

School of Economics and Finance

**Population Structure and Real Exchange Rate:
Evidence from the OECD Countries**

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**This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University of Technology**

February 2010

Declaration

To the best of my knowledge this thesis contains no material previously published by any other person except where due acknowledgement has been made

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: _____

Date: _____

Dedicated to

*My late father Md. Abdul Gafur and my mother Rahima Khatun, who brought me
in this world*

And

*My elder sister Zakia Sultana and elder brother AKM Nurul Hassan who brought
me up in this world.*

Acknowledgement

I am indebted to many individuals who have extended their generous and sincere support in completing this dissertation. I would like to express my heartiest gratitude to all of them.

First of all, I am immensely grateful to my supervisor Professor Harry Bloch. His continuous support, constructive and thoughtful advices, and sincerity in academic research helped me overcome several difficult stages during the research period. His timely and fatherly guidance steered me towards the successful completion of this thesis.

I am also greatly indebted to my co-supervisor Dr. Ruhul Salim, who continuously guided me in the right research track. Dr. Salim gave his valuable time on regular basis to discuss different thesis related problems and issues. I have enormously been benefitted from his caring guidance in writing and completing the thesis.

My special thanks to A/Prof. of Economics Dr. Helen Cabalu. I learnt a lot about research while working with her as a research assistant. My indebtedness also goes to A/Prof. of Finance Dr. Felix Chan who allowed me to sit in his econometrics class and help me on different econometric issues.

I also would like to express my gratitude to the authority of Rajshahi University, Bangladesh for granting me study leave to pursue my PhD study at Curtin University of Technology. My gratitude also goes to the Australian government and Curtin Business School (CBS) for providing me *International Postgraduate Research Scholarship (IPRIS)* and *Curtin Business School (CBS) Doctoral Scholarship* respectively. Without these financial supports it would not have been possible to pursue my doctoral study in Australia.

I sincerely acknowledge the supports of Dr. Ariful Hoque and Mr. Muammer Reza for their heartiest and timely cooperation in providing data and econometric software for my research purpose. In addition I am also indebted to my fellow PhD students Suyanto Suyanto, Mahfuz Kabir, Mohammad Nasiruddin, Shah

Azam, Faridul Islam, Fazlul Robbane, Mamunur Rashid, Enayet Hossain, AHM Aminul Ahsan, Shahriar Kabir, Shuddhasattwa Rafiq for the emotional support they provide me when that was needed.

I would like to express my heartiest gratitude to my family. My wife Rosy singlehandedly managed and controlled all family affairs keeping me free for writing the dissertation. I am thankful for her continuous support with great endurance. As a father I could not give enough time to my son Mouno and my little daughter Kangkhita. I am thankful to them too. Without the cooperation of my family this thesis would have taken much longer time to complete.

Abstract

This thesis examines the relationship between population structure and the real exchange rate in 23 OECD countries over the period 1980–2006. The motivation for this research stems mainly from the *Life-Cycle Hypothesis* (LCH) of consumption and saving. According to this hypothesis people accumulate saving during their working age to guard against the fall in consumption during their old age, thus smooth consumption over the entire span of life. Therefore, the size of the population that is at the earning stage affect the saving of an economy. In open economy domestic saving plays significant role in determining capital flows. Excess saving causes capital outflow, whereas shortfall of saving causes capital inflows. Capital flows are related to the appreciation or depreciation of the real exchange rate of an economy.

Capital flow is also affected by investment. Different cohorts of population affect investment differently. An increase in the labour supply raises return on capital by increasing marginal product of capital. Higher return causes capital inflow and real appreciation. Besides, demand for consumption goods from dependents also affects investment and capital flow, which influences the real exchange rate.

This thesis hypothesizes that the population structure affects the real exchange rate by affecting capital flows through its influence on saving and investment. Accordingly, objective of this thesis is to examine the effect of population structure on the real exchange rate.

The real exchange rate is modeled as a function of terms of trade, net foreign assets, government expenditure, interest rate differential and three demographic variables, namely, young dependents (population ages 0-14), working age population (population ages 15-64) and old dependents (population ages 65 and above). These cohorts are expressed as the percentage of total population. Unbalanced panel data method is used to examine the hypothesized relationship between population structure and the real exchange rate.

The estimation result shows 1% increase in the share of working age people in total population appreciates the real effective exchange rate index by 0.85%. This positive influence indicates that by increasing labour supply higher working age

population raises return on capital. Domestic saving falls due to lower wage caused by higher labour supply. Therefore, foreign capital flows in and appreciates the real exchange rate.

In case of 1% increase in the share of old dependents in total population, real effective exchange rate index depreciates by 0.97%. Although not supported by the LCH, this finding is consistent with the recent empirical studies that old people run down their assets very slowly due to various reasons. Thus they contribute positively to saving and depreciate the real exchange rate by causing capital outflow.

The case study on Australia shows that only the log of real effective exchange rate index, net foreign assets and working age population are I(1). Johansen cointegration analysis indicates that there is one cointegrating relationship among these three variables implying a long-run equilibrium relationship among these variables. Granger causality test shows that there is long-run causality running from the working age population and net foreign assets to the real exchange rate. However, short-run adjustment coefficients are found to be insignificant, leaving the correction of deviations of the real exchange rate from its long-run value undetermined.

This study identifies an important determinant of the real exchange rate, namely population structure. As transition of population structure is a long-run phenomenon, it can be utilized to study the long-run behavior of the real exchange rate.

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List of abbreviations

AIC	Akaike Information Criterion
AR	Auto Regressive
BLUE	Best Linear Unbiased Estimator
DF	Dickey-Fuller
DF-GLS	Dickey-Fuller Generalized Least Square
DW	Durbin-Watson
ECT	Error Correction Term
ERS	Elliot, Rothenberg and Stock
FAO	Food and Agricultural Organization
FEM	Fixed Effect Model
FGLS	Feasible Generalized Least Square
GDP	Gross Domestic Product
IMF	International Monetary Fund
IPS	Im, Pesaran and Shin
LCH	Life Cycle Hypothesis
LLC	Levin, Lin and Chu
LM	Lagrange Multiplier
MW	Maddala and Wu
NFA	Net Foreign Assets
ODEP	Old Dependents
OECD	Organization for Economic Co-operation and Development
OLG	Overlapping Generations Model
OLS	ordinary Least Square
PCSE	Panel Corrected Standard Error
PPP	Purchasing Power Parity
RBA	Reserve Bank of Australia
REER	Real effective Exchange Rate
REM	Random Effect Model
RER	Real Exchange Rate
SC	Schwarz Criterion
TOT	Terms of Trade
TSCS	Time Series Cross Section
UNCTAD	United Nations Conference on Trade and Development
VAR	Vector Auto Regressive
VECM	Vector Error Correction Model
WAPOP	Working Age Population
WDI	World Development Indicators
YDEP	Young Dependents

Chapter 1

Introduction

1.1: Initial words

This thesis examines the impact of population structure on the real exchange rate in 23 OECD countries. The real exchange rate is the building block of open economy macroeconomics. Linkage of an economy with the rest of the world is shaped, to a large extent, by its real exchange rate. It is defined as the nominal exchange rate adjusted for price level differences between countries. ‘It is a summary measure of the prices of one country’s goods and services relative to those of another country or group of countries...’(Ellis 2001:70). The real exchange rate defined this way is known as the external definition of the term. In internal term it is defined as the relative price of tradable to non-tradable goods within a country. Defined this way the real exchange rate reflects ‘the internal relative price incentive in a particular economy for producing or consuming tradable as opposed to nontradable goods’ (Hinkle and Nsengiyumva, 1999:41). It indicates how domestic resources are allocated between tradable and nontradable sectors. Whatever definition is used, the real exchange rate is used as an indicator of competitiveness in open economy macroeconomics.

Different real (*i.e.* terms of trade, productivity) and nominal (*i.e.* money supply) shocks cause the real exchange rate to deviate from its equilibrium value, temporarily or permanently. There is a large body of empirical literature that has examined the influences of real and nominal shocks on the real exchange rate. Terms of trade, interest rate differential, inflation differential, international capital flows, productivity differential, current account, etc. are found to have significant power to explain the movements in the equilibrium real exchange rate in developing as well as developed countries.

Recently demography has been subjected to empirical research to examine its influence on the real exchange rate in a few studies. Although demography has been used to explain the behavior of savings, capital flows and current account (Higgins, 1997; Serge, Guest and McDonald, 2000), the theoretical as well as empirical relation between the real exchange rate and demography is not so

developed. In other words, the neo-classical theories do not provide any clear cut specified relationship between these variables. The idea, however, behind this relationship is that population structure influences the real exchange rate through its effects on saving and capital flows.

1.2: Issues and research question

The interest in population structure in analyzing the real exchange rate is due to the significant changes in the world population structure, particularly those in developed countries. The demographic transition is significantly impacting and will continue to impact the size and age structure of the world's population. Before 1900, world population growth was slow and the age structure of population was broadly constant (IMF, 2004). However, the twentieth century observed significant change in the age structure of the world population caused by high life expectancy and low fertility rate. The share of the young people in total population declines and those of working-age and elderly rise modestly (Table A1.1 in Appendix 1). The table also shows that, given the current life expectancy, fertility and population growth rate, there will be a substantial change in the composition of different age groups in the total population by the year 2300. The most dramatic change will occur in the young and elderly age groups. These changes in the age structure will have profound effects on the economy.

There has been a large body of literature that looks into the impacts of demographic changes on the economy. Gross Domestic Product (GDP) per capita is largely affected by the relative size of the working-age population that reflects the productive impact of a large labor force. Crenshaw *et al.* (1997) and Bloom and Williamson (1998) find positive and significant effect of declining youth dependency ratios on economic growth in cross-country regressions both in developing and developed countries. Bloom *et al.* (2001) note that nations with high working-age people can produce demographic dividend by adding productivity; conversely, dependents can depress this effect. Similarly Gómez and Hernández de Cos (2003) find that a growing cohort of working-age population has a large positive effect on the growth of GDP per capita. Very recently Headey and Hodge (2009) conclude that adult population growth has significant positive,

while the young population growth has significant negative effects on economic growth.

As the world is heading towards having an aging population, it will have significant fiscal implications for governments. Fiscal issues mainly come from the elderly group of the population. This is because the government provides for old age benefits such as health care and nursing. However, countries that have limited social insurance commitments, like Asian countries, aging population may not adversely affect their fiscal balances (Heller, 1997). These effects are more crucial for developed countries those have social insurance commitments. For example, in Australia the size of the population over 65 years will be around 7 million by 2044-45¹ and it will affect every facet of life. Guest (2006) finds that the deadweight losses from the fiscal pressure in Australia caused by population aging are equivalent to an annual loss of consumption of \$260 per person in 2003 dollars. However, a feasible tax smoothing would reduce this loss by an equivalent of \$70 per person per year.

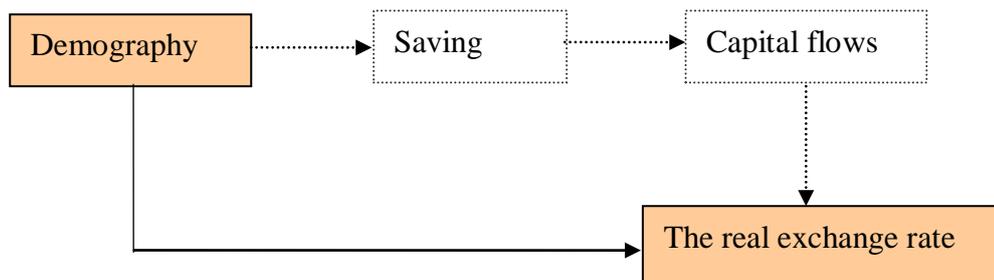
Beside these economic impacts, socio-political aspects of changing age-structure have also been examined in the literature. For example, Yashiro (2001) examines the social implications of demographic change in Japan. Razin (2001) discusses how demographic changes affect the welfare of an economy. Suárez-Orozco (2001) focuses on the cultural impact of demographic change in the USA.

Thus, demographic transition affects many facets of economic and social life in an economy. The real exchange rate has been added in this list recently. The main source of influence comes from the *Life-Cycle Hypothesis* (LCH), first forwarded by Modigliani and Brumberg (1954). In an open economy, external balance reflects the saving-investment gap. If saving is higher than investment, capital will flow out and capital will flow in when saving fall short of investment. Therefore, any change in saving caused by a change in age structure will affect capital flow and capital flow will affect the real exchange rate. Figure 1.1 below shows how the relationship between demography and real exchange rate is hypothesized. The figure shows that demography affects the real exchange rate indirectly by

¹ Productivity Commission (2005).

impacting on savings and capital flows. The dotted lines and boxes indicate the intermediate channels through which demography affects the real exchange rate, while the continuous lines and boxes implies that a direct relationship can be hypothesized between demography and the real exchange rate. A few studies have looked into this link between the real exchange rate and the population structure. These studies bear significance as the earlier contribution to the literature. However, these studies lack a formal model of the real exchange rate incorporating, among others, different age groups as independent variables.

Figure 1.1: Population structure and real exchange rate (saving channel)

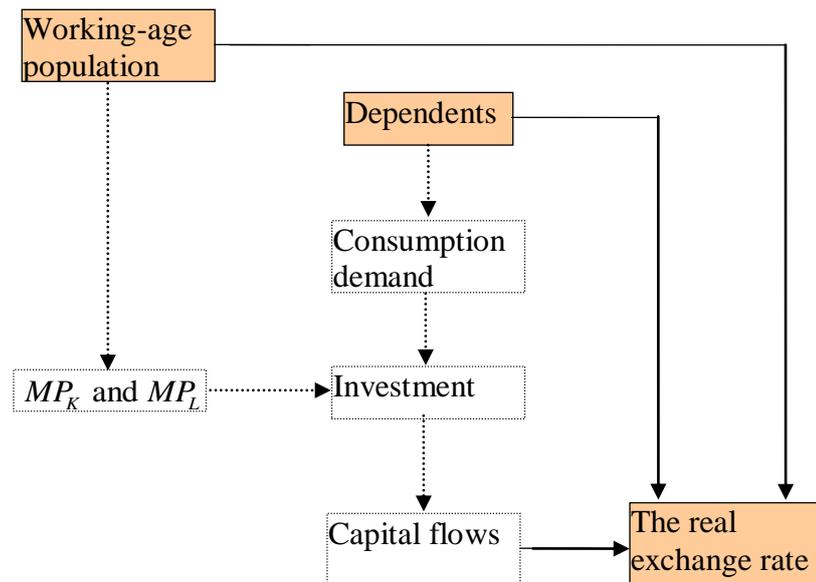


Besides saving, there is another potential channel of influence, namely investment, which can be considered to analyze the impact of the population structure on the real exchange rate. Population structure can affect investment in different ways. For example dependents can place higher consumption demand in the market, which necessitates higher investment. Working-age population can affect investment by changing the labour supply. Higher labour supply will raise marginal product of capital and hence return to capital. Higher return will attract capital. Again, higher working-age population will decrease the marginal product of labour and hence wage. Given the saving rate, there will be a change in aggregate saving due to this lower wage. Depending on the availability of funds from domestic markets, these investment demands will affect capital flows and the real exchange rate. Figure 1.2 shows how the real exchange rate may be affected by the population structure through the investment channel.

Existing studies have not taken this channel of influence into consideration in analyzing the effect of population structure on the real exchange rate (e.g. Cantor

and Driskill, 1999; Andersson and Österholm, 2005 & 2006; Aloy and Gente, 2009). The present thesis utilizes these relationships to hypothesize that age-structure has significant influence on the real exchange rate. Since the existing literature lacks convincing studies that address both these channels by which population structure affects real exchange rate of an economy this thesis attempts to fill this research gap. Thus, the aim of this thesis is to examine whether the composition of population structure affects the real exchange rate through its influence on saving and investment.

Figure 1.2: Population structure and real exchange rate (investment channel)



Depending on the influences of different age groups on saving and investment, following hypotheses are developed:

Hypothesis-1: Young dependents (age 0-14 years) cause capital inflow and the real exchange rate to appreciate.

Hypothesis-2: Working-age population (age 15 – 64 years) cause capital inflow (or outflow) and the real exchange rate to appreciate (or depreciate).

Hypothesis-3: Old dependents (age 64 and above) cause capital outflow and the real exchange rate to depreciate.

Rationale of these hypotheses are discussed in more detail in Chapter 3 where a theoretical framework to analyze the relationship between population structure and the real exchange rate is presented.

1.3: Outline of the thesis

The thesis consists of seven chapters including the present one. The rest of the thesis is structured as follows:

- (i) *Chapter 2:* This chapter presents a critical review of some previous literature. There is a vast array of literature on the population structure and on the real exchange rate separately. However, this thesis hypothesizes that the population structure affects the real exchange rate through its impact on saving, investment and capital flows. Accordingly this review chapter includes literature on (a) population structure and saving; (b) population structure and capital flows; (c) purchasing power parity and the real exchange rate; (d) population structure and the real exchange rate; and (e) population structure and investment. After reviewing the literature a research gap is identified.
- (ii) *Chapter 3:* This chapter develops the theoretical framework of the relationship between population structure and the real exchange rate. A model of the real exchange rate with tradable and non-tradable goods is developed where different age groups are included, among others, as additional independent variables.
- (iii) *Chapter 4:* This chapter discusses the econometric procedures followed in estimating the empirical model of the real exchange rate derived from the theoretical framework developed in Chapter 3. As this is a panel study, this chapter covers such issues as panel unit root; random effect and fixed effect models; Breusch-Pagan and Hausman model selection test etc. This chapter also includes descriptions of variables, list of the sample countries and sources of data.
- (iv) *Chapter 5:* This chapter presents the panel estimation results of the empirical model specified in Chapter 4. The estimation results show that there are significant influences of the working-age population and

the old dependents on the real exchange rate as hypothesized. However, although expected, results reported in Appendix 5b shows that the young dependents do not have any significant influence on the real exchange rate.

- (v) *Chapter 6:* After panel estimation in Chapter 5, a case study on Australia is presented in this chapter. Cointegration analysis suggests that Australia's real exchange rate is cointegrated with the working-age population and net foreign assets. Causality analysis (in Granger sense) indicates that there is long-run causality that runs from working-age population and net foreign assets to the real exchange rate.
- (vi) *Chapter 7:* This chapter provides a summary of major findings of the thesis. Conclusions are drawn from these findings followed by discussion of policy implications and contribution of the thesis. The chapter also discusses some limitations of the study and scope of further research.

Appendix 1

Table A1.1: Share of different age groups in total population: 1950 – 2300

Year	0-14 years			15-64 years			65+ years		
	World	MDR	LDR	World	MDR	LDR	World	MDR	LDR
1950	34.3	27.4	37.6	60.5	64.8	58.5	5.2	7.9	3.9
2000	30.1	18.3	33.0	63.0	67.4	61.9	6.9	14.3	5.1
2050	20.1	15.7	20.8	64.0	58.4	64.9	15.9	25.9	14.3
2100	16.4	16.9	16.4	59.2	55.5	59.7	24.4	27.7	23.9
2150	16.5	16.4	16.5	56.0	54.4	56.2	27.5	29.3	27.2
2200	16.5	15.7	16.6	54.7	52.4	55.1	28.8	31.9	28.2
2250	16.0	15.3	16.1	53.3	50.8	53.7	30.7	33.9	30.1
2300	15.6	14.9	15.7	52.0	49.5	52.4	32.3	35.6	31.8

Source: United Nations, 2004

Note: MDR = More Developed Region; LDR = Less Developed Region.

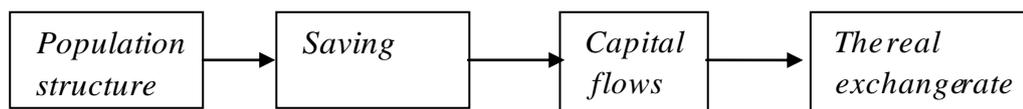
Chapter 2

Population Structure and Saving: Implications for Capital Flow and the Real Exchange Rate

2.1: Introduction

This chapter reviews some previous theoretical and empirical studies on the relationship between population structure, saving and investment along with their implications for capital flows and the real exchange rate. Saving mainly comes from the cohort of the population that is at its working age stage. Thus the age composition or population structure may affect the saving of an economy, which in turn has impact on capital flows. Lower saving will cause capital to inflow and *vice versa*. These capital flows (inflows/outflows) have considerable impacts on the real exchange rate (RER) of an economy. So the channel of influence of population structure on the real exchange rate can be shown in a pictorial form as follows:

Figure 2.1: Link between population structure and the real exchange rate through saving channel

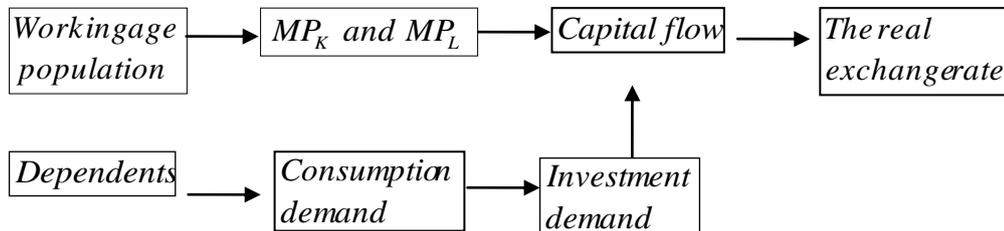


Another potential source of influence is investment. Investment demand may come from the consumption demand of the dependents. However, more direct route is through changing the size of labour force. Increase in labour force due to increase in working-age population raises marginal product of capital and hence return on capital. Higher return attracts capital and depreciates the real exchange rate. Higher working-age population may also change wage by changing marginal product of labour. This change in wage will change saving, capital flows and the real exchange rate. These are shown in Figure 2.2.

There is a voluminous body of research on capital flows and the real exchange rate. However, as the present study is on the impact of population structure on the real exchange rate, this review does not intend to cover all previous studies on capital flows and the real exchange rate. Accordingly, this review will focus on

the literature that is related to population structure and saving, saving and capital flows, population structure and investment, and impact of population structure and capital flows on the real exchange rate.

Figure 2.2: Link between population structure and the real exchange rate through investment channel



The rest of the chapter proceeds as follows: literature on the impact of the population structure on saving in the light of life-cycle hypothesis is reviewed in section 2.2, followed by some studies on population structure and capital flows in section 2.3. A brief review of real exchange rate and its determinants including capital flow is presented in section 2.4. Section 2.5 discusses studies on population structure and real exchange rate, followed by discussion on population structure and investment in section 2.6. The chapter concludes in section 2.7.

2.2: Population structure and saving

The proposition that the age composition of an economy's population may be associated with its saving rate emanates from the *Life-Cycle Hypothesis* (LCH) of saving and consumption developed in the 1950s and 1960s by Franco Modigliani, Richard Brumberg and Albert Ando.² The LCH posits that the motivation for saving during the earning period of an economic agent comes from her/his desire to smooth consumption over the entire span of life. Modigliani and Brumberg (1954) assume that individuals maximize their lifetime utility by allocating lifetime discounted income to consumption in various spans of their life-cycle by using capital market to equalize the discounted marginal utility of consumption in each period, assuming diminishing marginal utility in each period. So the crucial assumptions in deriving aggregate consumption, and hence the saving function,

² Modigliani and Brumberg (1954), Ando and Modigliani (1963)

hinge upon individuals' utility function and the age structure of population (Ando and Modigliani, 1963). According to the LCH, households save during their working-age life and dissave during retirement period (Modigliani, 1986) to support their consumption at the habitual standard during retirement.

The LCH is an extension of two-period neo-classical model to a multi-period context. In its general form the LCH assumes that an agent's lifetime utility depends on current consumption and future consumption and assets to be bequeathed. Mathematically this can be written as

$$U = U(c_t, c_{t+1}, \dots, c_L, a_{L+1}) \quad (2.1)$$

where U is utility, c_t is consumption of the individual during t -th period, a is assets and L is the lifespan of economic significance, therefore a_{L+1} is the assets to be bequeathed. The individuals want to maximize this utility function subject to their budget constraint, which is expressed as follows:

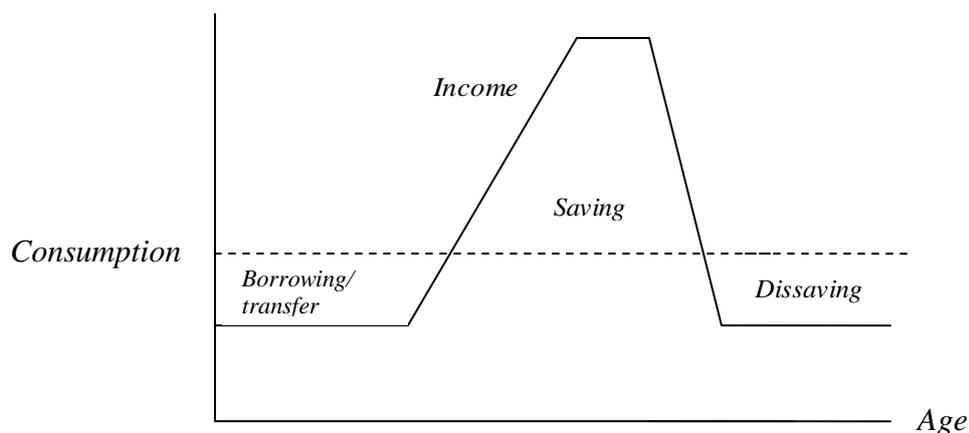
$$a_t + \sum_{i=1}^N \frac{y_i}{(1+r)^{t+1}} = \frac{a_{L+1}}{(1+r)^{L+1}} + \sum_{i=1}^N \frac{c_i}{(1+r)^{t+1}} \quad (2.2)$$

where N is the earning span, y_t and c_t are expected income and planned consumption expenditure in the t -th year for $\tau > t$.

In deriving equation (2.2) Modigliani and Brumberg (1954) assume that price of consumables and the interest rate (r) are not subject to change appreciably over the balance of the lifespan. The left hand side of Equation (2.2) is the present value of total wealth, which is the sum of wealth at period t and the present value of expected income. The right hand side of the equation represents present value of the sum of planned consumption and wealth at period $(L+1)$. Now, if the current income ($y_t + ra_t$) is greater than current consumption (c_t), then individual will save and the vice versa. Similarly, if the expected income ($y_\tau + ra_\tau$) is greater than the planned consumption (c_τ), then individual will be planning to save at age τ and *vice versa*. The LCH makes the assumption that the income stream of an

individual is relatively low at the beginning and the end of their lifespan and relatively high in their mid-life. Diagrammatically this is shown in Figure-2.3.

Figure 2.3: Life-cycle income, consumption and saving



Source: Jones (2008)

The aggregate private saving in an economy largely depends upon the number of people who are at their prime working-age. If the share of working-age population dominates the population structure, private saving will be higher. At the early and the late stage of life span current consumption is greater than the current income [$(y_t + ra_t) < (c_t)$], so people will dissave, and at their working life stage current income is greater than current consumption [$(y_t + ra_t) > (c_t)$], so they will save.

‘At this level of generality, the standard model has no empirical content and is best thought of as a framework for organizing thinking about saving and consumption (and other) decisions. It is only when researchers begin imposing particular structure on the general model that they can generate empirical predictions’ (Browning and Crossley, 2000:2). The empirical validity of the model has been extensively examined since its development and it remains ‘close to the core of analyses of the effects of rapid population growth upon economic growth and development’ (Conroy, 1979:425). Several studies conducted in the spirit of the LCH have confirmed that demographic structure of an economy can largely explain the variation of its saving rate.

Dependents are those cohorts of the population whose earnings are less than their consumption [in case of extreme dependents [$(y_t + ra_t) = 0$ and $c_t > 0$]. According

to the LCH dependents should dissave to smooth their consumption. However, as they do not have any income, their dissaving implies less saving of the working group. Therefore, countries with high dependency rates will have lower aggregate saving. The adverse effect on saving of high dependency rate has serious implication for underdeveloped countries that are generally characterized by high population growth and high dependency rate. High dependency rates in these countries limit the economy's ability to respond to the needs for saving and investment for development. With the proposition of the LCH in hand, one should be able to find that differences in saving rates across countries are associated with the differences in demographic characteristics.

Leff (1969) presents such evidence encompassing forty-seven underdeveloped, twenty developed and seven eastern European communist countries, a total of seventy-four countries. The study finds statistically significant negative relationships between dependency rate and saving ratio as well as per capita saving. Conroy (1979) finds that potential differences in steady-state saving rate might be attributable to the differences in mortality and fertility rates across nations. This author reaches this conclusion from the comparative study between Peru and the USA. The US estimates are taken from Tobin (1967) and the comparable estimates for Peru is prepared from data taken from the 1970 Multipurpose National Survey conducted by *Centro Estadístico de Estudios de Mano de Obra*, Arriaga (1966), Keyfitz and Flieger (1968) and Shryock and Siegel (1973). A similar result is found by Higgins (1998). Drawing on time-series and cross-section data for 100 countries Higgins finds a substantial demographic effect on national saving, with increases in young and old-age dependency ratios associated with lower saving rates.

One of the basic propositions of the LCH is that people save during their working age and dissave in retirement. However, microeconomic evidence on household saving by age shows that dissaving by the elderly is seldom observed (Jappelli and Modigliani, 2003). This gives rise to suspicion on the validity of the LCH. For example, Poterba (1994) argues that, even after retirement the median saving rate in almost all nations is positive and concludes that evidence provided by country studies lend little support in favor of the LCH of saving.

Jappelli and Modigliani (2003) refute the attack on the ground that the problem is not with the LCH; rather it is with the measurement of saving. In their own words ‘...individuals have forgotten that there are multiple ways of defining income and consumption, and hence numerous ways of measuring saving, which is essentially the differences between the two’ (Jappelli and Modigliani, 2003:8). They use Italian repeated cross-sectional data from 1989 to 2000 and show that when proper adjustment is made to arrive at income and saving figures implied by the LCH, saving and wealth over the life cycle exhibit the characteristics postulated by the LCH and the behavior of elderly saving follows the pattern implied by the LCH.

A study by Lee *et al.* (2000) shows that aggregate saving rates and wealth change during the demographic transition, given that the life-cycle considerations entirely determine saving before, during and after the transition. They simulate a model on Taiwanese economy and their simulation starts from 1800 to allow convergence to the steady state before the demographic transition begins. These authors, however, report their results for 1900-2050. In some cases they avoid taking into account the loss of capital during the World War II and report the results for 1950-2050 only. The overall finding of their study shows that life-cycle saving behavior operated well through the demographic transition and accounts for a substantial rise in the saving rate and for a high level of the saving rate in Taiwan.

China is one of the fastest growing economies in the world today. In the early 1990s, the Chinese personal saving rate was around 30 percent of GDP. However, over the period 1958-75 this rate becomes quite low, 5.3 percent of GDP (Modigliani and Cao, 2004). The LCH of consumption and saving is forwarded as an explanation of this Chinese saving puzzle in Modigliani and Cao (2004). They suggest that the major systematic determinants of private saving rate are income growth and demographic structure of the economy, ‘while per-capita income, the traditional and commonsensical explanation counts little’ (Modigliani and Cao, 2004:166). State level population policy after the 1970s to limit the number of children per family results in ‘drastic decline in the ratio of people under fifteen years to working population from 0.96 in the mid-70s to 0.41 at the turn of the century’ (Modigliani and Cao, 2004:166). This structural shift of Chinese demography causes the saving rate to increase.

The share of aged population (those aged 65 or older) in Japan is growing at the fastest rate in human history (Horioka *et al.*, 2007). In 1980 the share of aged population in Japan was around 9 percent and increased to more than 18 percent in 2002 (The World Bank, 2004). In 2006 this figure reached at 20.6 percent (Horioka *et al.*, 2007). The effect on household saving rate of this demographic structure is examined in Horioka *et al.* (2007). They show that Japan's population structure can explain the level of its household saving rate and also the past and future trends of household saving. They also suggest that Japan's aging population is causing the saving rate to decline and this decline is expected to continue. Horioka (2009) also concludes that Japanese household saving will continue to decline due to the rapid aging of its population.

Beside country-specific studies, the effect on the saving rate of population structure has also been evidenced in cross-country studies, for example, Bosworth and Chodorow-Reich (2007). These authors use a panel data set of 85 countries covering 1960-2005 and investigate the macroeconomic linkages between national rate of saving and investment and population aging. Their findings suggest that there is a significant correlation between the age composition of the population and saving and investment. Further, they note that demographic change is already exerting a downward pressure on saving in the high-income countries.

Thus, it is evident that population structure plays a significant role in determining the saving rate of an economy. Given this evidence one could logically argue that population structure, through its impact on saving, affects the capital flow of an economy. When an economy has more saving than required for its investment, it exports the excess saving abroad. Further, an economy having a shortage of saving, imports it from abroad. The next section reviews some studies in regard to population dynamics and capital flows.

2.3: Population structure and capital flow

Studies concerning the age structure and capital flow mainly focus on the link between the dependency rate and saving, along with the resulting capital flow. If the share of dependents, youth and old, is higher compared to the share of economically active population, most of the share of income goes to consumption and the result is lower saving. This implication of high dependency rate for

saving, investment and economic growth is first noted by Coale and Hoover (1958) in their study of India and the idea has come to be known as the *dependency hypothesis*, which emanates from the LCH. 'In the early stage of high fertility and rapid population growth, the average household is likely to be very young and therefore able to obtain only low or even negative saving rates. In the middle stages of declining fertility and maturing populations, the average household is likely to be middle-aged and therefore able to obtain a high and positive saving rate. In the late stages, older household may dominate, and therefore low saving rates may again characterize the economy'. (Taylor and Williamson, 1994:354).

Less developed or developing countries, especially Asian countries, attract much attention of researchers on the issues relating to age structure, saving and capital flows because of their large population size. However, the *dependency hypothesis* has equally been successful in application to developed countries. For example, between 1830 and 1900 the USA saving rate increased from 16 to 22 percent (Lewis, 1983). A number of explanations are forwarded for the rise in saving rate during this period. However, the convincing one comes from Lewis (1983). Lewis develops a life-cycle model with children as assets and shows that the rise in the saving rate in the USA can fairly be attributed to the decline in the dependency rate over the same period.

The dependency hypothesis can easily be extended to explain capital flows between two countries when their dependency ratios differ. If the dependency ratio of a country is higher than that of the other, then saving of the former is lower than that of the later. This will cause capital to flow from a low dependency ratio country to the higher one, with all other things equal.

