Chapman and Hall.
- Phillips, W. (1998). Catering to divergent customers. *ABA Banking Journal*, 20(2), S3-5.
- Piszczalski, M. (1999). War of attrition underway in Southeast Asian auto market. *Automotive Manufacturing and Production*, 11(2), 14-15.
- Poe, V., Klauer, P., & Brobst, S. (1998). *Building a data warehouse for decision support*. Upper Saddle River, NJ: Prentice Hall PTR.
- Polkwamdee, N. (1998). *Lesson on greed and laxity* [Online]. Available: <http://www.bkkpost.samart.co.th/n...chive/ecoreview97/review9709.html>. [1998, January 14].
- Pradhan, B. D. (1994). Telecom technology transfer- Experience in India. In K. Duncan & K. Krueger (Eds.), *The IFIP 13 th World Computer Congress 94* (Vol. 3, pp. 456-461). Amsterdam: Elsevier Science B.V. (North-Holland).
- Preece, D. A. (1989). *Managing the adoption of new technology*. London: Routledge.
- Premkumar, G., Ramamurthy, K., & Crum, M. R. (1997). Determinants of EDI adoption in the transportation industry. *European Journal of Information Systems*, 6(2), 107-121.
- Prendergast, G. P. (1993). Self-service technologies in retail banking: Current and expected adoption patterns. *International Journal of Bank Marketing*, 11(7), 29-35.
- Prendergast, G. P., & Marr, N. E. (1993). Consumer adoption of self-service technologies in retail banking: Is expert option supported by consumer research? *International Journal of Bank Marketing*, 11(1), 3-10.
- Prendergast, G. P., & Marr, N. E. (1994). The future of self-service technologies in retail banking. *Service Industries Journal*, 14(1), 94-114.

- Price, R. M. (1996). Executive forum: Technology and strategic advantage. *California Management Review*, 38(3), 38-56.
- Quaddus, M. A. (1995a). *Diffusion of information technology: A review of static and dynamic models* (Working Paper). Perth, Western Australia: Curtin University of Technology.
- Quaddus, M. A. (1995b). Diffusion of information technology: An exploration of the stage models and facilitating the user's choice by system approach. In C. H. Chuan & J. S. Dhaliwal (Eds.), *The 1995 Pan Pacific Conference on Information Systems* (pp. 191-199). Singapore.
- Quaddus, M. A. (1996). *GSS supported system dynamics: A model for IT planning*. Perth, Western Australia: Curtin University of Technology.
- Quaddus, M. A. (1997). Multiple criteria decision support for the strategic analysis of information system projects. *International Journal of Management*, 14(2), 302-312.
- Quaddus, M. A., Atkinson, D. J., & Levy, M. (1992). An application of decision conferencing to strategic planning for a voluntary organisation. *Interface*, 22(6), 61-71.
- Quaddus, M. A., & Intrapairot, A. (1998). System dynamics modelling of information and communication technologies: Policy studies in the banking industry in Thailand. *Proceedings of the 16th International Conference of the System Dynamics Society* [CD-ROM], Quebec City, Canada.
- Quaddus, M. A., & Siddique, M. A. B. (1994). *Multiobjective decision support in development planning* (Discussion paper). Perth, Western Australia: Curtin University of Technology.
- Radding, A. (1991). Banking technology in the '90s. *Bank Management*, 67(7), 34-36.
- Rafferty, K. (1985). Asia-Pacific: An economic miracle in jeopardy. *Institutional Investor*, 19(12), 289-294.
- Reagan-Cirincione, P., Schuan, S., Richardson, G. P., & Dorf, S. A. (1991). Decision modelling: Tools for strategic thinking. *Interface*, 21(6), 52-65.
- Recruitment goes high tech. (1994). *Personnel Journal*, 73(8), S 6-9.
- Redman, T. C. (1995). Improve data quality for competitive advantage. *Slone Management Review*, Winter, 99-107.
- Re-engineering in Thailand. (1997). *Economist*, 345(8038), 83-84.

- Reichardt, C. S., & Cook, T. D. (1978). Beyond qualitative versus quantitative methods. *Proceedings of the 2nd Annual Meeting of the Evaluation Research Society*, Washington, D.C., 7-45.
- Remenyi, D. S. J. (1988). *Increased profits with strategic information systems*. Oxford: The National Computing Centre Limited.
- Richardson, G. P. (1996). Problems for the future of system dynamics. *System Dynamics Review*, 12(2), 141-157.
- Richardson, G. P., & Anderson, D. F. (1995). Teamwork in group model building. *System Dynamics Review*, 11(2), 113-137.
- Richardson, G. P., & Pugh, A. L. (1981). *Introduction to system dynamics modelling with Dynamo*. Cambridge: Productivity Press.
- Richmond, B. (1994). Systems thinking/ system dynamics: Let's just get on with it. *System Dynamics Review*, 10(2-3), 135-157.
- Richmond, B., Peterson, S., & Charyk, C. (1994). *Introduction to system thinking and itthink*. Hanover, NH: High Performance Systems.
- Rifkin, G. (1987). Troubled Bank America looks to technology for financial relief. *Computerworld*, 21(10), 66.
- Robertson, T. S., & Gatignon, H. (1986). Competitive effects on technology diffusion. *Journal of Marketing*, 50(3), 1-12.
- Rodrigues, A., & Bower, J. (1996). System dynamics in project management: A comparative analysis with traditional methods. *System Dynamics Review*, 12(2), 121-139.
- Rodrigues, A. G., & Williams, T. M. (1997). System dynamics in software project management: Towards the development of a formal integrated framework. *European Journal of Information Systems*, 6(1), 51-66.
- Rodrigues, A. G., & Williams, T. M. (1998). System dynamics in project management: Assessing the impacts of client behaviour on project performance. *Journal of the Operational Research Society*, 49(1), 2-15.
- Rogers, E. M. (1983). *Diffusion of innovations*. (3 ed.). New York: The Free Press.
- Roth, A. V., & Van Der Velde, M. (1989). Investing in retail delivery system technology. *Journal of Retail Banking*, 11(2), 23-34.
- Saeed, K. (1989). Government's ability to manage political conflict over the course of economic development. In P. M. Milling & E. O. K. Zahn (Eds.), *Computer-based management of complex systems, the 1989 International Conference of the System Dynamics Society* (pp. 624-632). Berlin: Springer-Verlag.

- Saeed, K. (1990). Managing technology for development a systems perspective. *Socio Economic Planning Science*, 24(3), 217-228.
- Saeed, K. (1992). Slicing a complex problem from system dynamics modelling. *System Dynamics Review*, 8(3), 251-261.
- Saeed, K., & Brooke, K. (1996). Contract design for profitability in macro-engineering projects. *System Dynamics Review*, 12(3), 1-12.
- Saeed, K., & Prankprakma, P. (1997). Technological development in a dual economy: Alternative policy levers for economic development. *World Development*, 25(5), 695-712.
- Sahal, D. (1977). The multidimensional diffusion of technology. *Technological Forecasting and Social Change*, 10, 277-298.
- Sahin, K. (1997). *Multidimensional database technology and data warehousing* [Online]. Available: http://www.kenan.com/acumate/byln_mdw.htm [1997, December 4].
- Samiee, S. (1998). The Internet and international marketing: Is there a fit? *Journal of Interactive Marketing*, 12(4), 5-21.
- Samuels, R. J. (1994). Pathways of technological diffusion in Japan. *Sloan Management Review*, 35(3), 21-34.
- Sayeed, L., & Brightman, H. J. (1994). Can information technology improve managerial problem finding? *Information and Management*, 27(6), 377-390.
- Scarborough, H., & Lannon, R. (1994). The successful exploitation of new technology in banking. In E. Rhodes & D. Wield (Eds.), *Implementing New Technologies* (pp. 248-259). Cornwall, London: Blackwell.
- SCB sees new concept toward 2000. (1996). The Nation [Online]. Available: <http://www.scb.co.th/scb-bus-news/n260196-1.html> [1996, October 14].
- Schmidt, D. (1989). Computer based decision support of strategic planning and strategic management with system dynamics models illustrated by the example of the German federal railway. In P. M. Milling & E. O. K. Zahn (Eds.), *Computer-based management of complex systems, the 1989 International Conference of the System Dynamics Society* (pp. 177-185). Berlin: Springer-Verlag.
- Schoemaker, P. J. H., & Russo, J. E. (1993). A pyramid of decision approaches. *California-Management-Review*, 3(1), 9-31.
- Schulman, S. (1997). Early adopters: Ahead of the crowd. *Information Today*, 14(8), 56.

- Seaman, C. H. C. (1987). *Research methods: Principles, practice, and theory for nursing*. (3 ed.). New York: Appleton & Lange.
- Senge, P. M. (1989). Organisational learning: A new challenge for system dynamics. In P. M. Milling & E. O. K. Zahn (Eds.), *Computer-based management of complex systems, the 1989 International Conference of the System Dynamics Society* (pp. 229-236). Berlin: Springer-Verlag.
- Senge, P. M. (1992). *The fifth discipline: The art & practice of the learning organisation*. Sydney: Rando House.
- Senge, P. M., & Sterman, J. D. (1992). Systems thinking and organisational learning: Acting locally and thinking globally in the organisation of the future. *European Journal of Operational Research*, 59, 137-150.
- Sharif, M. N. (1994a). Integrating business and technology strategies in developing countries. *Technological Forecasting and Social Change*, 45, 151-167.
- Sharif, M. N. (1994b). Technology change management: Imperatives for developing economies. *Technological Forecasting and Social Change*, 47, 103-114.
- Sharif, M. N., & Haq, A. K. M. A. (1979). Determinants for forecasting technological substitution. *Technological Forecasting and Social Change*, 13, 59-81.
- Siam City Bank. (1999a). *Engineering force* [Online]. Available: http://www.siamcity.co.th/scit/about/about_e.htm [1999, August 23].
- Siam City Bank. (1999b). *Profile*. Siam City Bank [Online]. Available: <http://www.siamcity.co.th/html/profile.html> [1999, April 24].
- Siamwalla, A. (1996). *Two and a half cheers for economic growth: An assessment of long term changes in the Thai economy*. TDRI Quarterly Review [Online]. Available: <http://jjab.samart.co.th:80/tdri/library/quarterly/text/econ-grw.htm> [1996, September 9].
- Simon, H. A. (1977). *The new science of management decision*. (revised ed.). New Jersey: Prentice-Hall.
- Simon, H. (1982). *Models of bounded rationality*. Cambridge, MA: MIT Press.
- Sirimance, S. (1998). *The information technology revolution: What about the developing countries?* [Online]. Available: <http://www.acdi-cida.gc.ca/xpress/dex/dex9604.htm> [1999, April 26].
- Sivarama Prasad, A. V., & Somasekhara, N. (1990). The analytic hierarchy process for choice of technologies. *Technological Forecasting and Social Change*, 38, 151-158.

- Smith, C. (1984). *Retail banking in the 1990's: The technology suppliers' view*. London: Lafferty Publications.
- Smith, M. (1997). Technology and trust. *Canadian Banker*, 104(6), 34-35.
- Sraeel, H. (1996). Who's who in banking: The best and worst players of 1996. *Bank Systems and Technology*, 33(12), 7.
- Stedman, C. (1998). Warehousing tracks big spenders. *Computerworld*, 32(8), 1-2.
- Sterman, J. D. (1994). Learning in and about complex systems. *System Dynamics Review*, 10(2-3), 291-330.
- Stevens, M. (1988). *Practical problem solving*. London: Kogan Page Limited.
- Stevenson, R. (1993). Strategic business process engineering: A systems thinking approach using ithink. In K. Spurr, P. Layzell, L. Jennison, & N. Richards (Eds.), *Software assistance for business re-engineering* (pp. 99-118): John Wiley & Sons Ltd.
- Stoneman, P., & Kiederer, P. (1994). Technology diffusion and public policy. *Economic Journal: The Journal of the Royal Economic Society*, 104(425), 918-930.
- Strauss, P. (1994). Beyond talking heads: Videoconferencing makes money. *Datamation*, 40(19), 38-41.
- Subramanian, G. H., & Gershon, M. (1991). The selection of computer-aided software engineering tools: A multi-criteria decision making approach. *Decision Sciences*, 22(5), 1109-1123.
- Swierczek, F. W. (1988). Culture and job satisfaction: An obtrusive approach. *Management decision*, 26(6), 37-41.
- Swinyard, W. R., & Ghee, L. G. (1987). Adoption patterns of new banking technology in Southeast Asia. *International Journal of Bank Marketing*, 5(4), 35-48.
- Takac, P. F., & Singh, C. P. (1992). Banking technology: Improving its potential through better management. *Management Decision*, 30(5), 17-20.
- Tapscott, D. (1998, October 26). Death-spiral fears for traditional banks? *Computerworld*, 36.
- Taylor, J. R., Moore, E. G., & Amonsens, E. J. (1994). Profiling technology diffusion categories: Empirical tests of two models. *Journal of Business Research*, 31(1, 2), 155-162.
- Technology Atlas Team. (1987). Components of technology for resource transformation. *Technological Forecasting and Social Change*, 32, 19-35.

- Terdudomtham, T. (1998). *Economic review: Year end 1997: The bubble finally burst* [Online]. Available: <http://www.bkkpost.samart.co.th/n...chive/ecoreview97/review9701.html> [1998, January 14].
- Tesawanich, J. (1991). *Money and banking*. (3 ed.). Bangkok: Odean Store.
- Thach, L., & Woodman, R. W. (1994). Organisational change and information technology: Managing on the edge of cyberspace. *Organisational Dynamics*, 23(1), 30-46.
- Thai Farmer Bank Public Company Limited. (1999a). *Competitive advantage: Re-engineering program* [Online]. Available: <http://www.tfb.co.th/> [1999, April 23].
- Thai Farmer Bank Public Company Limited. (1999b). *Electronic banking* [Online]. Available: <http://www.tfb.co.th/> [1999, April 23].
- The National Identity Board Office of the Prime Minister. (1995). *Thailand in the 90s*. Bangkok: National Identity Office, Office of the Prime Minister.
- The Siam Commercial Bank PCL. (1995). *Toward Intelligent Banking*. Bangkok: Pikkanet Printing Center, Ltd.
- The Siam Commercial Bank PCL. (1996a). *The development of banks in Thailand*. Bangkok: Pikkanet Printing Center, Ltd.
- The Siam Commercial Bank PCL. (1996b). *Financial Highlights* [Online]. Available: <http://www.scb.co.th/pr-custodial-highlight-index.htm> [1996, February 11].
- The Siam Commercial Bank PCL. (1997a). Data Warehouse. *SCB Technologies*, 10, 7-9.
- The Siam Commercial Bank PCL. (1997b). *Significant progress and development*. The Siam Commercial Bank PCL. [Online]. Available: http://www.scb.co.th/datahtml/forshareholder/97_development.htm#link2-tech [1999, April 24].
- The Siam Commercial Bank PCL. (1999a). *Annual report' 98* [Online]. Available: <http://www.scb.co.th> [1999, August 7].
- The Siam Commercial Bank's executives. (1998). [Policy Analysis questionnaire and interview]. Unpublished raw data.
- The Siam Commercial Bank's executives. (1999). [Model Validation Interviews]. Unpublished raw data.
- The Siam Commercial Bank's staff. (1998a). [Banking Technologies questionnaire]. Unpublished raw data.

- The Siam Commercial Bank's staff. (1998b). [Data Warehouse Users questionnaire and interview]. Unpublished raw data.
- The Siam Commercial Bank's staff. (1998c). [Data Warehouse questionnaire and interview]. Unpublished raw data.
- The Siam Commercial Bank's staff. (1998d). [Extranet Banking questionnaire and interview]. Unpublished raw data.
- The Siam Commercial Bank's staff. (1998e). [Technology and Bank Staff' questionnaire]. Unpublished raw data.
- The Smart Card Cybershow. (1997). *Smart card applications* [Online]. Available: http://www.cardshow.com/applications/VisaCash/next_frontier.html [1997, February 15].
- The World Bank. (1993). *The East Asian miracle: Economic growth and public policy*. New York: Oxford University Press.
- Thompson, T. W. (1987a). Diffusion theory. *United States Banker*, 98(2), 54.
- Thompson, T. W. (1987b). Diffusion theory (Part 2). *United States Banker*, 98(3), 82-84.
- Thong, J., & Yap, C. S. (1995). CEO characteristics, organisational characteristics and information technology adoption in small businesses. *Omega*, 23(4), 429-442.
- Thurlby, R., & Chang, J. (1995). The application of systems dynamics to the re-engineering of value processes. *Executive Development*, 8(4), 26-31.
- Tognazzini, B. (1996). The next decade in the evolution of computers. *Computer Reseller News*, August (697), 157-162.
- Tornatzky, L. G., & Klein, K. J. (1982). Innovation characteristics and innovation adoption-implementation. *IEEE Trans. Eng. Management*, EM-29(1), 28-45.
- Triantaphyllou, E., & Sanchez, A. (1997). A sensitivity analysis approach for some deterministic multi-criteria decision-making methods. *Decision Sciences*, 28 (1), 151-194.
- Tye, E. M. W. N., & Chau, P. Y. K. (1995). A study of information technology adoption in Hong Kong. *Journal of Information Science*, 21(1), 11-19.
- Vennix, J. A. M., Akkermans, H. A., & Rouwette, A. J. A. (1996). Group model-building to facilitate organisational change: An exploratory study. *System Dynamics Review*, 12(1), 39-58.
- Vennix, J. A. M., Anderson, D. F., Richardson, G. P., & Rohrbaugh, J. (1992). Model building for group decision support: Issues and alternatives in knowledge elicitation. *European Journal of Operational Research*, 59, 28-41.

