

A Comprehensive Review of Supply Chain Uncertainty

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Abstract: Proper management of the supply chain is a critical factor in a competitive and dynamic business environment. A supply chain consists of every single link starting with the transformation of consumer needs to use products which are then redirected back to the clients. As a result, a smooth transition of operations is critical in the supply chain. Uncertainty at any of the links in the supply chain can cause delays and blockage which might affect the general performance of the output of the chain. Consequently, it is necessary to direct the different factors liable for the supply chain. Subsequently, appropriate planning and dealing with uncertainties will translate to better arranging right from the level of production to timely distribution and eventually a greater customer satisfaction.

Keywords: *Supply chain, Uncertainty, Uncertainty management, SC models*

Publication date: August, 2019

Publication online: 30 August 2019

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1 Introduction

Uncertainty is a very elaborate concept which needs in-depth analysis to provide a full understanding of the concept. Supply chain uncertainty is present in a wide range of fields. Awudu and Zhang^[1] address supply chain uncertainty in the biofuel sector. They recognize that sustainability in such a robust supply chain is inevitable to ensure successful delivery of biofuel to end users in the market, they introduced the general structure of the biofuel supply chain as well as its evolution. Thereafter, they address the three kinds of decision-making levels in the sector as well as discusses inherent uncertainties in its supply chain.

In properly managing uncertainty in the supply chain, identification of sources of uncertainty is the priority. Supply chain should be concerned with the mitigation or elimination of uncertainties which will see the improvement in performance of the supply chain. Identify sources of uncertainties including input data, decision and administrative processes as well as inherent uncertainties. Reduction of uncertainties is a great step in improving service levels considerably. Wilding recognized that internal systems used within a supply chain can translate to demand oscillations as orders pass through the system^[2]. Uncertainty is then generated as a result of the oscillations which can lead to late deliveries, increased reliance on inventory and order cancellations which shield the stipulated effects. There is increased uncertainty generated from these sources in as much as companies try hard to bring stabilisation in the generated dynamics^[3]. The supply chain complexity triangle proposed in the paper explores the interaction of parallel interactions, demand amplification and deterministic chaos.

Gupta and Maranas provide a brief on previous literature regarding the integration of demand uncertainty in midterm planning of supply chain of multiple sites. A stochastic programming model is employed in their works to describe the planning process due to its ability to react to realisations of demand which unfolds as time progresses. The existing solutions to these problems are not comprehensive as they are either modestly address a certain number of scenarios for uncertainty or are restricted to deterministic environments. As a result, a set of Pareto optimal solutions obtained can be used in the process of making decisions^[4].

The solution methodology suggested by Santoso contains an accelerated Bender's decomposition algorithm with a sampling strategy to provide high-quality solutions with a huge number of incidences^[5].

The significance of the stochastic model is shown in the study through highlighting of computational study which involves two supply chain networks. Additionally, the efficiency of the solution strategy is presented as well. The manufacturing decisions are designed into here and now decisions which are made before demand realisation. Moreover, the logistics decisions are set in a wait and see mode to adjust in the face of uncertainty^[6].

Alternatively, Pishvae and Torabi^[7] suggest a bi-objective probabilistic mixed integer model deal with issues of uncertainty in the supply chain. The proposed solution incorporates decisions in the network design of both the reverse a forward network of the supply chain as well as integrating the strategic design of network decision with the tactical flow of materials.

In measuring the impact of uncertainty, Bhatnagar proposes a framework which consists of qualitative factors regarding supply chain uncertainty, practices of manufacturing and plant location decisions. They argue that comprehensive consideration of such factors provides a good basis for describing supply chain competitiveness. The study concludes with the identification of a significant relationship between locations factors such as infrastructure, political stability, proximity to suppliers and qualitative plant as well as supply chain uncertainty.

Supply chain flexibility is a strategy employed by a business to react to uncertainty. Supply chain flexibility is widely recognised with its application by many practitioners^[8]. Nonetheless, supply chain flexibility is a costly remedy to implement. Empirical research regarding the relationship between supply chain and environmental uncertainty is limited. Consequently, it identifies evidence showing that there is increased performance from companies with high flexibility in the supply chain in uncertain environments as compared to companies with less flexibility working in certain environments.