Taylor and Williamson (1994) empirically show that the capital flow during the late nineteenth century, specifically from 1870 to 1913, from the Britain (the authors term it as the *Old World*) to Argentina, Australia, Canada and the United States (the authors refer them as the *New World*) can substantially be explained by the dependency gap between the Old and the New Worlds. Dependency ratios in the New World were higher than those of the Old World. 'Around 1900, the gap

was 7.7 percentage points for Argentina, 2.7 for Australia, 2.0 for Canada and 1.8 for the United States' (Taylor and Williamson, 1994:353). The authors find statistically significant support for the dependency hypothesis in three New World countries (Argentina, Australia, and Canada) and conclude that low savings caused these countries to import capital from the Old World, which they call the *intergenerational transfer* of capital.

Higgins and Williamson's (1997) work on the Asian dependency burden and foreign capital dependency provide further support for the dependency hypothesis. Their findings show that the Asian countries were net importers of foreign capital in the early 1950s, when the dependency burden (youth and old) of these countries was high, and they became the exporters of capital in the 1990s, when their dependency rates declined. In their econometric analysis covering the period from 1950 to 1992 these authors estimate saving and investment functions and find that changing age distribution of Asian countries exerts statistically significant impact on saving and investment rates. They also fail to accept the hypothesis that the demographic coefficients in saving and investment equations are equal, which implies a statistically significant link between demographic effects and net capital flow. This link emerges from the identity: National savings = Investment + Current Account Balance.

A panel study by Higgins (1998) also finds that the age distribution has significant impact on national saving and current account balance. Higgins examines the impact of age distribution in 100 countries on national saving and current account balance over the period from 1950 to 1989. His estimation results show that a higher (lower) dependency rate is associated with a lower (higher) national saving and a lower (higher) current account balance, that is, higher (lower) capital inflow.

Brooks (2000) uses an overlapping generations (OLG) model to simulate the global demographic transition over the period 1770 to 2230. The population dynamics over this period are calibrated to match the historical and projected data. The study predicts a significant change in global saving-investment balance around 2010. Due to population aging, the European Union and North America are forecast to experience a significant shortage of saving relative to investment at

this time, which will be financed by capital inflow from the developing world. Feroli (2003) conducts a similar study among G-7 countries and finds that demographic differences among major industrial countries over the past 50 years can explain some of the observed long-term capital movements in these countries, particularly, the timing of American current account deficit. Further, Japanese current account surpluses are explained by its demographic structure relative to other countries in the sample.

Although international capital flows are affected by a host of factors, Domeij and Flodén (2006) ignore those factors and use a model where all capital flows are generated by changes in countries' population structure. These authors use a standard neoclassical model consistent with the life-cycle theory of consumption and saving and calibrate the model with population data and projections for 18 OECD countries to examine if the data generated by the model explain the real world capital flows. Their population database is from the United Nations (2002) ranging from 1950 to 2050. Findings of this study suggest that the model can explain a substantial part of capital flows at low frequencies.

Most studies assume that demographic structure is an exogenous process. However, Kim and Lee (2007) allow demographics as an endogenous variable in their panel VAR estimation. They estimate the effects on saving and current account balance of demographic changes in East Asian countries between 1981 and 2003. They find statistically significant strong negative association between the dependency rate and the current account balance. This implies that a higher dependency rate is associated with higher capital inflows in these countries. Their study also suggests that the rapidly aging population and the resultant increase in the dependency rate in East Asia over the next decade might cause a significant decline in saving rate and deterioration in current account balance, or in other words, increase in capital inflow.

2.4: Purchasing power parity and the real exchange rate

Empirical findings of the research on the relationship between age structure and saving fairly support the theoretical prediction of the LCH that population dynamics play an important role in determining an economy's rate of saving. The macroeconomic savings-investment identity implies a corresponding flow of

capital required to maintain this identity when population structure causes any imbalance by affecting savings. A host of empirical studies confirms this implication of population dynamics for capital flows. Thus, it can be argued that macroeconomic variables that are affected by capital flows are also affected by the population structure of the economy. One such variable is the real exchange rate.

There is a vast literature dealing with the behaviour of the real exchange rate. The whole literature can conveniently be divided into two groups; one group is concerned with the stationarity of the real exchange rate (e.g. Baillie and Selover, 1987; Corbae and Ouliaris, 1988; Enders, 1988; Mark, 1990; Patel, 1990) and the other is concerned with the movement of the real exchange rate (e.g. Pakko and Pollard, 2003; Chen *et al.*, 2007). Stationarity of the real exchange rate is postulated in the famous Purchasing Power Parity (PPP) theory of exchange rate determination.

The PPP has its root in the *Law of one price*, which states that in the absence of such complicating factors as transportation costs, taxes and tariffs, any good that is traded in the world market will be sold in the same price in every country, when prices are expressed in a common currency. PPP is the generalization of this law by incorporating general price levels instead of the price of a single good. In its absolute form PPP states that the nominal exchange rate between the currencies of two countries should equal the ratio of the price levels of the two countries, that is,

$$E = \frac{P^h}{P^f} \quad (2.3)$$

where, E , P^h and P^f are nominal exchange rate (number of home currencies per unit of foreign currency), home price level and foreign price level respectively. However, this generalization of the *Law of one price* is restrictive. Two conditions must hold for this generalization-(i) price indices used to measure price levels must include same goods in each country, and (ii) weights assigned to the goods entering into the price indices must be same in each countries (Pakko and Pollard, 2003).

It is very unlikely that the above two conditions are satisfied across the countries, because goods and their weights are determined on the basis of actual

consumption or production shares. For this reason economists use another version of PPP, called the relative PPP hypothesis. The relative PPP hypothesis states that “exchange rate should bear a constant proportionate relationship to the ratio of national price levels” (Isard, 1995:58), that is,

$$E = k \frac{P^h}{P^f} \quad (2.4)$$

The real exchange rate is the nominal exchange rate adjusted for relative price levels and expressed as follows:

$$RER = E \frac{P^f}{P^h} \quad (2.5)$$

where, RER stands for ‘real exchange rate’. Now substituting (2.4) into (2.5), the following expression of the real exchange rate is obtained:

$$RER = k \frac{P^h}{P^f} \times \frac{P^f}{P^h} = k \quad (2.6)$$

where k is a constant. This expression shows that the real exchange rate is constant. If the absolute PPP formulation of (2.3) is used instead, the real exchange rate becomes 1 as follows:

$$RER = \frac{P^h}{P^f} \times \frac{P^f}{P^h} = 1 \quad (2.7)$$

Thus, it is seen that both formulations of PPP arrive at the conclusion that if PPP holds then the real exchange rate will be constant. Accordingly, empirical research has been concerned to verify if PPP holds, either in the long run or in the short run. If PPP holds then, either the nominal exchange rate, home price level and foreign price level will be cointegrated³, or alternatively the real exchange rate will be stationary or mean reverting.

³ Cointegration implies a long-run equilibrium relationship. For example, if two variables, say, x_t and y_t are individually non-stationary, but their linear combination is stationary, then it is said the variables are cointegrated and x_t and y_t are said to have long-run equilibrium relationship.

Taking logarithms in both sides of Equation (2.4) and letting lower case letters as logarithms, we get

$$e = p^h - p^f \quad (2.8)$$

In this formulation if p^h and p^f are individually non-stationary but their linear combination is stationary, it is said that the variables are cointegrated. This means the nominal exchange rate has a long-run equilibrium relationship with home and foreign price levels and this is what PPP implies. Some studies use the Engle-Granger two step method to determine whether a long-run equilibrium relationship holds. In this method, stationarity of each variable (here, nominal exchange rate, home price level and foreign price level) is tested and if they individually follow a random walk process then an equation of the following form is estimated

$$e_t = \beta + \alpha_0 p_t^h + \alpha_1 p_t^f + \mu_t \quad (2.9)$$

If the residual term (μ_t) is found stationary then PPP is said to hold.

Baillie and Selover (1987), Corbae and Ouliaris (1988), Enders (1988), Mark (1990) and Patel (1990) follow the Engle-Granger two steps procedure and find that the residual is non-stationary, which implies that the real exchange rate is not constant or mean reverting. However, Banarjee *et al.* (1986) note that this cointegration procedure suffers from several limitations such as small sample properties and in the presence of endogeneity and serial correlation, the asymptotic distribution of the estimates will depend on nuisance parameters. An alternative to this is the full information maximum likelihood method proposed by Johansen and Juselius (1988 & 1990). Studies that apply this method include Cheung and Lai (1993), Kugler and Lenz (1993), MacDonald (1993), MacDonald and Marsh (1994). All these studies report strong evidence of cointegration, which implies a constant real exchange rate.

Alternatively some studies use unit root test on the real exchange rate to examine its mean reverting property. In unit root test on any variable, say, x_t , the null hypothesis that x_t is not mean-reverting, instead follows a random walk is tested

against the alternative that x_t is mean-reverting. Let q_t be the real exchange rate, and then an equation of the following form can be used to test the mean reversion property

$$q_t = \alpha + \beta q_{t-1} + \varepsilon_t \quad (2.10)$$

If $\beta = 1$, then the process generating the real exchange rate contains a unit root, that is, the real exchange rate follows random walk.

Some argue that the random walk property of the real exchange rate is an implication of efficiency of international market, because prices and exchange rates reflecting all available information and all arbitrage opportunities are quickly exploited (Taylor and Taylor, 2004). Empirical studies employing this type of test on the real exchange rate data fail to reject the unit root hypothesis, for example Roll (1979), Darby (1980), Enders (1988) and Mark (1990). These findings indicate that PPP does not hold in the long run, which contradicts with the findings from cointegration analyses. This contradiction creates uncertainty as to how to model exchange rate.

Some authors cast doubt on the power of econometric test employed for detecting unit roots. For example, Frankel (1986 & 1990) makes the point that even if null of unit root cannot be rejected at a given significance level, it does not necessarily imply that the null then must be accepted. A short span of data is cited as the major source of such econometric findings. It is argued that if the real exchange rate tends to revert toward its mean in the long period, then studies covering short periods of time may not be able to detect such mean reversion property of the real exchange rate (Froot and Rogoff, 1995; Lothian and Taylor, 1996 & 1997). To overcome this small sample problem, some studies use panel data to examine the mean reversion property of the real exchange rate. The stylized result from the panel studies is that it takes around four years for half of a disturbance to PPP to reverse, which is too long to be consistent with the traditional PPP, where gravitational pull back to equilibrium is thought to be much faster than around eight years (MacDonald, 1998a).

Therefore, it is apparent from the literature that there is no unanimous empirical evidence that PPP holds in the long run. With regard to the mean reversion

property of the real exchange rate, evidence shows that either the real exchange rate is a random walk or the mean reversion speed is very slow. These findings inspired researchers to look for the factors that cause the real exchange rate to deviate from its mean.

Movements of the real exchange rate are deviations from PPP. One of the most cited reasons for deviation from PPP is the difference in weights that commodities carry in the price indices of home and foreign countries. Suppose there are two goods with prices p_1 and p_2 that enter into the price index with weights w_1 and w_2 respectively, overall price level is P at time t , then the price indices of home and foreign countries can be constructed as follows:

$$P^h = w_1^h p_1^h + w_2^h p_2^h \quad (2.11)$$

$$P^f = w_1^f p_1^f + w_2^f p_2^f \quad (2.12)$$

Now if the weights assigned to these commodities in home and foreign countries are not identical, that is, if $w_1^h \neq w_1^f$ and $w_2^h \neq w_2^f$, then the change in the relative price between these commodities will cause the price indices to diverge and PPP will not hold.

Another related problem is difference in the composition of the price indices across countries. Some studies take care of this problem by using the price of McDonald's Big Mac sandwich to test the validity of PPP. The attractive feature of Big Mac as an indicator of PPP is its uniform composition. With few exceptions, the Big Mac is same everywhere around the world. However, the results with this indicator are not unanimous. Pakko and Pollard (2003) do not find any result superior to the studies that use other measures. They note 'the Big Mac sandwich does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures' (Pakko and Pollard, 2003:22). Chen *et al.* (2007) find support for long run PPP using Big Mac prices, whereas when the consumer price index (CPI) is used, PPP is rejected.

The foregoing discussion makes it clear that the long-run validity of the PPP hypothesis is not well documented in empirical research. In other words, the mean

reversion property of the real exchange rate, implied in PPP theory, does not find that much support empirically. Therefore, researchers have looked for other factors that might help to explain the movement of the real exchange rate. One such effort is to explain the movements of the real exchange rate by the most cited Balassa-Samuelson effect. The Balassa (1964) and Samuelson (1964) analyses of the real exchange rate is an extension of two-goods, two-country model of international trade by introducing non-traded goods. When non-traded goods enter into the price indices at home and abroad, then, as non-traded goods are not arbitrated between countries, any differences between their prices at home and abroad can generate deviation from PPP.

Let the price levels of two countries at period t are p_t^h (home country price) and p_t^f (foreign country price). These prices can be decomposed into their traded (p^T) and non-traded (p^{NT}) components as follows:

$$p_t^h = \alpha_t p_t^{hT} + (1 - \alpha_t) p_t^{hNT} \quad (2.13)$$

$$p_t^f = \alpha_t^f p_t^{fT} + (1 - \alpha_t^f) p_t^{fNT} \quad (2.14)$$

where, α and $(1 - \alpha)$ are the share of traded and non-traded goods in price indices. With the decompositions in (2.13) and (2.14) and the definition of the real exchange rate in (2.5), the following expression of real exchange rate (q_t) can be obtained:

$$q_t = q_t^{hT} + (\alpha_t^h - 1)(p_t^{hT} - p_t^{hNT}) + (1 - \alpha_t^f)(p_t^{fT} - p_t^{fNT}) \quad (2.15)$$

The Balassa-Samuelson analysis assumes that the law of one price holds continuously. Therefore, the first term in the right hand side of (2.15) will be zero. Under some assumptions, such as one limiting factor (labor), constant input coefficient and constant marginal rate of substitution, the relative price of non-traded goods will be higher in the country with higher productivity levels than in the other (Balassa, 1964). Accordingly a country with relatively high productivity will have an appreciated real exchange rate and the *vice versa*.

Empirical evidence on the Balassa-Samuelson effect has been mixed. Studies that find evidence in favor of the Balassa-Samuelson effect include Heish (1982), Martson (1987), and De Gregorio *et al.* (1994). Among others, Froot and Rogoff (1991) and Asea and Mendoza (1994) do not find any support for this effect. However, Rogoff (1996) opines that there is substantial support for the Balassa-Samuelson hypothesis. Although this effect has been well documented for the industrial countries (Montiel, 1999), recently Choudhri and Khan (2005) find support for this effect in developing countries as well.

In international finance literature, the real interest rate differential is cited as the equilibrating factor of the real exchange rate between its current and long-run equilibrium value. The benchmark real exchange rate model using the real interest rate differential is as follows:

$$q_t = E_t(q_{t+k}) - (r^h - r^f) \quad (2.16)$$

where, q_t is the real exchange rate in the current period, $E_t(q_{t+k})$ is the expected real exchange rate in period $(t+k)$ and $(r^h - r^f)$ is difference between real interest rate at home and abroad. It is common practice to assume the unobservable $E_t(q_{t+k})$ as the long run equilibrium exchange rate (MacDonald, 1998a).

Re-writing the equation (2.16) with $E_t(q_{t+k})$ in the left:

$$E_t(q_{t+k}) = q_t + (r^h - r^f) \quad (2.17)$$

This equation shows that if foreign real interest rate is higher than that of home, then the equilibrium real exchange rate will be lower than the current real exchange rate. This will happen because arbitragers will attempt to take the advantage of higher interest rate abroad, fund will flow out and currency will depreciate. The opposite will be the case when $r^h > r^f$.

Empirical findings on this formulation of the real exchange rate are lopsided towards rejecting the long-run relationship between the real interest rate differential and the real exchange rate. For example Meese and Rogoff (1988), Edison and Pauls (1993), and Throop (1992) find no evidence of cointegration

between the real exchange rate and the real interest rates differential. These studies use Engle-Granger (1987) two-step method of cointegration. Some studies employ the maximum likelihood method proposed by Johansen and Juselius (1990) and find still mixed results, such as Johansen and Juselius (1992), MacDonald (1998b), and Edison and Melick (1999). Some more recent studies use panel cointegration techniques to see if there is any long-run equilibrium relationship between the real exchange rate and real interest rate. However, these results are also inconclusive (*i.e.* Narayan and Smyth, 2006).

Failing to get strong evidence on stationarity, some researchers (Meese and Rogoff, 1988; Edison and Pauls, 1993; Coughlin and Koedjik, 1990; MacDonald, 1998a; Clark and MacDonald, 1998) attempt to explain the movements of the real exchange rate by such macroeconomic fundamentals as productivity effects, fiscal imbalances, net foreign asset, terms of trade effects. The results are mixed. Some studies, such as Meese and Rogoff (1988), Edison and Pauls (1993), and Coughlin and Koedjik (1990) do not find any evidence of cointegration. However, another group of studies, such as MacDonald (1998a), Clark and MacDonald (1998) find evidence of cointegration between the real exchange rate and the above variables.

Studies so far reviewed are based on developed countries. Some studies also look into the issue from developing countries' context. The most notable study in this line is that of Edwards (1988). This study finds a significant relationship between the real exchange rate and other real variables (such as terms of trade, government expenditure, trade openness and capital flows) in the long run and between the real exchange rate and nominal variables (such as money supply, domestic credit etc.) in the short run. Almost all studies on the real exchange rate in developing countries find that macroeconomic variables, such as the terms of trade, capital flow, openness to trade and domestic credit, have significant impact on the movement of the real exchange rate (for example, Cottani *et al.*, 1990; Ghura and Grennes, 1993; Elbadawi, 1994; and Razin and Collins, 1997).

After a brief review of the real exchange rate literature above, the next task is to show whether international capital flows have significant influence on the real exchange rate to validate the claim that the population structure affects the real

exchange rate through a change in saving and thereby capital flows. The seminal paper by Salter (1959) makes the point that the real exchange rate responds to international capital flows. Salter maintains that international capital inflow increases expenditure, a part of which falls on non-traded goods, resulting in an appreciated real exchange rate.

Edwards (1998) argues that the exact way in which capital flow will impact the real exchange rate depends on the exchange rate regime in operation. Under a fixed exchange rate a capital inflow will result in domestic monetary expansion and higher inflation, which will appreciate the real exchange rate. Under flexible exchange rate capital inflow will result in nominal as well as real appreciation.

According to Athukorala and Rajapatirana (2003) if a country relies on foreign capital for maintaining a high level of domestic absorption its real exchange rate will appreciate regardless of the exchange rate regime. The majority of the empirical studies find a significant appreciating effect on the real exchange rate of capital inflows in the developing countries' context, such as, Edwards (1998); Elbadawi and Soto (1994); Dabós and Juan-Ramón (2000) and Athukorala and Rajapatirana (2003). Similar results are found in case of developed countries as well, such as Sachs (1981).

2.5: Population structure and the real exchange rate

From the above discussion the channel of impact from population structure to the real exchange rate may be depicted as follows: an economy with larger share of economically active population experiences higher savings, which causes capital to outflow, and when capital flows out, the real exchange rate depreciates. However, this influence on the real exchange rate of population structure has hardly been empirically tested directly.

The pioneering attempt to link population with the real exchange rate is taken by Cantor and Driskill (1999). They investigate the effects of changes in birth/death rates and changes in fiscal policy on the real exchange rate within the framework of an overlapping generations (OLG) model. They show that the effect of

demographic change on the real exchange rate comes through the change in steady-state net foreign indebtedness as a result of change in birth/death rate.

The steady-state net foreign indebtedness (\bar{F}) is defined as

$$\bar{F} = \left(\frac{Z - \tau}{r^* + \theta} \right) \left(\frac{r^* - \rho}{r^* - \theta - \rho} \right) \quad (2.18)$$

where $Z, \tau, r^*, \theta,$ and ρ represent fixed domestic output, aggregate lump-sum tax, foreign short-term interest rate, probability of death, and domestic rate of time preference respectively. To get the demographic effect the authors differentiate the above equation with respect to θ to obtain

$$\frac{\partial \bar{F}}{\partial \theta} = \frac{(2\theta + \rho)(r^* - \rho)(Z - \tau)}{(r^* + \theta)^2 (r^* - \theta - \rho)^2} \quad (2.19)$$

Cantor and Driskill (1999) define a country as net debtor or net creditor on the basis of r^* and ρ . If $\rho > r^*$, then the country is defined as net debtor, while if $\rho < r^*$, the country is defined as net creditor. For a net debtor country, an increase in θ decreases net foreign indebtedness, that is, $\frac{\partial \bar{F}}{\partial \theta} < 0$ and for a net creditor country an increase in θ increases net foreign indebtedness, that is, $\frac{\partial \bar{F}}{\partial \theta} > 0$.

These changes in foreign indebtedness lead to change in national saving and the real exchange rate. Although the model addresses the issue of demographic change, it is primarily built around the effects of fiscal actions on saving and the real exchange rate. In order to identify the effect of demographic structure on the real exchange rate a detailed and more focused model is warranted.

Andersson and Österholm (2005) focus specifically on the link between the real exchange rate and population structure in the Swedish economy. They use quarterly data over the period March 1960 to March 2002. For the real exchange rate, this study uses the Total Competitive Weight (TCW) index. For demographic

data the authors convert yearly data to quarterly by using a linear interpolation. Total population is divided into six age-groups: children (0-14), young adults (15-24), prime aged (25-49), middle-aged (50-64), young retirees (65-74) and old retirees (75 and above). The authors regress the real exchange rate on these six age groups as follows:

$$\ln(Q_t) = \alpha + \beta_1 1524_t + \beta_2 2549_t + \beta_3 5064_t + \beta_4 6574_t + \beta_5 75_t + \gamma_1 D_{1982} + \gamma_2 D_{1992} + \varepsilon_t \quad (2.20)$$

where, Q_t is the real exchange rate and the age groups are indicated by the numbers, for example young adult age group is indicated by 1524_t and so on. D_{1982} and D_{1992} are dummy variables used to capture the aggressive devaluation in 1982 and the shift of exchange rate regime from fixed to floating in 1992 respectively. In this specification the children group is excluded from the regression to avoid perfect multicollinearity, because the sum of all age groups is one.

Andersson and Österholm's (2005) OLS estimation yields expected result. They find that young adults, young retirees and old retirees group, who borrow or dissave, have an appreciating effect on the real exchange rate, whereas the prime and middle age group, who are productive and save and thereby generate capital outflow, have a depreciating effect on the real exchange rate. With this significant relationship between age structure and the real exchange rate, the study proceeds further to evaluate the forecasting ability of the age structure. The authors also perform the forecasting exercise with a dynamic autoregressive (AR) model. Out of these two forecasts, the one with age model and the other with AR model, they find that the age model captures the real exchange rate trend better than the AR model. Based on these findings the authors conclude that age structure could be a useful factor in forecasting the medium and long-term trend in Swedish real exchange rate.

The Andersson and Österholm (2005) study explicitly incorporates different age groups in the regression model to examine their effects on the real exchange rate and finds the results that are consistent with their prediction. However, some of their econometric results cast doubt on the accuracy of their model specification, such as finding an adjusted R^2 greater than the Durbin-Watson d statistic. Granger

and Newbold (1974) suggest that if in any regression the value of R^2 exceeds the Durbin–Watson (DW) d statistic, then it is very likely that the estimated regression suffers from the problem of spurious regression. The authors also admit that the age model is not a complete description of everything that affects the real exchange rate. There are other macroeconomic factors that should be considered while explaining the behavior of the real exchange rate. Moreover, the study is on the Swedish economy only, which may not be suitable for other countries. However, this deficiency is taken care of by the same pair of authors in their subsequent panel study in 2006.

Andersson and Österholm (2006) look into the same issue for a panel of 25 OECD countries with annual data over the period 1971-2002. They divide the population into six age groups as they did in their Swedish study, that is, children (0-14), young adults (15-24), prime aged (25-49), middle-aged (50-64), young retirees (65-74) and old retirees (75 and above). They estimate three regressions as follows:

$$Q_{i,t} = \alpha + \beta_1 1524_{i,t} + \beta_2 2549_{i,t} + \beta_3 5064_{i,t} + \beta_4 6574_{i,t} + \beta_5 75_{i,t} + \varepsilon_{i,t} \quad (2.21)$$

$$Q_{i,t} = \alpha + \beta_1 1524_{i,t} + \beta_2 2549_{i,t} + \beta_3 5064_{i,t} + \beta_4 6574_{i,t} + \beta_5 75_{i,t} + \mu_i + \varepsilon_{i,t} \quad (2.22)$$

$$Q_{i,t} = \alpha_i + \beta_1 1524_{i,t} + \beta_2 2549_{i,t} + \beta_3 5064_{i,t} + \beta_4 6574_{i,t} + \beta_5 75_{i,t} + \varepsilon_{i,t} \quad (2.23)$$

where regression Equations (2.21), (2.22) and (2.23) are pooled, random effects and fixed effects models, respectively. Like the previous study age groups are indicated by the numbers in this study as well, for example young adult age group is indicated by 1524_t . In the above equations, only the age data are included as independent variables, therefore, these can be seen as reduced-form representations, where all the effects that different age groups have on the real exchange rate through other factors (such as public and private saving and consumption, GDP growth, inflation, real interest rate) are taken into account.

Estimation of regression Equations (2.21), (2.22) and (2.23) yield results as per the authors' expectation. In all three specifications, they find that the prime and middle age groups exert depreciating effects on the real exchange rate. These two groups are characterized by family raising and high productivity. They save for

retirement, thereby generating capital flow out of the country that has a depreciating effect. No significant influence is observed from young adults and young retirees, however, the coefficient of old retirees is significantly positive, implying their positive effect on the real exchange rate that comes through their dissaving behavior.

Although this study includes 25 countries and the authors claim that their age model has substantial explanatory power for the real exchange rate, the econometric results do not seem to support their claim. For example, R^2 of different models varies between 0.082 and 0.273, which does not seem to be quite impressive. No model specification test is provided. Moreover, the fixed-effect model allowing for AR(1) shows that the errors are serially correlated. So, it can be said that their models might have suffered from a misspecification problem. The authors also note that only age shares are not enough to capture the complete dynamics of the real exchange rate.

Recently, Aloy and Gente (2009) develop a model in order to examine the effect of demography on the real exchange rate in the context of Japanese economy. In this model, a theoretical link is built through an OLG model between population growth and the real exchange rate. As population growth in Japan has been falling over the last couple of decades, the authors emphasize the fall in population growth, which is represented by a fall in birth rate.

With falling birth rate, the share of the new-born agent determines the aggregate wealth. However, the change in financial wealth depends on the net financial position of the country in question. If the country is a creditor one, the fall in population growth will increase financial wealth, whereas financial wealth will decrease in case of a debtor country. An increase (decrease) in financial wealth followed by fall in population growth leads to increase (decrease) in consumption causing the real exchange rate appreciation (depreciation). Aloy and Gente (2009) test this theoretical prediction with bilateral real exchange rate between Japanese Yen and the US dollar over the period 1966-2001 and find that this theoretical prediction is significantly supported by their empirical findings.

Although Aloy and Gente (2009) focus on the real exchange rate, some observations are in order. First, this study is on Japanese economy only. So, it need not be representative for all countries of the phenomenon under consideration. Second, the share of working-age population or dependency ratio seems to be a more relevant variable than population growth. This is because previous studies have shown that age structure has significant influence on saving in an economy. In the case of Japan the population growth rate has given significant result because of its rapidly aging population. It may not be the case for other countries that are not experiencing so rapid change in population growth. Third, the study considers only three variables; population growth rate, productivity level and world interest rate. However, in case of Yen/Dollar bilateral real exchange rate, the US trade deficit with Japan has also been cited as one of the major factors for Yen's real appreciation against Dollar (Rahman *et al.*, 1997). This has not been considered by Aloy and Gente (2009). Thus a general study encompassing a large of number countries is warranted to substantiate the claim that demography plays significant role in the determination of real exchange rate.

Therefore, it is seen that although the literature on the determinants of the real exchange rate is quite rich, research on its relationship with population structure is at a very preliminary stage. There is enough scope to examine the impact of population structure on the real exchange rate after allowing for the impacts of other variables that have been suggested in previous studies as important determinants of the real exchange rate.

2.6: Population structure and investment

The literature reviewed above focuses on the saving channel through which population structure affect capital flows and the real exchange rate. However, capital flows can also be influenced by the investment channel. Different cohorts of population affect investment differently.

Long ago, Sweezy (1940) points out that population growth might affect investment opportunities. For example, a population having high proportion of

dependents may be expected to have a relatively high propensity to consume. He notes that growing population ‘directs a relatively large proportion of its expenditure toward goods and services which require relatively heavy capital outlays for their production’ (Sweezy, 1940:66).

However, a more formal and direct link between age structure and investment can be found from a neo-classical production function. The standard Cobb-Douglas production function implies that a fall in the number of workers raises the wage and decreases the return to capital by raising marginal product of labour and decreasing marginal product of capital, respectively. Ludwig *et al.* (2007) find that due to aging population, the productivity of capital in major industrialized countries falls and wage rises. Their simulation results show that the rate of return on capital can be expected to fall by about 80 to 90 basis points until 2050 with a corresponding increase in wage. As, in the world of free capital mobility, capital flows from low-return to high-return locations (Chatterjee and Naknoi, 2007), the fall in return on capital would cause capital outflow and the real exchange rate to depreciate.

Thus, there is potential source of avenue that links population age structure to the real exchange rate through the former’s influence on investment. This channel of influence has not been yet explored in the literature. The challenge of examining both saving and investment channels is that no certain outcome is predictable. It depends on the relative influence of saving and investment on capital flows.

2.7: Conclusion

This chapter reviews some previous studies on population structure, saving, investment, capital flows and the real exchange. Population structure affects private saving as depicted in the *life-cycle hypothesis*. People save more in their working age and dissave in their old age to smooth consumption over their entire life span. Thus the saving of an economy is affected by the age composition of its population.

In an open economy disequilibrium between saving and investment is taken care of by capital flows. If saving is greater than investment, capital flows out and capital flows in for the opposite case. These capital flows have considerable impacts on the real exchange rate. Capital inflow has an appreciating effect on the real exchange rate, while capital outflow has a depreciating effect.

In addition to saving, population structure also affects investment in an economy. Investment opportunity affects capital flows and the real exchange rate. However, the direction of influence of age structure on capital flows through saving channel may be different from that of investment channel. As such impact on the real exchange rate is not certain *a priori*.

There is some empirical research on the link between population structure and the real exchange rate. However, these studies are either flawed due to misspecification and incomplete modeling or dated or both. Given the important policy implications of this link between population age structure, saving, investment, capital flow and the real exchange rate, a detailed study with an appropriate methodology and recent data is warranted. The next chapter develops an analytical framework of the relationship between population structure and the real exchange rate.

Chapter 3

Population Structure and the Real Exchange Rate: Theoretical Framework

3.1: Introduction

This chapter explores the theoretical relationship between age structure and the real exchange rate by incorporating the age structure in a model of the real exchange rate. As age structure is supposed to influence both saving and investment, both of these avenues are taken into consideration while exploring this relationship.

Population age structure influences saving in an economy, which in turn affects capital flows and the real exchange rate. For example, higher working-age population gives rise to high saving which causes capital outflow and the real exchange rate to depreciate. Age structure also affects investment. Higher working-age population raises marginal product of capital and causes capital inflows, which appreciates the real exchange rate. Therefore, *a priori* the impact of working-age population on the real exchange rate is uncertain.

The rest of the chapter proceeds as follows: a model of the real exchange rate is discussed in section 3.2. Section 3.3 provides theoretical justification of including demographic variables in the model of the real exchange rate discussed in section 3.2. Section 3.4 discusses how age structure influences investment, capital flows and thereby the real exchange rate. The hypotheses of the study are discussed in section 3.5. The chapter concludes in section 3.6.

3.2: A model of the real exchange rate

In this section a model of the real exchange rate is developed following Edwards (1988). The model also significantly draws on Drine and Rault (2003). We assume a small open economy, so the economy is a price taker in the international market. It is also assumed that the economy is in long-run equilibrium or at the full employment output level. The government budget is assumed to be balanced. The balanced budget assumption allows the analysis of domestic saving in terms of private saving only, *i.e.*, any change in private saving is interpreted as a change in

domestic saving. There are three goods in this model: (i) exportables (X), (ii) importables (M), and (iii) non-tradables (N). However, productivity differential between tradable and non-tradable sector (Balassa-Samuelson effect) is not explicitly modeled here.

The economy produces two goods: non-tradables (N) and exportables (X) and the residents of the economy consume two goods: non-tradables (N) and importables (M). The nominal exchange rate (number of units of domestic currency per foreign currency), domestic price of exportables, price of non-tradables, world price of importables and world price of exportables are denoted by E, P_X, P_N, P_M^* , and P_X^* respectively.

It is assumed that the country follows a freely floating exchange rate policy. Domestic price of exportable goods is $P_X = EP_X^*$. The world price of exportable is normalized to one, that is, $P_X^* = 1$ so that $P_X = EP_X^* = E$. Domestic relative price of importables with respect to non-tradables is given by $e_M = \frac{P_M}{P_N}$ and domestic

relative price of exportables with respect to non-tradables is given by $e_X = \frac{E}{P_N}$.

The relative world price of importable with respect to non-tradable is given by $e_M^* = \frac{EP_M^*}{P_N}$. Consistent with the current wave of globalization, it is assumed

that the country imposes minimum tariff that can be ignored.

Total demand for private consumption (C) consists of consumption of importables (C_M) and non-tradables (C_N) and is given by

$$C = C_M(e_M) + C_N(e_M); \frac{\partial C_M}{\partial e_M} < 0, \frac{\partial C_N}{\partial e_M} > 0 \quad (3.1)$$

On the supply side, total supply (Q) is the sum of the supply of exportables (Q_X) and non-tradables (Q_N) and is given by⁴

$$Q = Q_X(e_X) + Q_N(e_X); \quad \frac{\partial Q_X}{\partial e_X} > 0, \quad \frac{\partial Q_N}{\partial e_X} < 0. \quad (3.2)$$

Government consumption demand (G) is given by

$$G = P_N G_N + E P_M^* G_M \quad (3.3)$$

where, G_N and G_M are government demand for non-tradables and importables, respectively. Total demand and supply of non-traded goods are given by $C_N(e_M) + P_N G_N$ and $Q_N(e_X)$ respectively.