- Vennix, J. A. M., Gubbels, J. W., Post, D., & Poppen, H. J. (1990). A structured approach to knowledge elicitation in conceptual model building. *System Dynamics Reviews*, 6(2), 194-208.
- Vetschera, R. (1994). MCView: An integrated graphical system to support multi-attribute decisions. *Decision Support System*, 11, 363-371.
- Vežjak, M., Savsek, T., & Stuhler, E. A. (1998). System dynamics of eutrophication processes in lakes. *European Journal of Operational Research*, 109(2), 442-451.
- Visa International. (1998). *Smart cards* [Online]. Available: <http://www.cardshow.com/cgi-bin/outlink?url=http%3A%2F%2Fwww.visa.com%2Fcgi-bin%2Fvee%2Fnt%2Fmain.html%3F2%2B0> [1998, December 21].
- Vogt, E. E. (1988). Guerrilla warfare in the technology jungle. *Chief Executive* (Sep/Oct), 62-64.
- Von Winterfeldt, D., & Edwards, W. (1986). *Decision analysis and behavioural research*. New York: Cambridge University Press.
- Waema, T. M., & Walsham, G. (1990). Information systems strategy formation in a developing country bank. *Technological Forecasting and Social Change*, 38, 393-407.
- Wagenaar, W. A., Keren, G., & Lichtenstein, S. (1997). Islanders and hostages: Deep and surface structures of decision problems. In W. M. Goldstein & R. M. Hogarth (Eds.), *Research on judgement and decision-making* (pp. 552-565). New York: Cambridge University Press.
- Walker, R. (1985). An introduction to applied qualitative research. In R. Walker (Ed.), *Applied qualitative research* (pp. 1-22). Aldershot, England: Gower.
- Watabe, K., Holsapple, W. W., & Whinston, A. B. (1992). Co-ordinator support in a nemawashi decision process. *Decision Support System*, 8, 85-98.
- WebAustralia. (1996). *Internet Banking* [Online]. Available: <http://www.webaustralia.com.au/banking/brochures/folder/comm2.htm> [1996, August 3].
- Weber, R. P. (1985). *Basic content analysis*. Beverly Hills, CA: Sage.
- Whitten, J. L., Bentley, L. D., & Barlow, V. M. (1994). *Systems analysis and design methods*. (3 ed.). Burr Ridge, Ill: Irwin.
- Wilkes, G. A., & Krebs, W. A. (1995). *Collins English dictionary: An extensive coverage of contemporary international and Australia English*. (3 ed.). Sydney: HarperCollins Publishers.

- Williams, T., Eden, C., Ackermann, F., & Tait, A. (1995). The effects of design changes and delays on project costs. *Journal of the Operational Research Society*, 46, 809-816.
- Winch, G. W. (1995). Understanding the dynamics of technology switching in seeking to maintain international competitiveness. In T. Shimada & K. Saeed (Eds.), *1995 International System Dynamics Conference* (Vol. 1, pp. 277-289). Tokyo, Japan: The System Dynamics Society.
- Without technology, banks would be nowhere. But it could put them out of a job. (1999b, April 17). *The Economist (US)*, 351, 8.
- Wolstenholme, E. F. (1993). A case study in community care using systems thinking. *Journal of the Operational Research Society*, 44, 925-934.
- Wolstenholme, E. F. (1994). *System enquiry: A system dynamics approach*. Chichester: John Wiley & Sons.
- Wolstenholme, E. F., & Coyle, R. G. (1983). The development of system dynamics as a methodology for system description and qualitative analysis. *Journal of the Operational Research Society*, 34(1), 569-581.
- Woolley, S. (1998, June 15). Virtual banker. *Forbes*, 161, 127-127.
- Wynekoop, J. L., Senn, J. A., & Conger, S. A. (1992). *The implementation of case tools: An innovation diffusion approach*. Amsterdam: Elsevier (North-Holland).
- Yakal, K. (1999, April 6). Real-time Internet banking. *PC Magazine*, 48.
- Yin, C. Y., Abdel-Hamid, T. K., & Sherif, J. S. (1997). Software-Engineering Process Simulation model (SEPS). *Journal of Systems and Software*, 38(3), 263-277.
- Yin, R. K. (1994). *Case study research: Design and methods*. (2 ed.). Thousand Oak, CA: Sage Publications.
- Young, V. (1997). *ICTs and development: Testing a framework for evaluation*. Canadian International Development Agency [Online]. Available: http://www.acdi-cida.gc.ca/cida_ind.nsf/0e258f35e6cd1eb28525662d0057b6fe/0058916d51fb84c4852564bf005431a1?OpenDocument [1999, April 26].
- Zionts, S. (1979). MCDM - If not a Roman numeral, then what? *Interface*, 9(4), 94-101.
- Zionts, S. (1992). Some thoughts on research in multiple criteria decision-making. *Computers and Operations Research*, 19(7), 567-570.
- Zoreda, J. L., & Oton, J. M. (1994). *Smart cards*. London: Artech House.



Appendix 5.1. Banking Technologies

I. Existing Banking Technological Issues

1. What is the vision of the Siam Commercial Bank PCL (SCB)?

2. What are the main objectives that the SCB is trying to achieve?

3. What are the main purposes for which the SCB uses banking technologies?.....

4. How do you see the main problems regarding technology adoption and diffusion that the bank has confronted so far?.....

5. For problems identified from literature, and stated below, please indicate your view of the seriousness in regards to technology adoption and diffusion so far confronted by the bank.

Problems	Level of Seriousness						
	Not at all Serious			Extremely Serious			
High costs of technologies	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Rapid Obsolescence	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Selecting inappropriate technologies	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Cannot use adopted technology productively	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Level of acceptance from customers	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Level of acceptance from bank staff	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Lack of capable employees	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Lack of high executive support	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Delivery of receiving incorrect information	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Technology did not deliver expected performance	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Technological mismatch	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Different outcomes between a pilot project and real implementation	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Lack of understanding of the new technology	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Others..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐

II. Technology Adoption

1. Please specify the sources you consider the bank can obtain information from whenever it wants to adopt new technologies.

1.....

2.....

3.....

4.....

2. Who do you consider are the key persons to make decisions regarding technology adoption?

1.....

2.....

3.....

4.....

3. Please explain/list the decision-making process (steps that you go through) when the bank adopts new technologies

.....

III. Technology Alternatives

Please indicate how important you consider each of these technologies are in fulfilling the bank's vision (Check one box for each technology).

Technologies	Level of Importance						
	Not at all Important						Extremely Important
Smart cards	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Data warehousing	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Video conferencing	1☐	2☐	3☐	4☐	5☐	6☐	7☐
EFTPOS	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Extranet banking (SCB Cash management)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Other..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Other..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐

IV. Criteria Used for Technological Evaluation

1. High level criteria

Please indicate how important you consider these issues are in selecting the technologies that you selected in topic II page 2 (Check one box for each issue).

Issues	Level of Importance						
	Not at all Important						Extremely Important
Relative Advantages (e.g. competitive advantages, increased sales, increased market shares)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Features of Technology (e.g. reliability, easy to use, costs)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Bank Environments (e.g. staff, resources, facilities, executive support)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Customer Behaviour (e.g. satisfaction, acceptance)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Current economic Situation	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Other..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Other..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐

2. Low level criteria

Please indicate how important you consider these criteria are in selecting the technologies that you considered in topic II page 2 (Check one box for each criterion).

Criteria	Level of Importance						
	Not at all Important						Extremely Important
Increased sales	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Increased market share	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Increased competitive advantage	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Increased performance efficiency	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Providing more accurate and timely information	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Increased image	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Reduced costs (e.g. labour costs, operational costs, paper work, rework)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Reduced costs for branch establishment	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Improved decision making (timeliness, accuracy, comprehensives and availability)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Costs of technologies	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Easy for staff to learn/use	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Reliability (fewer breakdowns)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Security (less openness to abuse/ fraud)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Compatibility with existing systems	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Level of required skills for staff to use technology	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Trialability (ability to test it)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Observability (ability to see it works)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Available facilities (fit between existing facilities and new technology)	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Executive support	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Staff acceptance	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Level of actual skills in organisation and staff	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Experience in technology	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Customer satisfaction	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Customer acceptance	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Easy for customers to use	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Economic situation of the nation	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Other..... (please specify)	1☐	2☐	3☐	4☐	5☐	6☐	7☐

V. Future contact information (optional)

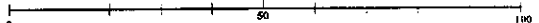
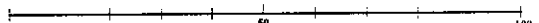
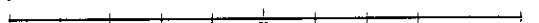


Name:	
Position:	
Department:	
Contact No:	
E-mail:	

Appendix 5.2. Evaluation of Banking Technologies

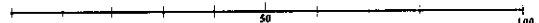
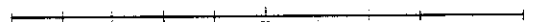
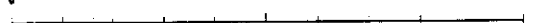


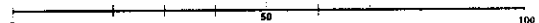
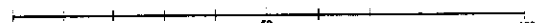


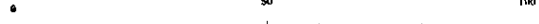
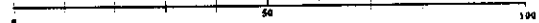
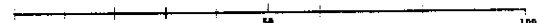
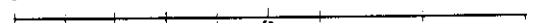

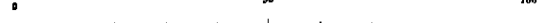
I. Scores Used for Technology Evaluation

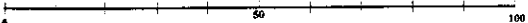
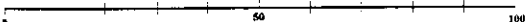
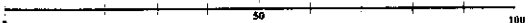
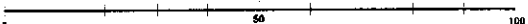
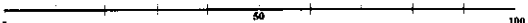
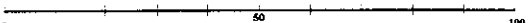
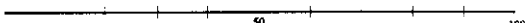
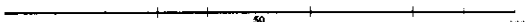

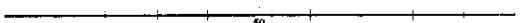
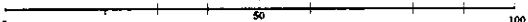
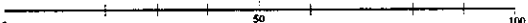
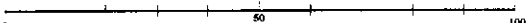
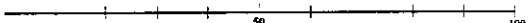
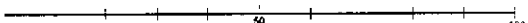
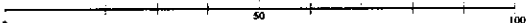
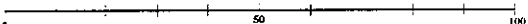
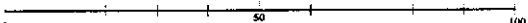
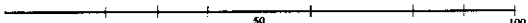
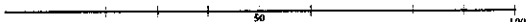
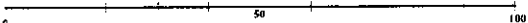
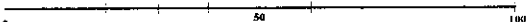
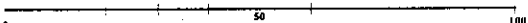
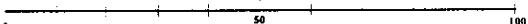
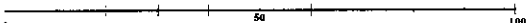
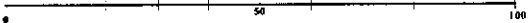
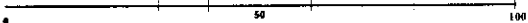
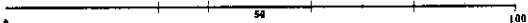
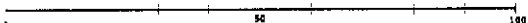
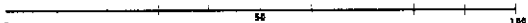
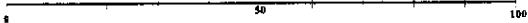
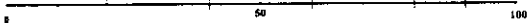
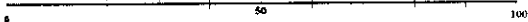
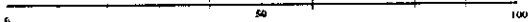
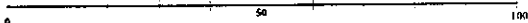
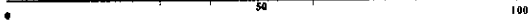



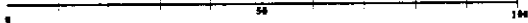
Please specify scores of each technology based on the following criteria. The scores have to be entered on a 0 to 100 scale, where a higher value represents a more preferred outcome.

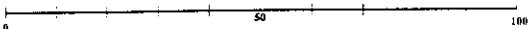
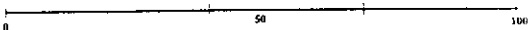
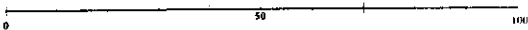
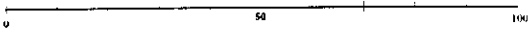
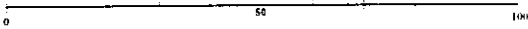
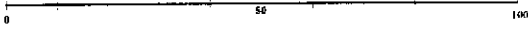
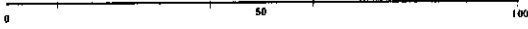
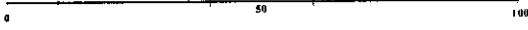
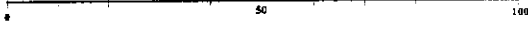
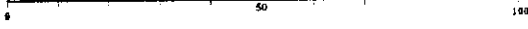
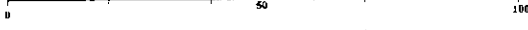
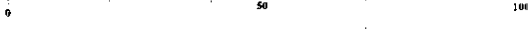
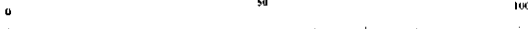
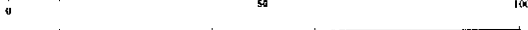

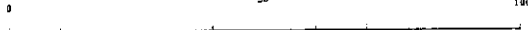
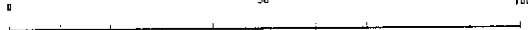



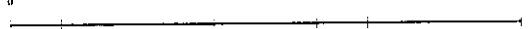
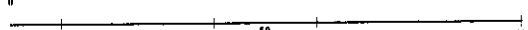
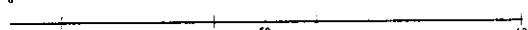
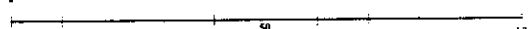

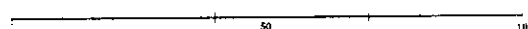
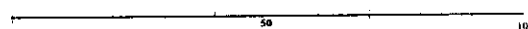
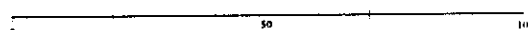
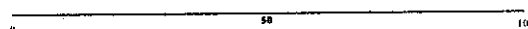

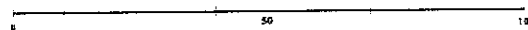
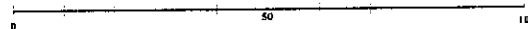
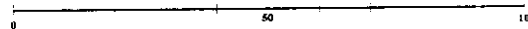
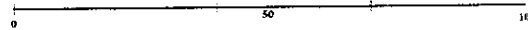
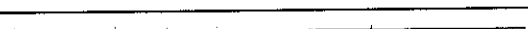
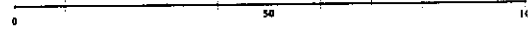
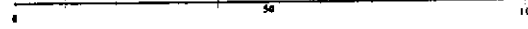
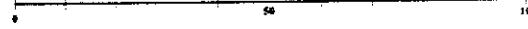


Example

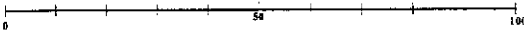
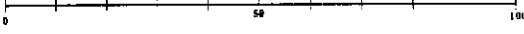

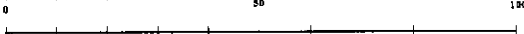

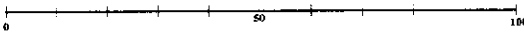
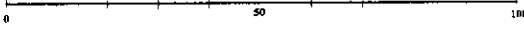
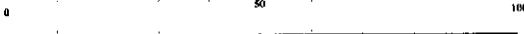
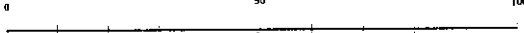

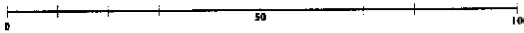
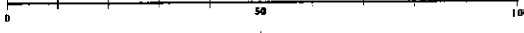
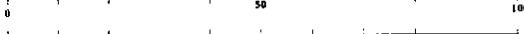
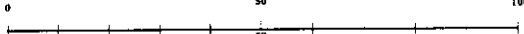

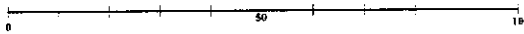
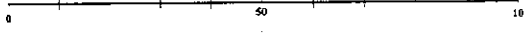
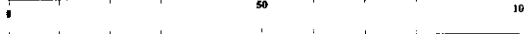
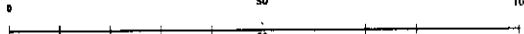
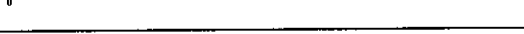
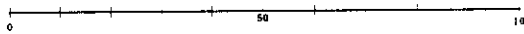
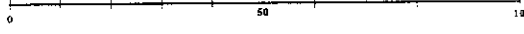

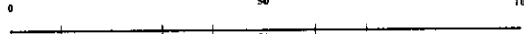

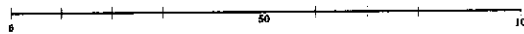
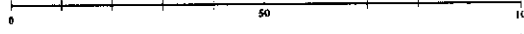
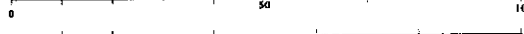
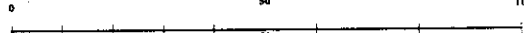

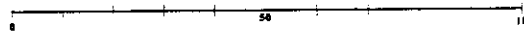
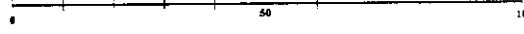
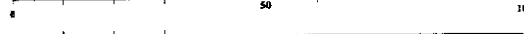
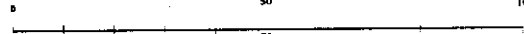

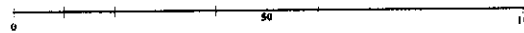
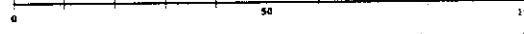

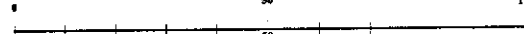

Criteria	Scores	
	Preferred outcome	More Preferred outcome
Increased sales	Smart cards	
	Data warehouse	
	Video conferencing	
	EFTPOS	
	Extranet banking	

For example, the technology which you consider does best depending on a particular criterion (e.g. increased sales) should be assigned a score of 100 (i.e. Extranet banking). The one which you consider does least well should be assigned a score of 0 (i.e. Video conferencing). All other alternatives should be given intermediate scores which reflect their performance relative to these two end points.

Criteria	Scores	
	Preferred outcome	More Preferred outcome
Increased sales	Smart cards	
	Data warehouse	
	Video conferencing	
	EFTPOS	
	Extranet banking	
Increased market share	Smart cards	
	Data warehouse	
	Video conferencing	
	EFTPOS	
	Extranet banking	
Increased competitive advantage	Smart cards	
	Data warehouse	
	Video conferencing	
	EFTPOS	
	Extranet banking	

Increased performance efficiency	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Providing more accurate and timely information	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Increased image	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Reduced costs (e.g. labour costs, operational costs, paper work, rework)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Reduced costs for branch establishment	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Improved decision making (timeliness, accuracy, comprehensiveness and availability)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Costs of technologies	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Easy for staff to learn/use	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>

Reliability (fewer breakdowns)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Security (less openness to abuse/ fraud)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Compatibility with existing systems	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Level of required skills for staff to use technology	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Trialability (ability to test it)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Observability (ability to see it works)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Available facilities (fit between existing facilities and new technology)	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Executive support	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>

Staff acceptance	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Level of actual skills in organisation and staff	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Experience in technology	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Customer satisfaction	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Staff acceptance	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Easy for customers to use	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Good economic situation of the nation	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>
Bad economic situation of the nation	<p>Smart cards </p> <p>Data warehouse </p> <p>Video conferencing </p> <p>EFTPOS </p> <p>Extranet banking </p>



Appendix 5.3. Data Warehouse (DW)

General Questions

1. How much do you think a data warehouse costs?

2. What are the current development plans (budget, personnel, resources) for DW?

3. How many people are actively involved in the following areas of data warehouse within the bank?

	Requirement	Actual
Operation, service		
Research		
Development		
Consulting		
Business analyst		
Executive		

4. Which departments are involved in the areas of data mining or data warehousing within the bank?

- | | |
|--|---|
| <input type="checkbox"/> All | <input type="checkbox"/> Marketing..... |
| <input type="checkbox"/> Personnel | <input type="checkbox"/> Technology Group |
| <input type="checkbox"/> Customer Service..... | <input type="checkbox"/> |

5. How long has the bank been involved in data mining or data warehouse?

6. Did the bank develop the product completely from scratch, or is it based somewhat on existing technologies (i.e. other data discovery algorithms, multi -dimensional cube implementation, etc.)?

