Reducing supply risk caused by the stockwhip effect in supply chains

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Abstract

To enhance today's supplier relationship management, it requires collaborative relationship information especially supplier's capability intelligence. Intimate knowledge about the supply network leads to the collective synergy to overcome supply uncertainties. Incompatible relationships create supply risk caused by the stockwhip effect. The challenge to procurement managers is to ensure that there are no supply disruptions. This paper investigates and proposes a conceptual model for reducing supply risk caused by 'stockwhip effect'. Stockwhip effect is the domino effect of constraints in the higher order supplier network. This conceptual model lays the foundation for future action research in better mitigation of supply risk.

Keywords
supply risk, stockwhip effect, supplier intelligence, network science

1. Introduction

The main supply chain management philosophy is that operational relationships among the supply chain entities is the idea of continuous flow of products from raw materials stage to finished goods stage and the final consumer. All the activities in this flow must work with each other to smoothly procure and deliver the goods/services through the chain. These goods/services may be raw materials, components, parts or sub-assemblies. Most suppliers have some sort of contractual arrangements for specific quantity of parts/components/subassemblies to be delivered on a timely basis; but these do not mitigate supply risk further up the supply chain. Most suppliers also normally have one supplier only, especially if it is high technology parts/components. This poses as a critical problem to most procurement and sourcing managers.

Procurement and purchasing managers have problems sourcing parts and components when a higher tier supplier faces constraints like production failure or fire in the factory. By the time these constraints are revealed to the procurement and purchasing managers, it is too late. New suppliers of critical parts and components have to be frantically sourced. There is also the rigour mol of quality testing, pricing, new contract development and management. There are other issues of trust and power playing their part in new supplier relationships.

Customer Relationship management (CRM) and Supplier Relationship Management (SRM) are equally vital in today's business environment. Most organisations have an accurate, reliable and timely data of their immediate customers and immediate suppliers. Very few organisations have any record of customers' customers nor suppliers' suppliers information. This paper investigates constrictions on the SRM side caused by the 'stockwhip effect'.

The 'stockwhip effect' can be expressed as the domino action of the unavailability of parts/components/sub-assemblies in a higher tier supplier that affects the downstream buyers and their SOP activities. The 'stock whip effect' may be defined as "any constraint or supply disruption in the higher order supply side of the supply chain will increase the disruptions in the lower order sequential entities along the supply chain". Entities along the supply chain must ensure that such constraints are eliminated immediately or find alternate sources of supply. Therefore supplier intelligence will assist in the strategic decision making process of existing suppliers or new suppliers in terms of new product development, purchasing strategy, sourcing strategy, long term supply contracts and other critical factors in sustaining long term operations. Hence, this paper draws attention to 'stockwhip effect' and how downstream buyers may reduce their supply risk with accurate and appropriate information. This paper will also address the issues in appropriate data collection and its techniques.