The real exchange rate is defined as the relative price of tradables to non-tradables as follows:

$$rer = \alpha e_M + (1 - \alpha) e_X = \frac{E[\alpha P_M^* + (1 - \alpha)]}{P_N}, \quad 0 < \alpha < 1 \quad (3.4)$$

Interest on net foreign asset (NFA) of the economy is earned at the world interest rate r^* . The current account of the country (CA) in a given year is equal to the sum of the net interest earning on NFA and the amount of trade balance in foreign currency, which is defined as the difference between exports and the consumption of imports as shown in equation (3.5) below

$$CA = r^* NFA + Q_X(e_X) - P_M^* C_M(e_M) \quad (3.5)$$

Assuming away country and exchange rate risk, the capital flow can be expressed as follows:

$$CF = \overline{CF} + k(i - r^*) \quad (3.6)$$

where, \overline{CF} is the magnitude of capital flows caused by factors other than interest rate differential. Here it is assumed that demographic structure is one of the factors that affect capital flows, for example, a larger share of working-age

⁴ Supply can also be affected by productivity differential shocks. However, productivity differential between tradable and non-tradable sector (Balassa-Samuelson effect) is not explicitly modeled here.

population will cause capital outflow, whereas larger share of dependents will cause capital inflow. K is the interest responsiveness of capital flows to interest rate differential $(i - r^*)$. The change in foreign currency reserve (R) is given by

$$\Delta R = CA + CF \quad (3.7)$$

where CF is net capital inflows.

The real exchange rate is said to be in equilibrium if it leads to both external and internal equilibrium. A country is in external balance when its official reserves does not change, meaning that current account balance and net capital inflows in the long run sum to zero, that is, $\Delta R = CA + CF = 0$. So, we can write the external equilibrium condition as follows:

$$r^* NFA + Q_X(e_X) - P_M^* C_M(e_M) + CF = 0 \quad (3.8)$$

Internal equilibrium is defined in terms of equilibrium in non-tradable goods market which is given by

$$C_N(e_M) + P_N G_N = Q_N(e_X) \quad (3.9)$$

When both external and internal sectors are in equilibrium, the equilibrium real exchange rate can be expressed, from (3.8) and (3.9) above, as a function of P_M^* , r^* , NFA , \overline{CF} and G_N , i.e.

$$rer = f(P_M^*, r^*, NFA, \overline{CF}, G_N) \quad (3.10)$$

3.3: Saving, population structure and the real exchange rate

A theoretical linkage between the real exchange rate and demography comes from the relation between age structure of population and the resultant consumption and saving patterns in an economy as postulated in the *Life-Cycle Hypothesis* (LCH). According to the LCH, people smooth their consumption by saving during their working life and dissaving in the rest of the life until death (Modigliani and Brumberg, 1954). So in an economy, where the proportion of working population is greater than the proportion of the young or old dependents, saving will be greater than dissaving. Thus, the theory identifies the age structure of the population as an important determinant of consumption and saving behavior. 'If

the population were growing, there would be more young people saving than when the population is constant, thus more saving in total than dissaving, and there would be net saving in the economy' (Dornbusch and Fischer, 1994: 305). Similarly there will be net dissaving where population is falling. If aggregate saving does not exactly match domestic investments, there will be international capital flows, which will affect current account (Andersson and Österholm, 2005). This, in turn, will influence the real exchange rate.

'In the early stage of demographic transition per capita income growth is diminished by large youth dependency burdens and small working-age adult shares. There are relatively few workers and savers. As the transition proceeds, per capita income growth is promoted by smaller youth dependency burdens and larger working-age adult shares. There are relatively many workers and savers. The early burden of having few workers and savers becomes a potential gift later on: a disproportionately high share of working-age adults. Still later on, the economic gift evaporates, perhaps becoming a burden again, as elderly share rises' (Williamson 2001: 263). Thus a country having larger share of working-age adults exports capital and this causes the real exchange rate to depreciate.

To consider the effect of a demographic shock on the real exchange rate, let us examine the external equilibrium from national income identity context. From the national income identity, we know that $CA = S - I$. From the LCH, we know that saving is a function of the share of working-age population. So we can express the saving function as $S = S(L)$. Again investment is a function of interest rate, i.e. $I = I(i)$. So equation (3.8) can be re-written as follows:

$$r^* NFA + Q_X(e_X) - P_M^* C_M(e_M) + CF = S(L) - I(i) = 0 \quad (3.11)$$

When saving decreases, $S(L) < I(i)$ and the supply of loanable fund decreases. This leads to increase in domestic interest above world interest, which, in turn, causes capital inflow and real exchange rate to appreciate.

In order to examine as to how population structure affects saving of an economy, the behavior of private saving is analyzed using an Overlapping Generations

Model as discussed in Obstfeld and Rogoff (1996). Let us consider an endowment economy with two generations; young and old. Each generation lives for two periods and a new generation is born in each period. An individual born in period t maximizes her lifetime utility U which depends on her consumption during young (c_t^j) and old (c_{t+1}^k) as follows:

$$U(c_t^j, c_{t+1}^k) = u(c_t^j) + \beta u(c_{t+1}^k), \quad 0 < \beta < 1 \quad (3.12)$$

Here, β is the individual's time preference rate.

Let y_t^j and y_{t+1}^k be the individual's income while young and old, respectively, and τ_t^j and τ_{t+1}^k are net lump-sum taxes paid by the individual during her young and old ages, respectively. Also assume that the individual can borrow or lend in the domestic market at the real interest rate i . Therefore, the budget constraint of the individual takes the following form:

$$c_t^j + \frac{c_{t+1}^k}{1+i} = y_t^j - \tau_t^j + \frac{y_{t+1}^k - \tau_{t+1}^k}{1+i} \quad (3.13)$$

The individual's problem is to maximize Equation (3.12) subject to Equation (3.13). The first order condition or the intertemporal *Euler Equation* of this maximization problem is given by:

$$c_{t+1}^k = (1+i)\beta c_t^j \quad (3.14)$$

Consumption demand of the young and old are obtained from budget constraint (3.13) and Euler Equation (3.14) as follows

$$c_t^j = \left(\frac{1}{1+\beta} \right) \left(y_t^j - \tau_t^j + \frac{y_{t+1}^k - \tau_{t+1}^k}{1+i} \right) \quad (3.15)$$

$$c_{t+1}^k = (1+i) \left(\frac{\beta}{1+\beta} \right) \left(y_t^j - \tau_t^j + \frac{y_{t+1}^k - \tau_{t+1}^k}{1+i} \right) \quad (3.16)$$

For simplicity it is assumed that the time path of aggregate consumption is flat, that is, individual's time preference rate or subjective discount factor is equal to

market interest rate, symbolically, $\beta = \frac{1}{1+i}$. Under this assumption Equations (3.15) and (3.16) reduce to Equation (3.17) as follows

$$c_t^j = c_{t+1}^k = \left(\frac{1}{1+\beta} \right) \left(y_t^j - \tau_t^j + \frac{y_{t+1}^k - \tau_{t+1}^k}{1+i} \right) \quad (3.17)$$

The young in period t starts with no prior assets and their saving, S_t^j is given by the following Equation

$$S_t^j = y_t^j - \tau_t^j - c_t^j \quad (3.18)$$

Substituting the value of c_t^j from Equation (3.17) into Equation (3.18), expression for private saving of the young takes the following form:

$$S_t^j = \left(\frac{\beta}{1+\beta} \right) \left((y_t^j - \tau_t^j) - (y_{t+1}^k - \tau_{t+1}^k) \right) \quad (3.19)$$

The older generation in period t reduces their saving accumulated in period $(t-1)$, that is, $S_t^k = -S_{t-1}^j$. Therefore, total private saving in period t is the sum of saving by young and old generation in period t , which is given by the following Equation

$$S_t^P = S_t^j + (-S_{t-1}^j) = \left(\frac{\beta}{1+\beta} \right) \left(\Delta(y_t^j - \tau_t^j) - \Delta(y_{t+1}^k - \tau_{t+1}^k) \right) \quad (3.20)$$

Equation (3.20) shows that total saving will rise if saving of the young in period t is greater than saving of the young in period $(t-1)$. Therefore, if the share of working-age people in total population increases total private saving will rise. Conversely, declining share of working-age people will cause private saving to fall.

The above discussion convince us to express saving as a function of the size of working-age population, that is, $S = S(L)$, where L stands for share of working-age population. From Equation (3.17), it is evident that higher interest rate implies lower consumption, and from Equation (3.18), this lower consumption means higher saving. Therefore, saving is also a function of interest rate. Again

investment is a function of interest rate, i.e. $I = I(i)$. Also from national income identity, we know that $CA = S - I$. So Equation (3.8) can be re-written as follows:

$$r^* NFA + Q_X(e_X) - P_M^* C_M(e_M) + CF = S(L, i) - I(i) = 0 \quad (3.21)$$

Starting from an equilibrium situation, a fall in the share of working-age population results in lower saving relative to investment. This leads to capital to flow in. Capital inflow results in nominal as well as real appreciation. Since change in NFA must be zero, the increase capital inflow will be matched by higher trade deficit (or lower trade surplus).

Appreciation of or decrease in nominal exchange rate, E , causes $e_M \left(= \frac{P_M}{P_N} \right)$ to decrease. According to equation (1) this will lead demand for importable to rise.

On supply side, decrease in E causes $e_X \left(= \frac{E}{P_N} \right)$ to fall. Thus, higher demand for importable and lower supply of exportable results in trade deficit (reduction in trade surplus) equal to the capital inflow and external balance is achieved.

On the other hand, lower e_M causes demand for non-tradable to fall and lower e_X causes supply of non-tradable to rise (Equation: 3.2). This higher supply and lower demand for non-tradable results in lower P_N . Lower demand for non-tradable will be matched by its lower price and internal equilibrium will be achieved.⁵

The share of working-age population (L) can be incorporated as one of the determinants of the real exchange rate as follows:

$$rer = f(P_M^*, r^*, NFA, G_N, L) \quad (3.22)$$

In Equation (3.22) capital flow is omitted, because it is assumed that capital flow is influenced by the share of working-age population and the world interest rate.

⁵ The fall in P_N must be relatively higher than, or at least equal to, that in E to ensure that e_X falls or at least does not change. This is so because if e_X increases then supply of exportable will rise and trade balance will improve, which is inconsistent with capital inflow.

In deriving the saving behavior of the working-age population, it is implicitly assumed that the income of the generation j at time t is spent on its own consumption and payment of lump-sum taxes. The situation, however, assumes a different shape when dependents are considered. Young dependents belong to the cohort of population that does not have any income. The population aged between 0-14 years falls within this category.

Empirical evidence on the impact of dependents on saving is first brought forward by Leff (1969). He suggests that the observed differences in saving-income ratio between developed and underdeveloped countries can be explained by the differences in their demographic structure. The author further argues that ‘children constitute a heavy charge for expenditure’ (p.887) that is, they ‘contribute to consumption but not to production’ (p.887); therefore, higher dependents exert negative effect on saving.

Subsequent research on Leff’s dependency hypothesis has yielded mixed results. For example, Gupta (1975) finds the dependency rate as one of the significant determinants of saving, while Ram (1982) does not find any significant relationship between saving and dependency rates in developing countries. However, a relatively recent panel data study by Kelley and Schmidt (1996) finds that the dependency rate accounts for a major portion of changes in saving across countries and over time. Their finding is robust and not sensitive to sample variation, different estimation procedures, functional forms and variable definitions. Given this strong influence of dependency rate on saving, it can safely be assumed that a larger proportion of dependents will lower saving, because consumption of young dependents is financed by the income of the working-age population.

When consumption of the dependents is considered, Equation (3.18) can be modified as follows:

$$S_t^j = y_t^j - \tau_t^j - (c_t^i + c_t^j) \quad (3.23)$$

here c_t^i is consumption of the dependents at time t . It shows that for a given level of income, lump-sum taxes and consumption of the working-age population, the larger proportion of dependents reduces saving (for $c_t^i > 0$), which causes capital inflow and appreciation of the real exchange rate.

The impact of old dependents on the real exchange rate is not so clear. This is because, although they do not participate in the current production, they have their own savings that they accumulated during their working-age life. Therefore, their consumption does not have any impact on the saving behavior of the working-age people. However, as their saving is a part of private saving, the pattern of the use of their saving for consumption is likely to affect total saving.

Although the life-cycle hypothesis predicts that aged people use up their saving to finance their consumption, empirical evidence suggests to the contrary. For example, Mirer (1979) uses data from the 1968 survey of the Demographic and Economic Characteristics of the Aged in the USA to examine the saving behavior of the aged people and finds that the wealth of the elderly rarely declines. In a similar study with 1972-73 Consumer Expenditure Survey data in the USA, Danziger *et al.* (1982-83) conclude that elderly people spend less than the nonelderly at the same level of income and the oldest people have the lowest average propensity to consume.

Several explanations are forwarded for this observed puzzling saving behavior of the aged people. A bequest motive may be one plausible explanation for this behavior. When the bequest motive dominates the consumption motive, people continue to save because the marginal utility of the aged people of leaving a dollar for their children is greater than the marginal utility of dollar used for their own consumption (Danziger *et al.*, 1982-83). However, empirical studies suggest that the dissaving pattern is mostly influenced by the concern over health condition in the old age. Palumbo (1999) finds that during the retirement period consumption of the elderly people is largely influenced by the potential future shocks to their wealth level, the shock being the out-of-pocket expenses to finance health care. The possibility of a person living past her/his life expectancy also affects the

consumption behavior. Nardi *et al.* (2006 & 2009) also finds that longevity and the risk of high medical expenses during the old age significantly explain why the elderly people run down their wealth so slowly.

The above empirical studies suggest that the old dependents are unlikely to exert a negative effect on saving. They may even have a positive effect on saving and thereby capital outflow instead. If this is the case, then the old dependents, as per the prediction of the model presented in this chapter, will have depreciating effect on the real exchange rate.

3.4: Investment, population structure and the real exchange rate

In the preceding section it is assumed that the population structure affects capital flow through its impact on saving and thereby influences the real exchange rate. In the Equation of current account, $(CA = S(L, i) - I(i))$ it is assumed that investment is exogenous as the interest rate is determined in the world market. This section departs from that assumption in that investment is assumed to be affected by the marginal product of capital. Given the world interest rate, when marginal product of capital increases, capital flows in to take the advantage of higher return on investment.

Standard economic growth theory predicts that, for a given amount of capital, increasing the number of workers results in a smaller quantity of capital per worker. As there is less capital for each worker to work with, the productivity of workers (marginal product of labor) and hence the wage falls. However, the contribution to output provided by each additional unit of capital, that is, marginal product of capital, will rise. Under the perfect competition assumption, the rate of return on capital is equal to its marginal product, which means the return on capital will also rise. Consider a simple Cobb- Douglas production function of the economy as follows:

$$Q = K^\alpha L^{1-\alpha} \tag{3.24}$$

where K and L stand for capital and labor inputs, and α is the share of capital in the production of Q . The marginal product of capital (MP_K) is obtained by partially differentiating Equation (3.24) with respect to K as follows:

$$\frac{dQ}{dK} = \frac{d}{dK}(K^\alpha L^{1-\alpha}) = \alpha \left(\frac{L}{K}\right)^{1-\alpha} = MP_K \quad (3.25)$$

Equation (3.25) implies that an increase in the number of worker increases MP_K . In a competitive market, the return on capital is equal to the MP_K , that is, $MP_K = r$, where r is the rate of return on capital. It, therefore, follows that a higher share of working-age population⁶ would result in a higher MP_K and hence a higher rate of return on capital, which would attract capital from the rest of the world and appreciate the real exchange rate.

However, before making any conclusion, it is imperative to take into account the impact of increasing labor force on wage and hence aggregate saving. The relevant concept to analyze this issue is marginal product of labor (MP_L). MP_L is the amount of output obtained by increasing the number of workers by one unit. MP_L is obtained by partially differentiating Equation (3.24) with respect to L as follows:

$$\frac{dQ}{dL} = \frac{d}{dL}(K^\alpha L^{1-\alpha}) = (1-\alpha) \left(\frac{K}{L}\right)^\alpha = MP_L \quad (3.26)$$

Under the perfect competition assumption, the wage is equal to the marginal product of labour, that is, $MP_L = w$, where w is the real wage. Therefore, according to Equation (3.26) increasing the number of worker would decrease MP_L and hence real wage. The effect of a lower wage on aggregate private saving is not clear. It depends on the change in aggregate wage income. If aggregate wage income increases, then saving will rise and *vice versa*.⁷ Depending on the change in saving two situations may arise. First, when the number of workers increases, MP_K (hence return to capital) rises and this attracts more capital. Now if saving decreases then capital inflow will take place. This capital inflow will appreciate the real exchange rate.

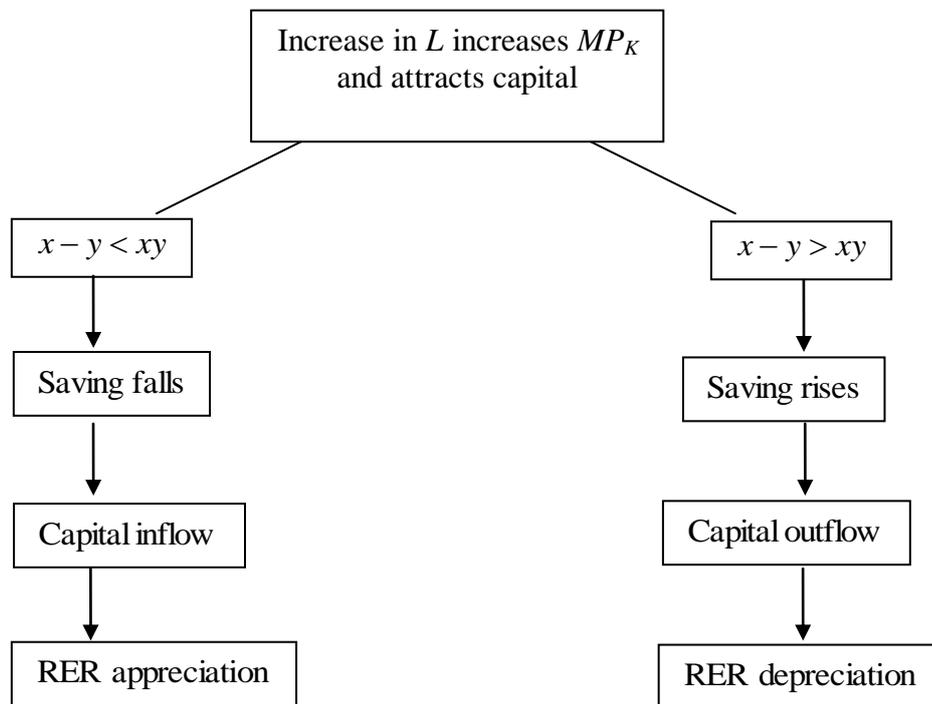
⁶ It is assumed that the economy is in full employment level and all people in the working-age are in the labour force.

⁷ Appendix 3 presents derivation of a general formula to determine whether saving will rise or fall in response to an increase in the size of the labour force.

Second, if saving increases, this higher saving may be invested at home as there is higher return on capital due to higher MP_K caused by larger work force. Empirical evidence suggest that there is a significant degree of home bias in investment, that is, *ceteris paribus*, investors are more likely to invest their saving in assets based in their own country (Page, 2009). Under this situation it is less unlikely that the real exchange rate will be affected by the size of working-age population. However, if the supply of saving more than offsets the amount of capital required to sustain higher MP_K ⁸, then the excess capital will flow out and the real exchange rate will depreciate.

It is therefore unclear *a priori* how the size of working-age population will impact the real exchange rate. Figure 3.1 below presents the pictorial form of the above analysis.

Figure 3.1: Marginal product of capital and the real exchange rate



Note: x is the percentage increase in the labour force or working-age population and y is the percentage decrease in wage.

⁸ When L increases with fixed amount of K , MP_K rises and MP_L falls. However, when capital also increases, MP_K starts falling and MP_L starts rising. In this situation the higher wage will raise saving, capital will flow out, and the real exchange rate will depreciate.

The young and old dependents are not involved in the production process. Therefore, their impacts on investment come through their consumption behavior. 'A population containing a high proportion of dependents may be expected to have relatively high propensity to consume' (Sweezy, 1940:66). This is because dependents, particularly young dependents, do not have any income. Their consumption is financed from the income of the economically active population. Higher dependents imply higher consumption demand and higher consumption demand necessitates higher investment. Consumption of the young dependents is mainly comprised of non-tradable goods, such as education and healthcare. Thus they reduce the saving on one hand and increase the investment in the non-tradable sector on the other hand. The gap between saving and investments is widened and capital inflow takes place to fill in this gap and the real exchange rate is appreciated. However, this picture may be somewhat different in case of old dependents.

It is mentioned earlier that empirical evidence on the saving behaviour of the elderly people does not support the theoretical prediction that they dissave, rather they continue to save for various reasons. Therefore, investment demand that comes from the consumption of the old dependents may be financed out of their saving. However, Lefebvre (2006) mentions that during old age expenditure on transport, food, clothing, *etc.* declines significantly. The bulk of the consumption expenditure goes to accommodation and health related purposes. Therefore, it is unlikely that consumption expenditure and hence investment demand will significantly increase with increase in old dependents. Thus, the elderly people may cause capital outflow and depreciate the real exchange rate.

3.5: Hypotheses of the study

A theoretical framework is presented above to analyze the impacts of demographic variables on the real exchange rate. Although the framework includes other macroeconomic variables, the main objective is to examine whether the demographic variables are significant in explaining movements in the real exchange rate. Three cohorts of population considered for this study are as follows:

- (i) Young dependents (age 0 – 14 years)
- (ii) Working-age population (age 15 – 64 years)
- (iii) Old dependents (age 64 years and above)

Accordingly, three hypotheses are developed. In developing the hypotheses, it is assumed that each of these cohorts affects saving and investment through its saving and consumption behavior. Changes in saving and/or investment brought about by different age groups are translated into corresponding capital flows and change in the real exchange rate. The hypotheses are as follows:

Hypothesis-1: Higher share of young dependents appreciates the real exchange rate.

This hypothesis is developed on the premise that young dependents reduce saving in the economy. This cohort of the population does not have any income, however, they incur substantial amount of costs in the form of consumption, education, health facility etc. These costs reduce saving of the earning cohort. Young dependents also influence investment through placing higher demand for consumption of, mainly non-tradables. The net effect of higher young dependents leads to increase in capital inflows and to appreciate the real exchange rate.

Hypothesis-2: Higher share of working-age population has uncertain impact on the real exchange rate.

This hypothesis is developed on the premise that this is the only cohort of population that has income from employment. Therefore, larger cohort size for this group indicates larger income and hence higher saving. Higher saving, in turn means capital outflow and real depreciation. This cohort is also expected to influence investment. However, depending on the relative change in marginal product of capital and labour, capital will flow in or flow out. Thus, the overall impact of this age group on capital flows and the real exchange rate is not certain *a priori*.

Hypothesis-3: Higher share of old dependents depreciates the real exchange rate.

This hypothesis is apparently contradictory with the theoretical prediction that elderly group reduces saving. However, the hypothesis is mainly based on empirical finding that the wealth of the elderly people rarely declines (Mirer 1997). Elderly people have been found to spend less than the nonelderly at the same level of income and the oldest people have the lowest propensity to consume (Danziger *et al.*, 1982-83). Explanations of this saving behavior include bequest motive (Danziger *et al.*, 1982-83); potential future shock to the health (Palumbo, 1999); longevity and the risk of high medical cost (Nardi *et al.*, 2006) etc. This group is also expected to increase investment by less than their saving. Thus, they cause capital outflow and real depreciation.

3.6: Conclusion

In this chapter a theoretical framework of the linkage between population age structure and the real exchange rate is presented. A model of the real exchange rate is described first and then the impacts of the population age structure on the real exchange rate are analyzed. First, the analysis focuses on the saving behavior of different age groups and their impacts on capital flows and the real exchange rate. It is argued that working-age population and old dependents increase saving and depreciate the real exchange rate through capital outflow, while young dependents reduce saving and appreciate the real exchange rate through capital inflows.

Next, the effects of population structure on investment are discussed. Young dependents increase demand for investment by consuming more non-tradable goods like education and healthcare. By reducing saving and increasing investment demand, this group is expected to appreciate the real exchange rate through capital inflows.

An increase in the working-age population causes the marginal product of capital (and hence the return to capital) to rise. This higher return attracts capital from the rest of the world and the real exchange rate tends to appreciate. An increase in the working-age population also decreases the marginal product of labour (and hence

wage). The resultant change in saving may be positive or negative. If it is negative, then capital inflow will take place and the real exchange rate is expected to appreciate. However, if it is positive, then the saving may go to investment to take the advantage of higher return. In this case no effect of increase in working-age population on the real exchange rate is expected. If saving is more than required to earn high return, capital outflow will take place and the real exchange rate will depreciate.

Old dependents are expected to continue to save as their consumption expenditure is likely to decline for various reasons. Due to this lower consumption expenditure, their contribution to investment demand is expected to be lower relative to their saving. It is, therefore, expected that the old dependents are likely to depreciate the real exchange rate through capital outflow.

After this theoretical discussion on the relationship between the real exchange rate and different age groups, the next chapter discusses methods to estimate this relationship empirically. These methods include discussion on econometric estimation strategies, data descriptions, data sources, sample of countries and study period.

Appendix 3

Change in the size of labour force and the change in aggregate saving

A general formula can be derived to see whether saving will rise or fall due to increase or decrease in labour force. Let, L_t and w_t be the size of the labour force and wage in period t . Assume that labour force increases by $x\%$ and wage decreases by $y\%$ in period $(t+1)$. Also assume that saving rate in both periods is s . Therefore, aggregate wage (AW) income in two periods are given by

$$AW_t = L_t w_t$$

$$AW_{t+1} = L_t(1+x)w_t(1-y)$$

As saving is a fixed percentage of wage income; change in aggregate saving will depend on aggregate wage income. If $AW_{t+1} > AW_t$, saving will increase and if $AW_{t+1} < AW_t$, saving will fall. Let consider first the situation when $AW_{t+1} > AW_t$.

In this case the following will hold:

$$\begin{aligned} L_t w_t(1+x)(1-y) - L_t w_t &> 0 \\ \Rightarrow L_t w_t(1+x)(1-y) &> L_t w_t \\ \Rightarrow (1+x)(1-y) &> 1 \\ \Rightarrow 1-y+x-xy &> 1 \\ \Rightarrow x-y &> xy \end{aligned}$$

The above inequality implies that if the difference between the percentage increase in labour force and the percentage decrease in wage ($= MP_L$) is greater than their product, aggregate saving will rise. Saving will remain unchanged if $x-y = xy$ and fall if $x-y < xy$. However, the relationship will be different when there is a fall in the labour force. A fall in the labour force will decrease the MP_K and increase the MP_L and hence wage. In this case (it is assumed that labour force decreases by $x\%$ and wage increases by $y\%$ in period $(t+1)$), aggregate wage in period $(t+1)$ will be $L_t(1-x)w_t(1+y)$. It can be shown that saving will increase if $y-x > xy$.

Table A3.1: Changes in saving due to changes in labour force and wage

Saving from period t to period $t+1$	Increase in L (MP_K rises and MP_L [=wage] falls)	Decrease in L (MP_K falls and MP_L [=wage] rises)
Increases	$x - y > xy$	$y - x > xy.$
Does not change	$x - y = xy$	$y - x = xy.$
Decreases	$x - y < xy$	$y - x < xy.$

Note: x and y are percentage change in labour force and wage.

Chapter 4

Econometric Methodology

4.1: Introduction

The objective of this chapter is to describe the methodological issues relating to the estimation of the theoretical model developed in the previous chapter. The empirical model covers 23 OECD countries and for most of the countries time-series data are available for more than 20 years. Therefore the data structure covers both cross-section and time-series dimensions. For this reason a panel data method is employed in this study to estimate the model to exploit the benefit of this sample. The rest of the chapter discusses the methodological steps for panel data that are followed in estimating the theoretical model and drawing inferences from the results in the next chapter.

This chapter is organized as follows: section 4.2 provides a brief overview of panel data regression model, including the potential benefits of using this method and some discussion on fixed effect and random effect models. Choice of model, i.e., whether fixed or random effect will be used, is discussed in sections 4.3 Time-series properties of the underlying data are discussed in section 4.4, followed by description of variables in section 4.5. Section 4.6 describes the sample of the study and data sources are described in section 4.7.

4.2: Panel data model

There are a number of advantages of panel data compared to cross-section and time-series data that justify its use. Cross-section or time-series data cannot control for the heterogeneous nature of countries; therefore results estimated by pure cross-section or time-series data may be biased (Moulton, 1986 & 1987). For example, countries may involve themselves in international trade due to differences in factor endowments and comparative advantage or because of scale of economies and product differentiation. However, differing trade patterns affect the adjustment of relative prices or the real exchange rate (Faruquee, 1996). Carter and Li (2004) find different trade patterns among OECD countries. This heterogeneity can best be captured by using the panel data estimation method.

Another major advantage of panel data method is the availability of more degrees of freedom, more information, more variability, less collinearity among the variables and more efficiency (Baltagi, 2001). Therefore, panel method would be the right one to estimate the model under consideration. There are 30 countries in OECD and annual observations on variables in the models are available for more than 20 years, resulting in at least 600 observations, which is quite a large data set to capture the phenomenon under consideration efficiently. Other advantages of panel data include better treatment of unobserved or omitted variables and the possibility of generating more accurate prediction than with only time-series data (Hsiao, 2003).

A panel data regression equation differs from time-series or cross-section regression equation in that it has double subscript on its variable; time subscript and individual cross-section unit subscript. A panel regression equation takes the following form:

$$y_{it} = \mu + \beta' \mathbf{x}_{it} + \alpha_i + u_{it} \quad i = 1, 2, \dots, N; t = 1, 2, \dots, T \quad (4.1)$$

Here i denotes individual cross-section unit, such as, households, firms, or countries and t denotes time. \mathbf{x}_{it} is the $N \times K$ vector of explanatory variables, μ is the common mean term and u_{it} is the disturbance term that represents the effects of omitted variables that change across individual cross-section units as well as time and is called *idiosyncratic error*. The term α_i represents influence of unobservable variables that are specific to individual cross-section units. It is also called *individual effect* or *individual heterogeneity*. The usual assumptions that are required to obtain a best linear unbiased estimator (BLUE) are as follows:

- (i) Mean value of residual is zero, that is, $E\mathbf{u}_i = \mathbf{0}$, where $\mathbf{0}$ is a null vector;
- (ii) There is no cross-sectional correlation, that is, $E\mathbf{u}_i \mathbf{u}_j' = 0$, for $i \neq j$;
and
- (iii) There is no serial sectional correlation, that is, $E\mathbf{u}_t \mathbf{u}_s' = 0$, for $t \neq s$;
and

- (iv) Residual variance is constant, that is, $E\mathbf{u}_i\mathbf{u}_i' = \sigma_u^2 I_T$, where I_T denotes T x T identity matrix.
- (v) Independent variables in each period are uncorrelated with the disturbances, that is, $E\mathbf{x}_{is}'\mathbf{u}_{it} = \mathbf{0}$ for $s, t = 1, \dots, T$.

Estimation of panel regression model depends upon the treatment of the individual effect. There are two ways to account for this unobservable individual effect; *fixed effect model* and *random effect model*. In a fixed effect model α_i captures the influence of those variables that are specific to an individual cross-section unit and remain constant over time, whereas, in random effect model it is treated as a random variable. In the following sections these models are discussed at greater length.

4.2.1 Fixed effect model

In the fixed effect model (FEM), α_i is treated as a parameter to be estimated, that is, α_i is allowed to be correlated with observed explanatory variables, symbolically $E(\alpha_i|\mathbf{x}_i) \neq 0$ (Wooldridge, 2002). In estimating FEM, a restriction is

put on α_i such that $\sum_{i=1}^N \alpha_i = 0$ (Hsiao, 2003, p.33), that is, the individual effect is the deviation of the i th individual from the common mean μ . Now the best linear unbiased estimators (BLUEs) of μ, α_i and β are obtained by minimizing sum of residual square $\left(\sum_{i=1}^N \mathbf{u}_i' \mathbf{u}_i = \sum_{i=1}^N \sum_{t=1}^T u_{it}^2 \right)$ subject to the restriction $\sum_{i=1}^N \alpha_i = 0$. Equation

(4.1) can be re-written as $u_{it} = y_{it} - \mu - \beta' \mathbf{x}_{it} - \alpha_i$. Now the residual sum of square (RSS) is given by

$$\sum_{i=1}^N \sum_{t=1}^T u_{it}^2 = (y_{it} - \mu - \beta' \mathbf{x}_{it} - \alpha_i)' (y_{it} - \mu - \beta' \mathbf{x}_{it} - \alpha_i) \quad (4.2)$$

Partial differentiation of Equation (4.2) with respect to μ yields the following:

$$\hat{\mu} = \bar{y} - \beta' \bar{\mathbf{x}} \quad (4.3)$$

$$\text{where, } \bar{y} = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T y_{it} \text{ and } \bar{\mathbf{x}} = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T \mathbf{x}_{it}$$

Similarly an estimate of α_i is obtained by partially differentiating equation (4.2) with respect to α_i :

$$\hat{\alpha}_i = \bar{y}_i - \hat{\mu} - \boldsymbol{\beta}'\bar{\mathbf{x}}_i \quad (4.4)$$

Now substituting (4.3) and (4.4) into (4.1), and partially differentiating the resultant expression with respect to $\boldsymbol{\beta}$, BLUE estimate of $\boldsymbol{\beta}$ is obtained as follows:

$$\hat{\boldsymbol{\beta}}_{FE} = \left[\sum_{i=1}^N \sum_{t=1}^T (\mathbf{x}_{it} - \bar{\mathbf{x}}_i)(\mathbf{x}_{it} - \bar{\mathbf{x}}_i)' \right]^{-1} \left[\sum_{i=1}^N \sum_{t=1}^T (\mathbf{x}_{it} - \bar{\mathbf{x}}_i)(y_{it} - \bar{y}_i)' \right] \quad (4.5)$$

where subscript FE stands for ‘Fixed effects’.