- | | |
|---------------------------------------|---|
| <input type="checkbox"/> From scratch | <input type="checkbox"/> Based on existing technologies |
| <input type="checkbox"/> Other | |

7. Are you affiliated with any other companies or labs?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

If yes, please specify the company name.....

8. Who are your vendors (technical supports)?

9. What types of support come from your vendors?.....

10. What are the economic gains from data warehousing so far?

11. What are the drawbacks of data warehousing that the bank has confronted so far?

12. What are the policies that you consider can be used to enhance the benefits from data warehousing?

List of Variables

Please consider the extent to which these variables will affect the development of the diffusion model of a data warehouse (DW).

A. Adoption and Diffusion

Variables	Operational Measurement
Rate of investment in DW	1. % of money investing in DW..... 2. Investment in DW/year.....baht
Investment in DW	1. Total investment in DW.....baht
Rate of technology diffusion	1. Numbers of staff using DW/ month..... 2. Numbers of usage, hours/ month..... 3. Numbers of transaction/month..... 4. Numbers of queries/ month..... 5. Numbers of login/ month.....
Diffused DW	1. Numbers of staff using technology..... 2. Numbers of usage (hours)..... 3. Numbers of transaction..... 4. Numbers of queries..... 5. Numbers of login.....
Investment in new technology/ year	1. Investment in new technology..... baht
Backlog of problems	1. Numbers of problems..... 2. Numbers of complaints..... 3. Estimated expenses
Rate of technology abandonment	1. Rate of Technology Abandonment.....%
Economic situation	1. Economic growth..... 2. The total amount of all deposits..... 3. The total amount of all loans.....

B. Features of technology

	Level of Actual Performance							Remarks
	Low						High	
Reliability	1□	2□	3□	4□	5□	6□	7□	1. % of expense for technology breakdown..... 2. Expense to loss.....baht
Security	1□	2□	3□	4□	5□	6□	7□	1. % of expense for loss from abuse fraud of DW..... 2. Expense for security.....baht
Ease of use	1□	2□	3□	4□	5□	6□	7□	
Compatibility with existing systems	1□	2□	3□	4□	5□	6□	7□	
Trialability	1□	2□	3□	4□	5□	6□	7□	
Observability	1□	2□	3□	4□	5□	6□	7□	
Quick response time	1□	2□	3□	4□	5□	6□	7□	

C. Bank environments

	Level of Actual Performance Low High	Remarks
Formalisation	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Centralisation	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Size of organisation	1□ 2□ 3□ 4□ 5□ 6□ 7□	The rank in the industry.....
Management support	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. Budget for IT development.....
Organisational complexity	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Organisational resource	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. Asset.....baht/year 2. Budget for IT development..... baht/year 3. No. of Staff.....
Communication amount –Co-operation between IT and users	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. No. of queries..... 2. No. of assistance.....
Experience in technology	1□ 2□ 3□ 4□ 5□ 6□ 7□	

D. Marketing

	Level of Actual Performance Low High	Remarks
Positive word of mouth	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Advertising	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. Expense on sales promotion
Timing of market entry	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Potential market	1□ 2□ 3□ 4□ 5□ 6□ 7□	2. No. of prospective customers....
Competitive gap	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. Desired market share...% 2. Actual market share....%
Network externality	1□ 2□ 3□ 4□ 5□ 6□ 7□	

E. Customer behaviour

	Level of Actual Performance Low High	Remarks
Customer acceptance	1□ 2□ 3□ 4□ 5□ 6□ 7□	1. No. of customers using this technology..... 2. No. of prospective customers.....
Active customers	1□ 2□ 3□ 4□ 5□ 6□ 7□	No. of customers.....
Customer satisfaction	1□ 2□ 3□ 4□ 5□ 6□ 7□	

F. Staff

	Level of Actual Performance Low High	Remarks
Required knowledge workers	1□ 2□ 3□ 4□ 5□ 6□ 7□	No. of required knowledge workers.....
Level of actual knowledge workers	1□ 2□ 3□ 4□ 5□ 6□ 7□	No. of actual knowledge workers.....
Rate of training	1□ 2□ 3□ 4□ 5□ 6□ 7□	No. of staff being trained/Month.....
Staff acceptance	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Perceived complexity	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Perceived relative advantage	1□ 2□ 3□ 4□ 5□ 6□ 7□	
Level of understanding in using DW	1□ 2□ 3□ 4□ 5□ 6□ 7□	

G. Vendors

	Level of Actual Performance							Remarks
	Low						High	
Vendors' technical support	1□	2□	3□	4□	5□	6□	7□	
Vendors' service support	1□	2□	3□	4□	5□	6□	7□	
Vendors' educational support	1□	2□	3□	4□	5□	6□	7□	
Promotion effort	1□	2□	3□	4□	5□	6□	7□	No. of times for business communication.....

H. Relative Advantages

	Level of Actual Performance							Estimated Value
	Low						High	
Increased sales	1□	2□	3□	4□	5□	6□	7□	
Increased market share	1□	2□	3□	4□	5□	6□	7□	
Competitive advantage	1□	2□	3□	4□	5□	6□	7□	
Image	1□	2□	3□	4□	5□	6□	7□	
More effective decision-making	1□	2□	3□	4□	5□	6□	7□	
Decreased uncertainty	1□	2□	3□	4□	5□	6□	7□	
Accurate and timely information	1□	2□	3□	4□	5□	6□	7□	
Improved access to information for strategic planning	1□	2□	3□	4□	5□	6□	7□	
Improved access to information for loan underwriting	1□	2□	3□	4□	5□	6□	7□	
Improved access to information for internal management	1□	2□	3□	4□	5□	6□	7□	
Cost saving	1□	2□	3□	4□	5□	6□	7□	
Improved efficiency through timely access to information	1□	2□	3□	4□	5□	6□	7□	
Mass customisation	1□	2□	3□	4□	5□	6□	7□	
Capitalise on business opportunity	1□	2□	3□	4□	5□	6□	7□	

I. Costs

	baht
Costs of technologies	
Training costs	
Operating costs	
Maintenance costs	
Costs from backlog of problems	
Total costs	

J. Time

	Month
Time for approval	
Time for customisation	
Time for prototype/pilot project	
Time for training staff	
Time for gaining staff satisfaction	
Time for gaining customer satisfaction	
Economic life of technology	

Appendix 5.4. Technology and Bank Staff

This questionnaire is aimed at obtaining data regarding technology usage (e.g. information technologies, banking technologies) of the Siam Commercial Bank PCL. Please consider the extent to which these variables will affect the technology usage of bank staff.

1. Level of actual performance of banking technologies

Issues	Level of Actual Performance						
	Low						High
Understanding regarding banking technologies	1□	2□	3□	4□	5□	6□	7□
Technological training from the bank	1□	2□	3□	4□	5□	6□	7□
Acceptance of new technology	1□	2□	3□	4□	5□	6□	7□
Technologies are easy to use	1□	2□	3□	4□	5□	6□	7□
Satisfaction in using technology	1□	2□	3□	4□	5□	6□	7□
Technological support from IT people	1□	2□	3□	4□	5□	6□	7□
Technology provides advantages to you	1□	2□	3□	4□	5□	6□	7□
Technology provides advantages to the bank	1□	2□	3□	4□	5□	6□	7□
Involvement with IT people when the bank brings in new technologies	1□	2□	3□	4□	5□	6□	7□
Understanding about a data warehouse	1□	2□	3□	4□	5□	6□	7□
Acceptance in using a data warehouse	1□	2□	3□	4□	5□	6□	7□
Satisfaction in using a data warehouse	1□	2□	3□	4□	5□	6□	7□
The bank can get advantages from a data warehouse	1□	2□	3□	4□	5□	6□	7□
You can get advantages from a data warehouse	1□	2□	3□	4□	5□	6□	7□

2. Obstacles in using and learning technology (could select more than one answer)

- Lack of understanding of new technology
- Limitation of time in learning new technology because of routine work
- Technology does not suit for requirements
- Technology changes too fast
- Insufficient training
- Insufficient support from IT people
- Other (Please specify)

3. Supportive factors in learning and using technology (could select more than one answer)

- Training from the bank
- Support from high executive managers
- Involvement with IT people when the bank brings new technology to user
- Technological assistance from IT people when problems occur
- User friendly technologies
- Provide additional benefits as an incentive in learning and using technology
- Other (Please specify)



Appendix 5.5. Data Warehouse Users

This questionnaire is aimed at identifying the level of performance of a data warehouse of the Siam Commercial Bank PCL, as perceived by users.

1. Position in the Bank (if could provide).....
2. Number of your superiors who are using a data warehouse.....
3. When did you start using a data warehouse?(Month/ Year)
 Have not used yet, but will start using in(Month/ Year)
4. How many times do you use the data from a data warehouse
(times/ day) or(times/week) or(times/month)
5. You use data from a data warehouse for.....
6. How frequently have you attended the training regarding a data warehouse so far?.....
 How many days on average for each training session.....
7. Your department could gain these following benefits from a data warehouse (you may select more than one)

<input type="checkbox"/> Increased sales	<input type="checkbox"/> Increased market share
<input type="checkbox"/> Increased competitive advantage	<input type="checkbox"/> More effective decision making
<input type="checkbox"/> More accurate and timely information	
<input type="checkbox"/> Improved access to information for strategic planning	
<input type="checkbox"/> Improved access to information for loan underwriting	
<input type="checkbox"/> Improved access to information for internal management	
<input type="checkbox"/> Cost saving	<input type="checkbox"/> Increased performance efficiency
<input type="checkbox"/> Mass customisation	<input type="checkbox"/> Capitalised on business opportunity
8. From your point of view, after your department has been using the data warehouse, the benefits from this usage will affect bank customers (e.g. increased sales, market share) within.....months or within years.

9. Level of actual performance of the data warehouse.

Issues	Level of actual performance						
	Low						High
Training about a data warehouse from the bank	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Data in a data warehouse meets your requirements	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
A data warehouse is easy to use	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Problems occurring in using a data warehouse	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Technical support from IT people	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Your understanding regarding a data warehouse	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Acceptance in using a data warehouse in your work	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
Satisfaction in using a data warehouse	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
A data warehouse provides advantages to you	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>
A data warehouse provides advantages to the bank	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	4 <input type="checkbox"/>	5 <input type="checkbox"/>	6 <input type="checkbox"/>	7 <input type="checkbox"/>

10. Please indicate problems that you have confronted or experienced from using a data warehouse



Appendix 5.6. Prospective Customers of Internet/Extranet Banking

This questionnaire is aimed at surveying the tendencies of patterns of user behaviour in Internet/ Extranet Banking in Thailand

1. How many times a month do you make business transactions?.....
2. How many times a month do you make the following transactions?

Bank in person	
Using ATM machines	
Using telephone banking	
Using Internet Banking	

3. Have you been aware that the Thai commercial banks provide Internet/ Extranet banking?
 - Yes No
 - If yes, which bank.....
4. Do you (or your organisation) use Internet/ Extranet Banking?
 - Yes No
 - If yes, from which bank.....
5. Please indicate the reasons that you do not use Internet/ Extranet banking (you may select more than one answer).
 - Not necessary
 - Lack of equipment (e.g. computer, modem)
 - Do not know that the bank provides this service
 - Insufficient computer knowledge
 - Uncertain about security systems
 - Other (please identify).....
6. Would you use Internet/Extranet Banking in the future?
 - Yes No Maybe Don't know
 - (Please state Why)
7. If yes, through which banks are you going to use Internet/Extranet banking in the future?.....
 - (Please state Why)
8. Are you aware that the Siam Commercial Bank PCL provides Extranet banking?
 - Yes No
 - How could you get the information?.....

Please provide the following information

1. Gender Male Female
2. Age
 - Under 20 21-30
 - 31-40 41-50
 - 51-60 More than 60
3. Education
 - High school degree Vocational/ technical degree
 - Bachelor degree Master/ Doctorate degree

Appendix 5.7. Policy Analysis

1. Please suggest ways you consider may help to solve problems regarding technologies as confronting by the bank.

Problem	Policy (How to solve the problem)
1. Rapid obsolescence	
2. Lack of capable employees	
3. High costs of technologies	
4. Cannot use adopted technology productively	
5. Selecting inappropriate technologies	
6. Lack of understanding of the new technology	
7. How to provide training and education productively	
8. Acceptance and satisfaction from bank staff	
9. Acceptance from customers	
10. Insufficient support from vendors	

2. Please indicate how important you consider these following strategic policies are in increasing effectiveness in adopting and diffusing technology

Policy	Level of Importance						
	Not at all Important						Extremely Important
1. Determine desired market share	1□	2□	3□	4□	5□	6□	7□
2. Determine desired percent investment in new technology	1□	2□	3□	4□	5□	6□	7□
3. Increase potential customers	1□	2□	3□	4□	5□	6□	7□
4. Determine desired level of vendors' support	1□	2□	3□	4□	5□	6□	7□
5. Supportive training factors							
- Increase management support	1□	2□	3□	4□	5□	6□	7□
- Increase co-operation bet is and users	1□	2□	3□	4□	5□	6□	7□
- Increase perceived relative advantages	1□	2□	3□	4□	5□	6□	7□
- Decrease perceived complexity	1□	2□	3□	4□	5□	6□	7□
6. Time adjustment							
- Decrease time for approval	1□	2□	3□	4□	5□	6□	7□
- Decrease time for customisation	1□	2□	3□	4□	5□	6□	7□
- Decrease time for training staff	1□	2□	3□	4□	5□	6□	7□
- Decrease time for gaining staff satisfaction	1□	2□	3□	4□	5□	6□	7□
- Decrease time for gaining customer satisfaction	1□	2□	3□	4□	5□	6□	7□
- Increase economic life of technology	1□	2□	3□	4□	5□	6□	7□
7. Change marketing strategies							
- Increase positive word of mouth	1□	2□	3□	4□	5□	6□	7□
- Increase advertisement	1□	2□	3□	4□	5□	6□	7□
- Decrease price/fee	1□	2□	3□	4□	5□	6□	7□
- Increase quality	1□	2□	3□	4□	5□	6□	7□
- Increase potential market	1□	2□	3□	4□	5□	6□	7□
- Increase/ decrease timing of market entry	1□	2□	3□	4□	5□	6□	7□
- Increase network externality	1□	2□	3□	4□	5□	6□	7□

Policy	level of importance						
	not at all important						extremely important
8. Positive organisational environments							
- Increase management support	1□	2□	3□	4□	5□	6□	7□
- Increase centralisation	1□	2□	3□	4□	5□	6□	7□
- Increase formalisation	1□	2□	3□	4□	5□	6□	7□
- Decrease organisational complexity	1□	2□	3□	4□	5□	6□	7□
- Increase organisational resource	1□	2□	3□	4□	5□	6□	7□
9. Positive feature of technology							
- Increased security	1□	2□	3□	4□	5□	6□	7□
- Increase time and effort for testing	1□	2□	3□	4□	5□	6□	7□
- Decrease costs of technology	1□	2□	3□	4□	5□	6□	7□
10. Sound economic situation	1□	2□	3□	4□	5□	6□	7□

Appendix 7.1 Variables of Technology adoption

Variables	Relationship with technology adoption	References
1.1 Increased sales	+	<ol style="list-style-type: none"> 1. The reasons for the requirements of EFTPOS- a bank can develop a new client (Mysior, Shuman, & Linstone, 1984). 2. Adopting new technology objective- increased sales(Preece, 1989, pp 246-247) 3. Home banking services allow the bank to reduce internal operation costs, increase sales, new services, and customer satisfaction, provide access to information, and minimise investments in establishing new branches (Kivel & Rubin, 1996).
1.2 Increased market share	+	<ol style="list-style-type: none"> 1. The results are presented in an extensive longitudinal study of the effects of early adoption of ATM by banks, on market share and income (Dos Santos & Peffers, 1995) 2. A competitive advantage means that the company has found a better way to serve its customers or acquire new customers through the way it uses its IT/IS leading to a greater market share or a higher profit or a better return on investment (Remenyi, 1988).
1.3 Increased competitive advantage	+	<ol style="list-style-type: none"> 1. Fliegel and Kivlin (1966) indicated that economically rewards, least risky and more competitiveness with adopters' values were the factors that enhance rate of technology adoption. 2. A competitive advantage means that the company has found a better way to serve its customers or acquire new customers through the way it uses its IT/IS leading to a greater market share or a higher profit or a better return on investment (Remenyi, 1988). 3. The findings support case study evidence that early adoption of new IT applications can lead to long-term competitive advantages for firms (Dos Santos & Peffers, 1995) 4. The reasons for the requirements of EFTPOS- the need to preserve competition (Mysior et al., 1984).
1.4 Increased performance efficiency	+	<ol style="list-style-type: none"> 1. The criteria for selection of a technology should be concerned with the issues of efficiency of production and the sustenance of the resource environment (Saeed, 1990). 2. There are increasing concerns regarding technological adoption and the overall gain in return for such massive investment. Some important considerations are effectiveness, cost, security, reliability and linkage (Takac & Singh, 1992). 3. Reasons for adopting information technology... <ul style="list-style-type: none"> - achieving organisational efficiently - evaluating working conditions more efficiently