Correspondingly, Wong, Boon-itt and Wong^[9], empirically test theoretical model for the contingency implications of uncertainty in the environment on the relationship between dimensions of four operational performance and three supply chain integration to extend research on supply chain. They argue that under high environmental uncertainty, the association between customer integration and supplier, flexibility and delivery performance, production cost and product quality will all be strengthened. The multi-

group structural path analysis was a collection of about 151 automotive manufacturing plants located in Thailand. They provide explanations which have been empirically proven and theory-driven which can be used by managers to distinguish the impacts of external as well as internal integration efforts under varied environmental conditions. Equally, Sreedevi and Saranga^[10] takes advantage of the International Manufacturing Strategy Survey to provide an analysis on the link between supply chain risk and environmental uncertainty as well as the impact of supply chain flexibility. Environmental uncertainty significantly affects the supply chain. The fact environmental uncertainty plays a significant role in the supply chain. As a result, researchers develop a model of the quality of supply chain relationships, uncertainty from environmental factors and the performance of the supply chain. The research model is tested using data obtained from electronics located in Ireland.

A Multi-echelon network can offer a remedy to demand uncertainty in the supply chain. According to Tsiakis, Shah and Pantelides^[11] the design of multi-echelon supply chain networks is crucial. The networks consist of numerous manufacturing sites at given locations, a number of customers zoned fixed locations, distribution centres and warehouses.

Proper supply chain management should offer proper decisions regarding uncertainty in the supply chain. Hult, Craighead^[12] capitalises on the lack of research on supply chain investment decisions whenever companies are facing increased levels of risk uncertainty. They takes a look into how supply chain decisions are generated which is of pragmatic as well as theoretical significance. Their research provides real options hypothesis to the context of the supply chain through examination of how various options are advanced relative to project investments in the supply chain.

2 Analysis

Uncertainty at any level from demand, supply or process has a significant effect on the manufacturing function. Uncertainty proliferates throughout the chain and translates to activities which are incapable of adding value and ineffective processing^[13]. Uncertainty can be expressed in questions such as how many products are there in stock? What will the customer order and if the supplier will deliver goods according to the specified requirements and on time? As a result, the presence of uncertainty inspires managers or decision

makers to create safety mechanisms to prevent a bad performance in the supply chain. Businesses which are capable of properly managing uncertainty often create bottom-line performances which are competitive.

In effectively managing uncertainty, there are certain specific requirements managers need to meet. The system of management must first have a goal and a conforming performance indicator to offer effective management to the supply chain and steer the business in the right direction. Secondly, information regarding the state of the current supply chain as well

as the environment is crucial to estimate the future. Additionally, the management system should have the ability to process data regarding the state of the supply chain and its environment. Also, decision-makers should be able to approximate the implications of alternative actions.

The following Thematic Analysis Table shows the classification of different previous literature on supply chain uncertainty(Figure 1). It groups different literature on different aspects of uncertainty of the supply chain.

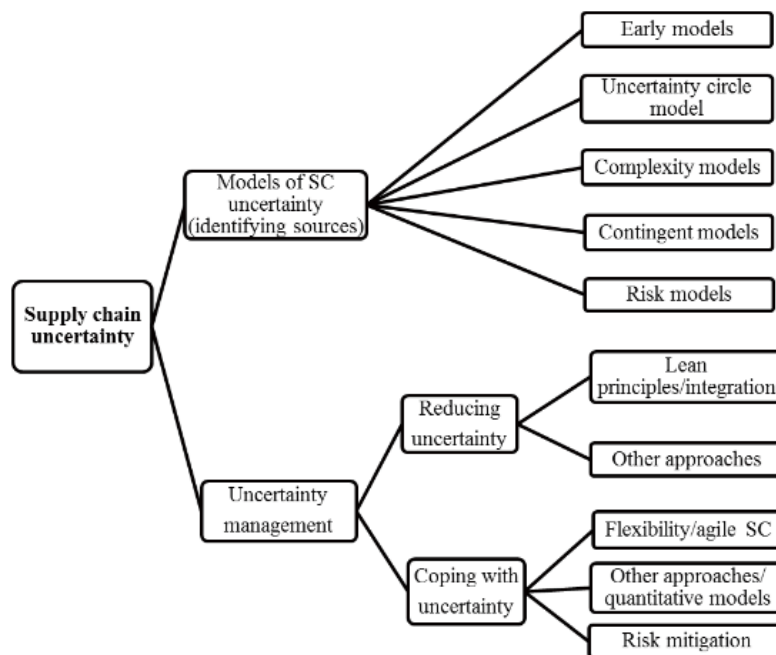


Figure 1. The classification of different supply chain uncertainty

In a supply chain, uncertainties originate from different levels and are of varied nature. The inherent characteristics of uncertainty cause less or more predictable variations^[14]. At such a level, uncertainty may take the form of processing and supply or high variability in terms of demand which present a problem during planning, controlling and scheduling. Food supply chains are usually vulnerable to this type of uncertainty due to factors such as variable production yield, harvest and different weather conditions which depends on the type of product and characteristics of processing. As a result, such uncertainty disturbs the system such as technology, competition, products, markets and governmental regulations.