4.2.2 Random effect model

Unlike FEM, the random effect model (REM) considers the individual effects as a random draw that is uncorrelated with the regressors. For RE representation, Equation (4.1) can be written as follows:

$y_{it} = \mu + \boldsymbol{\beta}'\mathbf{x}_{it} + \eta_{it}$, where $\eta_{it} = (\alpha_i + u_{it})$ is called the composite error. The conditional variance of this composite error is given by

$$E(\eta_{it}^2 / \mathbf{X}) = \sigma_{\alpha}^2 + \sigma_u^2$$

And the conditional variance within a unit is given by

$$E(\eta_{it}^2 \eta_{is}^2 / \mathbf{X}) = \sigma_{\alpha}^2, \text{ for } t \neq s.$$

Since observations i and j are uncorrelated, the full covariance matrix of η across the sample is a block diagonal matrix as follows

$$\boldsymbol{\Omega} = \begin{pmatrix} \Sigma & \mathbf{0} & \mathbf{0} & \cdot & \cdot & \cdot & \mathbf{0} \\ \mathbf{0} & \Sigma & \mathbf{0} & \mathbf{0} & \cdot & \cdot & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \Sigma & \mathbf{0} & \mathbf{0} & \cdot & \mathbf{0} \\ \cdot & & & & & & \cdot \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \cdot & \cdot & \cdot & \Sigma \end{pmatrix} = \mathbf{I}_n \otimes \Sigma \quad (4.6)$$

$$\text{where } \Sigma = \begin{vmatrix} \sigma_{\alpha}^2 + \sigma_u^2 & \sigma_{\alpha}^2 & \sigma_{\alpha}^2 & \dots & \sigma_{\alpha}^2 \\ \sigma_{\alpha}^2 & \sigma_{\alpha}^2 + \sigma_u^2 & \sigma_{\alpha}^2 & \dots & \sigma_{\alpha}^2 \\ \cdot & \cdot & \cdot & \dots & \cdot \\ \cdot & \cdot & \cdot & \dots & \cdot \\ \sigma_{\alpha}^2 & \sigma_{\alpha}^2 & \sigma_{\alpha}^2 & \dots & \sigma_{\alpha}^2 + \sigma_u^2 \end{vmatrix}$$

Therefore, the slope coefficient of this model is given by

$$\hat{\beta}_{RE} = (\mathbf{X}'\mathbf{\Omega}^{-1}\mathbf{X})^{-1}\mathbf{X}'\mathbf{\Omega}^{-1}\mathbf{y} \quad (4.7)$$

4.3: Model selection test

The natural extension of the above estimation procedure is to decide which method to apply. Although there are econometric tests to decide on which method to apply, theoretically the choice hinges upon the nature of inferences the researchers make. In case of the fixed effect model, researchers make inferences that are conditional to the particular cross-section unit in the sample. In case of the random effect model, the inferences are unconditional with respect to the population of all effects (Hsiao, 2003). In other words, when some effect is modeled as random, it is meant that the researcher wishes to draw inferences about the population from which the observed units were drawn, whereas, in case of fixed effects, the inferences drawn are specific to those particular units. In the words of Hsiao

'When inferences are going to be confined to the effects in the model, the effects are more appropriately considered fixed. When inferences will be made about a population of effects from which those in the data are considered to be a random sample, then the effects should be considered random.' (Hsiao, 2003:43)

From this point of view, the model under consideration should be a random effect model. The relationship between demographic structure and the real exchange rate is a phenomenon that is expected to hold in all economies, it is modeled not only for OECD countries. The OECD countries are chosen to test the hypothesis and

draw inference about the impact of demographic variables on the real exchange rate in general. It is not expected that the relationship is confined to the OECD countries only. Therefore, from theoretical point of view, it is appropriate to study the modeled relationship between the real exchange rate and demographic structure in terms of a random effect model.

However, as there are formal econometric tests to identify a model as ‘fixed’ or ‘random’, it is worthwhile to employ those tests and proceed accordingly. It is common in panel data literature to use the Hausman test to select the fixed or random effect model. If the Hausman test statistic is significant, then the researcher rejects the null hypothesis that the random effect estimator is consistent in favor of fixed effect model. Effectively the test of identifying the type of effect can be performed in two steps; first the Breusch and Pagan (1980) test identifies whether the regression model with single constant term is appropriate, second, the Hausman (1978) test identifies whether the effect is fixed or random. Accordingly these tests are described below.

4.3.1 Breusch and Pagan test

Consider a model with N individuals and T time periods as follows:

$$y_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + u_{it} \quad (4.8)$$

Where $u_{it} = \alpha_i + \lambda_t + v_{it}$ consists of individual specific effect (α_i), time effect (λ_t) and an error term (v_{it}) and these are normally distributed with zero mean and constant variance, that is,

$$\begin{aligned} v_{it} &\sim N(0, \sigma_v^2) \\ \alpha_i &\sim N(0, \sigma_\alpha^2) \\ \lambda_t &\sim N(0, \sigma_\lambda^2) \end{aligned}$$

Under the null hypothesis both time and individual specific effects are missing, that is,

$$H_o : \sigma_\alpha^2 = \sigma_\lambda^2 = 0$$

Breusch and Pagan (1980) derive the LM statistic as follows:

$$LM = \frac{NT}{2} \left\{ \frac{1}{T-1} \left[\frac{\tilde{u}'(I_N \otimes e_T e_T') \tilde{u}}{\tilde{u}' \tilde{u}} \right]^2 + \frac{1}{N-1} \left[\frac{\tilde{u}'(e_N e_N' \otimes I_T) \tilde{u}}{\tilde{u}' \tilde{u}} - 1 \right]^2 \right\}$$

where $e = (1,1,1,\dots,1)'$

Under the null hypothesis the LM is distributed as chi-squared with 2 degrees of freedom. If null hypothesis is rejected then the evidence is that the country-specific or time-specific effects are significant. The Hausman test described below determines whether the country specific effects are fixed or random.

4.3.2 Hausman test

The Hausman test utilizes the definition of the fixed or random effect model as the correlation of the individual effect term with the regressors. In other words, it is used to test the orthogonality of individual effects and the regressors. In REM individual effects and regressors are orthogonal, whereas in FEM they are correlated. If the individual effects and the regressors are not orthogonal, the fixed effect (FE) estimator is consistent while the random effect (RE) is inconsistent. However, if the individual effects and the regressors are orthogonal then FE estimator is consistent, but inefficient. In this case RE estimator is consistent and efficient.

The test of null hypothesis of orthogonality is to consider the difference between the two estimators, that is, $(\hat{\beta}_{FE} - \hat{\beta}_{RE})$. If the individual effects are uncorrelated with the regressors, then this difference should be near zero (Hausman, 1978:1263). The variance of this difference vector is (Greene, 2003) given by

$$Var(\hat{\beta}_{FE} - \hat{\beta}_{RE}) = Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE}) = \Psi$$

The chi-squared test based on Wald criterion is:

$$W = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' \Psi (\hat{\beta}_{FE} - \hat{\beta}_{RE})$$

Under the null W is distributed as χ^2 with $(K - 1)$ degrees of freedom, where K is the number of independent variables. If the test statistic exceeds the critical value at the chosen level of significance (usually 1% or 5%), then the null hypothesis is rejected and the individual effects appear to be correlated with the regressors and the fixed effect model is the right choice based on this test. Otherwise, the random effect model is the right choice.

4.4: Time-series properties

Testing for stationarity is an inextricable part of empirical time-series econometrics. However, this aspect of time-series data virtually did not receive attention in traditional panel data analysis until the beginning of the 1990's. The reason for this lack of attention on stationarity property in panel data model may be due to the traditional panel data structure, specifically micro panel data structure that consist of large N and small T that calls for only N having asymptotic properties. However, with the growing availability of large N and large T macro panel data, the asymptotic properties of T have also become an important issue to look into. It is now inappropriate to follow the traditional large N , small T panel regression procedure in analyzing large N and large T panel data model.

From the 1990's and onwards a body of theoretical as well as empirical research addresses the use of large N and large T , examining the stationarity property of underlying panel data. The present research is based on a panel, where $N(=23) < T(=27)$. This panel structure clearly demands examination of stationarity property to avoid the risk of running spurious regression.

4.4.1 Panel unit root test

The motivation to employ a panel unit root test comes from the low power of univariate unit root tests like ADF or PP tests. Panel unit root tests are more powerful because of the increased sample size. The alternative way to get a large sample is to use long time-series data, but this may cause the problem of structural break(s) (Maddala and Kim, 1998). By using panel data set one can exploit the extra information contained in pooled cross-section and time-series data. Besides, the asymptotic distribution of the panel unit root test is standard normal, which is in contrast to univariate time series unit root tests that have non-standard asymptotic distribution (Baltagi *at el.*, 2007).

Several methods have been proposed to test stationarity in panel data among which three methods are widely used: Im, Pesaran and Shin (2003) (hereafter IPS), Levin, Lin and Chu (2002) (hereafter LLC) and Maddala and Wu (1999) (hereafter MW). All these tests have their own limitations, such as LLC is applicable for homogeneous panel, where the autoregressive (AR) coefficients for

unit roots are assumed to be the same across cross-sections. Although IPS allows for heterogeneous panels, a major criticism of both LLC and IPS tests is that they require cross-sectional independence. Another problem with IPS test is that it is applicable for balanced panel. From these points of view, it appears that MW test, also called *Fisher's* test, is suitable for the panel data under consideration, because it can also be used for an unbalanced panel.

Although not identical, panel unit root tests are similar to unit root tests conducted on a single time series. Consider an AR (1) process for panel data as follows:

$$y_{i,t} = \rho_i y_{i,t-1} + X_{i,t} \delta_i + \varepsilon_{i,t} \quad (4.9)$$

where, $i = 1, 2, \dots, N$ represents cross-section units that are observed over periods $t = 1, 2, \dots, T$. $X_{i,t}$ represents the exogenous variables including any fixed or individual trend, ρ_i is the autoregressive coefficient and $\varepsilon_{i,t}$ is an idiosyncratic disturbance. If $|\rho_i| < 1$, y_i is said to be weakly stationary and if $|\rho_i| = 1$, then y_i is said to contain a unit root.

There are two assumptions that are made in different tests about ρ_i . LLC test assumes that the persistence parameter ρ_i is common across cross-sections so that $\rho_i = \rho$ for all i . However, in IPS and MW test ρ_i is allowed to vary freely across cross-section, which seems more reasonable. Moreover, as IPS is designed for balanced panel, this study concentrates on MW test only. MW uses Fisher's (1932) result to derive tests that combine the p -values from the individual unit root in each cross-sectional unit. If the p -value from individual unit root test for cross-section i is defined as π_i , then under the null hypothesis of unit root for all N

cross-sections, the test statistic is given by $-2 \sum_{i=1}^N \log(\pi_i) \rightarrow \chi_{2N}^2$.

4.4.2 Panel cointegration

When panel unit root tests indicate that the variables are I(1), it is likely that the variables are cointegrated, that is, there is long-run equilibrium relationship among the variables. In that case the unit root test is followed by a cointegration test. A

long-run relationship among multiple time series of a single cross-section unit is investigated using cointegration technique developed by Engle and Granger (1987), Johansen and Juselius (1990), Johansen (1991, 1995) and Phillips (1991).

Different procedures have been proposed for testing cointegration for panel data. In the literature both residual-based approach and system approach have been suggested for testing cointegration in panel data sets. Two widely used residual-based panel cointegration tests are those of suggested by Pedroni (1999 & 2004) and Kao (1999) and the system approach is suggested by Larsson *et al.* (2001). However, Monte Carlo comparison by Gutierrez (2003) shows that in homogeneous panels Kao's (1999) test have higher (lower) power than Pedroni's (1999) test when a small- T (high- T) are included in the panel. Gutierrez also shows that both these tests outperform Larsson *et al.*'s (2001) test. Based on this finding, this study will follow residual based cointegration tests suggested by Pedroni should the variables are found to be $I(1)$.

Pedroni's (1999 & 2004) test is the extension of Engle and Granger's (1987) cointegration test for a single cross-section unit. The Engle and Granger cointegration test is based on the examination of the residual of a spurious regression performed using $I(1)$ variables. If the variables are cointegrated then the residual will be $I(0)$, while if the variables are not cointegrated then residual will be $I(1)$. Pedroni proposes tests for cointegration that allow for heterogeneous intercepts and trend across cross-section units.

For two $I(1)$ variables x and y consider the following regression

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (4.10)$$

for $t = 1, 2, \dots, T$; $i = 1, 2, \dots, N$; $m = 1, 2, \dots, M$.

The parameters α_i and δ_i represent individual and trend effects respectively. The null hypothesis of the test is that $e_{i,t}$ is $I(1)$ against the alternative that $e_{i,t}$ is $I(0)$. To test whether the residuals are stationary following auxiliary regressions are estimated for each cross-section unit:

$$e_{i,t} = \rho_i e_{i,t-1} + u_{i,t} \quad (4.11)$$

$$e_{i,t} = \rho_i e_{i,t-1} + \sum_{j=1}^{p_i} \psi_{i,j} \Delta e_{i,t-j} + v_{i,t} \quad (4.12)$$

Against the null hypothesis of no cointegration ($H_0 : \rho_i = 0$), there are two alternative hypotheses, (1) the homogeneous alternative [$H_1 : (\rho_i = \rho) < 1$] for all i , also called *within-dimension test* or *panel statistic test* and, (2) the heterogeneous alternative ($H_1 : \rho_i < 1$, for all i), also called *between-dimension* or *group statistic test*. The panel cointegration test statistic $\mathfrak{N}_{N,T}$ is constructed from the residuals from the either auxiliary regression mentioned above. In total eleven statistics are generated with varying degree of size and power for different N and T . Pedroni shows that the standardized statistic is asymptotically normally distributed, $\frac{\mathfrak{N}_{N,T} - \mu\sqrt{N}}{\sqrt{\nu}} \Rightarrow N(0,1)$, where μ and ν are Monte Carlo generated adjustment terms.

4.5: Descriptions of variables

The model described previously in Chapter 3 identifies five macroeconomic factors as the determinants of the real exchange rate: (i) terms of trade (TOT); (ii) net foreign assets (NFA), (iii) government expenditure on non-tradables; (iv) world interest rate; and (v) three demographic variables. A brief description of the real exchange rate and its determinants is given below followed by the sample of the study and a note on data sources.

(i) *Real Exchange Rate*: There are two definitions of the real exchange rate: internal and external. The internal real exchange rate is defined as the ratio of traded to non-traded goods, *i.e.*, it is a relative price between two different categories of domestic goods. This definition of the real exchange rate reflects the relative price incentive for producing tradable as opposed to non-tradable goods. The real exchange rate defined this way serves as an indicator of domestic resource allocation incentive within an economy. The real exchange rate defined in terms of tradables and non-tradables assumes that the terms of trade between exportables and importables are fixed so that they can be aggregated into a single composite tradable good (Hinkle and Nsengiyumva, 1999).

The external real exchange rate is defined as the nominal exchange rate adjusted for price level differences between two countries. In other words, it is the ratio of foreign to domestic prices measured in a common currency, that is, external real exchange rate = nominal exchange rate \times (foreign price level/domestic price level). This is the real exchange rate between the currencies of two countries. When real exchange rate between the domestic currency and a basket of foreign currencies are considered, the concept of real effective exchange rate (REER) is used. The REER is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs (World Bank, 2008).

In this thesis, the definition of the external real exchange rate, represented by REER is used as a proxy for internal real exchange rate as described in the theoretical model in the previous chapter. This is done primarily because of non-availability of data on internal real exchange rate. Besides, the computation of internal real exchange rate poses both conceptual and empirical problems. The composition of tradable and non-tradable goods itself depends upon the level of real exchange rate. Moreover, price data are available for exports, imports and domestically produced goods, not for tradables and non-tradables. 'In addition, little empirical work has been done on how to compute internal real exchange rate directly, and procedures for doing so are not well documented in the literature' (Hinkle and Nsengiyumva, 1999:114).

(ii) *Terms of trade (TOT)*: Terms of trade data are used as a proxy for price of importables. As the price of tradables is a weighted average of the prices of exportables and importables, the effect of TOT on the real exchange rate cannot be determined *a priori* (Elbadawi and Soto, 1994). This is because two contrary effects, namely, *income effect* and *substitution effect*, work in opposite directions. An improvement in terms of trade, either through higher exportable prices or lower importable prices, raises the income of the economy. This *income effect* increases the demand for non-tradables and their prices, which in turn, reduces the relative price of tradables and appreciates the real exchange rate. Thus, the final effect of terms of trade improvement/deterioration hinges upon the relative strength of these two effects. For example, Elbadawi and Soto (1994) study seven

developing countries and find that for three of them terms of trade improvements lead to the real exchange rate appreciation, while for the four others it leads to real depreciation.

(iii) *Net Foreign Assets (NFA)*: The effect of NFA on the real exchange rate can be analyzed in terms of *wealth effect*. An improvement in NFA raises national wealth of an economy, thereby inducing larger expenditure and a higher price of non-tradable goods, which in turn appreciates the real exchange rate (MacDonald and Ricci, 2003). A wealth effect may also work by changing labour supply. Higher wealth may reduce the labour supply to the non-tradable sector, leading to an increase in the relative price of non-tradables and an appreciated real exchange rate (Lane and Milesi-Ferretti, 2004). It is therefore expected that NFA will have an appreciating effect on the real exchange rate.

(iv) *Government expenditure (G)*: The model includes government expenditure on non-tradables as one of the determinants of the real exchange rate. Higher government expenditure on non-tradables bids up their prices and appreciates the real exchange rate. However, as the precise estimate of government expenditure on non-tradables is not available, data on total government expenditure is used as a proxy for government expenditure on non-tradables. Therefore, the effect of government spending hinges upon the share of government expenditure falling on tradable and non-tradable goods.

(v) *Interest rate differential (INTDIFF)*: The model assumes that when world interest rate is higher than domestic interest rate, capital will flow out until they are equalized and vice versa. As there is no unique interest rate that can be termed as world interest rate, the variable poses a problem as to what rate should be taken as a proxy for it. Theoretically, the world interest rate is given for a small open economy, that is, a small open economy cannot influence this rate. All small open economies are affected by a change in world interest rate. From this point of view, the real interest rate of the USA can be taken as a proxy for the world interest rate, because any change/shock in the US economy affects other countries in the world. For this reason, the USA economy is used in the analysis of the large open economy textbook model (for example Mankiw, 2007).

When the world interest rate is higher than domestic interest rate, the interest rate differential (*domestic interest rate – world interest rate*) rises, capital flows out and the real exchange rate depreciates. Likewise, the exchange rate appreciates when domestic interest rate is higher than the world interest rate.

(vi) *Demographic variables*: Three demographic variables are used in this research: working-age population, young dependents and old dependents. *Working-age population (WAPOP)* is defined as the population aged 15-64 years as the percentage of total population. Similarly, *young dependents (YDEP)* and *old dependent (ODEP)* are defined as the population aged 0-14 years and 65 years and above, respectively, both as the percentages of total population.

4.6: Sample of the study

Countries included in the Organization for Economic Co-operation and Development (OECD) are selected as the sample of this research. Selection of these countries is motivated mainly by the availability of data for a relatively longer period of time. Most data are available from 1960. However, data on the real exchange rates are available from 1980 only. For this reason, the study period has been confined to 1980-2006. There are 23 countries for which all data (except the real exchange rate and terms of trade) are available for this period. For a few countries, observations on the real exchange rate and terms of trade are not available for the entire study period. This is why an unbalanced panel model is estimated to examine the hypothesized relationship between the real exchange rate and demographic variables. The countries included in the sample are as follows:

Australia	France	Japan	Portugal
Belgium	Germany	Korea Republic	Spain
Canada	Greece	Netherlands	Sweden
Czech Republic	Hungary	New Zealand	Switzerland
Denmark	Ireland	Norway	United Kingdom
Finland	Italy	Poland	

4.7: Sources of data

The prime source of data is *World Development Indicators (WDI)-2008*, published by the World Bank. WDI data are collected from various international sources, such as, International Monetary Fund (IMF), Food and Agricultural Organization

(FAO), United Nations Conference on Trade and Development (UNCTAD), Organization for Economic Co-operation and Development (OECD) etc. Moreover, the World Bank itself also collects some data.

Where data are not available in the WDI-2008, other sources have also been used that include *Thomson Datastream* and *OECD.Stat*. *Thomson Datastream* is the world's largest and most respected financial, statistical database. It contains more than two million financial instruments, securities and indicators for over 175 countries in 60 markets. Holding up to 50 years of history and over 8,000 different fields, it provides access to over one hundred million time series. The Datastream database mainly contains economic, equity, bond, and derivative data for the Asia Pacific. The Economics module includes interest rates, exchange rates, stock market indices, bonds indices and commodities. This international coverage is extended to stock market indices world wide and also has live and dead series information on Options and Futures Contracts. *OECD.Stat* is the statistical data base of OECD, which includes around 300 data sets on OECD countries. The specific source of data for each variable is given below:

(i) *Real effective exchange rate (REER)*: REER data are collected from the WDI-2008. The base year for nominal exchange rate (NER) is 2000 and weights for other currencies are given on the basis of trade in manufacturing goods. The REER index is calculated from the NER and a cost indicator of relative normalized unit labour cost in manufacturing. An increase in the REER index represents an appreciation of the local currency.

REER data for Korea Republic are not available in the WDI. The REER for Korea is calculated using data from the *OECD.Stat*. In calculating REER from NEER, the consumer price index and producer price index for manufacturing are used as proxies for domestic and foreign price levels, respectively.⁹

(ii) *Terms of trade (TOT)*: Terms of trade data on the sample countries (except Czech Republic, Finland and Switzerland) are taken from the WDI-2008. For each

⁹ It is argued that it is a much better proxy for internal real exchange rate (Athukorala and Rajapatirana, 2003).

country the measure used is the net barter or commodity terms of trade, which is the ratio of the export price index to the import price index. Improvement or increase in the TOT indicates that the exports of the country have become more valuable or import have become cheaper. For Czech Republic, Finland and Switzerland, TOT data have been collected from Thomson Datastream, however, the original source of these data is *Economist Intelligent Unit* as reported in Datastream.

(iii) *Net Foreign Assets (NFA)*: Net foreign assets data on all countries are collected from the WDI-2008. NFA are the sum of foreign assets held by monetary authorities and deposit money banks, less their foreign liabilities. NFA are reported in local currencies. In the estimation procedure NFA is measured as a percentage of Gross Domestic Product (GDP). The benefits of this conversion is twofold: first, the NFA data are uniform across countries, as all are measured as a percentage of GDP; second, conversion of national currency into Euro in 1999 in some of the OECD countries changes the NFA figures to a great extent. This problem is avoided by converting them into percentage of GDP form.

(iv) *Government Expenditure (G)*: Government expenditure data are also taken from the WDI-2008 and expressed as a percentage of GDP. General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditure on national defense and security, but excludes government military expenditures that are part of government capital formation.

(v) *Interest rate differential (INTDIFF)*: The interest rate differential is calculated as the difference between US and individual country's real lending interest rate. These are collected from the WDI-2008. To get a real lending interest rate, the nominal lending interest rate is adjusted for inflation as measured by the GDP deflator.

(vi) *Demographic variables*: Data on demographic variables are also collected from the WDI-2008.

Chapter 5

Empirical Analysis

5.1: Introduction

The econometric methods described in previous Chapter are applied empirically and the estimation results are reported and interpreted in this Chapter. A model of the real exchange rate is specified with three demographic and other relevant variables as follows:

$$\ln REER = f(\ln TOT, G, NFA, INTDIFF, WAPOP, ODEP, YDEP) \quad (5.1)$$

where, $\ln REER$ is log of real effective exchange rate index; $\ln TOT$ is log of terms of trade index; G is government expenditure as a percentage of GDP; NFA is net foreign assets as a percentage of GDP; $INTDIFF$ is the interest rate differential, that is, difference between world and domestic real interest rate, US real interest rate being the proxy for world interest rate; $WAPOP$ (meant for working-age population) is the population aged between 15 to 64; $YDEP$ (meant for young dependents) is the population aged between 0 to 14; and $ODEP$ (meant for old dependents) is the population aged 65 and above. All population variables are expressed as percentage of total population. As the sum of three demographic variables is one, only two of them are included in the model based on the correlation among them.

The remainder of this chapter is organized as follows: panel unit root test results are reported and discussed in Section 5.2, the then Hausman and Breusch and Pagan Lagrangian Multiplier (LM) tests are employed to select fixed or random effect model in Section 5.3. The models selected as per these tests are estimated and results are reported and discussed in Section 5.4. Residual diagnostic tests are reported in Section 5.5. Based on the diagnostic tests, the panel corrected standard error (PCSE) method is applied and results are discussed in Section 5.6. The chapter concludes in Section 5.7.

5.2: Panel unit root test

Before conducting a panel unit root test it is useful to have a look at the time series plots of the variables. Time series plots of the variables are presented in Figures A5a.1 through A5a.8 in Appendix 5a. These figures show that all but NFA have no abnormal fluctuations. That means all other variables except NFA appear to be stationary. However, to make statistical inference it is imperative to perform more formal test for stationarity than just pictorial presentation.

Panel unit root test results are reported in Table 5.1. Figures in the parentheses indicate *p*-values. These results show that, except NFA, all variables are stationary at level, that is, they are $I(0)$. Only NFA is non-stationary at level and stationary at its first difference, that is, it is an $I(1)$ variable. This gives rise to a problem in estimating the model, because a regression equation consisting of stationary and non-stationary variables may be spurious. For this reason NFA is not included in estimating subsequent regression equations.

Table 5.1: Panel unit root test results

Variables	Exogenous variables Test statistics at level		Test statistics at first difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LNREER	80.63 (0.002)	66.13 (0.042)	275.56 (0.000)	244.15 (0.000)
LNTOT	80.63 (0.002)	66.13 (0.042)	275.56 (0.000)	244.15 (0.000)
G	79.02 (0.003)	89.01 (0.000)	242.90 (0.000)	197.23 (0.000)
NFA	26.14 (0.995)	46.95 (0.515)	270.24 (0.000)	231.53 (0.000)
INTDIFF	94.54 (0.000)	68.23 (0.0183)	369.96 (0.000)	304.84 (0.000)
WAPOP	198.47 (0.000)	217.82 (0.000)	138.09 (0.000)	386.29 (0.000)
YDEP	79.35 (0.003)	215.22 (0.000)	138.21 (0.000)	92.92 (0.000)
ODEP	110.95 (0.000)	178.79 (0.000)	137.68 (0.000)	113.74 (0.000)

Note: Figures in parentheses are *p* values (Results are generated using EViews-6)

Since all variables turn out to be stationary (except NFA), the next stage of analysis involves estimating a fixed or a random effect panel regression model instead of conducting a panel cointegration test. Accordingly, in the following section model selection tests are carried out to decide whether the fixed or the random effect model should be estimated.

5.3: Model selection tests

Before performing model selection tests, it is necessary to make sure which variables will be included in the model. Simple correlations among the demographic variables are estimated to examine this and the results are reported in Table 5.2.

Table 5.2: Correlations among demographic variables

	WAPOP	ODEP	YDEP
WAPOP	1.0000		
ODEP	-0.040 (0.330)	1.0000	
YDEP	-0.566 (0.000)	-0.801 (0.000)	1.0000

Note: Figures in the parentheses are *p* values. (Results are generated using Minitab 13)

Table 5.2 reveals that YDEP is highly correlated both with ODEP and WAPOP, whereas correlation between WAPOP and ODEP is very low and insignificant. Therefore, equation (5.1) is re-specified excluding NFA¹⁰ and YDEP¹¹ as follows:

$$\ln REER = f(\ln TOT, G, INTDIFF, WAPOP, ODEP) \quad (5.2)$$

The model selection test is carried out in two steps. In the first step, A Breusch and Pagan (1980) test is conducted to ascertain whether the regression model with a single constant term is appropriate or whether there is individual effect in the model. In the second step, the Hausman (1978) test is performed to identify whether the effect is fixed or random.

¹⁰ As NFA is a part of the theoretical model of the real exchange rate described in Chapter 3, a model including NFA is estimated and the results are reported in Appendix 5b.

¹¹ A model including YDEP is estimated and the results are reported in Appendix 5b.

5.3.1 Breusch and Pagan test

The Breusch and Pagan test (henceforth BP test) is performed for the Equation (5.2). The test results are reported in Table 5.3. The results show that the test statistic is highly significant, that is, the null hypothesis of no country specific effect is rejected at a very high significant level as indicated by the p value.

Table 5.3: BP test results

Test statistic	662.98
P value	(0.000)

(Results are generated using Stata 10)

Given this result, the next step is to test whether the country specific effects are fixed or random. The Hausman test is performed and the results are discussed next.

5.3.2 Hausman test

Hausman test is carried out to examine if the country specific effects are fixed or random and the test results are reported in Table 5.4.

Table 5.4: Hausman test results

Test statistic	1.35
P value	(0.9296)

(Results are generated using Stata 10)

From the test statistic and its associated probability, it can be inferred that the null hypothesis of Hausman test, which is that the random effect estimator is consistent, cannot be rejected. This implies that country specific effects are not correlated with the exogenous variables. In short, the models under consideration are justifiably estimable with the random effect model (REM).

5.4: Estimation results of random effect model

Having found support for random effect model, Equation (5.2) is estimated and the estimation results are reported in column (1) of Table 5.5. The estimation

results show that all the coefficients are highly significant. Signs of the variables are also as per expectations.¹²

Table 5.5: Estimation results of REM and PCSE

Independent variables	REM including Korea & Poland (1)	REM excluding Korea & Poland (2)	PCSE (3)
lnTOT	0.6422*** (0.0519)	0.4506* (0.461)	0.4053* (0.0500)
G	0.0063** (0.0034)	0.0156* (0.0027)	0.0105* (0.0023)
INTDIFF	-0.0043*** (0.0016)	-0.0053* (0.0012)	-0.0028* (0.0009)
WAPOP	-0.0100** (0.0040)	0.0180* (0.0035)	0.0085*** (0.0051)
ODEP	-0.0178** (0.0041)	-0.0119* (0.0034)	-0.0097** (0.0052)
Constant	2.4976*** (0.3630)	1.2452* (0.2962)	2.1610* (0.3860)
R^2 : Within	0.2499	0.3337	
Between	0.3130	0.2372	$R^2 = 0.9825$
Overall	0.2935	0.2638	
Wald χ^2	169.42 (0.000)	220.35 (0.000)	98.68 (0.000)

Note: (1) Figures in the parentheses are standard errors
 (2) *, ** and *** indicate significant at 1%, 5% and 10%, respectively.
 (3) Wald χ^2 statistics, figures in the parentheses are p values
 (4) Results are generated using Stata 10

The positive sign of the terms of trade coefficients indicate that improvement in terms of trade leads to real exchange rate appreciation. This implies that in the countries under study, terms of trade improvement works through *income effect*, that is, an improvement in terms of trade, either through higher exportable prices or lower importable prices, raises the income of the economy. This *income effect* increases the demand for non-tradables and their prices, which in turn, reduces the relative price of tradables and appreciates the real exchange rate. This result is

¹² Exclusion of country and time dummies may lead to omitted variable bias. However, the results of Hausman test provide no evidence of fixed effects associated with countries.

consistent with the findings of previous studies on OECD countries that improvements in terms of trade appreciate the real exchange rate through income effect, for example, Gregorio and Wolf (1994).

The positive coefficient of government expenditure indicates that majority share of the government expenditure falls upon non-tradable goods. For this reason, with higher government expenditure the price of non-tradables rises and the real exchange rate appreciates.

Negative and significant coefficient of interest rate differential variable indicates that capital inflow leads to appreciation of the real exchange rate. The negative coefficient of WAPOP is consistent with the life cycle theory in which an increase in the share of working-age population increases saving. This leads to capital outflow and real exchange rate depreciation. The negative sign of ODEP coefficient contradicts with life cycle theory. However, it is consistent with the empirical finding that the old dependents dissave their wealth slowly to guard against different uncertainties, such as health risk, risk of living more than life-expectancy, meeting out-of-pocket medical expenses etc. The conclusions on the relationship between demographic variables and the real exchange rate from the above REM estimation results cannot be relied upon unless it is made sure that the model has well behaved residuals. Thus, residuals from the above REM are plotted in Figure 5.1.

The residual plot indicates that Korea and Poland are outliers. Plots of the real effective exchange rate indices in Figure 5.2 show that Korea had a highly appreciated real exchange rate in the early 1980s and then it depreciated sharply. Nam and Kim (1999) note that this sharp depreciation was mainly for two reasons. First, despite domestic price stability, the nominal exchange rate against US dollar depreciated continuously through 1986. Second, the strong Japanese yen since 1985 accelerated the effective depreciation of Korean currency. Figure 5.2 also shows that Poland's real effective exchange rate index experienced significant depreciation in the late 1980s. This may be due to different macroeconomic adjustments or policies that took place during its transition period from a planned to market economy. Also this may be due to a large number of missing

observations. Due to the outlier problems these two countries are excluded and the model is re-estimated. The results are reported in column (2) of Table 5.5.