			<p>- improving work design (Foschini, 1989)</p> <p>4. Adopting new technology objective- to improve efficiency (Preece, 1989, pp 246-247).</p>
1.5 Providing more accurate and timely information	+		<p>1. Reasons for adopting information technology... - to speed up information processing, - to improve the management information system (Preece, 1989, pp 246-247)</p> <p>2. Home banking services allow the bank to...provide an access to information... (Kivel & Rubin, 1996).</p>
1.6 Increased image	+		<p>Reasons for adopting information technology ...- to provide a better image to customers (Preece, 1989)</p>
1.7 Reduced costs (e.g. labour costs, operational costs, paper work, rework)	+		<p>1. Home banking services allow the bank to reduce internal operation costs,...and minimise investments in establishing new branches (Kivel & Rubin, 1996).</p> <p>2. Reasons for adopting information technology... - to reduce costs - to save labour cost (Preece, 1989, pp 246-247).</p> <p>3. Innovation is traditionally considered to have as its objectives increased flexibility, decreased costs or improved quality (Gerwin, 1988).</p>
1.8 Improved decision-making	+		<p>Huber suggested that computer-assisted information and communications support should improve decision making (Sayeed & Brightman, 1994)</p>
2.1 Costs of technologies	-		<p>1. Product price affects the number of potential adopters (Paich & Sterman, 1993).</p> <p>2. A more costly innovation is less likely to be adopted but once it is adopted and adapted, the large investment may influence infusion (Tornatzky & Klein, 1982)</p>
2.2 Easy for staff to learn/use	+		<p>One of the internal characteristics of organisational structure (e.g. centralisation, complexity, normalisation, inter connectiveness, organisational slack, size) (Rogers, 1983).</p>
2.3 Reliability (fewer breakdown)	+		<p>1. Economically rewards, least risky and more competitiveness with adopters' values were the factors that enhance rate of technology adoption Fliegel and Kivlin (1966)</p> <p>2. Many characteristics have been identified that appear to influence consumer acceptance of innovation: 1. relative advantage, 2. compatibility, 3. complexity, 4. Trialability, 5. Observability, 6. risk, and 7. Standardisation (Herbig & Day, 1992).</p> <p>3. There are increasing concerns regarding technological adoption and the overall gain in return for such massive investment. Some important considerations are effectiveness, cost, security, reliability, and linkage (Takac & Singh, 1992).</p>
2.4 Security (less openness to abuse, fraud)	+		<p>1. A technology creates one kind of uncertainty in the minds of adopters, as well as representing an opportunity for reduced uncertainty in another sense (Rogers, 1983).</p> <p>2. There are increasing concerns regarding technological adoption and the overall gain in return for such massive investment. Some important considerations are effectiveness, cost, security, reliability, and linkage (Takac & Singh, 1992).</p>

		<p>1992).</p> <ol style="list-style-type: none"> 1. Prior research has shown that successful innovation occurs when the task and the technology are compatible (Cooper & Zmud, 1990). 2. Compatibility (a new idea is perceived as being consistent with the potential adopter's prior experience, beliefs and values) (Manross & Rice, 1986). 3. Economic models of network effects stress how insufficient standardisation, compatibility and leadership can serve as barriers to change in situations where adopting a new product involved the interrelated decisions of many consumers and producers (Caskey & Sellon,). 4. The necessity that a technology be compatible with the organisation and its tasks is one of the more consistent findings in the innovation and technology diffusion literature (Kwon & Zmud, 1987). 5. An important factor affecting the adoption rate of any innovation is its compatibility with the values, beliefs and past experiences of the social system (Rogers, 1983). 6. Many characteristics have been identified that appear to influence consumer acceptance of innovation: ... compatibility... (Herbig & Day, 1992). <p>Successful IS implementation occurs when sufficient organisational resources (e.g. sufficient developer and user time, sufficient funding, sufficient technical skills) are directed toward first motivating and then sustaining implementation (Kwon & Zmud, 1987)</p> <ol style="list-style-type: none"> 1. Trialability (the degree to which a new idea can be given a small -scale trial by a potential adopter) .(Manross & Rice, 1986) 2. New ideas that can be tried on the instalment plan will generally be adopted more quickly than innovations that are not visible (Rogers, 1983). 3. Many characteristics have been identified that appear to influence consumer acceptance of innovation: ... trialability... (Herbig & Day, 1992). <ol style="list-style-type: none"> 1. A new idea is visible to potential adopter (Manross & Rice, 1986) 2. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt (Rogers, 1983). 3. Many characteristics have been identified that appear to influence consumer acceptance of innovation... observability... (Herbig & Day, 1992) <p>Successful IS implementation occurs when sufficient organisational resources (e.g. sufficient developer and user time, sufficient funding, sufficient technical skills) are directed toward first motivating and then sustaining an implementation effort (Kwon & Zmud, 1987).</p> <ol style="list-style-type: none"> 1. Top management support has been shown to be critical influence in implementation outcomes (Manross & Rice, 1986).
2.5 Compatibility with existing systems	+	
2.6 Level of required skills for staff to use technology	-	
2.7 Trialability (ability to test it)	+	
2.8 Observability (ability to see if it works)	+	
3.1 Available facilities (fit between existing facilities and new technology)	+	
3.2 Executive support	+	

		<p>2. Factors found to have a significant impact include: top management support of the implementation effort, good IT design, appropriate user designer interaction and understanding (Cooper & Zmud, 1990)</p> <p>3. Factor regular appear as being significantly related to IS implementation success and failures: top management support, interactions during implementation and a motivated and capable user (Kwon & Zmud, 1987)</p> <p>4. Must first pay attention to the manager's behaviour during the adoption of technology (Gagnon & Toulouse, 1996).</p> <p>5. Critical success factor is senior management commitment to maintenance of the quality of corporate data (Lambert, 1996).</p>
3.3 Staff acceptance	+	<p>1. Failure comes from an understanding of the politics of organisational decision making, technical difficulties, professional norms, lack of training, insufficient support, and absence of user involvement (Mamross & Rice, 1986).</p> <p>2. Characteristics of the user community (job tenure, education, resistance to change) (Kwon & Zmud, 1987).</p>
3.4 Level of actual skills in organisation and staff	+	<p>1. Technological innovation evolve from the stock of skills that organisations have accumulated over time (Pennings & Harianto, 1992).</p> <p>2. Barriers to adoption... shortage of personnel (Barras, 1994)..</p>
3.5 Experience in technology	+	<p>1. The findings indicated that prior experience in information technology, combined with a variety of interfirm linkages will affect the banks' decision to adopt this technology (Pennings & Harianto, 1992).</p> <p>2. The effects of the experience curve cause decreasing costs per unit, lower prices and increased probability of a purchase (Maier, 1998).</p>
4.1 Customer satisfaction	+	<p>1. Most consumers will base their decision to use a debit card on nonprice factors such as convenience and availability the consumer feel more secure (Caskey & Sellon,).</p> <p>2. To improve customer service, to provide a better image to customers (Preece, 1989).</p> <p>3. ...facilitation of user or consumer convenience (Mysior et al., 1984).</p> <p>4. Home banking services allow the bank is enabled to reduce internal operation costs, increase sales, new services, and customer satisfaction, provide an access to information, and minimise investments in establishing new branches (Kivel & Rubin, 1996).</p>
4.2 Customer acceptance	+	<p>1. Some technologies cannot be implemented because the bank does not assure that those technologies will be accepted by customers (P. Jirapinyo, personal Communication, December 19, 1996).</p> <p>2. Customer barriers to acceptance or usage of any technology or innovation include the customer's free will, the ability to understand, external stakeholders and incompatibility of the innovation with existing workflows (Herbig & Day, 1992).</p> <p>3. The history of banking technologies (ATM's and EFTPOS) indicates that it takes between ten and twelve years for public acceptance of a new technology to be achieved (Jenkins & McKenzie, 1997).</p> <p>4. Barriers to adoption... customer resistance (Barras, 1994).</p>

4.3 Easy for customers to use	+	<ol style="list-style-type: none"> 1. Perceived complexity is inversely related to the adoption of innovation (inconclusive) (Wynkoop, Senn, & Conger, 1992). 2. Characteristics of the technology being adopted...complexity (Kwon & Zmud, 1987). 3. In general, new ideas that are simpler to understand will be adopted more rapidly than innovations that require the adopter to develop new skills and understanding (Rogers, 1983). 4. Most consumers will base their decision to use a debit card on nonprice factors such as convenience and availability the consumer feel more secure (Caskey & Sellon,). 5. The simplicity, convenience and flexibility of Internet based banking will result in its emergence as a dominant force in the financial industry. (WebAustralia,)
5. Economic prosperity, recession	+/-	<ol style="list-style-type: none"> 1. Inextricable link between technology and economy (Sharif, 1994). 2. There are three factors in order to adopt technology: technology availability, the Thai economy - Customer behaviour (P. Jirapinyo, personal Communication, December 19, 1996).

Appendix 8.1 Variables of Technology Diffusion

Variables	Variables	Relationships	References
1. Customer Rate of technology diffusion	1.1 Perceived benefit/ Relative Advantage	+	<ol style="list-style-type: none"> 1. The greater the perceived benefits before use, the more likely the innovation will be adopted (inconclusive) (Wynkoop, Senn, & Conger, 1992). 2. Initial expectations of the relative advantage of the tool before it is used are not met when it is used, implementation will not be successful (Wynkoop, Senn, & Conger, 1992).
Rate of technology diffusion	1.2 Potential of the market	+	Market potential is one of the general aspects of innovation diffusion processes (Maier, 1995).
Rate of technology diffusion	1.3 Quality	+	<ol style="list-style-type: none"> 1. The diffusion of innovation over time is influenced by various factors like price, advertising, product quality, competition, the time of market entry (Maier, 1995). 2. Quality proves to be a prime competitive factor during all phases of innovation diffusion (Milling, 1996).
Rate of technology diffusion	1.4 Advertising	+	Advertising strategies is one of the factors directly influenced by the decision variables of a company (Maier, 1995).
Rate of technology diffusion	1.5 Repeat purchases	+	Potential repeat purchases is a general aspect of innovation diffusion processes (Maier, 1995).
Rate of technology diffusion	1.6 Network externality	+	An inferior product with network externality will defeat a product which has better quality and lower price but has no network externality (Kim & Juhn, 1996).
Rate of technology diffusion	1.7 Customer acceptance	+	<ol style="list-style-type: none"> 1. Some technologies cannot be implemented because the Siam Commercial Bank does not assure customer acceptance (P. Jirapinyo, personal Communication, December 19, 1996). 2. Customer barriers to acceptance or usage of any technology or innovation include the customer's free will, the ability to understand and incompatibility of the innovation with existing workflow (Herbig & Day, 1992). 3. The history of banking technologies (ATM's and EFTPOS) indicates that it takes between ten and twelve years for public acceptance of a new technology to be achieved (Jenkins & McKenzie, 1997).

Rate of technology diffusion	1.8 Price	-	Pricing is one of the factors directly influenced by the decision variables of a company (Maier, 1995).
Rate of technology diffusion	1.9 Delivery delays	-	(Maier, 1995).
Rate of technology diffusion	1.10 Negative word of mouth	-	(Maier, 1995).
Rate of technology diffusion	1.11 Substitution between technologies	-	Substitution among successive product generations is one of general aspects of innovation diffusion processes (Maier, 1995).
Rate of technology diffusion	1.12 Crowding effects	-	As the number of subscribers increases, the magnitude of crowding effects begins to exceed that of network externality. That is, a dominant feedback loop shifts from the positive loop of network externality to the negative loop of crowding effects (Kim & Juhn, 1996).
Rate of technology diffusion	1.13 Perceived complexity	-	Perceived complexity is inversely related to the adoption of innovation (inconclusive) (Wynekoop et al., 1992)
Rate of technology diffusion	1.14 Timing of market entry	+/-	1. Timing of market entry is one of the factors directly influenced by the decision variables of a company (Maier, 1995). 2. Time to market and time to volume are essential factors for innovation management. If a dominant market share is gained, it is difficult for competitors to attack. However, entering the market too early increases the risk of failures. (Milling, 1996).
Staff			
Rate of technology diffusion	2.1 Perceived benefit/Relative advantage	+	Similar to 1.1
Rate of technology diffusion	2.2 User involvement	+	Training and user involvement is one of the organisational factors that influences implementation outcomes (Manross & Rice, 1986)
Rate of technology diffusion	2.3 Training	+	1. Training is necessary to provide the knowledge base for IT (Manross & Rice, 1986). 2. Before the technology is finally adopted and implemented, education and training should be in place to reduce the level of resistance to technology, create skilled manpower and increase managerial potential necessary to operate a production process (Madu, 1989).
	2.4 Understanding	+	1. Lack of understanding of new technology and its implications is a significant barrier to diffusion (Gerwin, 1988). 2. Innovation and technology modification can only exist if those concerned have a full understanding of the technology (Madu, 1989).
Rate of technology diffusion	2.5 Communication amount	+	1. Acceptance and level of use are determined by communication amount (Wynekoop et al., 1992).

			<p>2. Factors that appear as being significantly related to IS implementation success and failures: top management support, interactions during implementation and a motivated and capable user (Kwon & Zmud, 1987).</p> <p>3. Communication is a process in which participants create and share information with one another to reach a mutual understanding (Rogers, 1983).</p> <p>4. The adoption of technological innovation by potential users results primarily from "messages" emitted by adopters. The potential users have different degrees of resistance. The resistance is overcome by a sufficiently large repetition of messages (Sahal, 1977).</p> <p>Similar to 1.7</p> <p>Acceptance and level of use are determined by perceived complexity (Wynkekoop et al., 1992).</p> <p>Successful IS implementation occurs when sufficient technical skills are directed toward first motivating and then sustaining an implementation effort (Kwon & Zmud, 1987).</p>
Rate of technology diffusion	2.6 Staff acceptance		
Rate of technology diffusion	2.7 Perceived complexity	-	
Diffused technology	2.8 Level of required skills from staff to use new technology	-	
3. Organisation			
Rate of technology diffusion	3.1 Centralisation	-	Low centralisation, high complexity and low formalisation make it difficult for an organisation to implement an innovation (Rogers, 1983)
Rate of technology diffusion	3.2 Formalisation	-	(Rogers, 1983)
Rate of technology diffusion	3.3 Normalisation	+	Normalisation acts to inhibit consideration of innovations by organisation members but encourages implementation of innovations (Rogers, 1983).
Rate of technology diffusion	3.4 Management support	+	<p>1. Top management support has been shown to be a critical influence in implementation outcomes (Manross & Rice, 1986).</p> <p>2. Factors found to have a significant impact includes top management support of the implementation effort (Cooper & Zmud, 1990).</p> <p>3. Factor regular appears as being significantly related to IS implementation success and failures: top management support (Kwon & Zmud, 1987).</p> <p>4. Critical success factor is senior management commitment to maintenance of the quality of corporate data (Lambert, 1996).</p> <p>5. Acceptance and level of use are determined by perceived management commitment (Wynkekoop et al., 1992).</p>
Rate of technology diffusion	3.5 System openness	+	An open system (i.e. exchanging information across its boundaries) is positively related to its

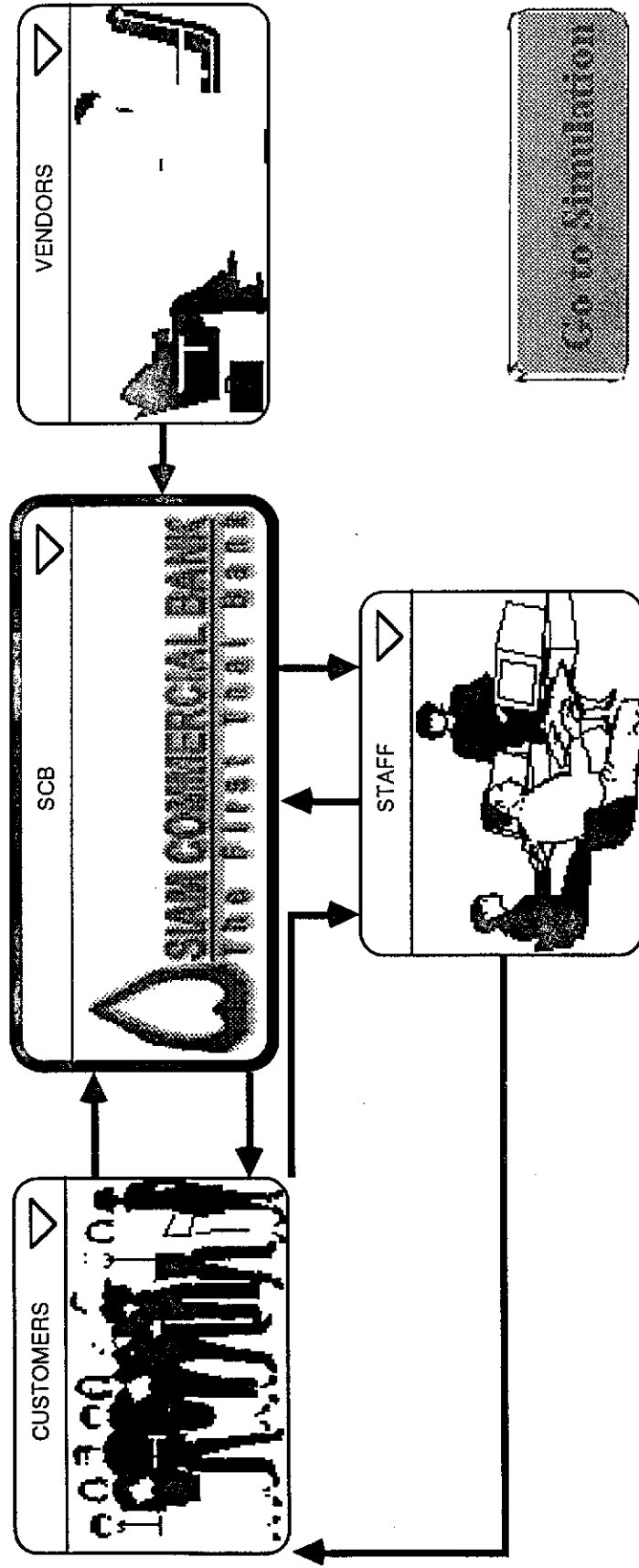
				innovativeness (Rogers, 1983).
Rate of technology diffusion	3.6 Size of organisation	+		The size of an organisation has consistently been found to be positively related to its innovativeness (Rogers, 1983).
Rate of technology diffusion	3.7 Organisational complexity	-		Complexity encourages organisational members to conceive and propose innovations, but it may make it difficult to achieve consensus about implementing them (Rogers, 1983).
Rate of technology diffusion	3.8 Perceived benefit/Relative advantage	+		Similar to 1.1.
Rate of technology diffusion	3.9 Diffusion effect	+		The diffusion effect is the cumulative increasing degree of influence upon an individual to adopt or reject an innovation (Rogers, 1983).
Rate of technology diffusion	3.10 Experience in Technology	+		Prior experience in information technology, combined with a variety of interfirm linkages will affect the banks' decision to adopt this technology (Pennings & Harianto, 1992).
Rate of technology diffusion	3.11 Organisation resource	+		Successful IS implementation occurs when sufficient organisational resources are directed toward first motivating and then sustaining an implementation effort (Kwon & Zmud, 1987).
Rate of technology diffusion	3.12 Economic Situation	+/-		1. Diffusion of benefits of a technology must occur through information relationships underlying the behaviour of the economic and political actors in the system (Saeed, 1990). 2. Inextricable link between technology and economy (Sharif, 1994). 3. Three main factors driving technology diffusion include features of technology, current economic situations, and customer behaviour (P. Jirapinyo, personal Communication, December 19, 1996).
4. Technology				
Rate of technology diffusion	4.1 Complexity (technology)	-		1. One of characteristics of the technology being adopted is complexity (Kwon & Zmud, 1987). 2. There is a negative relationship between the complexity of the technology and its successful implementation (Tomatzky & Klein, 1982). 3. In general, new ideas that are simpler to understand will be adopted more rapidly than innovations that require the adopter to develop new skills and understanding (Rogers, 1983; Manross & Rice, 1986).
Rate of technology diffusion	4.2 Reliability	+		1. Technology creates one kind of uncertainty in the minds of adopters, as well as representing an opportunity for reduced uncertainty in another sense (Rogers, 1983). 2. There are increasing concerns regarding technological adoption and the overall gain in return for such massive investment. Some important considerations are effectiveness, cost,