2. Background

However, any number of constraints or constrictions may affect the planned delivery of procured goods. Therefore the onus of contingency plans becomes the buyers' responsibility to source alternate suppliers within a time frame that allows smooth sales and operations planning. The constrictions and constraints may be caused by internal or external factors in the supplier firms. Internal factors may be caused by changes in corporate objectives. External factors may be caused by new competitors, market, environmental or economic factors. The main concern would be the suppliers' supplier's influencing factors. In a supply network the higher supplier tiers may cause this 'stockwhip effect' (see Figure 1). It is the final manufacturer of the finished product that is mainly affected by this 'stockwhip effect'. The manufacturer of the finished product will have several supply chains. If any one of these supply chains is severed, the finished product cannot be manufactured. Therefore this final manufacturer has the most to lose as one component/part/sub-assembly can hold up the complete sales and operations planning (SOP). A constriction in SOP can have major effects on future sales and could cause the demise of that firm or product line.
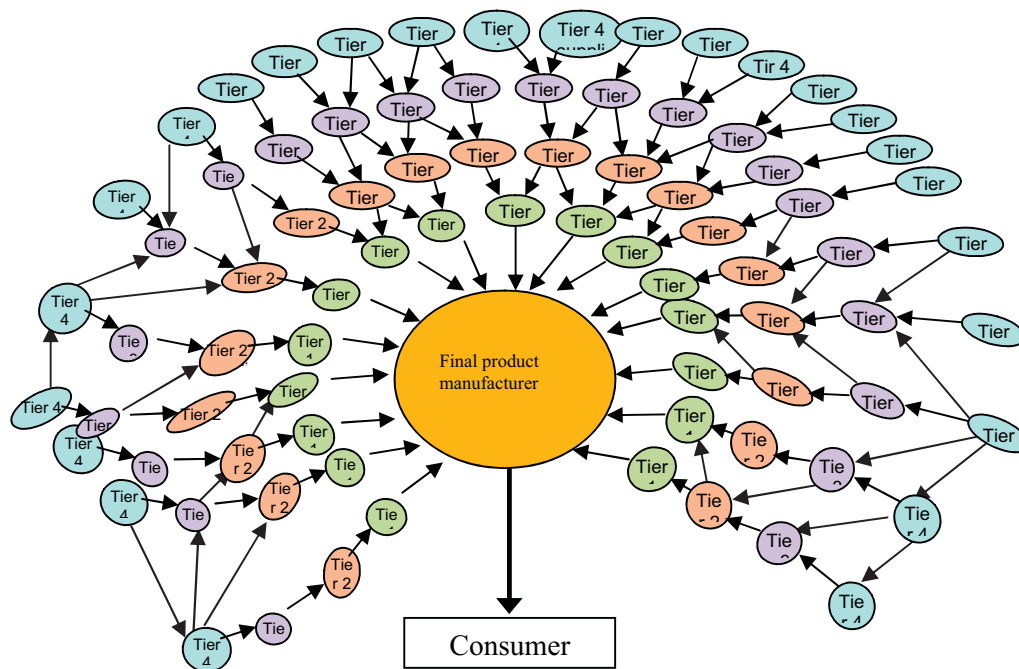

Figure 1: Example of Four Tiers of Supplier Network

Most research findings on supply chain management promote the idea of streamlining, optimising and seamless supply chains benefit all the entities along the supply chain and create value to the end customer. However, there are various influencing elements that prevent this achievement. For supply chain visibility to exist there needs to be a very close relationship between the entities along the supply chain. However, Forker and Stannack [1] report that some firms prefer to enhance their arm's length relationship with their suppliers by supplier switching to encourage competitive bargaining. Studies in transaction cost economics [2] also support the practice for adversarial relationships. A casual linkages study [3] found that there are two broad categories of elements in a supply chain – structural and control. The structural elements are mostly internal like production, transportation and distribution. The control elements are marketing, forecasting, routing and contracts. Buyers in the downstream side of the supply network need to be aware of these structural elements and the constrictions; and current and future limitations of their critical suppliers. These elements were greatly affected by the recent global financial crisis. Supplier intelligence must include both these elements.

Global business have undergone several environment uncertainties in recent times, The SARS virus, the 9/11 attack and the recent global financial crisis. The global financial crisis (GFC) has affected and caused the demise of many organizations [4] leading to many disruptions in the supply network. Traditional risks have been operational costs, competitors' strategies, changing corporate objectives, technological advances, new sources of supply and financial pressures [5].

This supply disruption becomes much more critical when the entities along the supply chain practice Just In Time and lean manufacturing philosophies. The increase in criticality is expounded when organizations cut back

even on their safety stock levels in times of uncertainties [6]. Normal forecasting practices and production planning are severely hampered. Hence, supply chain visibility of higher order suppliers becomes more necessary including greater collaboration with suppliers. It is not the normal practice of buyers to collect information of their suppliers' suppliers and also difficult to collect this information. However, this information is necessary to make the supply chain visible.

However, it is understandable that there is difficulty in obtaining or identifying the supplier's suppliers and beyond. This may be due to the fact that the higher tier suppliers are in distributed geographical locations or that the supplier information is scare, especially in low cost countries, or that the immediate supplier wants to maintain confidentiality.

It must also be considered that the amount of data may be over whelming and irrelevant. Also it could be time consuming and difficult to filter the critical information from the necessary information. Other attributes of information like validity and currency are important. An example of an automobile supply network is that about 200 first tier suppliers supply about 4,500 parts/components and sub-assemblies. Further upstream this supply network tier is expanded. The second tier supplier level may consist of even larger number of suppliers and components/parts. It then becomes an enormous task to collect, retain and analyze this amount of information as the tier level increases. Supply chain visibility assists in managing this enormous quantity of information.