Figure 5.1: Plot of residuals from Equation (5.2)

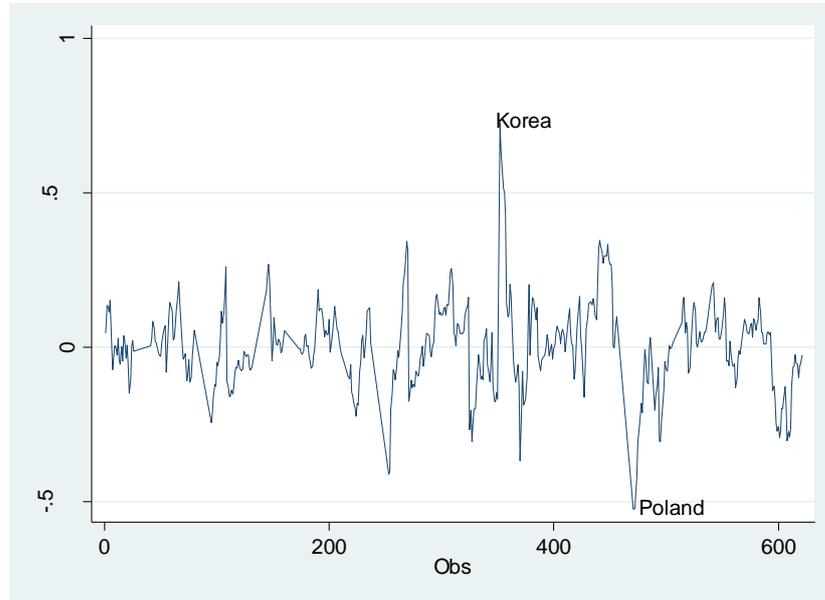


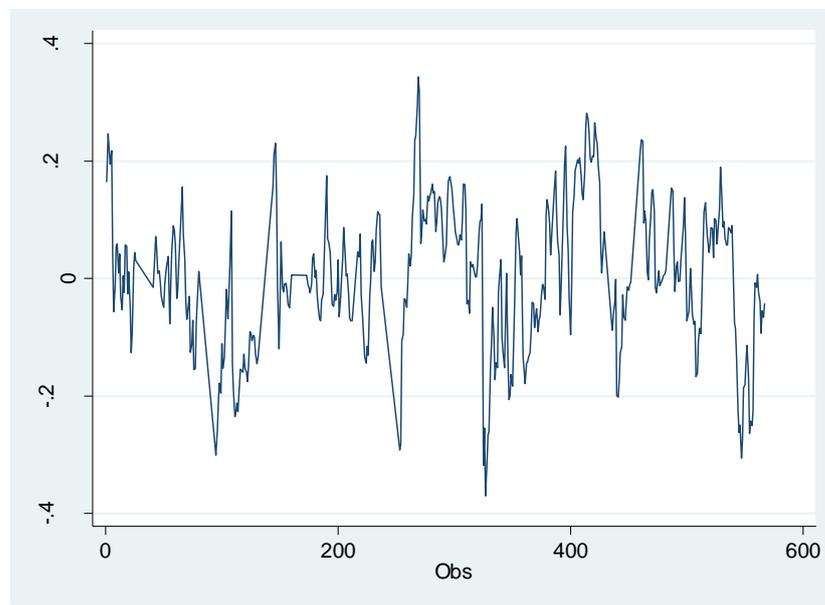
Figure 5.2: Real effective exchange rate indices of Korea and Poland



Estimation results for the sample without Korea and Poland in Table 5.5 show that all coefficients are significant 1% level. However, the sign of the coefficient of

WAPOP has changed. A positive coefficient is consistent with an increase in working-age population increasing marginal product of capital and decreasing marginal product of labour, and these changes occur in a way such that $x - y > xy$ (where x and y are the percentage changes in WAPOP and wage).¹³

Figure 5.3: Plot of residual from the model excluding Korea and Poland



The residual plot of this model in Figure 5.3 shows that there is no serious outlier problem. However, the residuals show a clear pattern of autocorrelation. The residuals may also be spatially correlated and have unequal variances. Kristensen and Wawro (2003) note that errors in time-series, cross-section (TSCS) or panel models are likely to exhibit any or all of the following:

- (i) Cross-sectional correlation: errors across cross-section units may be correlated because of a common shock in a given period;
- (ii) Panel heteroskedasticity: error variance may differ across cross-sectional units due to characteristics unique to each unit;
- (iii) Autocorrelation: errors within unit may be temporally correlated.

When a model suffers from these problems, estimates are not unbiased and efficient. It, therefore, becomes imperative to examine the model for these error related issues. The section that follows presents some diagnostics tests to see

¹³ Please see Appendix 3 for details.

whether the model suffers from spatial or cross-sectional correlation and autocorrelation.

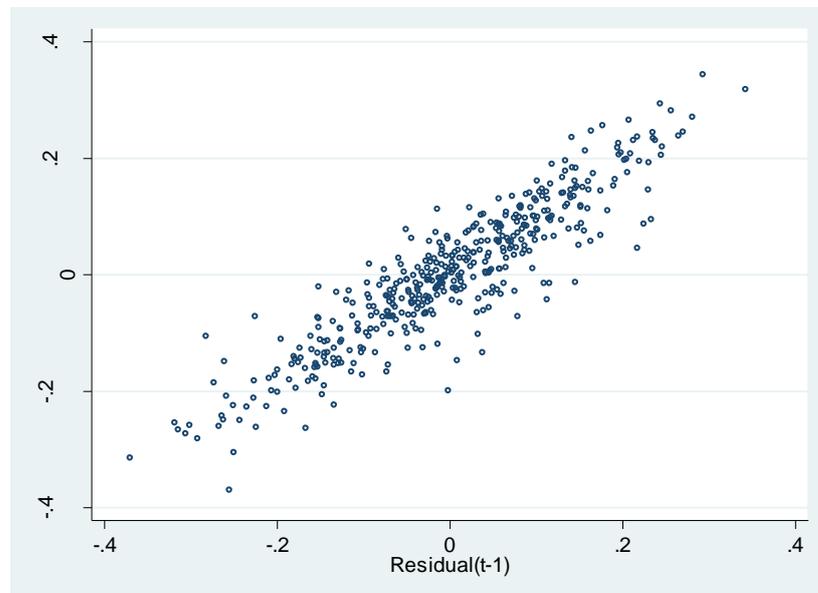
5.5: Diagnostic tests

In this section serial correlation and spatial correlation tests are performed and the results are reported and discussed. For serial correlation, Wooldridge's (2002) test is used and for spatial correlation Pesaran's (2004) cross-sectional dependence (CD) test is used. Stata 10 is used to calculate these test statistics.

5.5.1 Wooldridge's (2002) test

Although there are a number of tests available for testing serial correlation in panel data models, Wooldridge's (2002) test is used because it is easy to implement and requires relatively few assumptions (Drukker, 2003). The F statistic of Wooldridge's test is 33.983 with a p value 0.000, which clearly rejects the null hypothesis that there is no first order autocorrelation. Therefore, the residuals suffer from first order autocorrelation. From the plot of the residuals at time t against the residuals at time $(t-1)$ in Figure 5.4 it is confirmed that the autocorrelation is positive

Figure 5.4: Autocorrelation between Residual(t) and Residual($t-1$)



5.5.2 Pesaran's (2004) cross-sectional dependence (CD) test

This test is used to identify whether the disturbance terms are spatially correlated. A widely used test for this purpose is the Breusch and Pagan (1980) test.

However, this test is applicable for the panels where the number of cross-section units is fixed and the number of time periods approaches infinity. The sample in the present research contains 21 (excluding Korea and Poland) cross-section units and 27 time periods, that is, the difference is not substantial. Under this circumstance, Pesaran's (2004) test is more appropriate than the Breusch and Pagan (1980) test. This is because Pesaran (2004) notes that the CD test is likely to have good properties when both cross-section units and time periods are small. Moreover, The Breusch and Pagan (1980) test is applicable for fixed effect models, whereas, Pesaran's (2004) CD test is applicable for both fixed effect and random effect models. As the model under consideration is a random effect model, Pesaran's (2004) CD test is performed.

The test statistic of 7.927 with a p value of 0.000 indicates that the null hypothesis of cross-sectional independence is rejected at a very high significance level. The average absolute value of the off-diagonal elements 0.390 indicates that there is significant correlation between cross-sectional units.

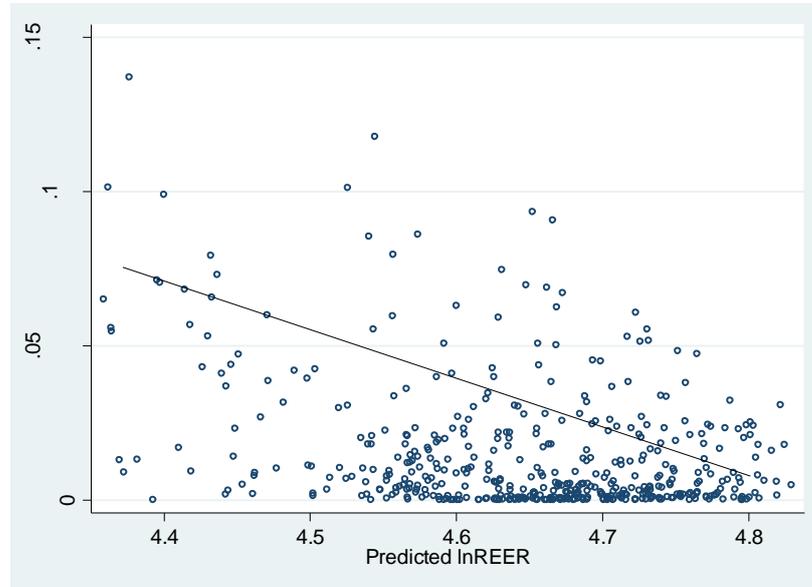
5.5.3 Heteroskedasticity in error terms

Unequal variances of the error terms pose another problem for efficient estimation of the parameters. Heteroskedasticity is traditionally assumed to be a problem of cross-section data. However, when cross-section and time series data are combined, variance of each cross-section unit is unlikely to be equal. This gives rise to a problem of group-wise heteroskedasticity. Greene (2000) proposes a test for examining this group-wise heteroskedasticity in fixed effect models. However, there is no test available for random effect models. Under this situation, one solution is to assume that the errors are homoskedastic and estimate the models correcting for serial and cross-sectional dependence. As heteroskedasticity is the result of characteristics unique to each cross-section unit, it is likely that the error variances are unequal across cross-sectional units. If this is the case, then the parameter estimates will not be efficient.

As there is no test available to examine heteroskedasticity in a random effect model, plotting squared residual against the predicted value of the dependent variable may give a rough idea of the nature of heteroskedasticity in the error

terms (Gujarati, 2003:401). Figure 5.5 shows that the estimated mean value of lnREER is systematically related to the squared residual.

Figure 5.5: Plot of squared residual and predicted lnREER



5.6: Regression estimates allowing for serial correlation, spatial correlation and heteroskedasticity

The above serial and cross-sectional correlation results and the plot of squared residuals against predicted lnREER suggest that the estimates of the parameters reported in Table 5.5 are not reliable as the disturbances do not hold the required desirable properties. Under this situation, that is, when disturbances are serially and spatially correlated and heteroskedastic, the options that are available to obtain unbiased and efficient parameter estimates are:

- (i) Feasible Generalized Least Square (FGLS);
- (ii) Panel Corrected Standard Errors (PCSE)

(i) Feasible Generalized Least Square (FGLS): When the errors are nonspherical the OLS estimate produces incorrect standard errors and the estimates are not best linear unbiased (BLUE). In this situation, Generalized Least Square (GLS) produces unbiased standard errors and the estimates are BLUE. The limitation of GLS is that it assumes that the variance-covariance matrix (Ω) used to weight the data is known, which is not the case in practice. An alternative to GLS is to use

the estimate of the variance-covariance matrix to weight the data. This method is known as Feasible Generalized Least Square (FGLS). This FGLS method, developed by Park (1967), is applicable in panels where the number of cross-section units (N) is larger than the number of time periods (T). However, this method produces biased standard errors when applied to panels where T>N (Beck and Katz, 1995). A panel with T>N is called a Time-Series, Cross-section (TSCS) model. In this present research T = 27 and N = 21, therefore, this effectively is a TSCS data model.

(ii) *Panel Corrected Standard Error (PCSE)*: As an alternative to FGLS, Beck and Katz (1995) advocate the method of Panel Corrected Standard Error (PCSE). The present study follows this PCSE method because the models under consideration are basically TSCS type. This section provides a brief description of PCSE method and discusses the estimation results. In PCSE coefficients are estimated by OLS and then standard errors are corrected for nonspherical distribution of the disturbance term. In this method the variance-covariance matrix Ω is a block diagonal matrix with an N x N matrix of contemporaneous correlations (Σ) along the diagonal. Σ is calculated from OLS residuals as follows:

$$\widehat{\Sigma}_{i,j} = \frac{\sum_{t=1}^T e_{i,t}e_{j,t}}{T}$$

Where $e_{i,t}$ is the OLS residual for a unit i at a time t . Then the standard errors of coefficients are computed as the square root of the diagonal elements of

$$(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\widehat{\Omega}\mathbf{X}(\mathbf{X}'\mathbf{X})^{-1}$$

where \mathbf{X} is the $NT \times NT$ matrix of stacked vectors of explanatory variables, $\mathbf{x}_{i,t}$. Monte Carlo studies show that PCSE produces more reliable standard errors than FGLS (Beck and Katz, 1995 & 1996). As the model in this study suffers from the problem of nonspherical disturbances, PCSE is applied and the estimation results are reported in column (3) of Table 5.5.

In the regression equation the dependent variable (REER) is in logarithmic form. Among independent variables, only the terms of trade (TOT) is in logarithmic form. Therefore, the coefficient of lnTOT is the elasticity of REER with respect to

TOT. The other variables are in percentage form. In these cases the interpretations of coefficients are that of log-linear model, where only dependent variable is in logarithmic form. In log-linear model, a slope coefficient indicates relative change in dependent variable for one unit change in an independent variable. Thus, when the coefficient is multiplied by 100, it is interpreted as the percentage change in dependent variable for a unit change in independent variable (Stewart, 2005:233). Therefore, all coefficients, except the coefficient of \ln TOT, are multiplied by 100 to express percentage change in REER index.

The estimation results reported in column (3) of Table 5.5 show that the coefficients of the independent variables are significant and have signs similar to those in column (2). However, the coefficient values are lower in the PCSE than the REM. For example, the \ln TOT coefficient in PCSE (column 3) is 0.4053, whereas it is 0.4506 in REM (column 2), that is, under PCSE method a 1% increase in log of TOT index appreciates the log of REER index by 0.4053%. As the coefficient is substantially less than one, it can be said that the real exchange rate is inelastic to the change in terms of trade. The coefficient of government expenditure shows that when government expenditure increases by 1% of GDP, the log of REER index appreciates by 1.05%. An increase in the interest rate differential depreciates the log of REER index by 0.28%.

The coefficients of demographic variables show that the magnitude of the impact of the old dependents on the real exchange rate is more than that of the working-age population. The coefficient of working-age population indicates that when the share of working-age people in the total population increases by 1%, the log of REER index appreciates by 0.85%, whereas, when the share of old dependents in the total population increases by 1%, the log of REER index depreciates by 0.97%.

The findings of the present study contrast with the results of previous studies. Previous studies on this issue are those of Andersson and Österholm (2005 & 2006). In those studies the higher share of population who are at their working-age cause real depreciation through saving and capital outflow, whereas, a higher share of population who are dependents and not productive causes real

appreciation through dissaving. To be specific, their studies find that more young and old dependents cause real appreciation and a larger working-age population causes real depreciation.

The results in Table 5.5, on the contrary, show that working-age population appreciates the real exchange rate. A higher share of working-age people increases the number of workers. An increased number of workers raises the marginal product of capital and hence return on capital. An increased number of workers also decreases the marginal product of labour and hence wage. On the one hand, wage decreases in such a way that aggregate saving falls, and the higher return on capital attracts capital, on the other hand. These two effects, lower saving and higher return on capital, combine to cause capital inflow and the real exchange rate to appreciate. Previous studies (Andersson and Österholm 2005 & 2006) consider only the impact on the saving channel and ignore the investment avenue that has significant influence on saving and capital flows.

Andersson and Österholm (2005 & 2006) argue that old dependents cause capital inflow through dissaving and thereby appreciate the real exchange rate. As mentioned in Chapter 3, the assumed saving behavior of the old in the life-cycle hypothesis is that they dissave to smooth their consumption does not agree with their observed saving behavior. Some convincing explanations for the observed behavior are that the old dependents dissave very slowly to guard against the out-of-pocket medical expenses, to guard against outliving their life expectancy and to leave bequests. The finding of the present study fits with these practical explanations of the observed saving behavior of the old. The finding also points to the fact that the supply of saving of the elderly people outweighs the demand for investment they place in the economy.

5.7: Conclusion

This chapter reports and interprets estimation results of empirical specifications based on the theoretical model developed in Chapter 3 following the econometric

methods discussed in Chapter 4. Three demographic variables are considered in the empirical specification: working-age (WAPOP), young dependents (YDEP), and old dependents (ODEP) – all are expressed as percentage of total population. However, due to high correlation of YDEP with the other demographic variables, only WAPOP and ODEP are included in regression equation. Other independent variables are the log of the terms of trade index (lnTOT); the interest rate differential (INTDIFF), government expenditure (G) and net foreign assets (NFA), with the last two variables measured as percentage of GDP.

As the data used in this study are for a number of countries over a period of time, the chapter begins with the examination of stationarity properties of the variables included in model. All variables are found stationary at level except NFA, which is I(1). For this reason NFA is excluded from the regression model. Model selection tests show that the random effect model (REM) is the appropriate model to estimate. Further, diagnostic tests suggest that the residuals from the REM suffer from significant serial and cross-sectional correlation and, as the data are in panel format; residual variances of different countries are most likely to be different. To correct for these residual related problems, Panel Corrected Standard Error (PCSE) is used to estimate the models.

Results of PCSE show that the proportion of working-age population has an appreciating effect and the proportion of old dependents has a depreciating effect on the real exchange rate. The appreciating effect of working-age population suggests that an increase in the size of this cohort raises return to capital. At the same time it lowers aggregate private saving by decreasing wage. As a consequence capital inflow takes place and the real exchange rate appreciates. Old dependents seem to continue to save for various reasons (as discussed in Chapter 3) and put lower investment demand relative to their saving. This excess saving causes capital outflow and the real exchange rate to depreciate.

The findings contrast with those of previous studies. However, the results seem to be contingent upon the choice of the sample. In regard to the effect of the working age population on the real exchange rate, the sample with Korea and Poland gives opposite results than the sample without those countries. This indicates that the results are sensitive to the selection of sample. Moreover, as the productivity

differential (Balassa-Samuelson effect) is not explicitly modeled here, it is possible that the demographic variables may partially capture the effect of productivity differential on the real exchange rate. Therefore, caution should be taken while interpreting the results.

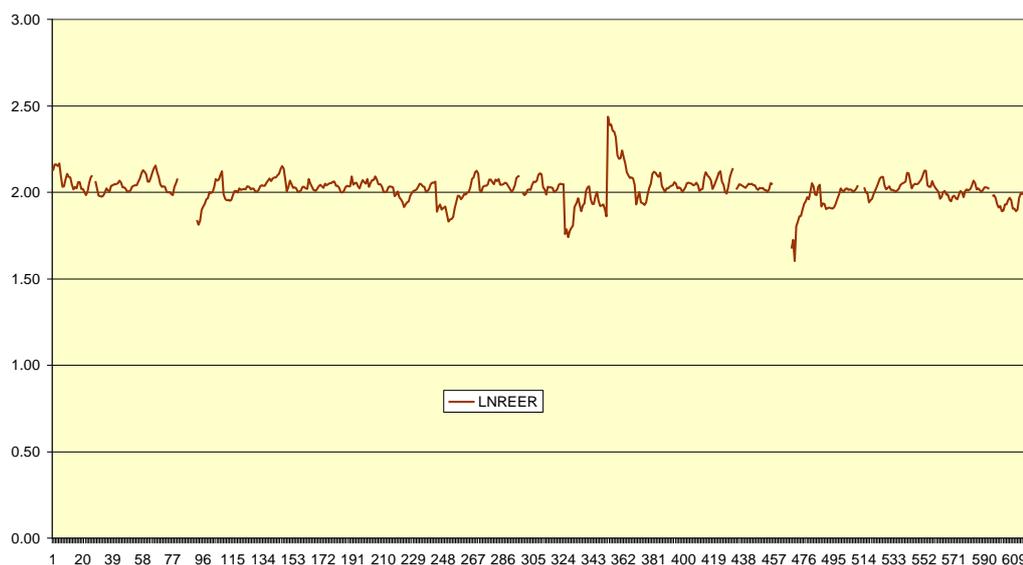
Appendix 5a

Table A5a.1: Descriptive statistics (panel data)

Variable	Obs	Mean	Std. Dev.	Min	Max
lnREER	592	4.64	0.181	3.687	5.610
lnTOT	559	4.59	0.132	3.995	4.930
G	589	18.94	4.599	9.742	29.943
NFA	588	5.33	16.219	-59.574	90.671
INTDIFF	557	0.21	3.706	-11.233	12.714
WAPOP	610	66.65	2.034	58.652	72.041
ODEP	610	13.63	2.803	3.811	20.254
YDEP	610	19.70	3.398	13.779	33.997

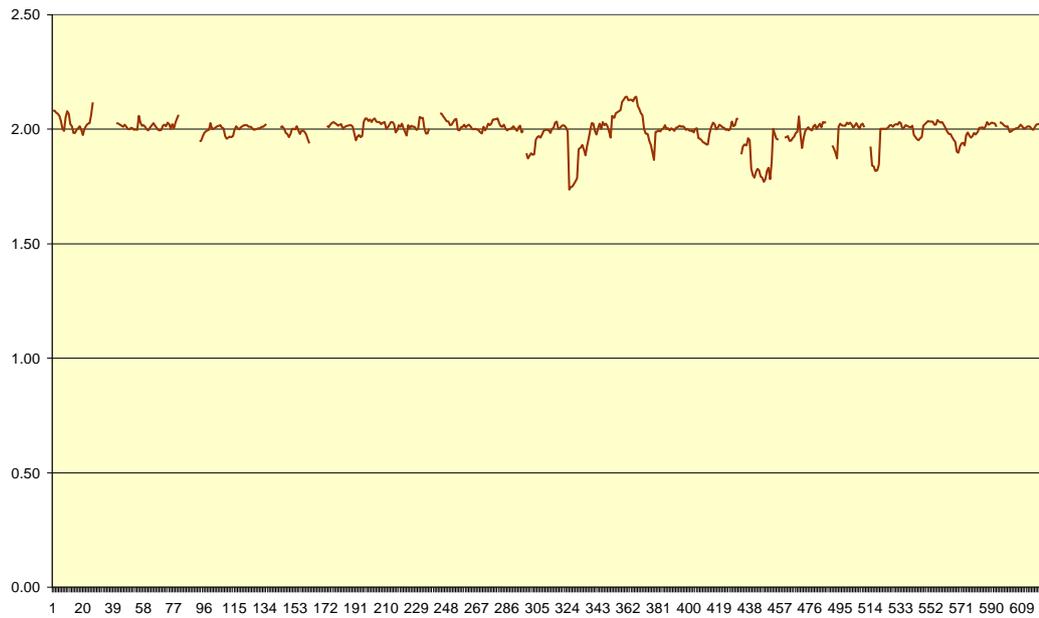
(Stata 10 is used to generate these statistics)

Figure A5a.1: Log of the real effective exchange rate index (lnREER)



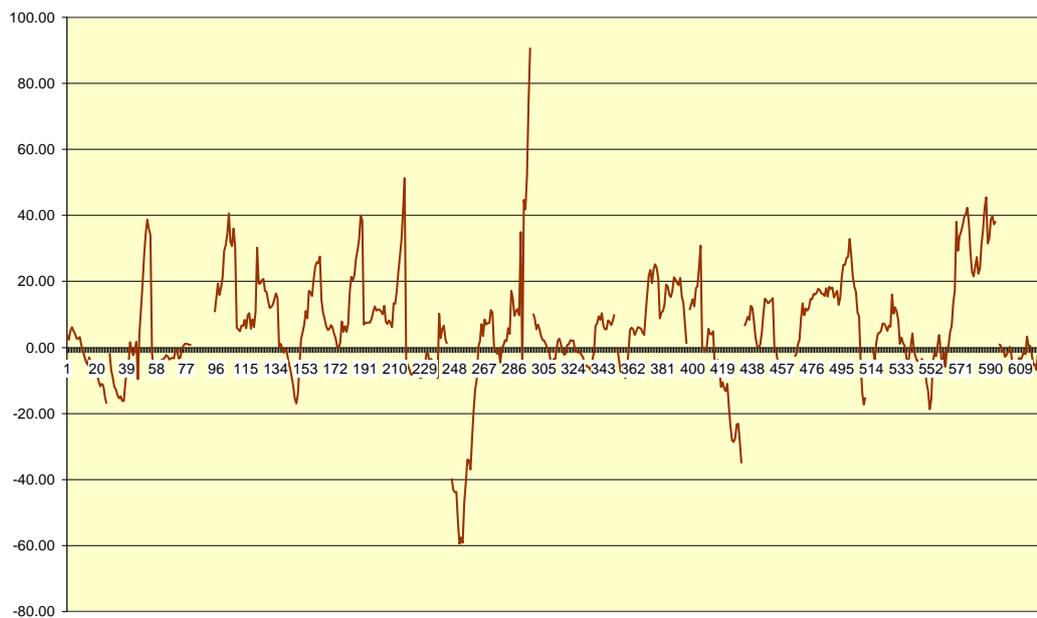
Source: World Bank, 2008

Figure A5a.2: Log of terms of trade index (lnTOT)



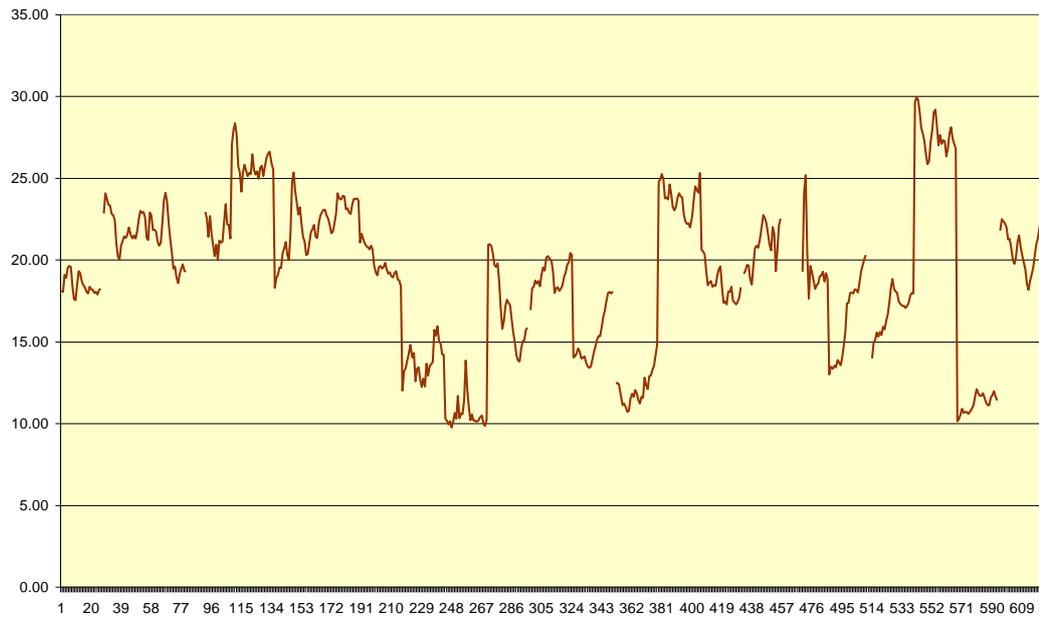
Source: World Bank, 2008

Figure A5a.3: Net foreign assets as % of GDP (NFA)



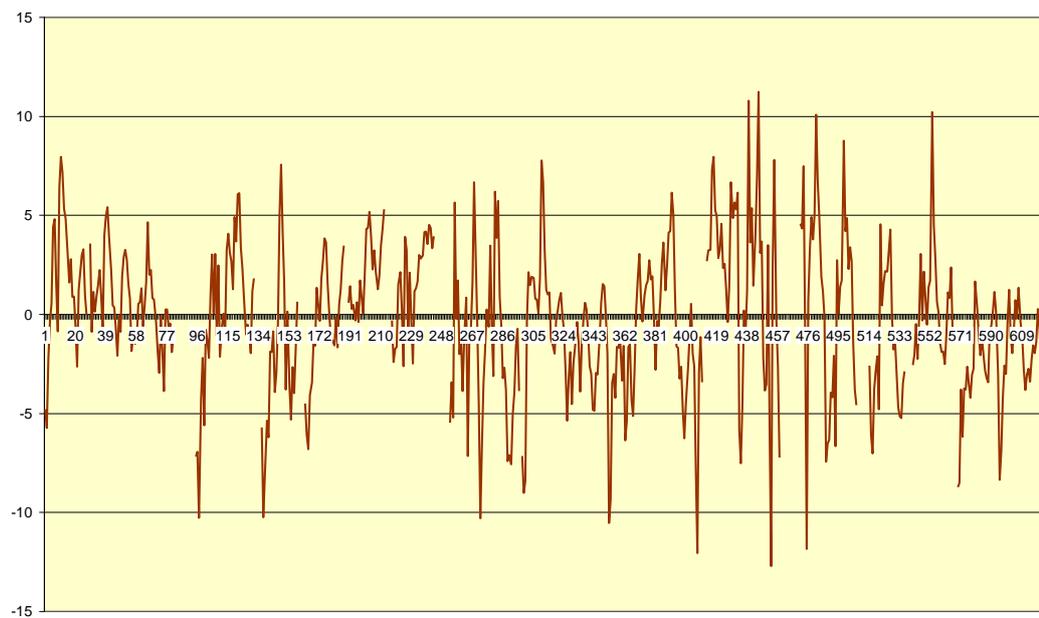
Source: World Bank, 2008

Figure A5a.4: Government expenditure as % of GDP (G)



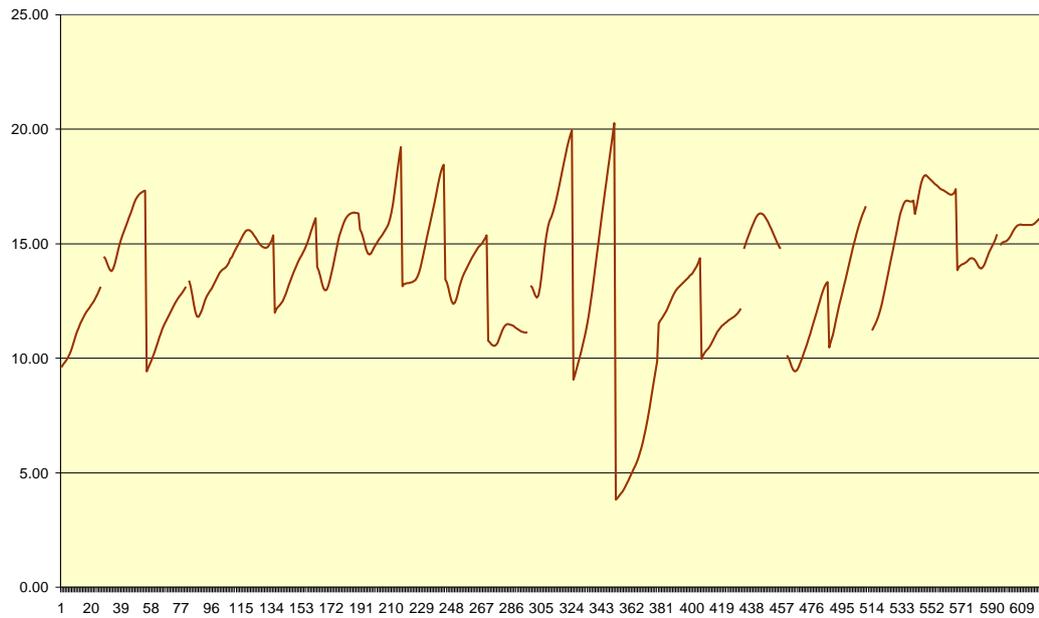
Source: World Bank, 2008

Figure A5a.5: Interest rate Differential (INTDIFF)



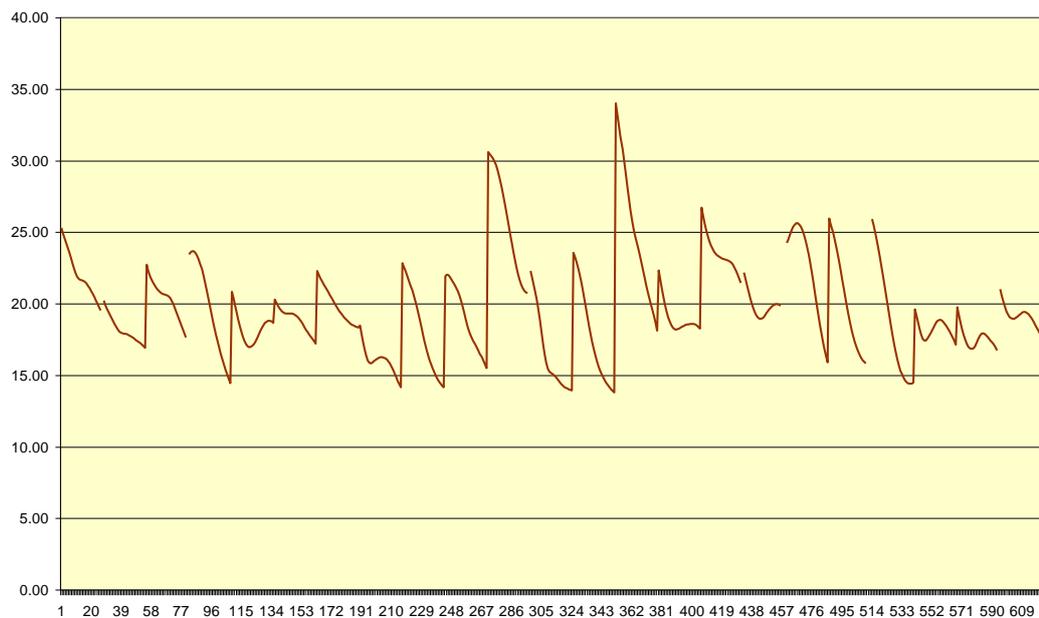
Source: World Bank, 2008

Figure A5a.6: Old dependents (ODEP)



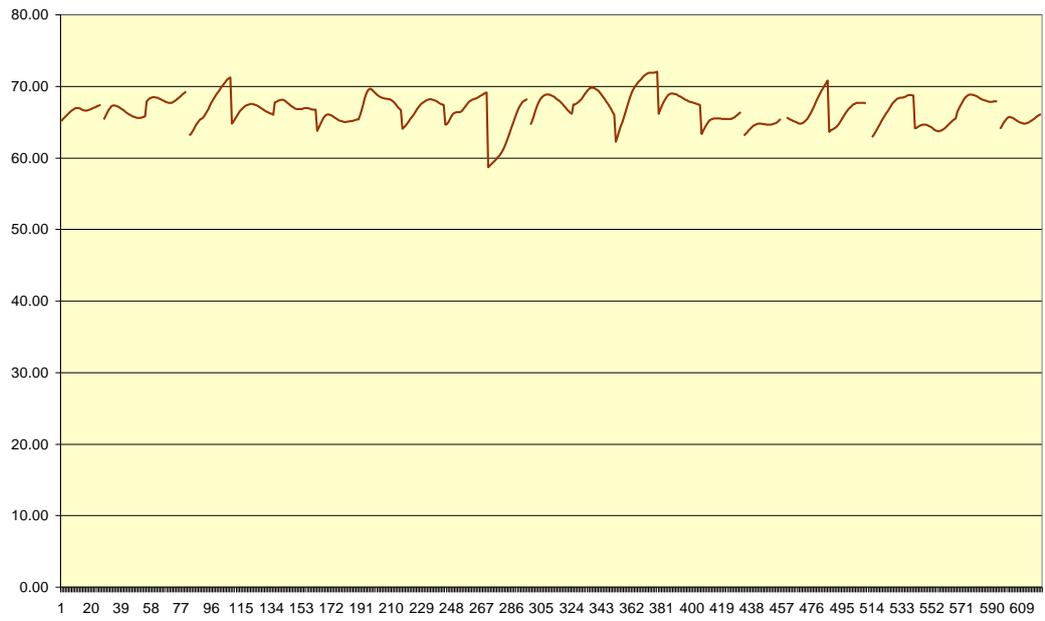
Source: World Bank, 2008

Figure A5a.7: Young dependents (YDEP)



Source: World Bank, 2008

Figure A5a.8: Working-age population (WAPOP)



Source: World Bank, 2008

Appendix 5b

Regression results with net foreign assets (NFA) and young dependents (YDEP)

In Chapter 5 NFA and YDEP are excluded from the panel regression model. This appendix reports estimation results of a panel regression model including these two variables.