			security, reliability, and linkage (Takac & Singh, 1992). (Takac & Singh, 1992).
Rate of technology diffusion	4.3 Security	+	
Rate of technology diffusion	4.4 Costs of technologies	-	<ol style="list-style-type: none"> 1. A more costly innovation is less likely to be adopted but once it is adopted and adapted, the large investment may highly motivate infusion (Tornatzky & Klein, 1982). 2. Costs of technology and operational costs are accommodated throughout the processes of adopting and diffusing new technology (Takac & Singh, 1992).
Rate of technology diffusion	4.5 Compatibility with existing systems	+	<ol style="list-style-type: none"> 1. Prior research has shown that successful innovation occurs when the task and the technology are compatible (Cooper & Zmud, 1990). 2. A new idea should be perceived as being consistent with the potential adopter's prior experience, beliefs and values (Manross & Rice, 1986). 3. Compatibility and leadership can serve as barriers to change in situations where adopting a new product involved the interrelated decisions of many consumers and producers (Caskey & Sellon, 1996). 4. The necessity that a technology be compatible with the organisation and its tasks is one of the more consistent findings in the innovation and technology diffusion literature (Kwon & Zmud, 1987). 5. An important factor affecting the adoption rate of any innovation is its compatibility with the values, beliefs and past experiences of the social system (Rogers, 1983).
Rate of technology diffusion	4.6 Trialability (divisibility)	+	<ol style="list-style-type: none"> 1. Trialability (the degree to which a new idea can be given a small -scale trial by a potential adopter) (Manross & Rice, 1986). 2. New ideas that can be tried on the instalment plan will generally be adopted more quickly than innovations that are not visible (Rogers, 1983).
Rate of technology diffusion	4.7 Observability (communicability)	+	<ol style="list-style-type: none"> 1. A new idea should be visible to potential adopters (Manross & Rice, 1986). 2. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt (Rogers, 1983).
5. Vendors			
Rate of technology diffusion	5.1 Change agents' Promotion effort	+	There is positive relationship between these two factors (Rogers, 1983)
Rate of technology diffusion	5.2 Technical support	+	Levels of technical support and other services depend on success in negotiation (Auer, 1993).
Diffused technology	Relative advantages - Performance efficiency - Improve decision making - Decreased for branch	+	<ol style="list-style-type: none"> 1. The criteria for selection of a technology should be concerned with the issues of efficiency of production and the sustenance of the resource environment (Saeed, 1990). 2. There are increasing concerns regarding technological adoption and the overall gain in return for such massive investment (Takac & Singh, 1992).

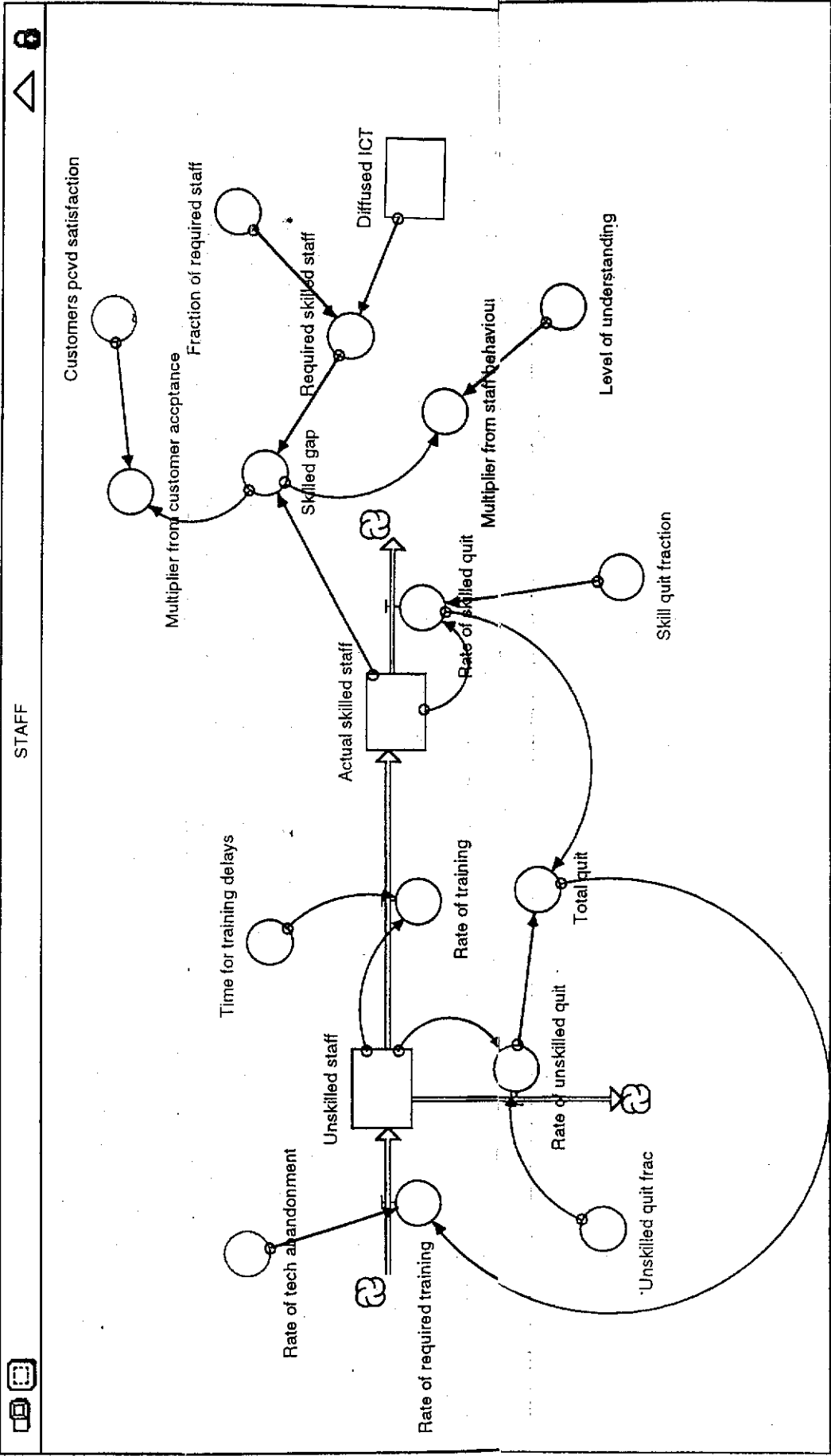
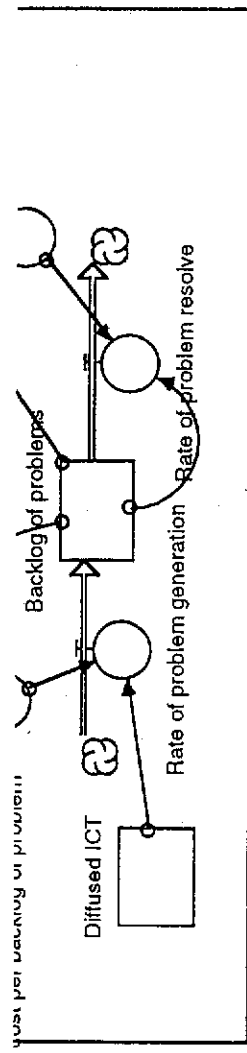
	<p>establishment</p> <ul style="list-style-type: none"> - Accurate and timely information - Image - Costs 		<ol style="list-style-type: none"> 3. Reasons for adopting information technology: solving work problems, achieving organisational efficiency, improving communication, evaluating working conditions more efficiently, improving work design, increasing the participation of workers in decision, and reducing the number of employees (Foschini, 1989). 4. Reasons for the requirements of EFTPOS: preserving competition, facilitating of user or consumer convenience, preserving the right to privacy for the user, developing a new client, reducing establishment costs for new branches, and having 24-hour devices (Mysior, Shuman, & Linstone, 1984). 5. Huber suggested that computer-assisted information and communications support should improve decision-making (Sayeed & Brightman, 1994). 6. Reasons for adopting and diffusing information technology (Preece, 1989): <ul style="list-style-type: none"> - Financial & Economic (e.g. increasing productivity, improving budgetary control, keeping up with competitors, and reducing costs) - Technical & production (e.g. improving the management information system, keeping up with new technology, bettering security of data, improving quality, increasing flexibility, reducing scrap and rework, and improving accuracy, increased speed) - Social and organisational (e.g. increasing productivity, keeping up with competitors, and retaining skilled people) - Other (e.g. improving customer service, and providing a better image to customers). 7. Technology also aids delivery: services (e.g. less paper clearing, fewer paper records and reduced need brick-and-mortar branches) (Jordan, 1996).
<p>Diffused technology</p>	<p>2. Customer satisfaction (e.g. convenience, providing better customer service)</p>	<p>+</p>	<ol style="list-style-type: none"> 1. Most consumers will base their decision to use a debit card on non-price factors such as convenience (Caskey & Sellon, 1996). 2. The simplicity, convenience and flexibility of Internet based banking will result in its emergence as a dominant force in the financial industry (WebAustralia, 1996) 3. Reasons for adopting new technology. To improve customer service, to provide a better image to customers (Preece, 1989) 4. Facilitation of user or consumer convenience (Mysior et al., 1984). 5. Home banking services allow the bank to reduce internal operation costs, increase sales, new services, and customer satisfaction, provide an access to information, and minimise investments in establishing new branches (Kivel & Rubin, 1996)
<p>Diffused technology</p>	<p>Backlog of problems</p>		<p>As a new technology is diffused, a backlog of unsolved problems begins to build (Saeed, 1990).</p>

Diffused technology	Level of required skilled		Generally, diffusing information technologies demands an increase in the number of "required knowledge workers" (Bezdek & Jones, 1990).
Rate of technology diffusion	Rate of technology obsolescence	-	After some time period all new IT become obsolete (Quaddus, 1996).

Appendix 8.2. Model of Diffusion of Information and Communication Technologies (ICT)



3



CUSTOMERS

Active_customers(t) = Active_customers(t - dt) + (Rate_of_customer_generation) * dt
INIT Active_customers = 1000

INFLOWS:

Rate_of_customer_generation = if time < Economic_life_of_technology then
((Active_customers*(Customer_growth_fraction/12)))*Multiplier_from_customer_acceptance else 0

Market_potential(t) = Market_potential(t - dt) + (- Rate_of_customer_generation) * dt
INIT Market_potential = 2500

OUTFLOWS:

Rate_of_customer_generation = if time < Economic_life_of_technology then
((Active_customers*(Customer_growth_fraction/12)))*Multiplier_from_customer_acceptance else 0

Economic_life_of_technology = 60

Customers_pcvd_satisfaction = GRAPH(Diffused_ICT-Backlog_of_problems_per_diffused_ICT)
(0.00, 0.7), (1000, 0.765), (2000, 0.83), (3000, 0.89), (4000, 0.95), (5000, 1.00)

Customer_growth_fraction = GRAPH(Customers_pcvd_satisfaction)
(0.00, 0.00), (0.1, 0.02), (0.2, 0.045), (0.3, 0.075), (0.4, 0.1), (0.5, 0.13), (0.6, 0.16), (0.7, 0.2), (0.8, 0.25), (0.9, 0.3), (1, 0.35)

SCB

Backlog_of_problems(t) = Backlog_of_problems(t - dt) + (Rate_of_problem_generation - Rate_of_problem_resolve) * dt
INIT Backlog_of_problems = 0

INFLOWS:

Rate_of_problem_generation = Percentage_of_backlog_of_problem*Diffused_ICT

OUTFLOWS:

Rate_of_problem_resolve = Backlog_of_problems*Resolve_fraction

Costs_from_backlog_problem(t) = Costs_from_backlog_problem(t - dt) + (Rate_of_costs_from_problems) * dt
INIT Costs_from_backlog_problem = 0

```

INFLOWS:
    ⚡ Rate_of_costs_from_problems = if time < Economic_life_of_technology then (Backlog_of_problems*Unit_cost_per_backlog_of_problem)
    else 0
 Cost_of_technology(t) = Cost_of_technology(t - dt) + (Chg_in_costs_of_technology) * dt
INIT Cost_of_technology = 0
INFLOWS:
    ⚡ Chg_in_costs_of_technology = (Chg_in_invest_in_new_technology)
 Diffused_ICT(t) = Diffused_ICT(t - dt) + (Rate_of_ICT_diffusion - Rate_of_tech_abandonment - Rate_of_technology_obsolescence) * dt
INIT Diffused_ICT = 0
INFLOWS:
    ⚡ Rate_of_ICT_diffusion = IF time < Economic_life_of_technology
    THEN((Chg_in_invest_in_new_technology*Diffusion_fraction)/Time_for_customisation)*Multiplier_from_staff_behaviour ELSE 0
OUTFLOWS:
    ⚡ Rate_of_tech_abandonment = Diffused_ICT*Abandonment_fraction
    ⚡ Rate_of_technology_obsolescence = Diffused_ICT/(Economic_life_of_technology*2)
 Investment_in_ICT(t) = Investment_in_ICT(t - dt) + (Chg_in_invest_in_new_technology) * dt
INIT Investment_in_ICT = 0
INFLOWS:
    ⚡ Chg_in_invest_in_new_technology = if time < Economic_life_of_technology then Min((ICT_requirement/Time_to_correct_technology_gap),
    (ICT_maximum_requirement/Time_to_correct_technology_gap)) else 0
 Operation_costs(t) = Operation_costs(t - dt) + (Rate_of_operation_cost) * dt
INIT Operation_costs = 0
INFLOWS:
    ⚡ Rate_of_operation_cost = If time < Economic_life_of_technology then (Avg_operation_cost*Diffused_ICT) else 0
 Relative_advantages(t) = Relative_advantages(t - dt) + (Gaining_rel_advantages) * dt
INIT Relative_advantages = 0

```

```

INFLOWS:
☞ Gaining_rel_advantages = if time < Economic_life_of_technology then (Avg_rel_advantage_per_Diffused_ICT*Diffused_ICT) else 0
☐ Revenue(t) = Revenue(t - dt) + (Rate_of_revenue_generation) * dt
INIT Revenue = 0
INFLOWS:
☞ Rate_of_revenue_generation = Gaining_rel_advantages+Sales_rate
☐ Sales(t) = Sales(t - dt) + (Sales_rate) * dt
INIT Sales = 0
INFLOWS:
☞ Sales_rate = (Rate_of_customer_generation*Price)
☐ Total_costs(t) = Total_costs(t - dt) + (Rate_of_cost_generation) * dt
INIT Total_costs = 0
INFLOWS:
☞ Rate_of_cost_generation = if time < Economic_life_of_technology then
-(Rate_of_operation_cost+Chg_in_costs_of_technology+Rate_of_training_costs+Rate_of_costs_from_problems) else 0
☐ Training_costs(t) = Training_costs(t - dt) + (Rate_of_training_costs) * dt
INIT Training_costs = 0
INFLOWS:
☞ Rate_of_training_costs = if time < Economic_life_of_technology then (Training_costs_per_unit*Rate_of_training) else 0
○ Abandonment_fraction = (0.03/12)+Backlog_of_problems_per_diffused_ICT
○ Avg_operation_cost = 0.04
○ Avg_rel_advantage_per_Diffused_ICT = 0.250
○ Backlog_of_problems_per_diffused_ICT = if (Diffused_ICT=0) then (Backlog_of_problems) else (Backlog_of_problems/Diffused_ICT)
○ Bank_environment = .82
○ customer_behaviour = .66

```

- Diffusion_fraction = (Bank_environment+Perceived_relative_advantages+Positive_features_of_technology+customer_behaviour)/4
- ICT_maximum_requirement = 900
- ICT_requirement = ((SCB's_technological_gap*Propensity_to_invest))
- Perceived_relative_advantages = .76
- Percentage_of_backlog_of_problem = .1/12
- Positive_features_of_technology = .78
- Price = .150
- Profits = Revenue-Total_costs
- Propensity_to_invest = .1
- Resolve_fraction = .8
- SCB's_technological_gap = if time<Economic_life_of_technology then (Avaliable_valid_ICT_at_a_market-Investment_in_ICT) else 0
- Time_for_customisation = 2
- Time_to_correct_technology_gap = 2
- Training_costs_per_unit = .2
- Unit_cost_per_backlog_of_problem = .150

STAFF

- Actual_skilled_staff(t) = Actual_skilled_staff(t - dt) + (Rate_of_training - Rate_of_skilled_quit) * dt
- INIT Actual_skilled_staff = 1

INFLOWS:

- ☞ Rate_of_training = (Unskilled_staff/Time_for_training_delays)

OUTFLOWS:

- ☞ Rate_of_skilled_quit = Actual_skilled_staff*Skill_quit_fraction

Unskilled_staff(t) = Unskilled_staff(t - dt) + (Rate_of_required_training - Rate_of_training - Rate_of_unskilled_quit) * dt
 INIT Unskilled_staff = 5000

INFLOWS:

☞ Rate_of_required_training = Total_quit+Rate_of_tech_abandonment

OUTFLOWS:

- ☞ Rate_of_training = (Unskilled_staff/Time_for_training_delays)
- ☞ Rate_of_unskilled_quit = Unskilled_staff*Unskilled_quit_frac
- Fraction_of_required_staff = 1
- Level_of_understanding = .6
- Multiplier_from_customer_acceptance = if Skilled_gap > 0 then 1 else 1+Abs(1-Customers_pcvd_satisfaction)
- Multiplier_from_staff_behaviour = if Skilled_gap > 0 then 1 else 1+Abs(1-Level_of_understanding)
- Required_skilled_staff = Diffused_ICT*Fraction_of_required_staff
- Skilled_gap = if (Actual_skilled_staff>Required_skilled_staff) then 0 else (Required_skilled_staff-Actual_skilled_staff)
- Skill_quit_fraction = .01
- Time_for_training_delays = 6
- Total_quit = Rate_of_skilled_quit+Rate_of_unskilled_quit
- Unskilled_quit_frac = .05