Sources of uncertainty can be categorised into three, manufacturing process, demand and supply

uncertainty. Uncertainty from demand and supply has a bearing to the process of manufacturing which translates to effects of timely orderly fulfilment. On matter severity, demand uncertainty is considered to have a profound effect emanating from inaccurate predictions and volatile demands. Demand uncertainty can be divided into two, demand amplifications and end-customer demand.

Uncertainties in the supply chain either at processing, demand or supply levels all have a profound effect on the optimal functioning of a business^[15]. As a result, it is crucial to develop a solution to the given predicament. The solution would capitalise on the supply chain planning tools to develop the remedy. Supply chain planning tools can be categorised into different sections. Supply network planning on the other hand, dynamically harmonises the

market demand through production and sourcing activities as well as planning of material flow to offer optimisation of the entire logistics network. Production planning gives a seamless flow of resources through the promotion of improved production timelines to minimise delays, maximise the return of assets and reduce process inventory work.

Identification of management strategies to handle supply chain uncertainty is crucial for businesses. These approaches can cope with uncertainty as well as reduce uncertainty strategies. In reducing uncertainty strategy, a company can provide new product design, quality control and redesign of the entire supply chain. Total quality control and new product design approach reduced the process of uncertainty. The redesign of the supply chain, on the other hand, deals with the reduction of demand and supply related uncertainty. In redesigning the supply chain, it is important to consider chain configuration, chain control, chain information systems and chain governance and organisation. In handling supply chain infrastructure, collaboration from customers and suppliers is important as it helps in bypassing barriers in the supply chain stages hence reducing uncertainty related to complexities in the decision-making process.

A supply chain integration framework, in this case, means extending the systems of management to suppliers and consumers by first attaining internal and functional integration. In this concept of collaboration, information sharing is essential. At this point, there is reliance on Information Communication Technology to ensure seamless flow of information.

In reducing demand uncertainty, promotion or pricing strategy is an alternative approach a firm can use. Revision of prices or using promotions which are market controlled are effective ways of dealing with the implications of uncertainty. Strategic planning is usually a long term which is aimed at identifying optimal location and timing over a long period. These decisions have an impact on the long term performance of the system. Operational decisions, on the other hand, are short term and have an immediate impact on the supply chain.

In integrating uncertainty into the supply chain planning process, it is important to determine the fitting representation of uncertain parameters^[16].

Uncertainty representation involves two separate methodologies including scenario based and distribution based approach. Each scenario is concomitant by discrete scenarios capturing how the uncertainty might be in future. Supply chains need to be adaptive, flexible and consumer-oriented to tackle uncertainty. As a result, supply chains need to be resilient, robust, anti-fragility and continuity in its management. The idea of an agile supply is to be able to flexibly react to changes. On the contrary, resilience is aimed at overcoming problems altogether. Flexibility is a component of robustness which is supposed to manage any form of fluctuation within the supply chain efficiently.

The postponement is also a strategy to cope with demand uncertainty. A firm can make lead time promised to its customers longer as compared to the usual lead time which provides manufacturers with the much-needed flexibility to deal with unexpected changes regarding the consumer's demands. An obvious disadvantage of this method is it reduces the speed to market and is only preferred where speed is not a necessity on competitive priority. Additionally, financial measures such as insurance are commonly used to mitigate risk and reduce its implications and criticality of their disruptions. The objective of the postponement strategy is to delay supply chain activities to the extent of revealing customer demands to provide a fast response at a lower cost. Some of this strategy includes purchasing postponement where some expensive and fragile materials are delayed. There is also manufacturing, time, logistics and product development postponement.

In providing a solution to uncertainty, a firm can manage supply. A company can vary the supply of product through control of certain different factors. A firm can manage production capacity by using time flexibility from a workforce. In such an approach, a company uses flexible working time from its workforce, to provide a better match in the production with demand. Usually, plants are not continually operational at all times and such plant dormant time to offer diversity to match the disparity of demand. This system would enable a close match between demands from customers to production from different plants. A company can use a seasonal workforce where the company uses spare workforce time to increase the capacity to match the varied demand. Different fields such as tourism and

agriculture often employ this approach. Nonetheless, the sustenance of this approach might be difficult when there is a tight labour market.

Managing Inventory is another measure in dealing with uncertainty in the supply chain. Inventory can be managed through using similar components across different products with a predictable variable on demand. Additionally, a company can build an inventory of predictable demand products r high demand. A firm needs to change its inventory during off season which can offer more demand predictability during this period^[17-19].