NFA is found to be an I(1) variable, whereas all other variables found I(0). Therefore, it is not included in the main regression equation. However, this variable is a part of the theoretical model discussed in Chapter 3. It is, therefore, useful to examine the impact of this variable on the real exchange rate. As such, a regression model including NFA is estimated. The results are reported in column (1) of Table A5b.1.

YDEP is highly correlated with WAPOP and ODEP. For this reason this variable is excluded from the regression. As the objective in this thesis is to examine the impact of different cohorts of population on the real exchange rate, this variable is included in the regression model and the results are reported in column (2) of Table A5b.1. Column (3) of Table A5b.1 reports estimation results of a regression model that includes both NFA and YDEP.

The results in column (1) of table A5b.1 show that NFA does not affect the real exchange rate index significantly. The coefficient has the expected sign, that is, an improvement in NFA raises national wealth of an economy, thereby inducing larger expenditure on and, therefore, the price of non-tradable goods, which, in turn appreciates RER. The values of the coefficients of other variables show some changes, however, the signs remain the same as in Table 5.5.

The coefficient of YDEP in column (2) of the table implies that the young dependents do not have any significant impact on the real exchange rate. The sign of the coefficient is as per *a priori* expectation, that is, higher share of young dependents in the population reduces saving and increases investment demand and thereby causes capital inflow and appreciation of the real exchange rate. However,

the estimated coefficient shows that this effect is not significant at any acceptable level.

Finally column (3) of the table reports results both with NFA and YDEP. The results do not produce any substantially different outcome than those reported in column (1) and (2) where NFA and YDEP are included separately in the regression model.

Table A5b.1: PCSE regression results with NFA and YDEP

Variables	Results with NFA	Results with YDEP	Results with NFA & YDEP
	(1)	(2)	(3)
<i>lnTOT</i>	0.4086*** (0.0501)	0.4054*** (0.094)	0.4094*** (0.0495)
G	0.0103*** (0.0022)	0.0090*** (0.0023)	0.0088** (0.0022)
NFA	0.00040 (0.0003)		0.00042 (0.0003)
INTDIFF	-0.0029*** (0.0009)	-0.0029*** (0.0009)	-0.0029** (0.0009)
WAPOP	0.0073 (0.0049)		
ODEP	-0.0100** (0.0050)		
YDEP		0.0009 (0.0035)	0.0018 (0.0033)
Constant	2.231*** (0.3778)	2.600*** (0.2518)	2.567*** (0.2507)
R^2	0.9834	0.9819	0.9830
Wald χ^2	100.34 (0.000)	87.45 (0.000)	89.96 (0.000)

Note: (1) Figures in the parentheses are panel-corrected standard errors
(2) *, ** and *** indicate significant at 1%, 5% and 10%, respectively.
(3) Wald χ^2 statistics, figures in the parentheses are *p* values
(4) Results are generated using Stata 10.

Chapter 6

Population Structure and Real Exchange Rate in Australia: A Case Study

6.1 Introduction

The impact of population structure on the real exchange rate in a panel setting is documented in Chapter 5. Given that panel evidence, it is of practical importance to see whether the variables behave in the similar fashion when applied to a single cross-section unit or country. In this chapter, Australia is selected for such a case study to examine the relationship between the real exchange rate and population structure. Australia is selected because it is one of the countries that is passing through very notable changes in its population composition. It is, therefore, interesting to see how these changes affect Australia's real exchange rate as modeled in Chapter 3. Accordingly, the objective of this chapter is to examine the impact of different cohorts of Australia's population on its real exchange rate.

The remainder of this chapter consists of a general discussion on Australia's population presented in Section 6.2 followed by methodology in Section 6.3. Section 6.4 reports and discusses estimation results, followed by implications of empirical finding and conclusion in Section 6.5.

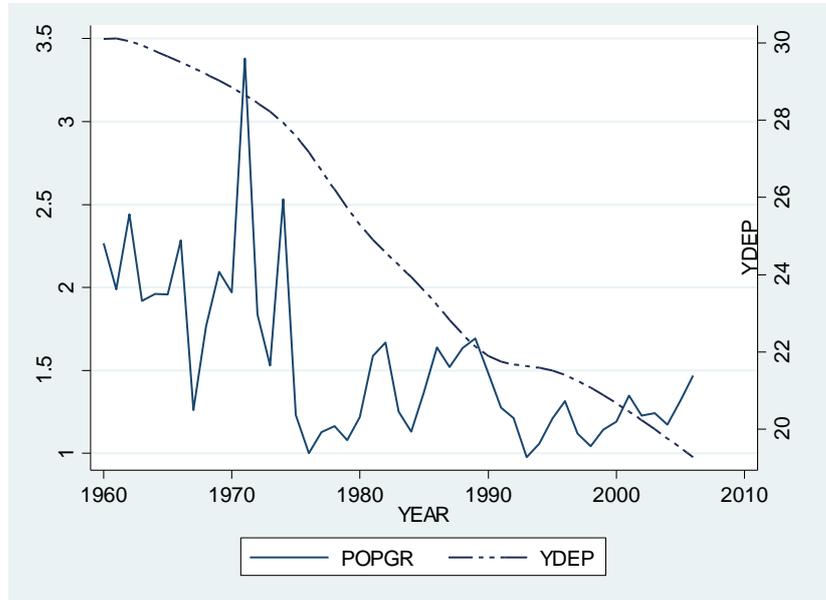
6.2: Population dynamics in Australia

Australia's population composition has been changing over a long period of time giving rise to an aging society. Due to a fall in the population growth rate, different cohorts of population show consistent changes over time. Figures 6.1 to 6.3 show how three groups of population have changed over the period 1960-2006.

These changes, especially the increase in old dependents, have attracted attention of policymakers because of fiscal consequences of having such a large portion of old dependents in the total population. For example, the Australian Productivity Commission projects that there will be a significant increase in old age related

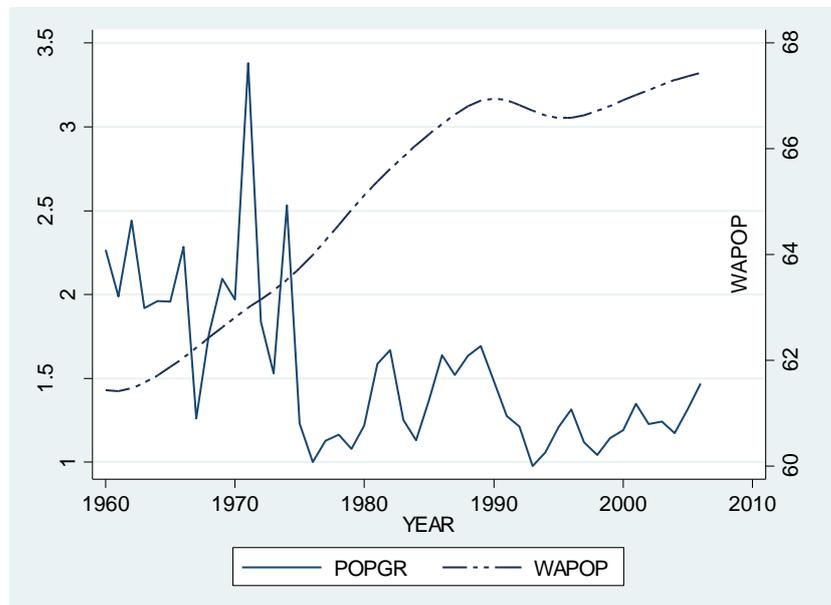
expenditure by the years 2044 – 45. Table 6.1 below shows how change in the age structure will affect government spending as a percentage of GDP.

Figure 6.1.: Population growth rate (POPGR) and young dependents (YDEP)



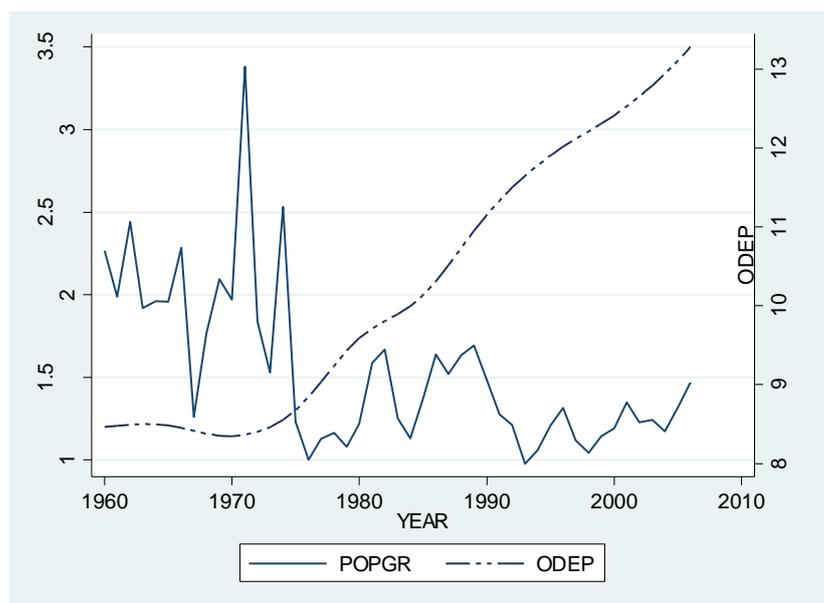
Source: World Bank, 2008.

Figure 6.2: Population growth rate (POPGR) and working-age population (WAPOP)



Source: World Bank, 2008.

Figure 6.3: Population growth rate (POPGR) and old dependents (ODEP)



Source: World Bank, 2008.

Table 6.1: Age related government spending to GDP ratios in Australia

Spending category	2003-04 (%)	2044-45 (%)	Difference (Percentage points)
Health care	5.7	10.3	4.5
Aged cares & careers	1.1	2.4	1.4
Age pensions	2.9	4.6	1.7

Source: Productivity Commission (2005)

These increases in government spending on aged people have been the focus of a number of research studies. However, as Figure 6.1 and 6.2 show that the lower population growth has also been accompanied by lower young dependents (aged between 0-14) (hereafter YDEP) and higher working-age population (aged 15 to 64) (hereafter WAPOP), these trends also have significant implications for the real exchange rate through their effects on capital flows. The implications of this changing demographic structure for capital flow and the real exchange rate in Australia have largely been overlooked in literature.

It is hypothesized in Chapter 3 that a larger share of working-age population may either depreciate or appreciate the real exchange rate by generating net positive or negative saving, whereas, young dependents will appreciate the exchange rate by reducing saving. Although traditional view on the relationship between old age

population and saving postulates that higher share of old dependents will have negative impact on saving, empirical evidence suggests to the contrary (Mirer, 1979; Danziger *et al.*, 1982-83; Nardi *et al.*, 2006 & 2009); that is, the old generation contribute to saving positively, which appreciates the real exchange rate.

The population structure will affect capital flows through its impacts on saving and investment. In Chapter 3, it is hypothesized that higher WAPOP will generate net positive (or negative) saving and thereby cause capital outflow (or inflow) and depreciate (or appreciate) the real exchange rate. ODEP will have similarly ambiguous effects on capital flow and the real exchange rate. However, YDEP will have negative effect on saving and appreciate the real exchange rate. A number of empirical studies have shown that population structure has significant influence on the movement of capital (for example Taylor and Williamson 1994; Higgins and Williamson 1997; Higgins 1998; Brooks 2000; Feroli 2003; and Domeij and Flode'n 2006). Investment is affected by different cohorts of population differently. YDEP and ODEP affect investment through their consumption demand for, mainly, non-tradable goods. WAPOP affects investment through labour supply.

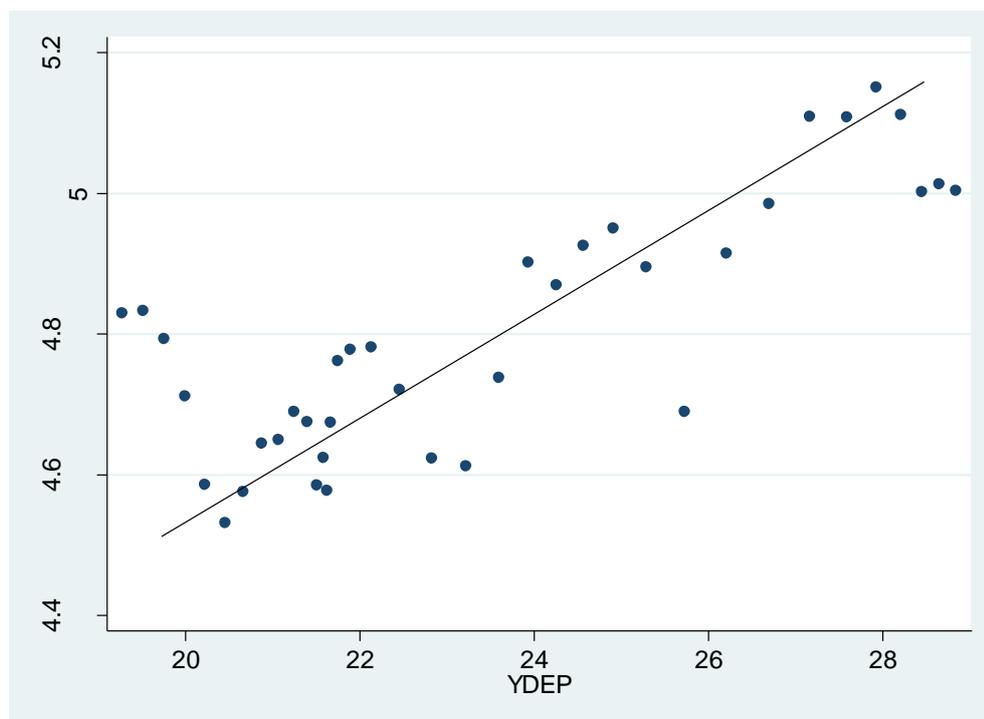
Given the impact of demographic variables on saving and capital flows, it is useful to see whether Australian data show any significant relation between its real exchange rate and demographic variables. Figure 6.4 through Figure 6.6 plot Australia's real effective exchange rate against the three demographic variables and Table 6.2 reports their correlations coefficients. It is clear from the plots and the correlation coefficients in the table that there is a significant negative association between Australia's real effective exchange rate and working-age population and old dependents, and a positive association between the real effective exchange rate and young dependents.

A negative association between the real exchange rate and WAPOP could indicate that a higher share of WAPOP increases saving and therefore causes a capital outflow and appreciation of the real exchange rate. A higher share of WAPOP also increases the marginal product of capital and the return on capital, while

decreasing the marginal product of labour and causing the wage to fall. However, the wage could fall in a way such that aggregate private saving rises.¹⁴ Increase in domestic saving outweighs the increase in investment demand required by the higher return on capital. Excess capital flows out and the real exchange rate depreciates.

A negative association between ODEP and the real exchange rate indicates that elderly people continue to save and their saving outweighs the investment demand they place in the market through their consumption behavior. This causes capital outflow and the real exchange rate to depreciate. The positive association between YDEP and the real exchange rate indicates that the young group reduces saving and affects investment positively causing capital inflow and real appreciation.

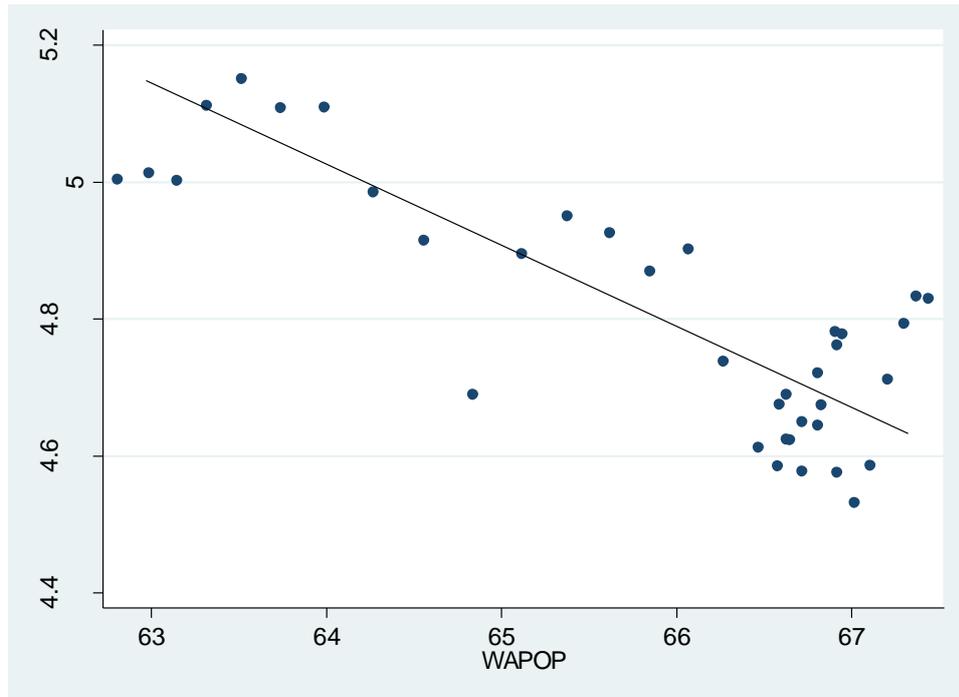
Figure 6.4: Log of real effective exchange rate (lnREER) and young dependents (YDEP), 1970 – 2006



Source: World Bank, 2008 and Reserve Bank of Australia, 2009.

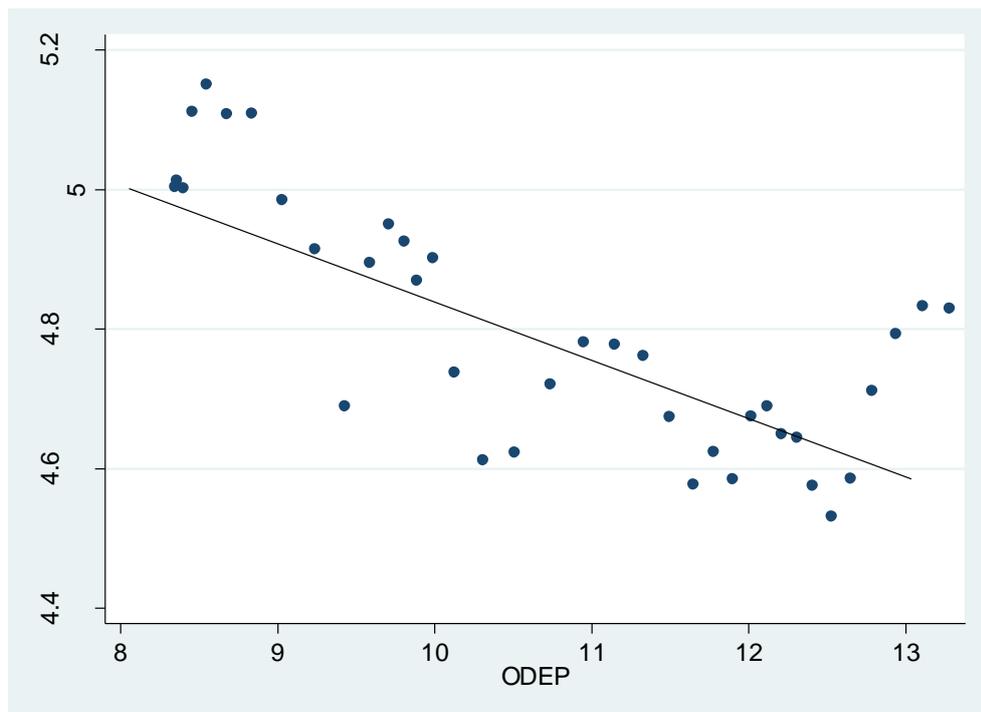
¹⁴ Please see Appendix 3 for details.

Table 6.5: Log of real effective exchange rate (lnREER) and working-age population (WAPOP), 1970-2006



Source: World Bank, 2008 and Reserve Bank of Australia, 2009.

Figure 6.6: Log of real effective exchange rate (lnREER) and old dependents (ODEP), 1970-2006



Source: World Bank, 2008 and Reserve Bank of Australia, 2009.

Table 6.2: Correlations between real effective exchange rate (REER) index and three demographic variables, 1970-2006.

	YDEP	WAPOP	ODEP
REER	0.816	-0.828	-0.771
<i>p</i> -values	(0.000)	(0.000)	(0.000)

Data Source: World Bank, 2008 and Reserve Bank of Australia, 2009.
(Minitab 13 is used to generate these statistics)

To provide more sophistication to these empirical relations, formal econometric estimation procedures according to the model developed in Chapter 3 are carried out. Econometric methods are described in the following section followed by the empirical estimation results in Section 4.

6.3: Methodology

This section describes the empirical methods of estimating the regression model of the real exchange rate for Australia and reports and discusses the estimation results of the model. As the dataset consists of only one cross-section unit, the estimation procedure will differ from those of panel dataset used in Chapter 5. This section begins with specifying the empirical model of the real exchange rate. Then econometric estimation procedures are described, which include testing time-series properties of the variables and estimation of a suitable regression model.

6.3.1 The model

The relation between the real effective exchange rate (REER) and other variables is specified as follows:

$$\ln REER = f(\ln TOT, G, NFA, INTDIFF, WAPOP, ODEP, YDEP) \quad (6.1)$$

where $\ln REER$ stands for the log of the real effective exchange rate index, $\ln TOT$ for the log of terms of trade index, G for government expenditure as a percentage of GDP, NFA for net foreign assets as a percentage of GDP, $INTDIFF$ for interest rate differential, $WAPOP$ for working-age population, $ODEP$ for old dependents and $YDEP$ for young dependents. These three demographic variables are expressed as percentage of total population. However, although three

demographic variables are included in (6.1), only two will be included in the regression equation to avoid the problem of perfect multicollinearity.

6.3.2 Unit root test

Unit root testing is a pre-requisite of examining the relationship between two or more time series of data. The Augmented Dickey-Fuller (ADF) is the widely used test for examining whether the series under consideration is stationary or contains a unit root. For any time series, y_t the ADF test involves estimating regression equations of the following forms:

$$\Delta y_t = \beta_1 + \delta y_{t-1} + \alpha_i \sum_{i=1}^m \Delta y_{t-i} + \varepsilon_t \quad (6.2)$$

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^m \Delta y_{t-i} + \varepsilon_t \quad (6.3)$$

Equation (6.2) tests the null hypothesis of a unit root against a mean-stationary alternative in y_t and equation (6.3) tests the null hypothesis of a unit root against a trend-stationary alternative. The term Δy_{t-i} is the lagged first difference included to accommodate serial correlation in errors and lag lengths are selected by information criteria.

Although the ADF test is widely used in empirical research, DeJong *et al.* (1992) note that it has low power against the alternative hypothesis. Elliot, Rothenberg and Stock (ERS) (1996) develop a feasible point optimal test, called DF-GLS¹⁵ test, which relies on local GLS de-trending to improve the power of the unit root tests. The DF-GLS t test is performed by testing the hypothesis, $\alpha = 0$, in the following regression

$$\Delta y_t^d = \alpha_0 y_{t-1}^d + \alpha_1 \Delta y_{t-1}^d + \dots + \alpha_p \Delta y_{t-p}^d + \varepsilon_t \quad (6.4)$$

Phillips and Perron (1988) propose an alternative non-parametric method of controlling for serial correlation. The Phillips-Perron (PP) method involves estimating a non-augmented Dickey-Fuller (DF) equation [without $\alpha_i \sum_{i=1}^m \Delta y_{t-i}$ term in equation (6.2) and (6.3)] and modifies the t ratio of the δ coefficient so that

¹⁵ DF-GLS stands for Dickey-Fuller-Generalized Least Square

serial correlation does not affect the asymptotic distribution of the test statistic. For comparison purpose all these three tests are used in this chapter for examining the stationarity properties of the variables under study.

However, one limitation of the traditional unit root tests is that they cannot identify the structural breaks in the underlying time series data, if there are any. Therefore, the traditional unit root test results may not be valid for series having structural breaks. A number of authors have pointed out this limitation of the conventional unit root tests, for example, Perron (1989 & 1997); and Zivot and Andrews (1992). To overcome this problem Perron (1989) develops a procedure that allows an exogenous structural break at time T_b , that is, the time of break is assumed to be known *a priori*. However, Zivot and Andrews (1992) criticize this test for treating the break point as exogenous. Zivot and Andrews (1992), and latter Perron (1997), further develop unit root tests that consider the break point as endogenous. A large number of empirical studies have allowed structural breaks in the series in question in recent years (for example, Salman and Shukur, 2004; Narayan and Smyth, 2005; Salim and Bloch 2009; Hacker and Hatemi-J, 2008).

Breaks in time-series data by a shock occur either instantaneously or gradually. Instantaneous change to the new trend function is modeled in the *Additive Outlier (AO)* model and the change that takes place gradually is modeled in the *Innovational Outlier (IO)* model. Both models are estimated and results are compared with other tests.

One problem with the Perron (1997) test is that it assumes that there is no break under the unit root null against the alternative of structural break. Therefore, rejection of null implies rejection of unit root without break, which does not remove the possibility of unit root with structural break. The danger of this type of test with break under null is that ‘researchers might incorrectly conclude that rejection of the null indicates evidence of a trend-stationary time series with breaks, when in fact the series is difference stationary with breaks’ (Lee and Strazicich, 2003:1082). Besides, Nunes *et al.* (1997) note that this type of test presents important size distortions when the true data generating process (DGP) is $I(1)$ with break and this size distortion leads to over rejection of the unit root null.

To overcome this problem Lee and Strazicich (2003) develop a Lagrange Multiplier (LM) test that allows for breaks both under the null and alternative hypotheses. Therefore, when this LM test rejects the null it unambiguously implies a trend stationary process.

The LM unit root tests developed by Lee and Strazicich (2003) (hereafter LS) that allows for breaks under null and alternative hypotheses is based on a DGP given by,

$$y_t = \delta'Z_t + e_t, \quad e_t = \beta e_{t-1} + \varepsilon_t \quad (6.5)$$

where Z_t is a vector of exogenous variables and ε_t is an iid error term. There are two versions of the test; one allows changes only in the level and the other allows changes in level and trend. In this study, the test that allows for changes in level and trend will be used. In that case, Z_t is given by the following vector:

$$Z_t = \begin{bmatrix} 1 \\ t \\ D_{1t} \\ DT_{1t} \\ D_{2t} \\ DT_{2t} \end{bmatrix} \quad (6.6)$$

where D_{jt} and DT_{jt} (for $j=1,2$) are dummies with $D_{jt}=1$ for $t \geq T_{Bj}+1$ and 0 otherwise and $DT_{jt}=t-T_{Bj}$ for $t \geq T_{Bj}+1$ and 0 otherwise. T_{Bj} denotes the j^{th} break date. The following regression is estimated to obtain the LM statistic for unit root

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^k \gamma_i \Delta \tilde{S}_{t-i} + u_t \quad (6.7)$$

where $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}$ for $t=2, \dots, T$, $\tilde{\delta}$ s are the coefficients from the regression of Δy_t on ΔZ_t , and $\tilde{\psi}_x = y_1 - Z_1 \tilde{\delta}$, where y_1 and Z_1 correspond to the first observations. From (6.7) above, the LM test statistics are given by the t -statistics testing the null hypothesis $\phi = 0$. The break dates are determined endogenously by a grid search over all possible dates.

6.3.3 Cointegration

When variables do not contain unit roots, the relationship between dependent and independent variables can be examined by Ordinary Least Square (OLS). However, when variables are integrated of order one [*i.e.* I(1)], the usual route of analysis involves examining the long-run or cointegrating relationship among those variables. When there exists a long-run relationship between two variables, say, Y_t and X_t , then their linear combination will be an I(0) variable. Consider the following regression

$$Y_t = \beta_1 + \beta_2 X_t + u_t \quad (6.8)$$

If this regression is estimated and the residual given by $\hat{u} = Y_t - \hat{\beta}_1 - \hat{\beta}_2 X_t$ is stationary, that is, $\hat{u} \sim I(0)$ then the variables Y_t and X_t are said to be cointegrated.

The traditional method of estimating a cointegrating relation between two variables is that of Engle and Granger (1987). However, one of the major drawbacks of Engle-Granger (EG) procedure is that it cannot be used to study the long-run relations among more than two variables. When there are more than two variables, there may be more than one cointegrating relationships and the EG procedure using the residual from a single relationship cannot treat this possibility (Asteriou and Hall, 2007). Under this circumstance, a multiple equation cointegration test procedure proposed by Johansen (1991 & 1995) is the widely used alternative to the single equation EG method.

The Johansen procedure is the extension of single-equation error correction model to a multivariate system. Let \mathbf{X} a vector of n variables ($n > 2$), then the Vector Autoregression (VAR) model containing these variables would be

$$\mathbf{X}_t = \beta_1 \mathbf{X}_{t-1} + \beta_2 \mathbf{X}_{t-2} + \dots + \beta_k \mathbf{X}_{t-k} + \mathbf{u}_t ; \quad (6.9)$$

where k is the lag included in the VAR. To implement Johansen procedure, the above VAR is expressed into Vector Error Correction Model (VECM) of the form

$$\Delta \mathbf{X}_t = \Pi \mathbf{X}_{t-k} + \Gamma_1 \Delta \mathbf{X}_{t-1} + \Gamma_2 \Delta \mathbf{X}_{t-2} + \dots + \Gamma_{t-k} \Delta \mathbf{X}_{t-(k-1)} + \mathbf{u}_t \quad (6.10)$$

Where, $\Pi = \left(\sum_{i=1}^k \beta_i \right) - \mathbf{I}_n$ and $\Gamma = \left(\sum_{j=1}^i \beta_j \right) - \mathbf{I}_n$

The Johansen procedure involves calculating the number of cointegrating vectors by examining the rank of the Π matrix through its eigenvalues. It is also interpreted as a long-run coefficient matrix. Two test statistics are used to ascertain the number of cointegrating relationship(s) among the variables, namely, trace statistic (λ_{trace}) and maximum eigenvalues statistic (λ_{max}) formulated as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad (6.11)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (6.12)$$

where r is the number of cointegrating vector (or the rank of Π matrix) under the null hypothesis and $\hat{\lambda}_i$ is the estimated value for the i th ordered eigenvalues from the Π matrix.

λ_{trace} is a joint hypothesis where the null is that the number of cointegrating vectors is equal or less than r against a general alternative hypothesis that the number of cointegrating vectors is more than r . The null hypothesis of λ_{max} is that the number of cointegrating vectors is equal to r against the alternative hypothesis that the number of cointegrating vectors is $(r+1)$. Thus the outcome of λ_{max} seems to be more specific than that of λ_{trace} . An empirical problem arises when the number of cointegrating vectors given by λ_{trace} and λ_{max} do not agree. Under this situation Johansen and Juselius (1990) suggest that the results given by λ_{max} may be better.

There are two extreme cases with regard to the rank of Π (*i.e.* number of cointegrating vectors). It may have full rank (*i.e.* $r = n$). In this case the number of cointegrating vectors is equal to the number of variables. This is actually the case

where all the variables are stationary. The other extreme case is that Π has zero rank, which implies that there is no long-run relationship among the variables. Thus the rank of Π or the number of cointegrating vectors among the n $I(1)$ variables can be expressed as $1 \leq \text{rank}(\Pi) < n$.

The matrix Π is the product of two matrices, α and β' , that is, $\Pi = \alpha\beta'$, where β is the matrix of cointegrating vectors and α is the matrix of adjustment parameters or the amount of each cointegrating vector entering each equation of the VECM. For example, if there are two cointegrating relationships among a system of three variables, then the Π matrix can be written as follows:

$$\Pi = \alpha\beta' = \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{pmatrix} \quad (6.13)$$

Therefore, the VECM representation of a system containing three variables, say, P, Q and R, with one lag takes the following form:

$$\begin{pmatrix} \Delta P \\ \Delta Q \\ \Delta R \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta P_{t-1} \\ \Delta Q_{t-1} \\ \Delta R_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{pmatrix} \begin{pmatrix} P_{t-1} \\ Q_{t-1} \\ R_{t-1} \end{pmatrix} + \mathbf{e}_t \quad (6.14)$$

6.3.4 Data

The variables that are used in this chapter are the same as in the panel study in Chapter 5. However, the number of observations has been increased. In the panel analysis data are used for the period 1980-2006, *i.e.* 27 observations per cross-section unit. For time-series analysis of a single cross-section unit this number of observations is not sufficient to draw meaningful conclusions. Therefore, an effort is made to increase the number of observations.

World Development Indicator (WDI) 2008 provides all data, except the real effective exchange rate (REER) and interest rate, for the period 1970-2006. REER data are available only from 1980 and interest rate data are available from 1975.

Therefore, two other sources are used to collect these data. Quarterly data on REER are obtained from Reserve Bank of Australia (RBA) website (www.rba.gov.au). Arithmetic averages of these quarterly figures are then used to arrive at annual observations.