VEVDORS

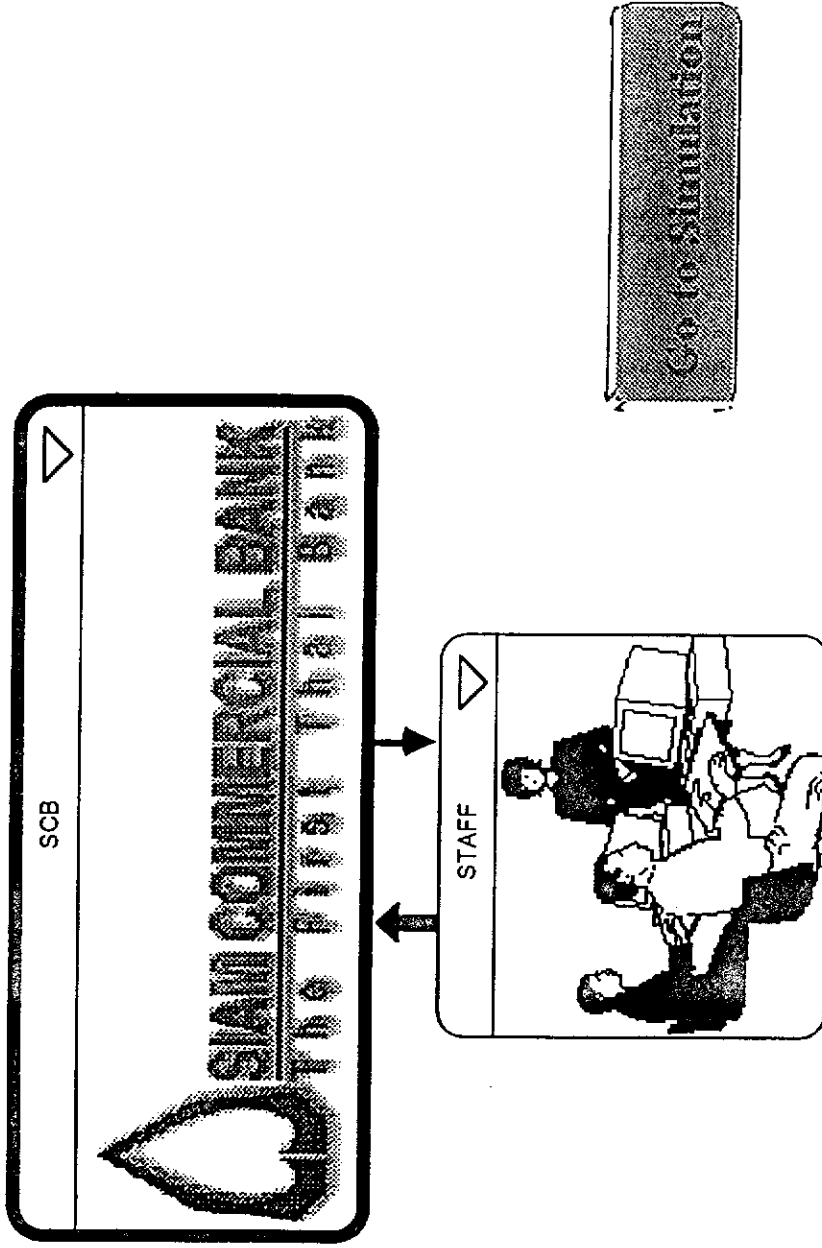
Available_valid_ICT_at_a_market(t) = Available_valid_ICT_at_a_market(t - dt) + (Rate_of_chngange_in_new_tech) * dt
 INIT Available_valid_ICT_at_a_market = 1000

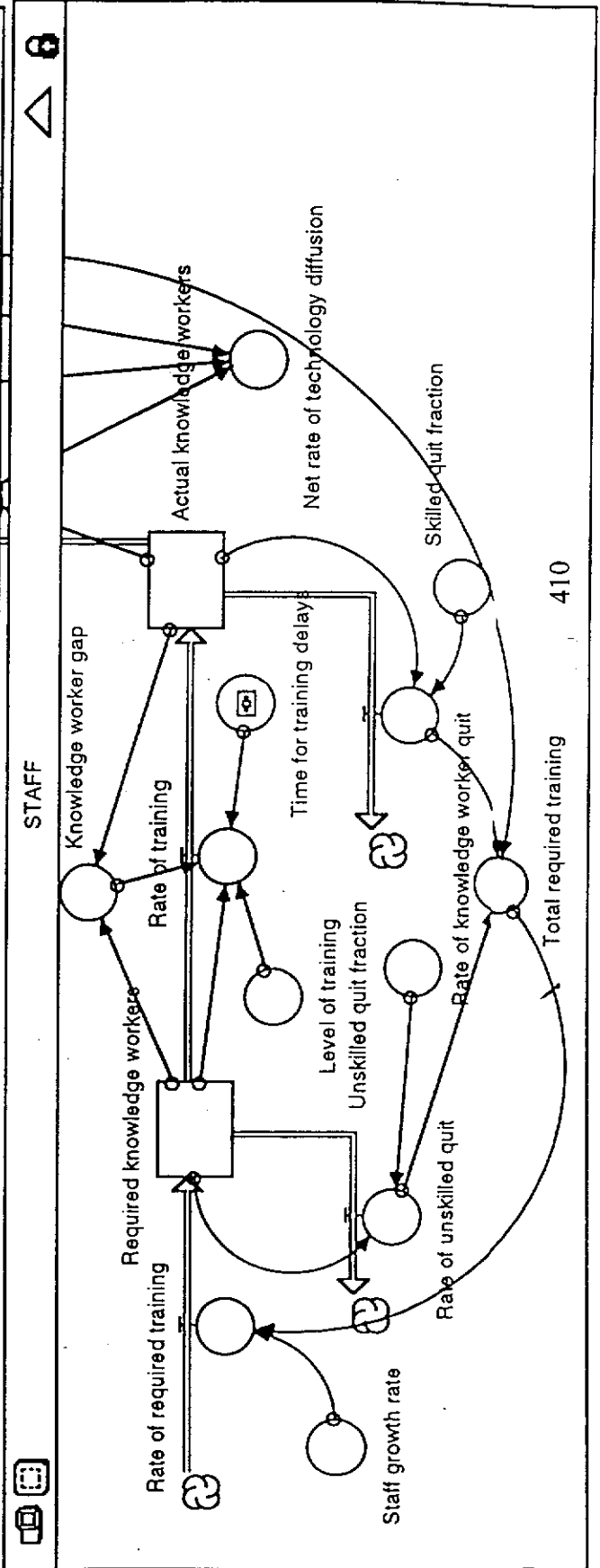
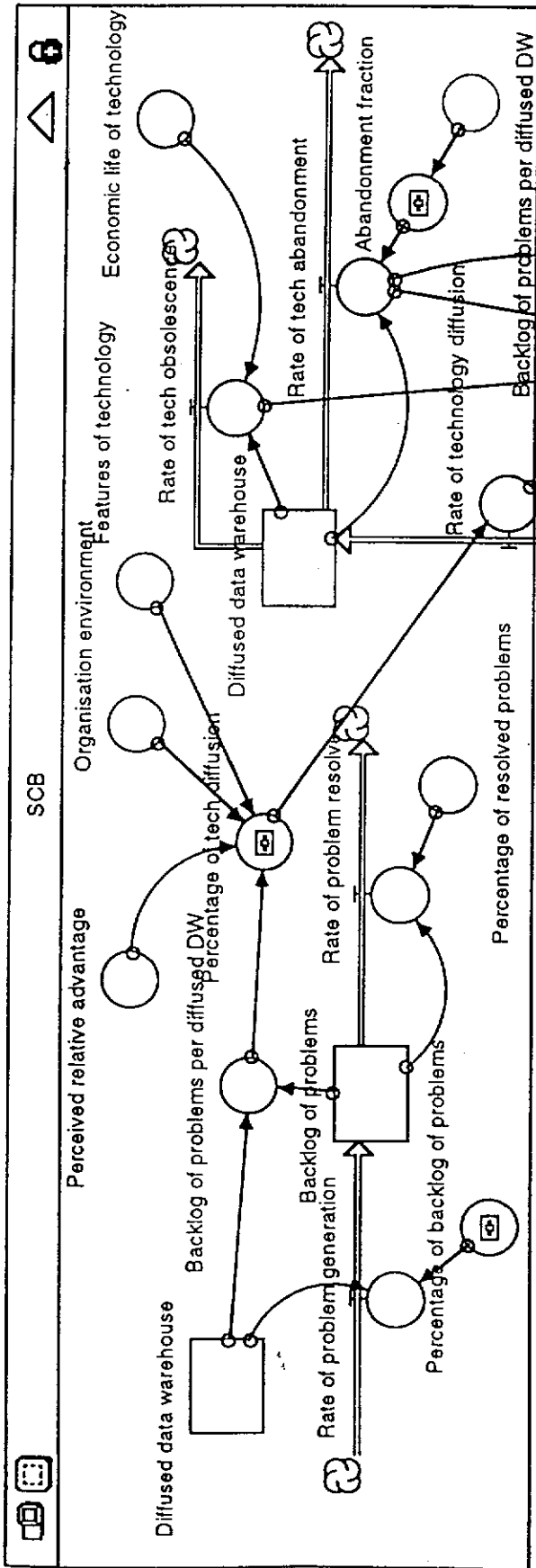
INFLOWS:

- ☞ Rate_of_chngange_in_new_tech = Available_valid_ICT_at_a_market*Percentage_of_new_arrival_technology
- Percentage_of_new_arrival_technology = .05

Not in a sector

Appendix 9.1. Technology Diffusion of a Data Warehouse: The Price-less Model





SCB

- Backlog_of_problems(t) = Backlog_of_problems(t - dt) + (Rate_of_problem_generation - Rate_of_problem_resolve) * dt
- INIT Backlog_of_problems = 0
- INFLOWS:
 - ☞ Rate_of_problem_generation = Diffused_data_warehouse*Percentage_of_backlog_of_problems
- OUTFLOWS:
 - ☞ Rate_of_problem_resolve = Backlog_of_problems*Percentage_of_resolved_problems
- Diffused_data_warehouse(t) = Diffused_data_warehouse(t - dt) + (Rate_of_technology_diffusion - Rate_of_tech_abandonment - Rate_of_tech_obsolescence) * dt
- INIT Diffused_data_warehouse = 54
- INFLOWS:
 - ☞ Rate_of_technology_diffusion = Actual_knowledge_workers*Percentage_of_tech_diffusion
- OUTFLOWS:
 - ☞ Rate_of_tech_abandonment = Diffused_data_warehouse*Abandonment_fraction
 - ☞ Rate_of_tech_obsolescence = Diffused_data_warehouse/(Economic_life_of_technology*2)
- Abandonment_fraction = (.03/12)+(Backlog_of_problems_per_diffused_DW)
- Backlog_of_problems_per_diffused_DW = (Backlog_of_problems/Diffused_data_warehouse)
- Economic_life_of_technology = 60
- Features_of_technology = .67
- Organisation_environment = .76
- Perceived_relative_advantage = .64
- Percentage_of_backlog_of_problems = (.12)/12
- Percentage_of_resolved_problems = 0.8
- Percentage_of_tech_diffusion = (Features_of_technology+Organisation_environment+Perceived_relative_advantage)/3-Backlog_of_problems_per_diffused_DW

STAFF

$\text{Actual_knowledge_workers}(t) = \text{Actual_knowledge_workers}(t - dt) + (\text{Rate_of_training} - \text{Rate_of_knowledge_worker_quit} - \text{Rate_of_technology_diffusion}) * dt$

INIT $\text{Actual_knowledge_workers} = 200$

INFLOWS:

$\text{Rate_of_training} = \text{If}(\text{Knowledge_worker_gap} < 0) \text{ then } ((\text{Required_knowledge_workers} * \text{Level_of_training}) / \text{Time_for_training_delays}) \text{ else } 0$

OUTFLOWS:

$\text{Rate_of_knowledge_worker_quit} = \text{Actual_knowledge_workers} * \text{Skilled_quit_fraction}$

$\text{Rate_of_technology_diffusion}$ (IN SECTOR: SCB)

$\text{Required_knowledge_workers}(t) = \text{Required_knowledge_workers}(t - dt) + (\text{Rate_of_required_training} - \text{Rate_of_unskilled_quit}) * dt$

INIT $\text{Required_knowledge_workers} = 6000$

INFLOWS:

$\text{Rate_of_required_training} = \text{Total_required_training} + \text{Staff_growth_rate}$

OUTFLOWS:

$\text{Rate_of_training} = \text{If}(\text{Knowledge_worker_gap} < 0) \text{ then } ((\text{Required_knowledge_workers} * \text{Level_of_training}) / \text{Time_for_training_delays}) \text{ else } 0$

$\text{Rate_of_unskilled_quit} = \text{Required_knowledge_workers} * \text{Unskilled_quit_fraction}$

$\text{Knowledge_worker_gap} = \text{Actual_knowledge_workers} - \text{Required_knowledge_workers}$

$\text{Level_of_training} = .40$

$\text{Net_rate_of_technology_diffusion} = \text{Rate_of_technology_diffusion} - \text{Rate_of_tech_abandonment} - \text{Rate_of_tech_obsolescence}$

$\text{Skilled_quit_fraction} = .01$

$\text{Staff_growth_rate} = 0$

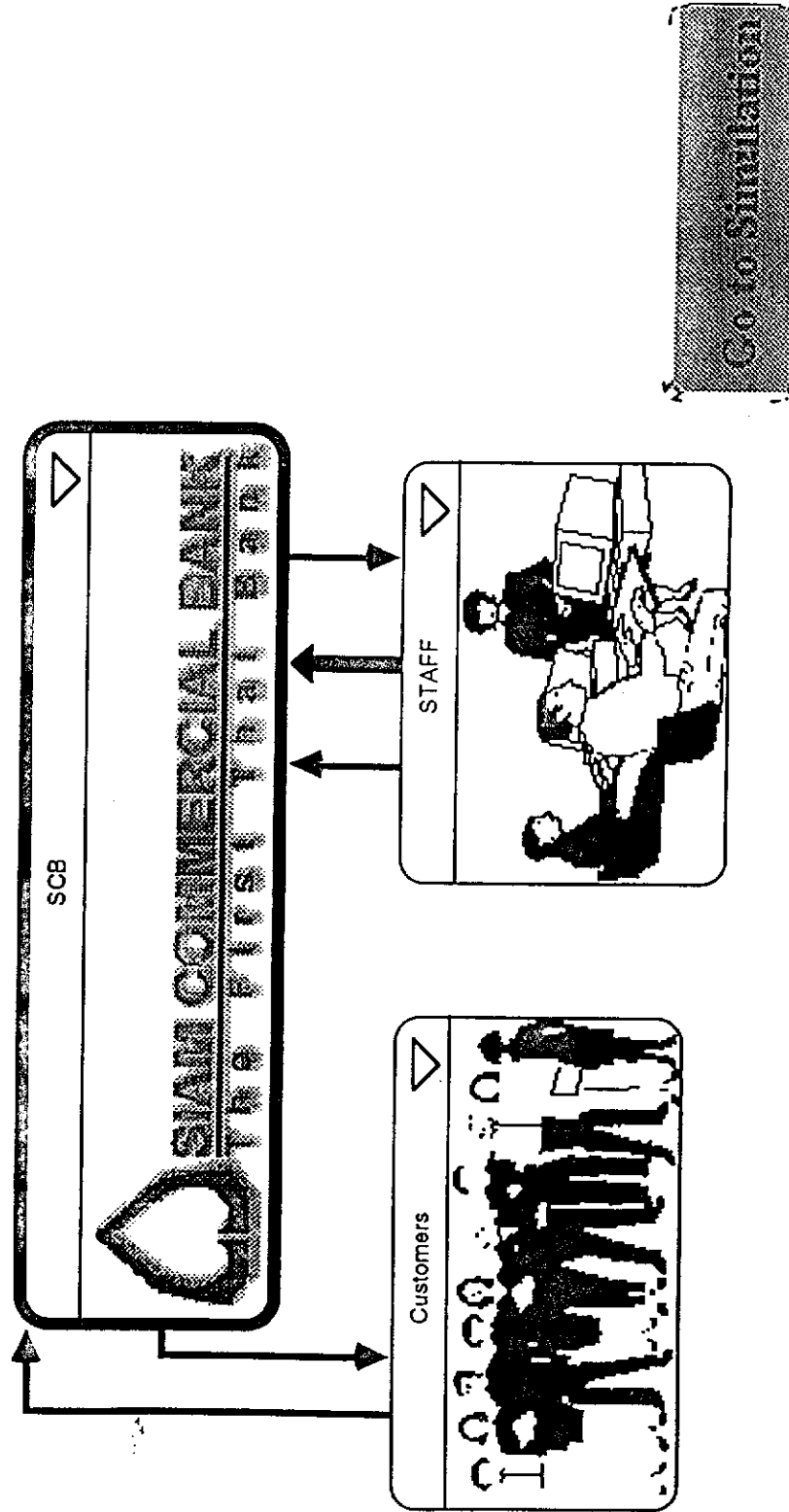
$\text{Time_for_training_delays} = 12$

$\text{Total_required_training} = \text{Rate_of_unskilled_quit} + \text{Rate_of_knowledge_worker_quit} + \text{Rate_of_tech_abandonment}$