Uncertainty is pervasive in the supply chain with varied points of origin. Uncertainty can originate as a result of inter-functional inconsistencies in the flow of material, dates of delivery or even the quantity of products as per the demand of customers.

Supply Chain Integration (SCI), is classified by information sharing mechanism both formally and informally which can help different members of the supply chain to deal with uncertainty. Implications of uncertainty normally do not solely exist. Whenever there is uncertainty in the supply chain, its member dependence on the supply chain integration might weaken or strengthened depending on the organization structure.

3 Ethical and social responsibility for risk management

Ethical responsibility principles are based on the alignment between form business processes and structures with informal traditions and culture which inspire members of an organization or firm to behave ethically^[20]. As a result, it is inevitable for leaders to demonstrate commitment and moral integrity through their actions. Consequently, it is critical for businesses to develop and sustain their ethical culture and go beyond normal compliance with legal requirements to actively advocating for moral values. The principles of ethical responsibility towards risk management include value driven responsibility, process integrity, leadership effectiveness and long-term perspective.

In a business environment which is filled with variability and uncertainty, values of the systems are supposed to remain constant. Value goes beyond meaningless statements to tough calls guiding decision making when it is least convenient for the business^[21]. Additionally, business should maintain process integrity throughout its supply chain. As a result, the unnecessary

risk would be avoided leading to losses incurred by the company^[22]. Leadership effectiveness is another principle responsible for an ethical business culture leading to the reduction of risks. Managers and business leaders should be in a position to enforce moral to the organization through their ethical acts.

Corporate Social Responsibility is referred to as a response by an organization to economic, social, ethical and environmental issues^[23]. These issues drastically increase as an organization expands. Good governance is a good social responsibility practice which can reduce risk in a business. Good governance will ascertain that both future and current risks which have an impact on stakeholders are easily identified and appropriate control measures are used to mitigate the risk. Business should be able to have effective role of board and business operations. Good communication and information sharing is another effective practice in promoting social responsibility in a firm. Businesses should share information effectively to their stakeholders and attain the highest level of engagement per stakeholder to address issues and reap the best results as a result of accountability.

There are numerous business practice frameworks which incorporate ethical and social responsibility^[24]. Code of ethics is such a framework where ethical responsibility is included in the business practice. Code of ethics is a list of values and morals a company aspires to conduct its business within. It specifies the ethical, operational rules. Additionally, the code of conduct is another commonly used framework. Codes of conduct are the standards of operations and general behaviour a firm plus its stakeholders is expected to operate within. Moreover, an ethical culture which is regularly assessed and cultivated is a good framework for business practice. Ethical culture is the values, traditions and norms of organizations. An ethical culture is a company's tradition to operate in certain moral conduct. Ethical training is another structure where businesses use to develop and maintain their culture. Ethical training is supposed to tutor stakeholders regarding a company's ethical behaviour and its role.

4 Future research direction

A supply chain involves all stages which are involved either directly or indirectly in fulfilling customer demands. A managing system in the supply chain is aimed at producing a strategy ad conforming performance indicator to manage the supply chain

properly. A good management system is, therefore, able to identify varied sources of uncertainty and get enough information to handle the uncertainty properly. Contingency-based research for supply chain management is one area which needs further research. Research done on supply chain integration to create a unit like a supply chain which is seamless is unlikely applicable in certain instances. Supply chain integration heavily relies on lean. As a result, it is not that flexible when faced with disruptions. Moreover, the viability of management strategies with a focus on areas with incurred cost due to implementation is another area which needs further studies. For example, in as much as flexible capabilities might lead to a competitive advantage, it is a costly process. Consequently, research to evaluate optimal flexible solutions which have a bearing on cost-effectiveness is prudent.

Studies regarding supply chain uncertainty have tended to provide generic explanations about the effects of uncertainty management policies on performance. Moreover, the explanations lack unequivocal clarifications for every given performance measures. As a result, it is difficult for future studies to be based on the previous studies to determine the exact anticipated changes in terms of performance of the supply chain. It is critical for managers to have insightful knowledge about the effects of the proposed strategies on the competitive position of a particular firm. Consequently, further research is inevitable to determine the implications of various strategies applied to the management of the supply chain. Present studies have presented links between management strategies and sources of uncertainty. In prioritizing management activities, it might be important to have knowledge and understanding of the level of uncertainty. Majority of present literature does not address the gradation which cannot be incorporated into the theoretical model. It is important to have further explorations in terms of research on sources of uncertainty.

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