In the panel analysis, the interest rate differential is calculated as the difference between real interest rates of the US (as a proxy for world interest rate) and each individual country. However, real interest rate data for Australia are not available from 1970. Therefore, the difference between the real short-term interest rate of Australia and the USA is used as INTDIFF. The nominal short-term interest rate is deflated by consumer price indices to arrive at the real short-term interest rates. These data are taken from *Thomson Datastream*; however, original source of these data is the *OECD Economic Outlook*.

6.4: Estimation results and discussion

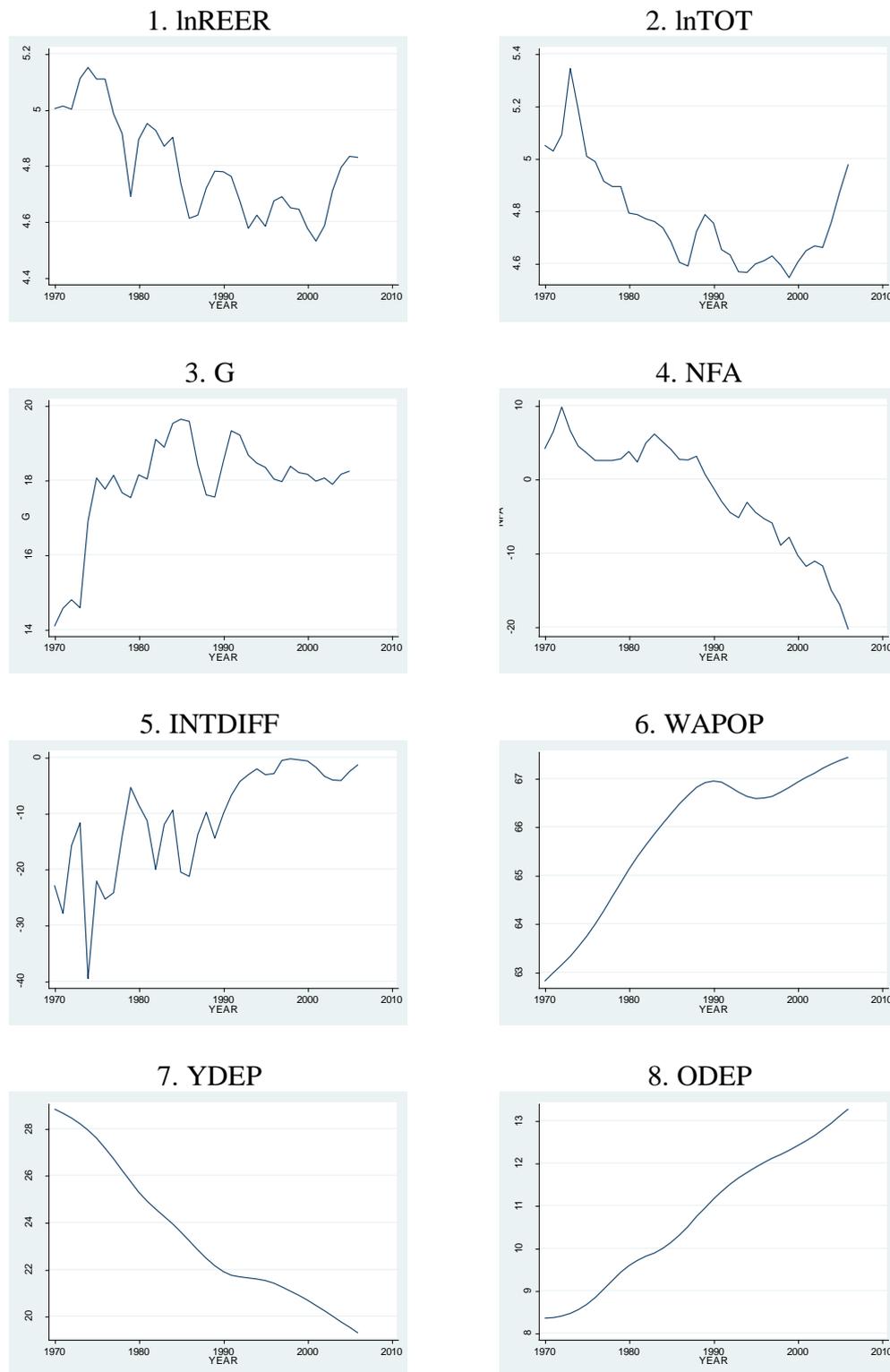
Different estimation results and their interpretations are presented in this section. Estimation results include unit root tests (without and with structural break), Johansen cointegration and Granger causality tests.

6.4.1 Unit root test

Before applying the econometric tests formally, it is useful to take a glance at the plots of the variables. Time series plots of eight variables are presented in Figure 6.7. Visual inspection of the plots indicates that $\ln\text{REER}$, NFA and INTDIFF contain stochastic trends, whereas $\ln\text{TOT}$ appears to experience a change in trend in the 2000s. Among demographic variables, WAPOP seems to have a break in the level in early 1990s. The other two demographic variables seem to have deterministic trends.

However, as it is always not possible to arrive at a sound conclusion based solely on visual inspection, examination of the time-series properties of the variables from statistical analyses is in order. Accordingly, unit root test results from five unit root test methods are reported in Table 6.3. In this table it is reported whether the variables are stationary or not (test statistics are reported in Table A6a.2 and A6a.3 in the appendix 6a). All test equations include an intercept and a trend.

Figure 6.7: Time series plots of variables



Source: World Development Indicator, 2008.

The results show that lnREER, lnTOT, G and NFA are non-stationary according to three tests without break. As per ADF test, all demographic variables are I(0).

However, none is stationary under PP test. As per DF-GLS test, only WAPOP is non-stationary. It is interesting to note that INTDIFF is $I(0)$ at a very high significance level, although the plot of this variable seems to be non-stationary.

Table 6.3: Summary of unit root tests in level under different methods.

Series	Tests without break			Tests with break		
	ADF	PP	DF-GLS	Perron97 (IO)	Perron97 (AO)	LS
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln REER$	NS	NS	NS	NS	NS	NS
$\ln TOT$	NS	NS	NS	NS	S (5%)	S (5%)
G	NS	NS	NS	S (1%)	S (1%)	S (5%)
NFA	NS	NS	NS	NS	NS	NS
INTDIFF	S (1%)	S (1%)	S (1%)	S (10%)	NS	S (5%)
WAPOP	S (5%)	NS	NS	S (1%)	NS	NS
YDEP	S (5%)	NS	S (1%)	S (10%)	S (1%)	S (1%)
ODEP	S (5%)	NS	S (5%)	S (1%)	NS	S (1%)

Note: (a) ‘NS’ and ‘S’ stand for ‘non-stationary’ and ‘stationary’ respectively.
 (b) Figures in the parentheses indicate significance level.
 (c) EViews-6 is used for tests without break and RATs 7 is used for tests with structural break.

Next when the possibility of structural breaks is considered, the outcomes of the unit root tests become quite different. According to Perron’s (1997) innovational outlier model (column 4) G and INTDIFF are found $I(0)$ at 1% and 10% levels respectively. All demographic variables are also found $I(0)$. Perron’s (1997) AO model provides somewhat different results from the IO model as shown in column 5 of the table.

As mentioned earlier, Perron’s (1997) test suffers from the problem of size distortion and also from the problem of the formulation of a null hypothesis without break. Therefore, to get better results, the Lee and Strazicich (2003) unit root test with structural break is performed and the results are reported in column (6) of Table 6.3. The results show that only $\ln REER$, NFA and WAPOP are non-stationary and all other variables are $I(0)$. As the Lee and Strazicich (2003) unit root test takes care of Perron’s (1997) limitation, the results given by this test are considered best for determining the stationarity properties of the variables. Next

first differences of these three variables are examined for their stationarity and the results are reported in Table 6.4

Table 6.4 shows that the first differences of the variables are I(0) under all tests. Although lnREER is originally modeled as a function of lnTOT, G, NFA, INTDIFF and demographic variable, the stationarity of other variables leaves lnREER as a function of only two variables, NFA and WAPOP. Accordingly subsequent analyses are performed with these three variables (lnREER, NFA and WAPOP) only.¹⁶

Table 6.4: Unit root test results for Δ LNREER, Δ NFA and Δ WAPOP

Series	ADF	DF-GLS	PP	LS
Δ lnREER	-6.621*(5)	-5.227*(0)	-5.793*(13)	-6.016*(1)
Δ NFA	-5.642*(0)	-5.340*(0)	-5.637*(1)	-6.676*(1)
Δ WAPOP	-6.087*(0)	-5.899*(0)	-6.083*(3)	-10.676*(1)

- Note: (1) *,** and *** indicate significant at 1%, 5% and 10% levels respectively
 (2) For ADF and DF-GLS tests, figures in the parentheses are optimum lag length selected by SIC.
 (3) For PP test, figures in the parentheses are Newey-West bandwidth using Bartlett kernel.
 (4) For LS test, critical values are -5.823(1%), -5.286(5%) and -4.989(10%) (Lee and Strazicich, 2003).

The next analysis involves examination of the long-run equilibrium relationship among lnREER, NFA and WAPOP using the cointegration technique. This is discussed in the following section.

6.4.2 Cointegration

As the number of variables is more than two, the Johansen method is applied to test if there is any cointegrating relationship among the variables. The first step of cointegration analysis is to ascertain the order of integration of the variables, which is already done in the previous section and it is found that the variables are integrated to the order of one, that is, the variables are I(1). The second step is to

¹⁶ As the real exchange rate is theoretically modelled as a function of five variables, the model is estimated with all variables, both I(0) and I(1) and the results are reported and discussed in Appendix 6b.

set the appropriate lag length. Setting the appropriate lag length is very important, because if the lag length is not optimum then the error term may not be Gaussian and the resultant inference will not be valid. To determine the optimum lag length, unrestricted VAR models with all variables in levels are estimated for lag from 0 to 5 and the corresponding Akaike information criterion (AIC) and Schwarz criterion (SC) are recorded. These criteria are tabulated in Table A6a.4 in Appendix 6a. The AIC and SC statistics show that the minimum values are obtained at lag one. Therefore, one lag is used in cointegration analysis.

The next step in Johansen cointegration analysis is to determine the trend specification in the data and cointegrating equation. The Pantula (1989) principle as suggested by Johansen (1992) is used to determine the appropriate trend specification. Three trend specifications considered are as follows:

1. Model (i): No trend in data and intercept and no trend in cointegrating equation;
2. Model (ii): Linear trend in data and intercept and no trend in cointegrating equation;
3. Model (iii): Linear trend in data and intercept and trend in cointegrating equation.

The Pantula principle involves performing the Johansen cointegration test with the trend specifications above and comparing the trace statistic with its critical value, stopping only when it is concluded for the first time that the null hypothesis is not rejected (Asteriou and Hall, 2007). Estimation results of the three models are reported in Table 6.5 below.

Table 6.5: Number of cointegrating relations in different models

	Model (i)	Model (ii)	Model (iii)
Data Trend	None	Linear	Linear
Test Type	Intercept No Trend	Intercept No Trend	Intercept Trend
Trace	2	1	2

(Eviews-6 is used to generate these results)

Model (i) and (iii) show that there are two cointegrating relations among three variables, whereas model (ii) gives 1 cointegrating relations, that is, the null

hypothesis that the cointegrating vector is ‘at most 1’ is not rejected. Therefore, according to the Pantula principle the cointegration test should be performed with trend in data and intercept and no trend in cointegrating equation. According to this trend specification the Johansen cointegration test is performed next with three variables and 1 lag. Test results are reported in Table 6.6 below.

Table 6.6: Johansen cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Probability
$r = 0^*$	0.452979	32.99679	29.79707	0.0207
$r \leq 1$	0.264577	11.27913	15.49471	0.1949
$r \leq 2$	0.005982	0.216003	3.841466	0.6421
		Max-Eigen Statistic		
$r = 0^*$	0.452979	21.71766	21.13162	0.0413
$r \leq 1$	0.264577	11.06313	14.26460	0.1511
$r \leq 2$	0.005982	0.216003	3.841466	0.6421

(EViews-6 is used to generate these results)

Two test statistics are reported in Table 6.6: trace statistics, presented in the upper part of the table and maximum-eigenvalue statistics, reported in the lower part of the table. Trace statistics show that the null of zero rank is rejected at 5% significance level, which implies that there is one cointegrating relation among the variables. Maximum-eigenvalue statistics, reported in the lower part, also provides similar result that there is one cointegrating relation among the variables. One cointegrating relation among three variables implies that two stochastic trends are shared by these three variables.¹⁷

Having found one cointegrating vector among three variables, the next analysis of interest is to estimate the cointegrating equation. As the prime objective of this study is to examine the impact on $\ln REER$ of WAPOP, the vector is normalized on $\ln REER$ and is reported in Table 6.7.

¹⁷ To accommodate a structural break in the cointegrating relation, Gregory-Hansen (1996) cointegration analysis is presented in Appendix 6c.

Table 6.7: Vector error correction (VEC) estimates

Cointegrating Equation			
	$\ln REER_{t-1}$	1.000000	
	NFA_{t-1}	-0.005700 (-0.42185)	
	$WAPOP_{t-1}$	0.274393 (4.68981)	
	Constant	-22.83557	
Error Correction:	$\Delta \ln REER$	ΔNFA	$\Delta WAPOP$
Cointegrating Equation	-0.020633 (-0.47660)	-2.111817 (-2.71099)	-0.285455 (-3.29954)
Constant	-0.004855 (-0.33649)	-0.680077 (-2.61922)	0.154444 (5.35586)

Note: Figures in the parentheses are t statistics. EViews-6 is used to generate these results.

From the results in Table 6.7, the regression functions of this VEC can be specified as follows:

$$\Delta \ln REER = -0.0206 (\ln REER_{t-1} - 0.0057 NFA_{t-1} + 0.2743 WAPOP_{t-1} - 22.8355) - 0.0048$$

$$\Delta NFA = -2.1118 (\ln REER_{t-1} - 0.0057 NFA_{t-1} + 0.2743 WAPOP_{t-1} - 22.8355) - 0.6800$$

$$\Delta WAPOP = -0.2854 (\ln REER_{t-1} - 0.0057 NFA_{t-1} + 0.2743 WAPOP_{t-1} - 22.8355) + 0.1544$$

where, $(\ln REER_{t-1} - 0.0057 NFA_{t-1} + 0.2743 WAPOP_{t-1} - 22.8355)$ is the estimated cointegrating equation.¹⁸

6.4.3 Granger causality test

The existence of a cointegrating vector suggests that there must be some causal relation among $\ln REER$, NFA and $WAPOP$. Causality analyses among economic variables are generally conducted with the famous Granger causality theorem forwarded by Granger (1969). According to this theorem ‘if two variables, say, X_t and Y_t are cointegrated and each is individually $I(1)$, that is, integrated of order

¹⁸ The error correction analysis is presented in Appendix 6d

one, then either X_t must Granger cause Y_t or Y_t must Granger cause X_t , (Gujarati 2004:852). Following this theorem next step of analysis involves estimating VECM augmented with a lagged error correction term derived from the long-run cointegrating relation as follows:

$$\Delta \ln REER_t = \alpha_0 + \sum_{i=1}^n \beta_i \Delta \ln REER_{t-i} + \sum_{i=1}^n \theta_i \Delta NFA_{t-i} + \sum_{i=1}^n \phi_i \Delta WAPOP_{t-i} + \varphi ECT_{t-1} + \mu_t \quad (6.17)$$

$$\Delta NFA_t = \pi_0 + \sum_{i=1}^n \delta_i \Delta NFA_{t-i} + \sum_{i=1}^n \eta_i \ln REER_{t-i} + \sum_{i=1}^n \lambda_i \Delta WAPOP_{t-i} + \zeta ECT_{t-1} + \varepsilon_t \quad (6.18)$$

$$\Delta WAPOP_t = \nu_0 + \sum_{i=1}^n \gamma_i \Delta WAPOP_{t-i} + \sum_{i=1}^n \sigma_i \Delta NFA_{t-i} + \sum_{i=1}^n \psi_i \Delta \ln REER_{t-i} + \xi ECT_{t-1} + \mu_t \quad (6.19)$$

where ECT_{t-1} is the lagged error correction term derived from the long-run cointegrating relations among these three variables.

In the above formulation coefficients of the explanatory variables in each of the three equations indicate statistical significance of the short-run causal effect, whereas ECT term indicates the statistical significance of the long-run causal effect. One important issue in this formulation is to determine the lag length of differenced endogenous variables. The vector error correction (VEC) Lag Exclusion Wald test is carried out to determine the lag length. In this test, for each lag the χ^2 (Wald) statistic for the joint significance of all endogenous variables at that lag is reported for each equation separately and jointly. The χ^2 (Wald) statistics reported in Table A6a.5 indicate that the causality test should be done with one lag. Therefore, the VECM specified above is estimated with one lag and the resultant Granger causality test results are reported in Table 6.8.

The Granger causality test results show that error correction term is significant only in the first equation, where $\Delta \ln REER$ is dependent variable. In the other two equations, the signs of the error correction terms are not as per expectation. It indicates that there is uni-directional long-run causality from NFA and WAPOP to $\ln REER$. The coefficient on error correction term implies that a deviation from the equilibrium level of real effective exchange rate index during the current period will be corrected by 28 percent in the next period. However, the χ^2 statistics on

the explanatory variables indicate that in the short run there is no causal effect from NFA and WAPOP to lnREER. The cointegrating vector estimated in Table 6.7 indicates that WAPOP is the only significant variables in the long run equilibrium relationship. Therefore, it can be inferred that the long-run causality, as evidenced in the significance of the error correction term in the Granger causality test reported in Table 6.8, mainly comes from WAPOP.

Table 6.8: Granger-causality test

	χ^2 statistics			ECT_{t-1} (<i>t</i> statistics)
	$\Delta \ln REER$	ΔNFA	$\Delta WAPOP$	
$\Delta \ln REER$		1.377 (0.2411)	2.635 (0.1045)	-0.282** (-2.765)
ΔNFA	4.852 (0.027)**		0.487 (0.485)	0.070 (0.034)
$\Delta WAPOP$	1.137 (0.286)	4.322** (0.037)		0.493 (2.194)

1. Figures in the parenthesis for the differenced endogenous variables are *p* values
2. Figures in the parenthesis for the ECT terms are *t* statistics
3. ** indicates significant at 5% level.
4. Eviews-6 is used to generate these results.

6.5: Conclusion

In this chapter the impact of Australia's population structure on its real exchange rate is examined by using standard econometric methods. This study is, if not pioneering, the first of its kind in Australia. Australia's falling population growth accompanied by higher aged population is a major concern for the policy makers. This is because of higher costs associated with providing old age benefits to the elderly people and the fiscal pressure thereof. However, the implications of other demographic groups have largely been ignored in policy analyses. With falling population growth, the share of young dependents in the total population is also falling, indicating a lower burden on saving in the economy. At the same time higher working-age population contributes positively to saving. Moreover, contrary to the traditional view on elderly-saving relationship, empirical evidence shows that saving is positively associated with the share of old-aged people. These influences of demographic variables on domestic saving affect the movements of Australia's real exchange rate.

Although initially the log of Australia's real effective exchange rate (lnREER) is modelled as a function of several variables, examination of the time-series properties of the variables allows only two variables, namely, net foreign assets (NFA) and working-age population (WAPOP), to be included in the model. All these three variables are found I(1) and other variables are found I(0). Therefore, the long-run relationship among these three variables is examined by the Johansen cointegration test. The test result shows that there is one cointegrating relation among these three variables.

As the variables are cointegrated, causality testing is conducted next to see whether there is any causal effect running from WAPOP to lnREER. Granger causality testing shows that there is long-run causality from WAPOP and NFA to lnREER. However, in the short-run no causal effect is found from WAPOP and NFA to lnREER. The significant long-run coefficient of WAPOP implies that the long-run causality runs interactively through the error correction term from WAPOP to lnREER.

The implication of this finding is derived from the fact that WAPOP significantly affects Australia's real exchange rate in the long run. The external competitive position of a country is largely determined by its real exchange rate. Forecasting the real exchange rate and taking policy actions to steer the movements of the real exchange rate to gain or regain competitive position in international market is of paramount importance for achieving macroeconomic stability and growth. It, therefore, follows that demographic variables are important in understanding the behavior of Australia's real exchange rate in the long run.

However, as with the panel estimation in Chapter 5, caution should be taken in interpreting these results, as the Balassa-Samuelson effect has not been explicitly modeled here.

Appendix 6a

Table A6a.1: Descriptive Statistics (Australian data)

Variables	No. of observations	Mean	Standard deviation	Minimum	Maximum
$\ln REER$	37	4.798	0.1777	4.53	5.15
$\ln TOT$	37	4.782	0.1941	4.55	5.34
G	37	17.90	1.341	14.09	19.63
NFA	37	-1.808	7.476	-20.36	9.76
INTDIFF	37	-10.884	9.560	-39.56	-0.35
WAPOP	37	65.757	1.600	62.11	67.67
ODEP	37	10.720	1.581	8.35	13.28
YDEP	37	23.439	2.956	19.28	28.84

(These statistics are generated using Stata 10)

Table A6a.2: Unit root tests without structural break

Series	ADF test	DF-GLS test	PP test
$\ln REER$	1.753(6)	-1.904(0)	-1.930(3)
$\ln TOT$	-0.851(1)	-1.484(1)	0.301(7)
G	-3.142(2)	-1.798(0)	-3.031(18)
NFA	-1.287(0)	-1.265(0)	-1.287(0)
INTDIFF	-4.577*(0)	-4.707*(0)	-4.591*(1)
WAPOP	-1.823(0)	-1.318(3)	-1.880(2)
ODEP	-4.142**(9)	-3.720**(8)	-2.689(4)
YDEP	-3.793**(8)	-4.903*(3)	-0.902(4)

Note:

(1) *, ** and *** indicate significant at 1%, 5% and 10% levels respectively.

(2) For ADF and DF-GLS tests, figures in the parentheses are optimum lag length selected by SIC

(3) For PP test, figures in the parentheses are Newey-West bandwidth using Bartlett kernel.

Table A6a.3: Unit root tests with structural break

Series	Perron (97) test				LS test ³	
	AO ¹		IO ²		Test statistics	Break dates
	Test statistics	Break date	Test statistics	Break dates		
ln <i>REER</i>	-3.200(9)	1993	-1.022 (6)	1998	-4.951(1)	1978; 1983
ln <i>TOT</i>	-5.382**(12)	1991	-3.458(1)	1996	-5.882*(1)	1976; 1996
G	-6.035*(3)	1980	-8.910 *(3)	1985	-5.286**(1)	1976; 1981
NFA	-4.146(12)	1988	-5.222(12)	1995	-4.108(1)	1974; 1980
INTDIFF	-3.444(8)	2002	-5.496*** (11)	1998	-6.180*(1)	1974; 1981
WAPOP	-3.861(4)	1984	-7.961*(11)	1987	-3.986(1)	1980; 1992
YDEP	-6.016*(1)	1986	-5.415*** (10)	1985	-16.927*(1)	1979; 1993
ODEP	-3.369(8)	1976	-8.791*(10)	1989	-12.128*(1)	1979; 1993

Note:

1. Critical values are -5.45(1%), -4.83(5%), and -4.48(10%) (Perron, 1997)
2. Critical values are -6.32(1%), -5.59(5%) and -5.29(10%) (Perron, 1997).
3. Critical values are -5.823(1%), -5.286(5%), and -4.989(10%) (Lee and Strazicich, 2003)
4. Perron (97) and LS test are performed in WinRats, version 7.20 with command code @perron97.src and @lsunit.src. For Perron(97) test maximum lag length is set 12 and the lag lengths retained by the program are reported in the parentheses. For LS test default lag length 1 (one) set by the program is used in estimation.

Table A6a.4: AIC and SC for optimum lag length in VAR

Lag	AIC	SC	HQ
0	7.540343	7.677756	7.585892
1	0.092851*	0.642502*	0.275044*
2	0.271663	1.233552	0.590502
3	0.542360	1.916488	0.997845
4	0.792849	2.579215	1.384979
5	0.871962	3.070566	1.600737

* indicates lag order selected by the criterion. EView-6 is used to generate these results.

Table A6a.5: VEC Lag Exclusion Wald Tests

Chi-squared test statistics for lag exclusion: Numbers in () are p-values				
Lags	$\Delta \ln REER$	ΔNFA	$\Delta WAPOP$	Joint
1	3.022106 (0.388229)	6.184133 (0.102987)	9.818736 (0.020171)	23.39024 (0.005377)
2	1.372588 (0.711973)	0.840435 (0.839773)	4.746105 (0.191361)	7.334422 (0.602345)

(EView-6 is used to generate these results)

Appendix 6b

Estimation results of the real exchange rate model with all variables included

In Chapter 6 the variables of the real exchange rate model for Australia are found to be integrated to different orders, some are I(0) and some are I(1). Therefore, cointegration and error correction methods are applied to the I(1) variables only. However, as the main model includes both I(0) and I(1) variables, it is advisable to estimate the full model of the real exchange rate to see how the variables behave.

In this appendix the real exchange rate model is estimated both with I(0) and I(1) variables. Standard diagnostic tests are conducted to make sure that the model performs well.

To see whether all demographic variables can be included in the same regression model, correlation coefficients among them are examined. Table A6b.1 below shows that the variables are highly correlated.

Table A6b.1: Correlation among demographic variables

	WAPOP	ODEP	YDEP
WAPOP	1.0000		
ODEP	-0.9720	1.0000	
YDEP	0.9123	-0.9804	1.0000

(Minitab 13 is used to generate these statistics)

As the demographic variables are highly correlated, to avoid perfect or near perfect multicollinearity problem each variable is included in the regression model separately. Consequently three regression equations are estimated as follows

$$\ln REER = f(\ln TOT, G, NFA, INTDIFF, WAPOP) \quad (A6b.1)$$

$$\ln REER = f(\ln TOT, G, NFA, INTDIFF, ODEP) \quad (A6b.2)$$

$$\ln REER = f(\ln TOT, G, NFA, INTDIFF, YDEP) \quad (A6b.3)$$

Estimation results of regression Equations (A6b.1)-(A6b.3) are presented in Table A6b.2 below. As the regressions include both I(0) and I(1) regressors, before discussing the regression results, it is useful to examine whether the regressions are spurious. Granger and Newbold (1974) suggest that if in any regression the value of R^2 exceeds the Durbin–Watson (DW) d statistic, then it is very likely that the estimated regression suffers from the problem of spurious regression. According to this criterion, none of the regressions is spurious. In all three equations the R^2 is well below the value of DW d statistics.

Table A6b.2: Estimation results of real exchange rate model with all variables

Variables	Eq. (A6b.1)	Eq. (A6b.2)	Eq. (A6b.3)
$\ln TOT$	0.739*	0.703*	0.689*
G	0.045*	0.029**	0.036**
NFA	0.0009	-0.0025	-0.0016
INTDIFF	-0.0017	-0.0022	-0.002
WAPOP	-0.035		
ODEP		-0.039	
YDEP			0.022
Constant	2.73	1.29	0.289
R^2	0.8653	0.8602	0.8651
DW	1.48	1.44	1.47
\bar{R}^2	0.8436	0.8376	0.8434
Ramsey RESET	$F(3,28) = 0.43$ $p = 0.73$	$F(3,28) = 0.98$ $p = 0.41$	$F(3,28) = 0.52$ $p = 0.6705$
ARCH(1)	$\chi^2 = 0.092$ $p = 0.7616$	$\chi^2(1) = 0.091$ $p = 0.7624$	$\chi^2(1) = 0.145$ $p = 0.70$
Breusch-Godfrey LM test for autocorrelation	$\chi^2(1) = 2.55$ $p = 0.11$	$\chi^2(1) = 2.87$ $p = 0.09$	$\chi^2(1) = 2.67$ $p = 0.102$

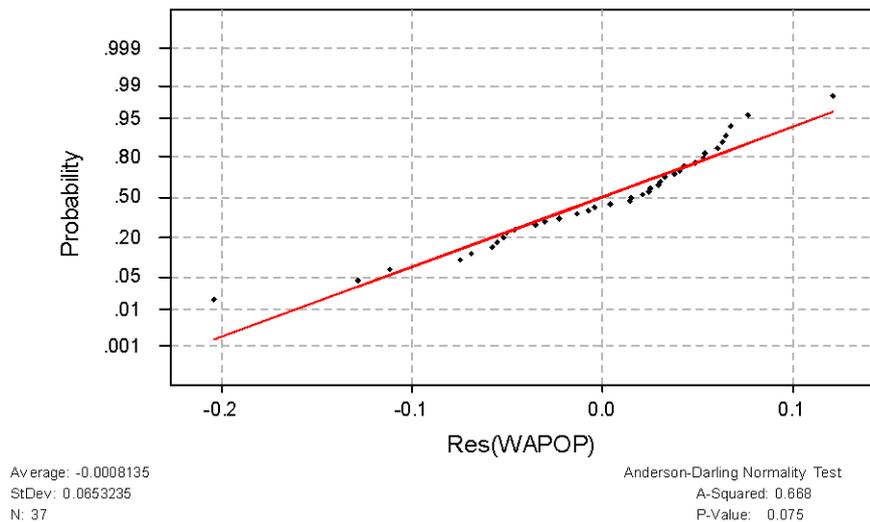
Note: * and ** indicate significant at 1% and 5% levels respectively. Stata 10 is used to generate these results.

Estimation results show that all demographic variables have expected signs. A higher share of working-age and old age population depreciates and higher share of young dependents appreciates the real exchange rate. With regard to other variables, the terms of trade and government expenditure have expected and significant influence on the real exchange rate. Both the variables appreciate the real exchange rate. The interest rate differential also has the expected negative

impact on the real exchange rate. However, this impact is not statistically significant. Coefficients of net foreign assets are insignificant in all equations. Moreover, in Equations (A6b.2) and (A6b.3) the signs are not as expected.

Different diagnostic tests show that all three models perform well. The Ramsey RESET test statistics fail to reject the null of no omitted variables, which implies that the models are not misspecified. The ARCH(1) tests show that there is no ARCH effect in the residuals. Although the DW tests show some signs of positive serial correlation, the Breusch-Godfrey general LM tests for serial correlation fail to reject the null of no serial correlation at 5% significance level. Normal probability plots of residuals presented in Figure A6b.1, A6b.2 and A6b.3¹⁹ show that the residuals are approximately normally distributed. The Anderson-Darling normality test statistic reported below each plot shows that the null of normality of residuals cannot be rejected at 5% significance level.

Figure A6b.1: Normal probability plot of residuals from Equation (A6b.1)



¹⁹ Minitab 13 is used to generate these graphs and associated statistics.

Figure A6b.2: Normal probability plot of residuals from Equation (A6b.2)

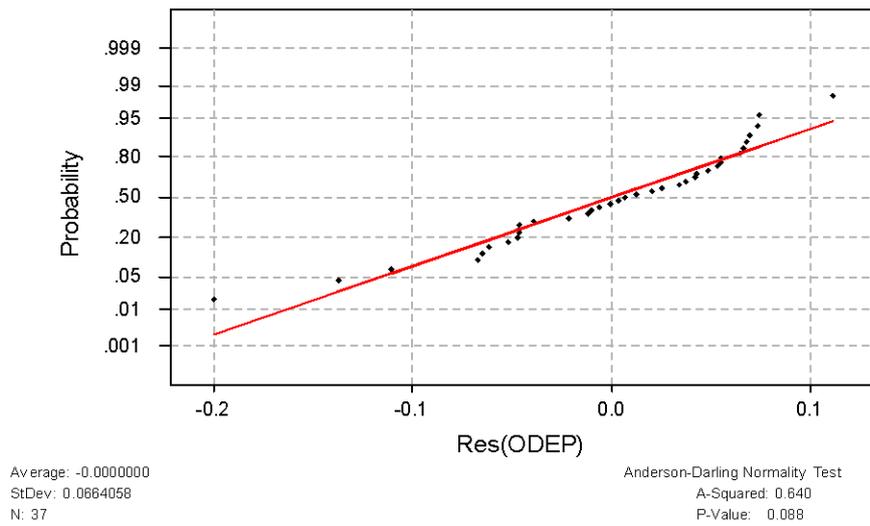
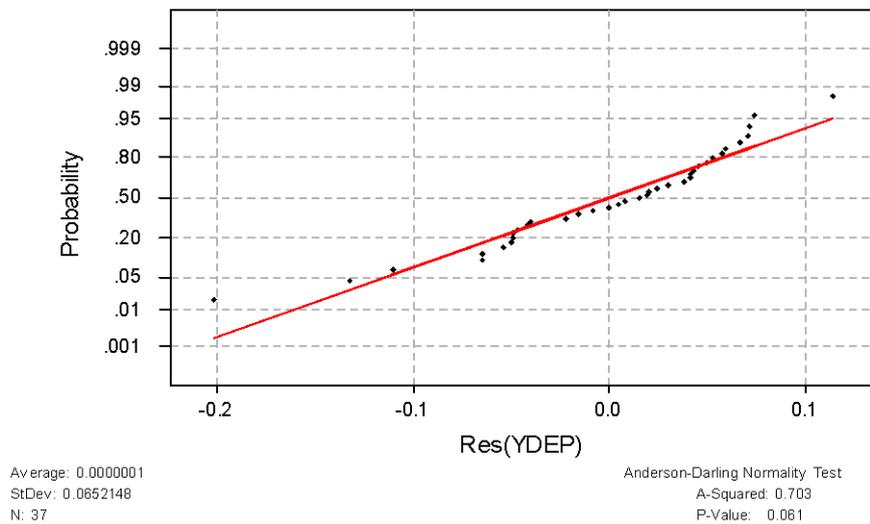


Figure A6b.3: Normal probability plot of residuals from Equation (A6b.3)



Despite satisfactory results of diagnostic tests, the high R^2 and mostly insignificant t ratios indicate that there might be some problems of multicollinearity. Therefore, correlations among the explanatory variables are examined (Table A6b.3) and it is found that demographic variables have high correlation with other explanatory variables. As regression results in Table A6b.2 show that the coefficients of NFA and INTDIFF are not significantly different from zero, these two variables are dropped and regression is run with \ln TOT, G and demographic variables. Although the coefficients of demographic variables

are also not different from zero, they are retained on the ground that the objective of this study is to examine their impact on the real exchange rate. Accordingly, the following models are estimated

$$\ln REER = f(\ln TOT, G, WAPOP) \quad (A6b.4)$$

$$\ln REER = f(\ln TOT, G, ODEP) \quad (A6b.5)$$

$$\ln REER = f(\ln TOT, G, YDEP) \quad (A6b.6)$$

Table A6b.3: Correlation among independent variables

	$\ln TOT$	G	NFA	INTDIFF	WAPOP	ODEP	YDEP
$\ln TOT$	1.0000						
G	-0.7091	1.0000					
NFA	0.4102	-0.3108	1.0000				
INTDIFF	-0.6095	0.3324	-0.6959	1.0000			
WAPOP	-0.7808	0.7405	-0.7326	0.7476	1.0000		
ODEP	-0.6789	0.4920	-0.9172	0.8128	0.9123	1.0000	
YDEP	0.7542	-0.6110	0.8423	-0.7935	-0.9720	-0.9804	1.0000

(Minitab 13 is used to generate these statistics)

Regression results in Table A6b.4 show that all variables are highly significant with expected signs. R^2 and DW values confirm that there is no evidence of spurious regression. Positive and highly significant terms of trade coefficients indicate that improvement in the terms of trade leads to real exchange rate appreciation. This implies that in Australia, the terms of trade improvement works through an *income effect*, that is, an improvement in terms of trade, either through higher exportable prices or lower importable prices, raises the real income of Australian economy. This *income effect* increases the demand for non-tradables and their prices, which, in turn, reduces the relative price of tradables and appreciates the real exchange rate.²⁰ Gruen and Dwyer (1995) note that rise in terms of trade increase domestic income, which increases demand and prices of non-tradables relative to tradables. This in turn appreciates the real exchange rate.