$\text{Unskilled_quit_fraction} = .05$

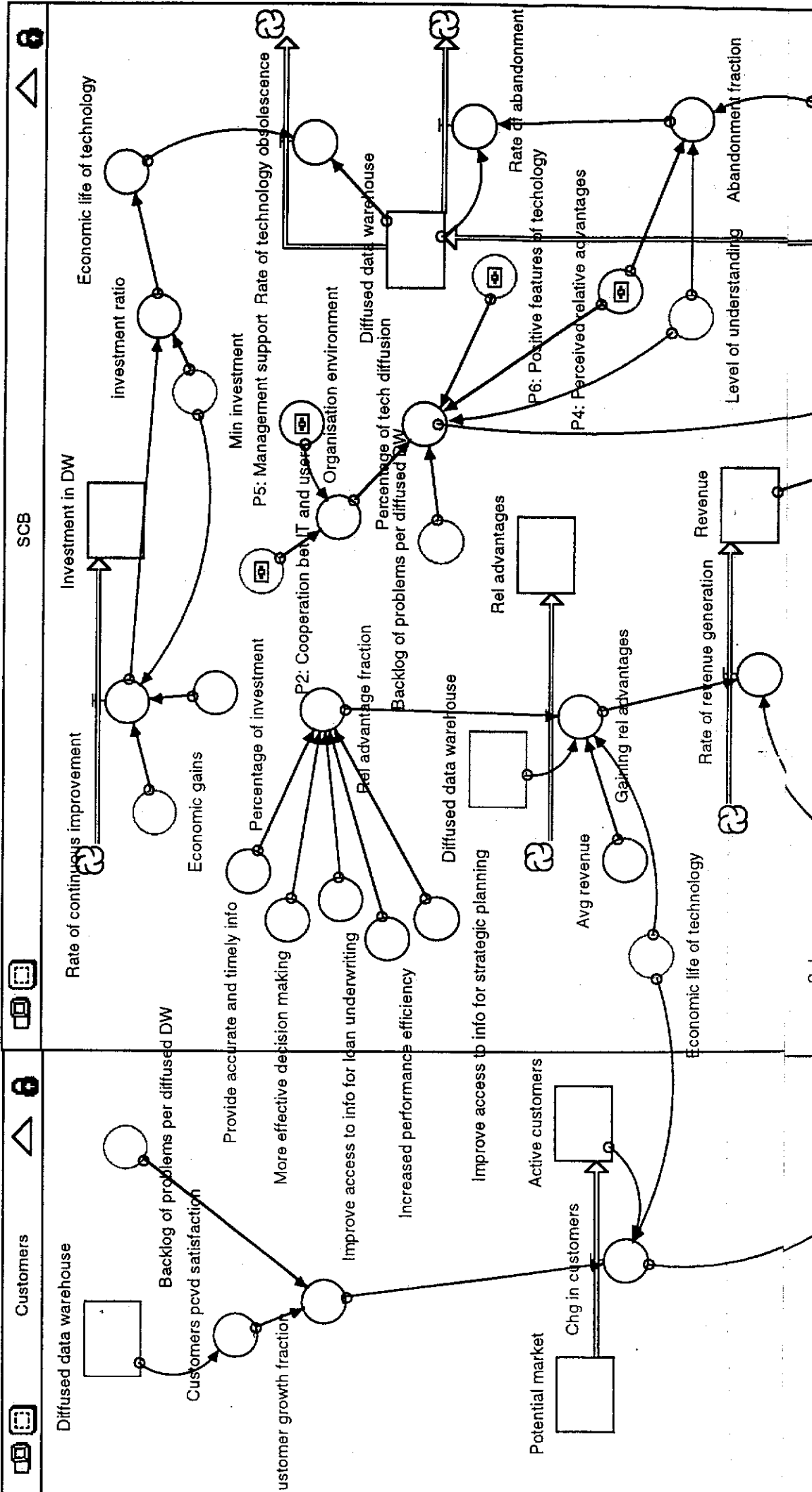
Appendix 9.2. Technology Diffusion of a Data Warehouse:
The Estimated Price Model

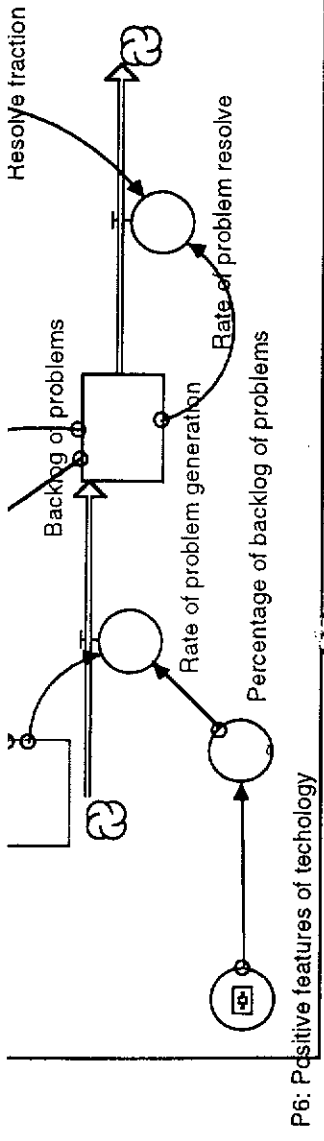
Policy Analysis



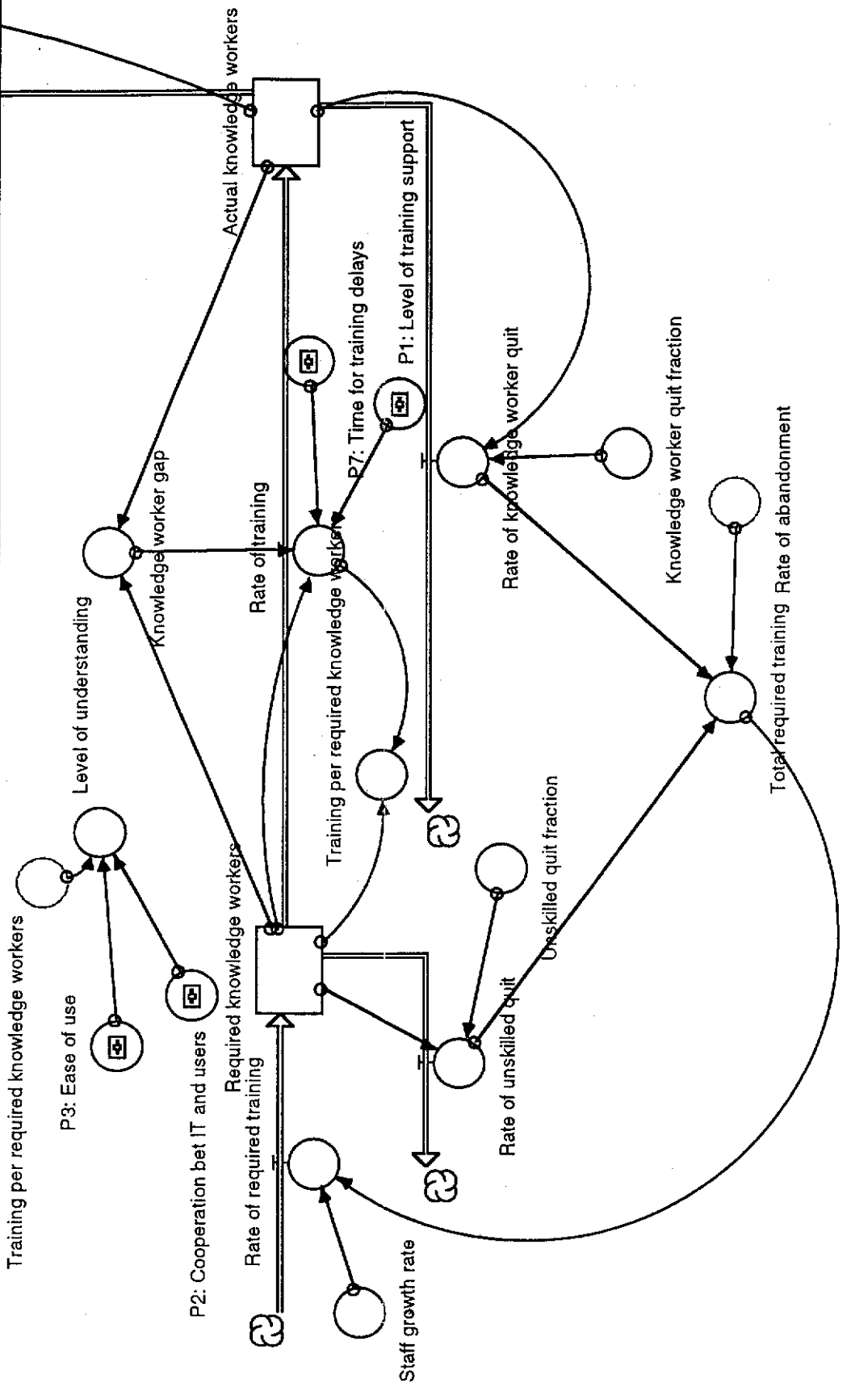
1

1 2 3





STAFF



Customers

Active_customers(t) = Active_customers(t - dt) + (Chg_in_customers) * dt
INIT Active_customers = 10000

INFLOWS:

$\text{Chg_in_customers} = \text{if time} < \text{Economic_life_of_technology}$ then Active_customers*(Customer_growth_fraction/12) else 0
Potential_market(t) = Potential_market(t - dt) + (- Chg_in_customers) * dt
INIT Potential_market = 100000

OUTFLOWS:

$\text{Chg_in_customers} = \text{if time} < \text{Economic_life_of_technology}$ then Active_customers*(Customer_growth_fraction/12) else 0
Customers_pcvd_satisfaction = GRAPH(Diffused_data_warehouse)

Customer_growth_fraction = GRAPH(Customers_pcvd_satisfaction-Backlog_of_problems_per_diffused_DW)
(0.00, 0.00), (10.0, 0.02), (20.0, 0.04), (30.0, 0.06), (40.0, 0.08), (50.0, 0.1), (60.0, 0.12), (70.0, 0.14), (80.0, 0.16), (90.0, 0.18), (100, 0.2)

SCB

Backlog_of_problems(t) = Backlog_of_problems(t - dt) + (Rate_of_problem_generation - Rate_of_problem_resolve) * dt
INIT Backlog_of_problems = 0

INFLOWS:

Rate_of_problem_generation = Diffused_data_warehouse*Percentage_of_backlog_of_problems
OUTFLOWS:

Rate_of_problem_resolve = Backlog_of_problems*Resolve_fraction

Cost_from_backlog_problems(t) = Cost_from_backlog_problems(t - dt) + (Rate_of_costs_from_backlog) * dt
INIT Cost_from_backlog_problems = 0
INFLOWS:

Rate_of_costs_from_backlog = if time < Economic_life_of_technology then (Backlog_of_problems*Unit_cost_per_backlog) else 0


```

 Diffused_data_warehouse(t) = Diffused_data_warehouse(t - dt) + (Rate_of_technology_diffusion - Rate_of_abandonment - Rate_of_technology_obsolescence) * dt
INIT Diffused_data_warehouse = 54
INFLOWS:
    ➤ Rate_of_technology_diffusion = (Percentage_of_tech_diffusion*Actual_knowledge_workers)
OUTFLOWS:
    ➤ Rate_of_abandonment = Diffused_data_warehouse*Abandonment_fraction
    ➤ Rate_of_technology_obsolescence = Diffused_data_warehouse/(Economic_life_of_technology*2)
 Investment_in_DW(t) = Investment_in_DW(t - dt) + (Rate_of_continuous_improvement) * dt
INIT Investment_in_DW = 0
INFLOWS:
    ➤ Rate_of_continuous_improvement = if Economic_gains>0 then Min_investment+(Economic_gains*(Percentage_of_investment/12)) else Min_investment
 Operation_costs(t) = Operation_costs(t - dt) + (Rate_of_Oper_&_maintenance_Costs) * dt
INIT Operation_costs = 0
INFLOWS:
    ➤ Rate_of_Oper_&_maintenance_Costs = if time< Economic_life_of_technology then (max(Rate_of_continuous_improvement,Min_investment)) else 0
 Rel_advantages(t) = Rel_advantages(t - dt) + (Gaining_rel_advantages) * dt
INIT Rel_advantages = 0
INFLOWS:
    ➤ Gaining_rel_advantages = if time< Economic_life_of_technology then (Rel_advantage_fraction*Diffused_data_warehouse*Avg_revenue) else 0
 Revenue(t) = Revenue(t - dt) + (Rate_of_revenue_generation) * dt
INIT Revenue = 0
INFLOWS:

```

- $\text{Rate_of_revenue_generation} = (\text{Gaining_rel_advantages}) + \text{Sales_rate}$
- $\text{Sales}(t) = \text{Sales}(t - dt) + (\text{Sales_rate}) * dt$
- INIT Sales = 0
- INFLOWS:
 - $\text{Sales_rate} = \text{Chg_in_customers} * \text{Price}$
- $\text{Total_cost}(t) = \text{Total_cost}(t - dt) + (\text{Rate_of_cost_generation}) * dt$
- INIT Total_cost = 0
- INFLOWS:
 - $\text{Rate_of_cost_generation} = (\text{Rate_of_Oper_}\&_maintenance_Costs + \text{Rate_of_training_costs} + \text{Cost_of_technology} + \text{Rate_of_costs_from_backlog})$
- $\text{Training_costs}(t) = \text{Training_costs}(t - dt) + (\text{Rate_of_training_costs}) * dt$
- INIT Training_costs = 0
- INFLOWS:
 - $\text{Rate_of_training_costs} = \text{if time} < \text{Economic_life_of_technology} \text{ then } (\text{Avg_training_cost} * \text{Rate_of_training}) \text{ else } 0$
- $\text{Abandonment_fraction} = \text{MAX}(0, (.03/12 - ((P4_Perceived_relative_advantages * .64) + (\text{Level_of_understanding} * .43)/12) + \text{Backlog_of_problems_per_diffused_DW}))$
- $\text{Avg_revenue} = .2$
- $\text{Avg_training_cost} = 1$
- $\text{Backlog_of_problems_per_diffused_DW} = \text{Backlog_of_problems}/\text{Diffused_data_warehouse}$
- $\text{Economic_gains} = \text{Revenue} - \text{Total_cost}$
- $\text{Economic_life_of_technology} = \text{if investment_ratio} > 1 \text{ then } 84 \text{ else } 60$
- $\text{Improve_access_to_info_for_loan_underwriting} = .64$
- $\text{Improve_access_to_info_for_strategic_planning} = .75$
- $\text{Increased_performance_efficiency} = .61$
- $\text{investment_ratio} = \text{Rate_of_continuous_improvement}/\text{Min_investment}$

- Min_investment = 10000/12
- More_effective_decision_making = .93
- Organisation_environment = (P2:_Cooperation_bet_IT_and_users+P5:_Management_support)/2
- P4:_Perceived_relative_advantages = .64
- P5:_Management_support = .88
- P6:_Positive_features_of_technology = .67
- Percentage_of_investment = 0.09
- Percentage_of_tech_diffusion =
- If(Level_of_understanding+Organisation_environment+P4:_Perceived_relative_advantages+P6:_Positive_features_of_technology)/4>0.625
then(.69-Backlog_of_problems_per_diffused_DW+((Level_of_understanding-.43)+(Organisation_environment-.76)+(P4:_Perceived_relative_advantages-.64)+(P6:_Positive_features_of_technology-.67)/4))else(.69-Backlog_of_problems_per_diffused_DW)
- Price = 1
- Provide_accurate_and_timely_info = .89
- Rel_advantage_fraction =
- (Improve_access_to_info_for_loan_underwriting+Improve_access_to_info_for_strategic_planning+Increased_performance_efficiency+More_effective_decision_making+Provide_accurate_and_timely_info)
- Resolve_fraction = 0.8
- Unit_cost_per_backlog = .6
- Cost_of_technology = GRAPH(TIME)
(1.00, 50000), (2.00, 0.00), (3.00, 0.00), (4.00, 0.00), (5.00, 0.00), (6.00, 0.00), (7.00, 0.00), (8.00, 0.00), (9.00, 0.00), (10.0, 0.00), (11.0, 0.00), (12.0, 0.00), (13.0, 0.00), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0, 0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00), (26.0, 0.00), (27.0, 0.00), (28.0, 0.00), (29.0, 0.00), (30.0, 0.00), (31.0, 0.00), (32.0, 0.00), (33.0, 0.00), (34.0, 0.00), (35.0, 0.00), (36.0, 0.00), (37.0, 0.00), (38.0, 0.00), (39.0, 0.00), (40.0, 0.00), (41.0, 0.00), (42.0, 0.00), (43.0, 0.00), (44.0, 0.00), (45.0, 0.00), (46.0, 0.00), (47.0, 0.00), (48.0, 0.00), (49.0, 0.00), (50.0, 0.00), (51.0, 0.00), (52.0, 0.00), (53.0, 0.00)...
- Percentage_of_backlog_of_problems = GRAPH(P6:_Positive_features_of_technology)
(0.5, 0.02), (0.583, 0.015), (0.667, 0.01), (0.75, 0.008), (0.833, 0.004), (0.917, 0.002), (1.00, 0.00)

STAFF

Actual_knowledge_workers(t) = Actual_knowledge_workers(t - dt) + (Rate_of_training - Rate_of_knowledge_worker_quit - Rate_of_technology_diffusion) * dt
INIT Actual_knowledge_workers = 200

INFLOWS:

☞ Rate_of_training = If(Knowledge_worker_gap<0) then
((Required_knowledge_workers*P1:_Level_of_training_support)/P7:_Time_for_training_delays) else 0

OUTFLOWS:

☞ Rate_of_knowledge_worker_quit = Actual_knowledge_workers*Knowledge_worker_quit_fraction
☞ Rate_of_technology_diffusion (IN SECTOR: SCB)

Required_knowledge_workers(t) = Required_knowledge_workers(t - dt) + (Rate_of_required_training - Rate_of_training - Rate_of_unskilled_quit) * dt
INIT Required_knowledge_workers = 6000
INFLOWS:

☞ Rate_of_required_training = Total_required_training+Staff_growth_rate
OUTFLOWS:

☞ Rate_of_training = If(Knowledge_worker_gap<0) then
((Required_knowledge_workers*P1:_Level_of_training_support)/P7:_Time_for_training_delays) else 0
☞ Rate_of_unskilled_quit = Required_knowledge_workers*Unskilled_quit_fraction

Knowledge_worker_gap = Actual_knowledge_workers-Required_knowledge_workers
 Knowledge_worker_quit_fraction = .01