Research also shows that in some industry sectors, firms have a higher visibility of their supply chain using information from their competitive relationship rather than their cooperative relationship with their suppliers [7]. In any business environment, trust and cooperation is necessary. Trust and cooperation develops the quality and reliability of suppliers [8] .

3. Literature Review

A literature review of supply risk and supplier relationship articles indicate all surveys and solutions are for intermediate dyadic relationships between buyers and immediate suppliers. Very few publications go beyond the immediate supplier, that is, the supplier's suppliers and the suppliers' supplier's supplier relationships. This extended relationship spreads out into the supplier network. It is critical that buyers in the lower tiers of the supply network are aware of the constrictions and factors affecting the higher tier suppliers. Any restrictions, delays or supply risks in the higher tier suppliers will cause a domino effect or a 'stockwhip effect' on the lower tier suppliers who are also buyers in the supplier network.

However, the GFC has forced many organizations to abandon their traditional cooperative relationship practices and aim for self survival. Hence, these organizations were forced to practice traditional risk management practices for sustainable survival. These were designed for the immediate environment and included strategies like increasing safety stock, contractual obligations with suppliers, lean manufacturing, etc. However, very little risk analysis has been conducted on higher tiers of a supply chain to anticipate or predict risk. Very little data or information has been collected on the supplier network or even the value added products in a supply network.

Some researchers have focused on sources of risk [9-11]. Very little research has been conducted on the influencing elements of risk. Uncertainty along the supply chain includes environmental uncertainty as well as supply network entity capabilities. This capability and availability of internal and external resources directly impacts the subsequent entities along the supply chain like a domino effect. Capability includes manufacturing process, process controls and technology adaptability [12].

Supplier Relationship Management (SRM) software are limited in their ability in obtaining information from external sources about their immediate suppliers. Wisner et al. [13] state that AMR research has identified five key tenets of an SRM system. These are automation, integration, visibility, collaboration and optimization. These are attributes of organizational relationships and internal processes. It provides limited information and knowledge of external factors like the financials and competitors strategies and market economics of the supplier organization. Collaborative planning, forecasting and replenishment (CPFR) combines the intelligence of multiple trading partners, but this is also limited to the immediate tier of suppliers and does not extend beyond the suppliers' suppliers. Intelligence data collection process needs to be a systematic process [14] and this information must be collected externally to organizations. One method is using network science.

The paradigm of network science suggests that the study of theoretical foundations of network structures and dynamic behaviours can be applied to many fields [15]. Its application of linear coupled systems integrates network dynamics like behaviour. Similarly, Borner et al. [16] suggest that network science is a highly interdisciplinary area that develops theoretical and practical approaches and techniques to increase an

understanding of natural and man made networks. This paper suggests that network science can be applied into the supplier network.

4. Concept Framework for Supplier Intelligence

To have a total approach on risk management in the supply network, a holistic approach must be undertaken. This holistic approach needs to include the attributes and characteristics of the dimensions and elements of risk; and attributes and characteristics of their relationships to other influencing elements. The changes in the attributes and characteristics of the elements and dimensions will change the nature and power of the relationships; thereby changing the intensity of the supply network risk. These changes will be reflected in how the entities in the higher tiers of the supply network operate and what evasive or strategic directions are taken. Therefore, these influences and operational changes will filter downstream along the supply chain like a domino effect. Hence supplier intelligence is critical to recognize these changes. This supplier intelligence should encompass all the information of the attributes and characteristics of the elements and dimensions of risk and supply network entities and their products.

Supplier Intelligence is defined as 'the up to date knowledge of critical supplier network incorporating the suppliers' suppliers' market intelligence, business intelligence, competitive intelligence, financial stability including their suppliers' suppliers' supplier intelligence [17].

Table 1: Examples of Risk Scoring Metrics

Product Metrics	Political & Economic Factors
Continued supply	Factors that affect the capacity and capability of suppliers.
Quality & Quantity	Existing supplier locations – which country
Technology competence & leadership	Labour trends
Financial situation	Unemployment
Price competitiveness	Cost of fuel, land
Location risk	Political stability
Shipping mode	Tax environment
Competitive factors	Infrastructure – roads, rail, telecommunications, technology
External factors influencing suppliers	development
Internal factors influencing suppliers	Population growth
Long term capacity and capability	Propensity for natural disasters
Long term pricing factors	Healthcare
Total cost of commodity	Terrorism
Cost Drivers	**Long-term Relationship Potential**
Lowest cost acquisition cost	Committed to a long-term partnership arrangement?
Lower total costs	Willingness to commit resources in relationship?
Quicker delivery	Genuine interest in joint problem solving?
Greater product innovation	Commitment to processes inherent in strategic relationships?
Higher customer satisfaction	Free and open exchange of information?
Higher competition	Willingness to share in future planning?
Proliferation of suppliers	Willingness to commit capacity exclusively to needs?