Coefficients of government expenditure are also highly significant with expected signs. This suggests that the majority share of Australian government's

²⁰ However, a more direct impact of terms of trade improvement is channeled through nominal appreciation. Under flexible exchange rate regime real appreciation comes through nominal appreciation, whereas, under fixed regime real appreciation comes through fall in price level (Broda, 2004)

expenditure falls upon non-tradable goods. For this reason higher government expenditure causes the price of non-tradables to rise and the real exchange rate to appreciate.

With regard to demographic variables, all three models provide satisfactory results. Results show that the impacts of different cohorts of population are as per expectations. A higher share of working-age population contributes to saving and capital outflow, thereby causing the real exchange rate to depreciate. The coefficients of ODEP support empirical evidence that people contribute positively to saving in their old age, which depreciates the real exchange rate. This is contrary to the theoretical prediction that they affect saving negatively. The coefficient of YDEP shows that higher YDEP affects saving negatively and causes the real exchange rate to appreciate.

Table A6b.4: Regression results excluding NFA and INTDIFF

Variables	Eq. (A6b.4)	Eq. (A6b.5)	Eq. (A6b.6)
$\ln TOT$	0.756*	0.770*	0.738*
G	0.054*	0.033**	0.040*
WAPOP	-0.048*		
ODEP		-0.035*	
YDEP			0.022*
Constant	3.404*	0.8943	0.0152
R^2	0.8621	0.8543	
DW	1.47	1.44	1.46
\bar{R}^2	0.8496	0.8410	
Ramsey RESET	$F(3,30) = 0.16$ $p = 0.92$	$F(3,30) = 0.86$ $p = 0.47$	$F(3,30) = 0.43$ $p = 0.589$
ARCH(1)	$\chi^2 = 0.308$ $p = 0.578$	$\chi^2(1) = 0.478$ $p = 0.489$	$\chi^2(1) = 0.413$ $p = 0.520$
Breusch-Godfrey LM test for autocorrelation	$\chi^2(1) = 2.501$ $p = 0.11$	$\chi^2(1) = 2.78$ $p = 0.095$	$\chi^2(1) = 2.66$ $p = 0.102$

Note: * and ** indicate significant at 1% and 5% levels respectively. Stata10 is used to generate these results.

Diagnostic tests show that the models perform well. The RESET test shows that none of the models suffer from the problem of omitted variables. The ARCH tests show that there is no ARCH(1) effect in the residuals in any model. The Breusch-

Godfrey LM test shows that the residuals are not autocorrelated. The normal probability plots and the Anderson-Darling normality tests show that residuals from model (A6b.4) (Res_WAPOP) are not normally distributed at 5% significance level (see Figure A6b.4 below). However, if the probability of Type-1 error is set at 1%, then the residuals are normally distributed.

Figure A6b.4: Normal Probability plot of Res-WAPOP

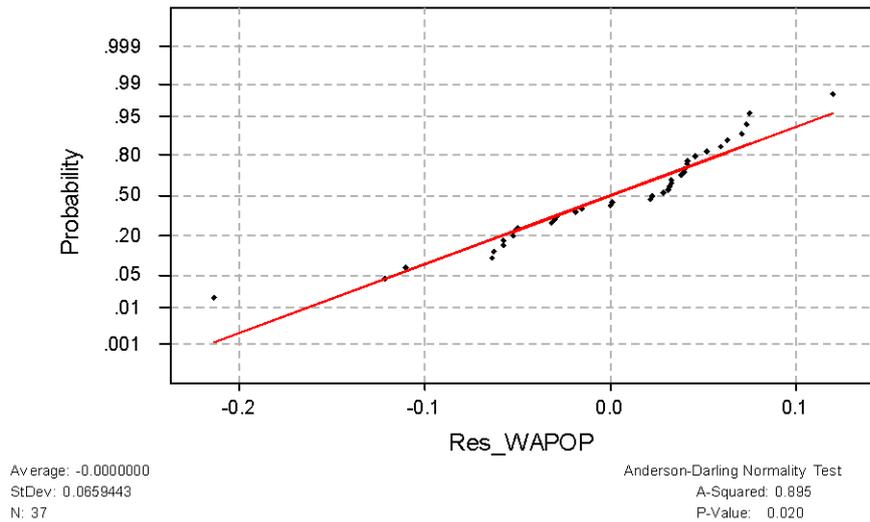
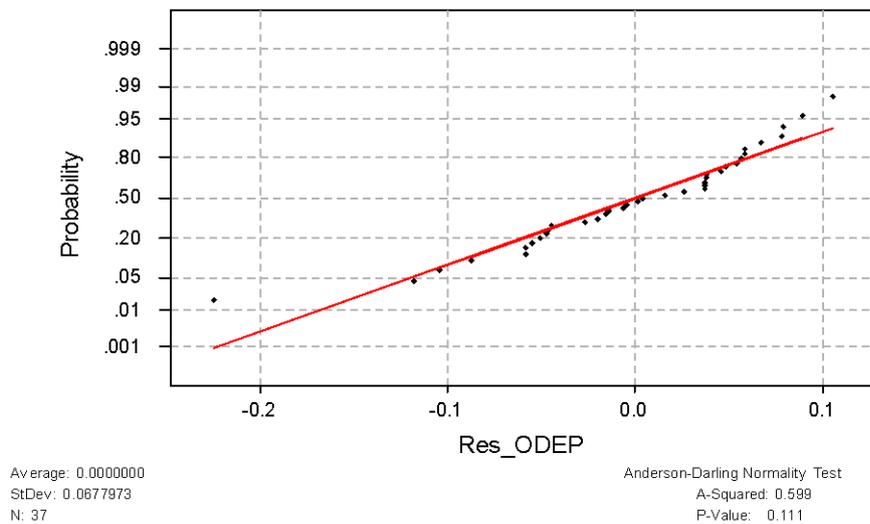


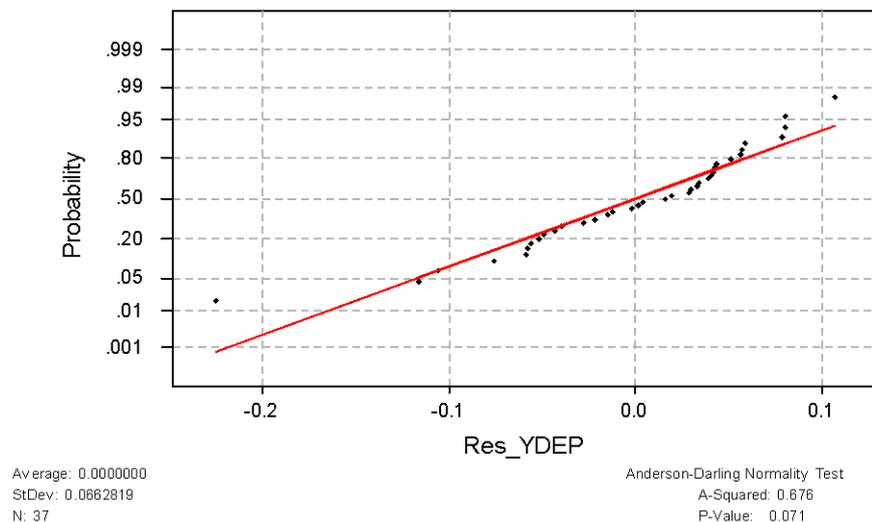
Figure A6b.5: Normal Probability plot of Res-ODEP



The normal probability plot of residuals from model (A6b.5)(Res_ODEP) in Figure A6b.5 above shows that the residuals are normally distributed. The Anderson-Darling normality test statistic fails to reject the null of normality at

10% significance level. Residuals from model (A6b.6)(Res_YDEP) are also normally distributed as shown in Figure A6b.6 below. The normal probability plot and the Anderson-Darling normality test fail to reject the normality null at 5% significance level.

Figure A6b.6: Normal Probability plot of Res-YDEP



In addition to above diagnostic tests, residuals are also subjected to unit root tests and the tests indicate they are I(0) as shown in Table A6c.5 below.

Table A6b.5: Unit root tests for Res_WAPOP, Res_ODEP and Res_YDEP

	Res_WAPOP	Res_ODEP	Res_ODEP
ADF statistics	-4.247**	-5.206*	-5.518*
(with constant and trend)			

Note: * and ** indicate significant at 1% and 5% levels respectively. EViews-6 is used for estimating these statistics.

From the different tests and the estimated coefficients it can be inferred that the behavior of Australia's real effective exchange rate is well explained by the models (A6b.4), (A6b.5) and (A6b.6). More importantly, the hypothesized relationship between demographic variables and the real exchange rate is well established.

Appendix 6c

Gregory-Hansen (1996) cointegration with structural break.

The Lee and Strazicich (2003) test in Chapter 6 shows that lnREER, NFA and WAPOP are I(1) with structural breaks. When variables are first difference stationary with structural breaks, it is useful to examine their long-run relation(s) allowing for breaks. Gregory and Hansen (1996) introduce a methodology to test for cointegration in the presence of structural breaks. Three models are estimated to test for the null of no cointegration against the alternative of cointegration with structural breaks. The first model allows change in the intercept

$$Y_t = \mu_1 + \mu_2\psi_{tk} + \alpha_1 X_t + \varepsilon_t \quad (\text{A6c.1})$$

The second model allows change in the intercept with trend

$$Y_t = \mu_1 + \mu_2\psi_{tk} + \beta_1 t + \alpha_1 X_t + \varepsilon_t \quad (\text{A6c.2})$$

The third model allows change in the intercept and slope coefficient

$$Y_t = \mu_1 + \mu_2\psi_{tk} + \alpha_1 X_t + \alpha_2 X_t \psi_{tk} + \varepsilon_t \quad (\text{A6c.3})$$

In each equation above, Y is dependent and X is the vector of independent variables, t is the time subscript, ε is the error term, k is the break data and ψ is a dummy variable such that

$$\psi_{tk} = 0 \text{ if } t \leq k, \text{ and } \psi_{tk} = 1 \text{ if } t > k$$

The break date is found by estimating the cointegration equation for all possible break dates in the sample. For all possible break dates, the ADF corresponding to the residuals of the above models are computed and the smallest value is selected as the test statistic, which is the most favorable for the rejection of null hypothesis. Table A6c.1 reports the test results.²¹

²¹ RATs 7 is used to perform this cointegration test.

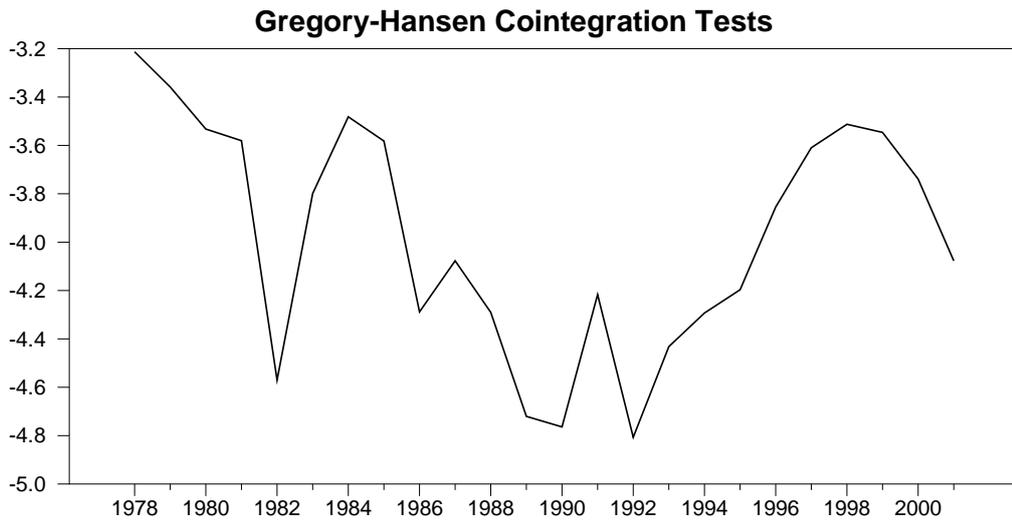
Table A6c.1: Gregory-Hansen (1996) cointegration test

Model	Test statistics	Break date
(A7.1)	-4.80	1992
(A7.2)	-5.40	1999
(A7.3)	-5.08	1998

Critical values are: Model (A6c.1): -5.44(1%), -4.92(5%), -4.69(10%)
 Model (A6c.2): -5.80(1%), -5.29(5%), -5.03(10%)
 Model (A6c.3): -5.97(1%), -5.50(5%), -5.23(10%).

The test results show that the test statistics reject the null of no cointegration in favor of cointegration with structural breaks when only changes in intercept, with and without trend, are considered. However, when changes in intercept and slope are considered, the test statistic fails to reject the null of no cointegration. It, therefore, indicates that even if the variables experience structural breaks, some forms of their linear combinations are stationary. Cointegration graphs of these three models are shown in Figure A6c.1 through Figure A6c.3²² below.

Figure A6c.1: Cointegration graph for model (A6c.1)



²² RATs 7 is used to generate these graphs.

Figure A6c.2: Cointegration graph for model (A6c.2)

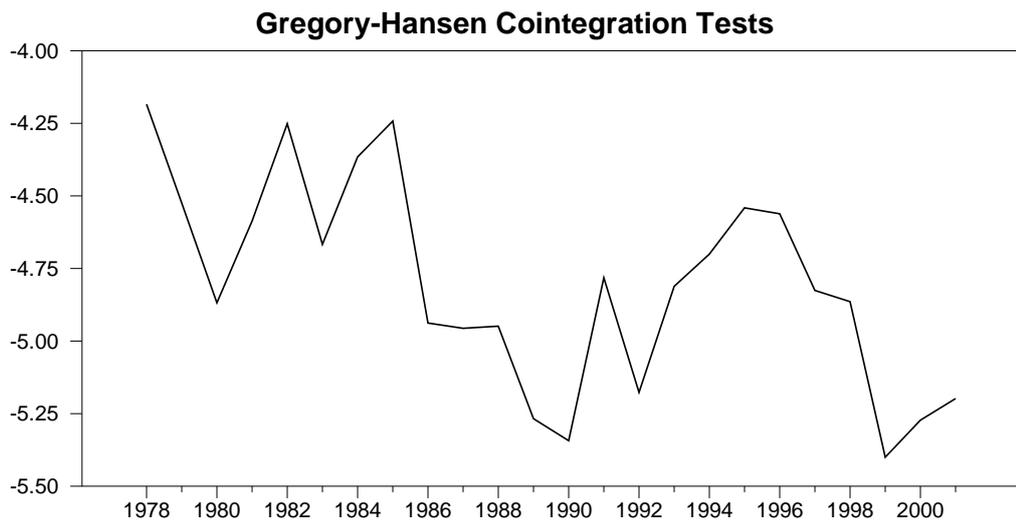
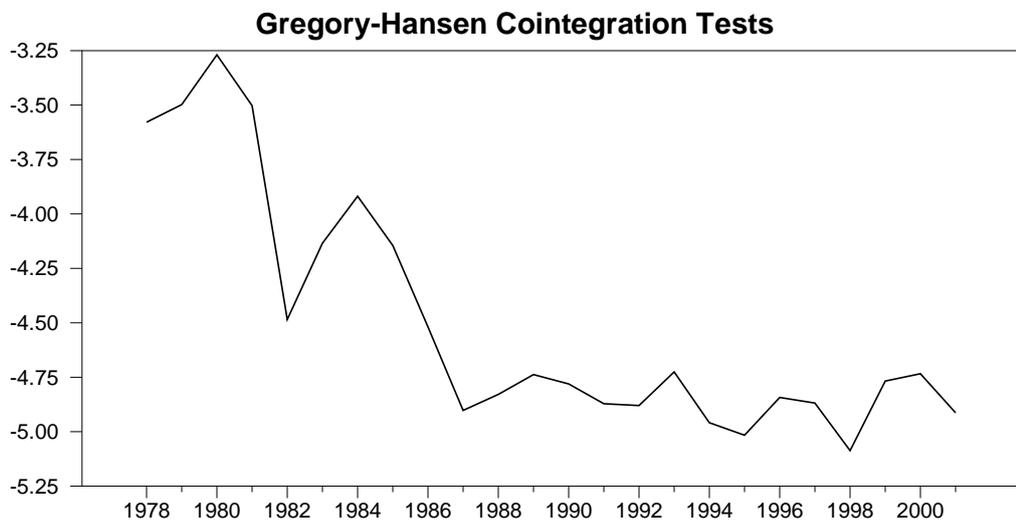


Figure A6c.3: Cointegration graph for model (A6c.3)



Appendix 6d

Error correction analysis²³

In Chapter 6 it is found that for Australia $\ln REER$, NFA and WAPOP are cointegrated. In this appendix short-run adjustment of this long-run relationship or error correction is obtained by looking at the matrix of adjustment coefficients (lower part of Table 6.7) presented in Table A6d.1.

Table A6d.1: Adjustment coefficients

Vector Error Correction:	$\Delta \ln REER$	ΔNFA	$\Delta WAPOP$
Cointegrating equation	-0.0206 (-0.476)	-2.1118 (-2.710)	-0.2854 (-3.299)

Note: Figures in the parentheses are t statistics

Before commenting on the speed of adjustment, a weak exogeneity test is in order. Weak exogeneity test shows which variables are weakly exogenous. This test is done by imposing zero restriction on the elements of α' matrix in Equation (6.13), which are reported in Table A6d.1. Table A6d.2 below reports the weak exogeneity test results.

Table A6d.2: Weak exogeneity test

Null hypotheses	Test statistics
$\alpha_{11} (= -0.0206) = 0$	$\chi^2(1) = 4.32 (0.037)$
$\alpha_{21} (= -2.118) = 0$	$\chi^2(1) = 0.001 (0.972)$
$\alpha_{31} (= -0.285) = 0$	$\chi^2(1) = 3.266 (0.070)$
$\alpha_{21} = \alpha_{31} = 0$	$\chi^2(2) = 3.321 (0.190)$

Note: Figures in parentheses indicate p -values

Test results in Table A6d.2 show that the null hypotheses that the error correction terms in ΔNFA and $\Delta WAPOP$ equations are not significantly different from zero are not rejected at 5% significance level. The joint restriction on error correction terms of ΔNFA and $\Delta WAPOP$ is also not rejected at the 5% significance level. However, the null hypothesis that the error correction term in $\Delta \ln REER$ equation is not significantly different from zero is rejected at 5% significance level. Thus

²³ EViews-6 is used for generating all results in this Appendix.

from separate and joint zero restrictions on the adjustment coefficients it can be inferred that ΔNFA and $\Delta WAPOP$ are weakly exogenous with respect to $\Delta \ln REER$.

Under this situation Valadkhani (2004) suggests to model short-run dynamics of dependent variable by a single equation and estimate it by OLS. However, as the adjustment coefficient of $\Delta \ln REER$ is quite low and not statistically significant, the short-run $\ln REER$ model is not estimated separately, only the error correction term of $\Delta \ln REER$ is explained in terms of Equation (6.14).

If equation (6.14) is re-written in terms of $\ln REER$, NFA and $WAPOP$ as

$$\begin{pmatrix} \Delta \ln REER_t \\ \Delta NFA_t \\ \Delta WAPOP_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta \ln REER_{t-1} \\ \Delta NFA_{t-1} \\ \Delta WAPOP_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{pmatrix} \begin{pmatrix} \ln REER_{t-1} \\ NFA_{t-1} \\ WAPOP_{t-1} \end{pmatrix} + \mathbf{e}_t \quad (A6d.1)$$

A6d.1

then the error correction term in terms of $\Delta \ln REER(ECT_{\Delta \ln REER})$ can be written as follows

$$ECT_{\Delta \ln REER} = -0.0206(\ln REER - 22.83 - 0.0057NFA + 0.274WAPOP) \quad (A6d.2)$$

Long-run and short-run relations between $\ln REER$ and NFA and $WAPOP$ as estimated above show that the short-run adjustment of the disequilibrium in the long-run relation is not significant. When the short-run adjustment parameter or error correction term is found insignificant, statistically it implies that the error correction term is zero. This suggests that the dependent variable adjusts to changes in independent variables in the same period (Gujarati, 2004). In the long-run relation, the impact of NFA on $\ln REER$ is quite insignificant as evidenced from the cointegrating equation in Table 6.7. However, the coefficient of $WAPOP$ is highly significant implying that the movement of $\ln REER$ in the long run is mainly influenced by $WAPOP$.

Chapter 7

Concluding Remarks and Policy Implications

7.1: Introduction

This thesis examines the influence of population structure on the real exchange rate. In the literature different macroeconomic factors have been identified as the determinants of the real exchange rate, such as, productivity differentials, interest rate differentials, terms of trade, capital flows, trade balance, government expenditure, and investment spending. However, the impact of population structure has not been empirically examined in the framework of a model of the real exchange rate. In this thesis a model of the real exchange rate incorporating population structure is developed and estimated for 23 OECD countries and for Australia as a single country example. Each estimation is carried out with suitable econometric methods.

This chapter proceeds as follows: the theoretical link between population structure and the real exchange rate is discussed in section 7.2, followed by the summary of estimation procedure in section 7.3. Section 7.4 contains major findings of the thesis. The contribution of this thesis to the literature is discussed in section 7.5, followed by policy implications in section 7.6. The chapter is concluded by discussing some limitations of the study and future research scope in section 7.7.

7.2: Population structure and the real exchange rate: Theoretical link

A theoretical linkage between the real exchange rate and demography primarily comes from the relation between age structure of population and the resultant consumption and saving pattern in an economy as postulated in the *Life-Cycle Hypothesis* (LCH). According to the LCH, people smooth their consumption by saving during their working life and dissaving in the rest of the life until death (Modigliani and Brumberg, 1954). Thus the theory identifies the age structure of population as an important determinant of consumption and saving behavior. In an open economy domestic saving plays important role on capital flows. The shortfall of saving relative to investment causes capital inflow, whereas excess of saving causes capital outflow. Capital inflows and outflows are closely associated

with appreciation and depreciation of the real exchange rate. Thus, population structure exerts influence on the real exchange rate through its impacts on saving and capital flows.

Population structure also exerts influence on the real exchange rate through its impact on investment and the resultant capital flows. Economically active or working-age population affects investment through its impact on marginal product of capital (MP_K) and marginal product of labour (MP_L). Larger working-age population increases MP_K and thereby attracts capital. Again, larger working-age population reduces MP_L and hence wage. Given the saving rate, lower wage affects private saving. Changes in saving and investment determine the amount of capital to be imported or exported. These capital flows, in turn, influence the real exchange rate. Dependents also affect investment through their consumption behavior and therefore influence capital flows and the real exchange rate.

The relevant literature on population structure, saving, investment, capital flow and the real exchange rate are reviewed in Chapter 2. From this review it is identified that the linkage between population structure and the real exchange rate has not been formally modelled in the literature. This research gap acts as the motivation for this thesis. Accordingly, a model of the real exchange rate with demographic variable is developed in Chapter 3.

The model basically draws on Edward (1988) and Drine and Rault (2003). In this model it is assumed that the economy is a small open economy, so it is a price taker in the international market. It is also assumed that the economy is in long-run equilibrium or full employment level. The government budget is assumed to be balanced. The balanced budget assumption allows the analysis of domestic saving in terms of private saving only. There are three goods in this model: (i) exportables, (ii) importables, and (iii) non-tradables. The equilibrium real exchange rate is defined as the relative price of tradables to non-tradables when both internal and external equilibrium are achieved.

Population structure is incorporated as a variable that affects external equilibrium through its impact on capital flows and hence the real exchange rate. Based on

previous empirical studies, it is assumed that population structure affects saving and investment and therefore, capital flows. The contribution of working-age population to the appreciation or depreciation of the real exchange rate hinges upon the net change in saving those results from changes in MP_K and MP_L as discussed above. Capital flows and the real exchange rate are affected accordingly. Old dependents are likely to contribute to saving and capital flows positively and depreciate the real exchange rate. Young dependents reduce saving and increase investment demand through their consumption. These lead to capital inflow and real appreciation.

Thus, the model includes population structure as one of the independent variables. Finally the real exchange rate is modeled as a function of world price of importables, world interest rate, net foreign assets, government expenditure on non-tradables and population structure.

7.3: Estimation procedure of the empirical model

The econometric methods used to estimate an empirical model for a panel of countries based on the theoretical link between population structure and the real exchange rate is discussed in Chapter 4. A case study on Australia is presented in Chapter 6. For empirical estimation purpose, the log of the real effective exchange rate index is used as dependent variable and it is modelled as a function of the log of terms of trade index (instead of world price of importables), net foreign asset as a percentage of GDP, government expenditure as a percentage of GDP (as a proxy for government expenditure on non-traded goods), interest rate differential (difference between world and domestic interest rate) and three demographic variables, namely, young dependents (0-14 years old), old dependents (aged 65 and above) and working-age population (15-64 years old). In calculating the interest rate differential the US interest rate is used as a proxy for world interest rate. Data are sourced mainly from the *World Development Indicators (WDI)-2008*. Other sources include *Thomson Datastream* and *OECD.Stat*. For Australia some data are collected from the website of the Reserve Bank of Australia (RBA).

Panel estimation results of the real exchange rate model are presented in Chapter 5. The chapter begins with the examination of stationarity properties of the

underlying variables. Applying Fisher's test, also called MW test, it is found that all variables are stationary except NFA, which is first difference stationary. Because a regression equation cannot contain both stationary and non-stationary variables, this NFA is excluded from the estimation. Breusch and Pagan and Hausman tests suggest that a random effect model is suitable for the data under consideration. Accordingly a random effect model is estimated. The residual plot from this random effect model suggests that the observations for Korea and Poland are abnormally different from observations for other countries. For these outlier problems, these two countries are excluded from the sample, which leave 21 countries to work with. Further diagnostic tests suggest that the error terms are serially and spatially correlated. To guard against these error related problems, the panel corrected standard error (PCSE) method is applied.

It is of practical importance to see whether the relationship between the real exchange rate and demographic variables found in panel study also holds for individual countries in the panel. With this objective, a case study on Australia is presented in Chapter 6. The chapter begins with checking stationarity properties of the variables. Two types of tests are employed; one without structural break (*i.e.* ADF, PP and DF-GLS) and the other is with structural break [*i.e.* Perron (1997) and Lee and Strazicich (2003)]. As ADF, PP and DF-GLS do not take into account structural break in series, Perron (1997) and Lee and Strazicich (2003) tests are used to encompass the possibility of structural break. The conclusion is made based on Lee and Strazicich (2003) tests and it is found that proportion of working-age population (WAPOP), log of the real effective exchange rate index (lnREER), and net foreign assets (NFA) are I(1) and the other variables are I(0). Therefore, Johansen cointegration and Granger causality tests are performed to examine the long-run and causal relationships of the I(1) variables.

7.4: Major findings

The objective this thesis is to examine the relationship between real exchange rate and population structure. From the panel estimation results in Chapter 5 and the case study results in Chapter 6 it is evident that the population structure has significant impact on the real exchange rate. In the panel setting, working-age population and old dependents are found to have significant impact on the real

exchange rate, whereas, in case of Australia only the working-age group is found to have significant impact on the real exchange rate.

In the panel setting, the working-age population is found to have an appreciating effect on the real exchange rate. This suggests that on one hand, due to increased labour supply marginal product of labour and hence wage falls. Lower wage results in lower saving of the working-age group. On the other hand, higher labour supply raises marginal product of capital and hence return on investment. This higher return attracts capital. As saving falls, capital flows in and appreciates the real exchange rate.

Another interesting finding of the thesis is the impact of old dependents on the real exchange rate. According to the traditional view old dependents dissave and appreciate the real exchange rate (Andersson and Österholm, 2005). This thesis finds evidence to the contrary. Old dependents are found to have depreciating effect on the real exchange rate, which suggests that they continue to save or dissave at a very low rate even after their retirement as evidenced in recent empirical studies.

The positive effect found for the terms of trade on the real exchange rate implies that improvement in terms of trade raises income of the economies. This higher income increases the demand for non-tradables and raises their prices, which in turn appreciates the real exchange rate. This positive association between the terms of trade and the real exchange rate indicates that improvement in terms of trade ensures consumption of non-tradable goods and services as higher income increases demand.

Another important finding is in regard to the relation between government expenditure and the real exchange rate. The finding of a significant positive effect of government expenditure on the real exchange rate suggests that a significant share of government expenditure in the sample countries falls on non-tradable goods and services. This raises the prices of non-tradables and appreciates the real exchange rate.

In addition to the above, unit root tests of the variables provide evidence in favor of an extensively researched macroeconomic phenomenon, namely, stationarity of the real exchange rate. Validity of Purchasing Power Parity (PPP) theory of exchange rate determination is conditional upon the stationarity of the real exchange rate. A huge number of studies have been conducted on the validity of PPP theory and the research is still going on. Unfortunately, no consensus has yet been reached. Some studies find that the real exchange rate is stationary, whereas some find that it is non-stationary. In this thesis unit root test in panel setting find that the log of the real effective exchange rate index is $I(0)$. This finding, as a byproduct of the thesis, is an addition to those strands of literature that find support in favor of PPP theory of exchange rate determination.

Findings from the analyses on Australian data are somewhat different from those of panel analyses. Unlike in the panel setting, the real exchange rate, working-age population and net foreign assets are found to be non-stationary and have a long-run equilibrium relationship. The cointegrating equation also shows that working-age population has depreciating effect on the real exchange rate in the long-run. Causality analysis shows that, in the long run, causal effects run from the working-age population and net foreign assets to the real exchange rate. This result suggests that in the long run an increase in working-age population reduces wage or raise the rate of return on capital in such a way that the net saving coming from this group increases. This causes capital outflow and the real exchange rate to depreciate.

Net foreign assets are found to have insignificant appreciating effect on the real exchange rate. This suggests that while an increase in net foreign assets increases the national wealth, wealth is not substantially spent on non-tradable goods and services. For this reason the prices of non-tradables do not rise that much and the real exchange rate is not appreciated significantly.

7.5: Contribution of the research

This thesis makes two major contributions. First, it develops a model of the real exchange rate where different cohorts of population are considered. Population structure is included in a three goods (i.e. exportable, importable and non-traded

goods) model of the real exchange rate. It is argued that population structure affects the real exchange rate by influencing capital flows.

Second, unlike previous studies, this thesis considers the impact of population structure on investment. Previous studies in this field analyze the relationship in the spirit of the LCH only and assume that age structure affects the real exchange rate only through its impact on saving and the resultant capital flows. In this thesis it is argued that population age structure affects capital flows through its impact not only on saving, but also its impact on investment. Dependents affect investment through their demand for consumption of, mainly non-tradable, goods and services. Working-age population affects investment and, therefore, impacts capital flows through marginal product of capital and labour as well as through consumption and saving.

7.6: Policy implications

Sustainability of the competitive position of a country in the world market largely hinges upon its real exchange rate. An extensive body of research has emerged to identify the factors that significantly affect the movement of the real exchange rate. In this thesis population structure has been identified as another important determinant of the real exchange rate. Changes in the age structure influence the real exchange rate. However, change in age structure is a long-run phenomenon. Therefore, the relationship found in this thesis could effectively be used to analyze the long-run behavior of the real exchange rate.

Another concern for the policy makers emerges from the finding that old dependents impact the real exchange rate through their saving behavior. Various analyses have shown that the OECD countries are heading towards aging population due to falling birth rate. Under this circumstance, these countries will experience real depreciation in the years to come. This will have negative effects on foreign asset holding and the countries will be poorer in terms of net international investment position.

In summary, the effects of the pattern or composition of population age structure on the economy, specifically its effect through the real exchange rate, should

carefully be analyzed to avoid any adverse macroeconomic consequences in the long-run.

7.7: Limitations and further focus of future study

This study explores the relationship between population structure and the real exchange rate. Limitations and further research directions may be described as follows:

- (i) This study is on selected OECD countries. Therefore, before generalizing the findings, the model developed in this thesis should be applied to other countries that are at different stages of economic development; such as developing, less developed or least developed countries where changes in the population structures are even more pronounced. Therefore further research including countries from different regions in world is warranted. The divergent results from the case of Australia emphasize the need for caution in generalization.
- (ii) It is assumed that saving of the working-age people are motivated by the concern over their old age consumption. However, a more realistic analysis should include future expected rates of return on the assets in their portfolio. In that case saving rates will also vary in response to the future expected rates of return unlike the fixed saving rate assumed in this thesis (see Appendix 3). Thus a possible future research agenda would be to consider a model where saving rates vary based on the expected future rate of return.
- (iii) The thesis finds different results in regards to the effects of working-age population on the real exchange rate in panel setting and in Australian data. This is possibly because of the difference in the wage changes in response to changes in the size of working-age population. A possible future research may examine empirically how changes in the size of working-age population or work force affect wage and therefore, saving in the economy as formularized in Appendix 3.

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