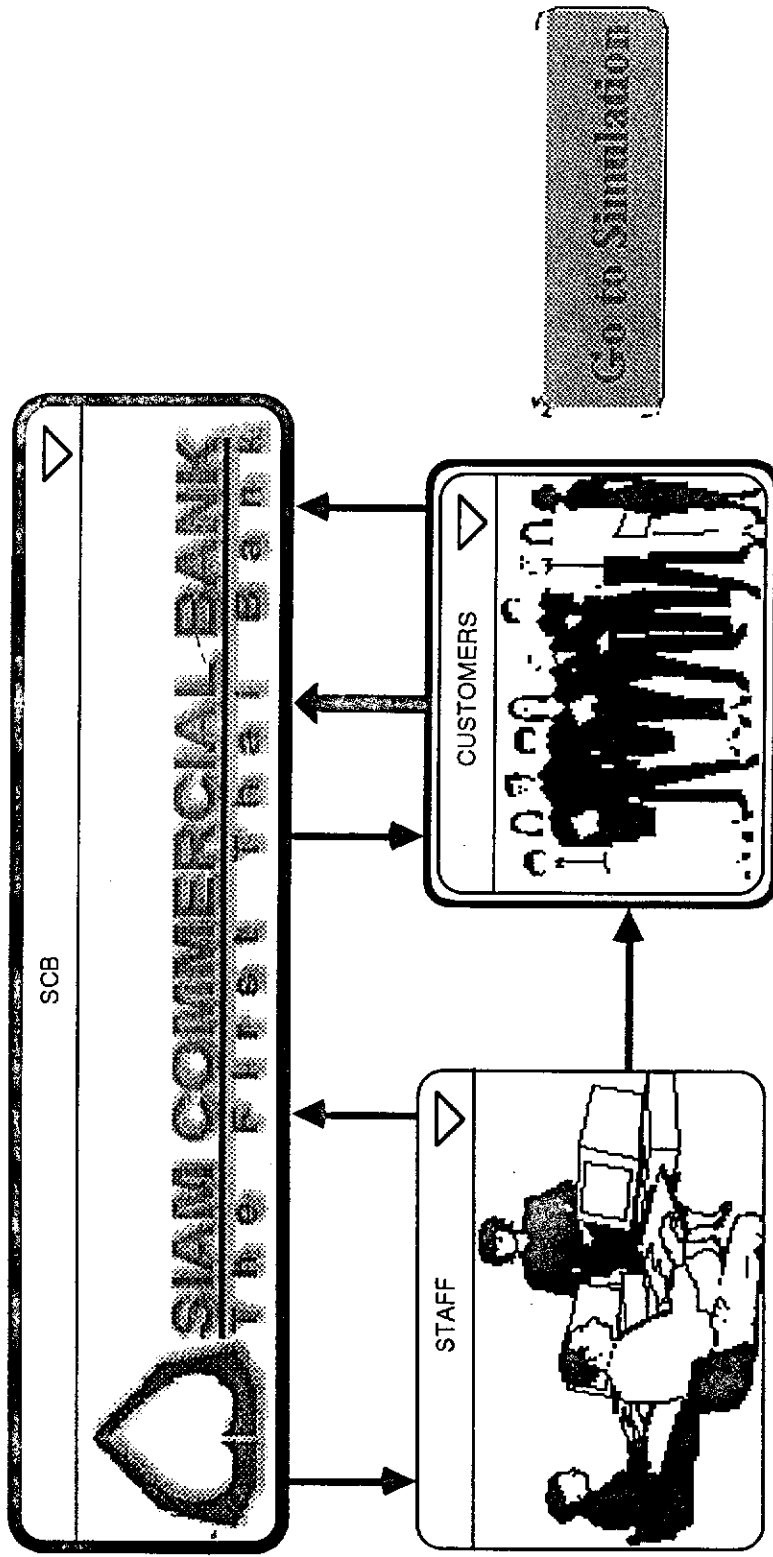
Level_of_understanding = if ((P3:_Ease_of_use+P2:_Cooperation_bet_IT_and_users+Training_per_required_knowledge_workers)/3)>0.376 then .43+ ((P3:_Ease_of_use-.46)+(Training_per_required_knowledge_workers-.03)+(P2:_Cooperation_bet_IT_and_users-.64))/3 else .43
 P1:_Level_of_training_support = .40

P2:_Cooperation_bet_IT_and_users = .64

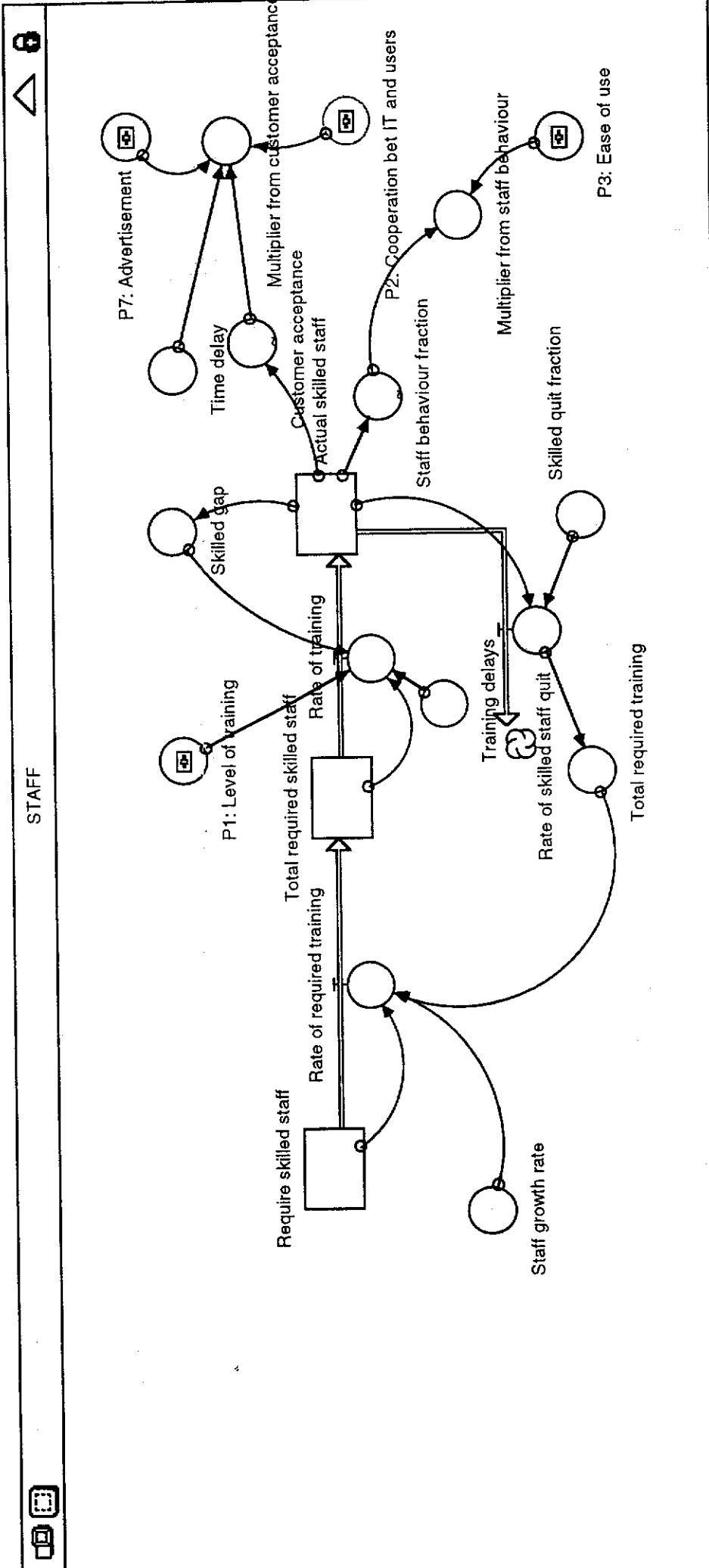
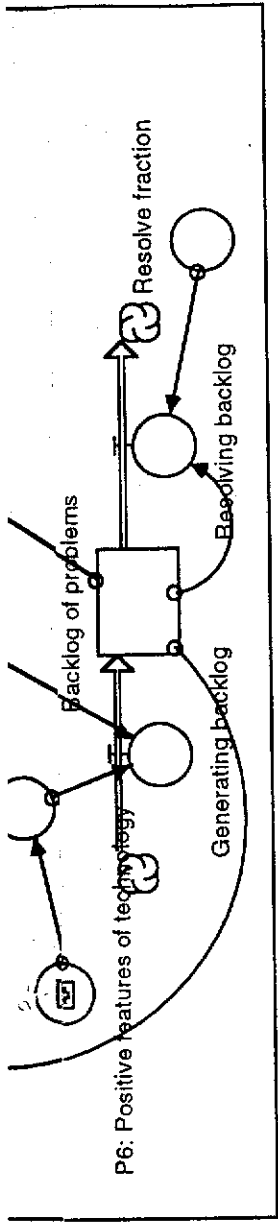
- P3: Ease_of_use = .46
- P7: Time_for_training_delays = 12
- Staff_growth_rate = 0
- Total_required_training = Rate_of_unskilled_quit+Rate_of_knowledge_worker_quit+Rate_of_abandonment
- Training_per_required_knowledge_workers = Rate_of_training/Required_knowledge_workers
- Unskilled_quit_fraction = .05

Not in a sector

Appendix 10.1.1. Model of Diffusion of Extranet Banking (EB)



3



CUSTOMERS

Market_potential(t) = Market_potential(t - dt) + (- Rate_of_diffusion) * dt
INIT Market_potential = 10000

OUTFLOWS:

Rate_of_diffusion (IN SECTOR: SCB)

Accelerator_factor = 1 +

((Multiplier_from_customer_acceptance-Backlog_of_problems_per_diffused_EB)-0.7485)+((Multiplier_from_staff_behaviour-Backlog_of_problems_per_diffused_EB)-0.7085)

Active_customers = Diffused_EB

P4:_Perceived_relative_advantages = .71

SCB

Backlog_of_problems(t) = Backlog_of_problems(t - dt) + (Generating_backlog - Resolving_backlog) * dt

INIT Backlog_of_problems = 0

INFLOWS:

Generating_backlog = Percentage_of_backlog_per_problems*Diffused_EB

OUTFLOWS:

Resolving_backlog = Backlog_of_problems*Resolve_fraction

Costs(t) = Costs(t - dt) + (Rate_of_cost_generation) * dt

INIT Costs = 0

INFLOWS:

Rate_of_cost_generation =

Rate_of_expense_on_promotion+Rate_of_Operational_Costs+Rate_of_training_costs+Cost_of_technology+Rate_of_costs_from_problem

$Costs_from_backlog_problem(t) = Costs_from_backlog_problem(t - dt) + (Rate_of_costs_from_problem) * dt$
 INIT $Costs_from_backlog_problem = 0$
 INFLOWS:
 $Rate_of_costs_from_problem = if\ Economic_life_of_technology > time\ then\ (Backlog_of_problems * Unit_cost_per_backlog)\ else\ 0$
 $Diffused_EB(t) = Diffused_EB(t - dt) + (Rate_of_diffusion - Rate_of_technology_abandonment - Rate_of_technology_obsolescence) * dt$
 INIT $Diffused_EB = 2000$
 INFLOWS:
 $Rate_of_diffusion = ((Diffused_EB * (Diffused_fraction_growth_rate/12) * Percentage_of_technology_diffusion)) * Accelerator_factor$
 OUTFLOWS:
 $Rate_of_technology_abandonment = Diffused_EB * Abandonment_fraction$
 $Rate_of_technology_obsolescence = Diffused_EB / (Economic_life_of_technology * 6)$
 $Expense_on_promotion(t) = Expense_on_promotion(t - dt) + (Rate_of_expense_on_promotion) * dt$
 INIT $Expense_on_promotion = 0$
 INFLOWS:
 $Rate_of_expense_on_promotion = if\ Economic_life_of_technology > time\ then\ (if\ P7:_Advertisement > 0.57\ then\ (16666 + (16666 * (P7:_Advertisement - .57)))\ else\ 16666)\ else\ 0$
 $Investment_in_EB(t) = Investment_in_EB(t - dt) + (Rate_of_investment_in_EB) * dt$
 INIT $Investment_in_EB = 0$
 INFLOWS:
 $Rate_of_investment_in_EB = if\ time < 84\ then\ (if\ Profits > 0\ then\ Minimum_investment + ((.09/12) * Profits)\ else\ Minimum_investment)\ else\ 0$
 $Operation_costs(t) = Operation_costs(t - dt) + (Rate_of_Operational_Costs) * dt$
 INIT $Operation_costs = 0$
 INFLOWS:
 $Rate_of_Operational_Costs = if\ Economic_life_of_technology > time\ then\ (Max((Diffused_EB * Avg_operational_cost), Rate_of_investment_in_EB))\ else\ 0$

- $\text{Rel_advantages}(t) = \text{Rel_advantages}(t - dt) + (\text{Gaining_rel_advantages}) * dt$
- $\text{INIT Rel_advantages} = 0$
- INFLOWS:
 - $\Rightarrow \text{Gaining_rel_advantages} = \text{if Economic_life_of_technology} > \text{time then } (\text{Diffused_EB} * \text{Avg_cost_saving}) \text{ else } 0$
- $\text{Revenue}(t) = \text{Revenue}(t - dt) + (\text{Rate_of_revenue_generation}) * dt$
- $\text{INIT Revenue} = 0$
- INFLOWS:
 - $\Rightarrow \text{Rate_of_revenue_generation} = \text{Gaining_rel_advantages} + \text{Sales_rate}$
- $\text{Sales}(t) = \text{Sales}(t - dt) + (\text{Sales_rate}) * dt$
- $\text{INIT Sales} = 0$
- INFLOWS:
 - $\Rightarrow \text{Sales_rate} = \text{if Economic_life_of_technology} > \text{time then } (\text{Diffused_EB} * \text{No_of_transation_per_person_per_month} * \text{Fee_per_transaction}) \text{ else } 0$
- $\text{Training_costs}(t) = \text{Training_costs}(t - dt) + (\text{Rate_of_training_costs}) * dt$
- $\text{INIT Training_costs} = 0$
- INFLOWS:
 - $\Rightarrow \text{Rate_of_training_costs} = \text{if Economic_life_of_technology} > \text{time then } (\text{Avg_training_costs} * \text{Rate_of_training}) \text{ else } 0$
- $\text{Abandonment_fraction} = \text{MAX}(0, (.03/12 - ((\text{P6: Positive_features_of_technology} - .90)/12) + \text{Backlog_of_problems_per_diffused_EB}))$
- $\text{Avg_cost_saving} = 150$
- $\text{Avg_operational_cost} = 160$
- $\text{Avg_training_costs} = 400$
- $\text{Backlog_of_problems_per_diffused_EB} = \text{if } (\text{Diffused_EB} = 0) \text{ then } (0) \text{ else } (\text{Backlog_of_problems}/\text{Diffused_EB})$
- $\text{Bank_environments} = \text{if } (\text{P2: Cooperation_bet_IT_and_users} > 0.78) \text{ or } (\text{P5: Management_support} > 0.86) \text{ then } 0.89 + (\text{P2: Cooperation_bet_IT_and_users} - 0.78) + (\text{P5: Management_support} - 0.86) \text{ else } 0.89$
- $\text{Economic_life_of_technology} = \text{if investment_ratio} > 1 \text{ then } 84 \text{ else } 60$

- Fee_per_transaction = 6.25
 - Investment_ratio = Rate_of__investment_in_EB/Minimum_investment
 - Minimum_investment = 200000/12
 - No_of_transaction_per_person_per_month = 40
 - P2: Cooperation_bet_IT_and_users = .78
 - P5: Management_support = .86
 - P6: Positive_features_of_technology = .9
 - Percentage_of_technology_diffusion = ((Bank_environments+P6:_Positive_features_of_technology+P4:_Perceived_relative_advantages)/3)
 - Percentage_of_backlog_per_problems = if P6:_Positive_features_of_technology= 0.90 then (.0015) else Max (0, (.0015-(P6:_Positive_features_of_technology-.90)))
 - Profits = Revenue-Costs
 - Resolve_fraction = .8
 - Unit_cost_per_backlog = 150
 - Cost_of_technology = GRAPH(TIME)
 - (1.00, 2e+007), (2.00, 0.00), (3.00, 0.00), (4.00, 0.00), (5.00, 0.00), (6.00, 0.00), (7.00, 0.00), (8.00, 0.00), (9.00, 0.00), (10.0, 0.00), (11.0, 0.00), (12.0, 0.00), (13.0, 0.00), (14.0, 0.00), (15.0, 0.00), (16.0, 0.00), (17.0, 0.00), (18.0, 0.00), (19.0, 0.00), (20.0, 0.00), (21.0, 0.00), (22.0, 0.00), (23.0, 0.00), (24.0, 0.00), (25.0, 0.00), (26.0, 0.00), (27.0, 0.00), (28.0, 0.00), (29.0, 0.00), (30.0, 0.00), (31.0, 0.00), (32.0, 0.00), (33.0, 0.00), (34.0, 0.00), (35.0, 0.00), (36.0, 0.00), (37.0, 0.00), (38.0, 0.00), (39.0, 0.00), (40.0, 0.00), (41.0, 0.00), (42.0, 0.00), (43.0, 0.00), (44.0, 0.00), (45.0, 0.00), (46.0, 0.00), (47.0, 0.00), (48.0, 0.00), (49.0, 0.00), (50.0, 0.00), (51.0, 0.00), (52.0, 0.00), (53.0, 0.00)...
 - Diffused_fraction_growth_rate = GRAPH(Rate_of__investment_in_EB)
 - (0.00, 0.00), (166667, 0.2), (333333, 0.25)
- STAFF**
- Actual_skilled_staff(t) = Actual_skilled_staff(t - dt) + (Rate_of_training - Rate_of_skilled_staff_quit) * dt
 - INIT Actual_skilled_staff = 8

INFLOWS:

- ☞ Rate_of_training = if Skilled_gap < 0 then (Total_required_skilled_staff * P1: _Level_of_training) / Training_delays else 0

OUTFLOWS:

- ☞ Rate_of_skilled_staff_quit = Actual_skilled_staff * Skilled_quit_fraction

Require_skilled_staff(t) = Require_skilled_staff(t - dt) + (- Rate_of_required_training) * dt

INIT Require_skilled_staff = 1000

OUTFLOWS:

- ☞ Rate_of_required_training = (Require_skilled_staff + Total_required_training) * Staff_growth_rate

Total_required_skilled_staff(t) = Total_required_skilled_staff(t - dt) + (Rate_of_required_training - Rate_of_training) * dt

INIT Total_required_skilled_staff = 0

INFLOWS:

- ☞ Rate_of_required_training = (Require_skilled_staff + Total_required_training) * Staff_growth_rate

OUTFLOWS:

- ☞ Rate_of_training = if Skilled_gap < 0 then (Total_required_skilled_staff * P1: _Level_of_training) / Training_delays else 0

Multiplier_from_customer_acceptance = if (P7: _Advertisement > .57) or (P2: _Cooperation_bet_IT_and_users > 0.78) then Customer_acceptance + (P7: _Advertisement - .57) / Time_delay + (P2: _Cooperation_bet_IT_and_users - .87) else Customer_acceptance

Multiplier_from_staff_behaviour = if (P3: _Ease_of_use > 0.57) then Staff_behaviour_fraction + (P3: _Ease_of_use - .57) else Staff_behaviour_fraction

P1: _Level_of_training = .6

P3: _Ease_of_use = .57

P7: _Advertisement = .57

Skilled_gap = Actual_skilled_staff - 1000

Skilled_quit_fraction = 0.01

Staff_growth_rate = 1

- Time_delay = 2
- Total_required_training = Rate_of_skilled_staff_quit
- Training_delays = 12
- Customer_acceptance = GRAPH(Actual_skilled_staff
(0.00, 0.75), (200, 0.8), (400, 0.85), (600, 0.9), (800, 0.95), (1000, 1.00))
- Staff_behaviour_fraction = GRAPH(Actual_skilled_staff
(0.00, 0.71), (200, 0.78), (400, 0.84), (600, 0.895), (800, 0.95), (1000, 1.00))

Not in a sector