4.1 Risk scoring

Supply risk should be categorized into two basic taxonomies – supplier organization and product (see Table 1). The organizational capabilities, attributes and characteristics must be differentiated from the attributes of critical products. Critical parts/components and raw materials that are difficult to source or have high uncertainty of supply and cost should be identified and scored using risk levels. In most cases there will always be new entrants to the market; but the supply of product and raw materials may become scarce or difficult to manufacture immaterial of the number of suppliers.

4.2 Relationships

All influencing factors, both internal and external need to be listed and categorized. Entity relationships and attribute relationships needs to be created. This relationship must be dynamic and must be updated in real life. Any changes in relationships, factors or attributes must be highlighted. These changes in relationship indicate changes in the market environment. It indicates the dynamics of the competitive environment. Examples of iterations that may be derived from these changes are market share changes, power transfer among market players, effect on supply and demand metrics.

5. Sources of Information and Collection Methods

It is well known that the maximization of resources in attempting to collect supplier network intelligence could be futile due to the lack of information about who these suppliers are. There is also a limit as to how much an

organization can allocate its resources to collect unsubstantiated information. This paper proposes that information is collected from easily and publicly accessible sources, especially the internet. Metasearch techniques which identify relevant documents can be collected and collated [18]. Spidering and web crawlers can also be used. Dedicated algorithms can further exploit content and structural information found in web pages [19, 20].

5.1 Business Intelligence Technologies

Most current technologies are named business intelligence (BI) technologies. These technologies are incorporated into ERP systems and may include similar technologies to corporate dashboards, hyper-cubes and visualization systems. However these are mostly effective within the enterprise only. Seldom is external data collected and assimilated. These BI technologies are limited to decision making and are inadequate in collecting and analyzing external data.

In recent years in the area of data mining there have been developments in bioinformatics and cheminformatics disciplines. However, there is still a disparity of how these disciplines take advantage of the available data between different applications, standards, structured and unstructured data. Intelligent agents are currently being improved to retrieve data from the web.

5.2 Organizational Risk Assessment

There are some organizational risk analyzer (ORA) tools available. CASOS [21] uses computer network analysis and dynamic network analysis of complex socio-technical systems. Since the supplier network can be considered as a social network, computational and social network techniques are appropriate in this instance. Krackhardt and Carley [22] in their research application of network analysis found that multiple domains and multiple relationships and structural factors can be understood better.

6. Limitations and future research

Supplier intelligence needs to be collected from a very wide variety of sources which include financial, economics, stock market, competitors, legal, logistics, political and geographical factors. This paper has limited its literature review to the operational aspects of the transparent supply chain and supplier relationships. Future papers and research must take a holistic conceptual perspective and needs to validate the basis for supplier intelligence data collection from all the various aspects of the influencing factors of the supplier network.

Because of the complexity and quantity of publicly available data, concerted systemic efforts need to be applied. It is humanly not possible and a waste of resources to dedicate a worker to collect this data. Future research should be focused on using intelligent web search engines and systemic approaches. This should be extended to the collation and analysis of data. Future research should be applied to how the collated intelligence can be tagged to identify as risky or not.

Network based approaches can also be used in conjunction with resource dependency theory, coordination theory and conflict theory to future analyze supply risk factors.

7. Conclusion

The global business environment will continue to be volatile and maintain uncertainty in many quarters including the product/goods supply network. Supply chain management practitioners will continue to promote supply chain visibility. This conceptual paper has set the basis for the requirement for supplier intelligence or supply network intelligence. It has traced some previous research, identified gaps and promotes the requirement for collecting supplier intelligence. Any final product manufacturer who possesses the most reliable and current supplier intelligence would be able to predict and mitigate risk and strategize future operations and enhance competitive advantage. The supplier intelligence information will also provide intrinsic and tacit knowledge for supplier selection, new product development, contract management and sourcing strategy. It also provides a greater visibility along the supply chains.

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