Volume 6 - Issue 3

International Journal of Business Science and Applied Management

A fresh approach to business and management research

www.business-and-management.org

ISSN 1753-0296

Int. Journal of Business Science and Applied Management, Volume 6, Issue 3, 2011

A Perspective for Supply Chain Management: Building a Conceptual Framework

Luai E. Jraisat
Faculty of Business and Finance, American University of Madaba (AUM), Jordan
P.O. Box 2777, Amman 11821, Jordan
Telephone: +962 6 55 48 230/32
Email: l.jraisat@aum.edu.jo

Abstract

Supply chain relationships play a significant role in supply chain management to respond to dynamic export market changes. If the dyadic exporter-producer relationships are still weak, they impede the emergence of a high performance supply chain within an export market. This paper develops a conceptual framework for understanding how exporter-producer relationships include not only the relationship system but also network and transaction systems; and thus introduces a more integrated way of looking at supply chain management based on information sharing as a key process between exporters and producers. To achieve this aim, supply chain relationships are reviewed from the perspectives of relationship marketing theory, network theory and transaction cost theory. Findings from previous research are discussed to provide a better understanding of how these relationships have evolved. A conceptual framework is built by offering a central proposition that specific dimensions of relationships, networks and transactions are the key antecedents of information sharing, which in turn influences export performance in supply chain management.

Keywords: supply chain management, marketing, exporter-producer relationship, information sharing

1 INTRODUCTION

To date, there have been a number of studies that have tended to concentrate on the background and phenomena of supply chain management as well as the supply chain relationships. However, conceptually the management of supply chains is not particularly fully understood, and many authors have highlighted the necessity of clear concepts and conceptual frameworks on supply chain management (e.g. Harland, 1996; Wilson, 1996; Croom et al., 2000; Svensson, 2002; Williamson, 2008). Most of the discussions were about supply chain relationships, information and product flow, networks and transactions (e.g. Anderson et al., 1994; Ritter 1999; Toften and Olsen, 2003; Parker et al., 2006; Hsu et al., 2008). Little research (e.g. Harland, 1996; Croom et al, 2000) has claimed and confirmed that buyer-seller relationships, networks and transactions are highly related to supply chain management. Some studies (e.g. Wilson, 1996; Moberg et al., 2002; Hsu et al., 2008) have suggested that information sharing is one of the most important aspects of supply chain management for better understanding of supply chain relationships and performance.

Nevertheless, the impact of relationship, network and transaction perspectives on supply chain management has not been examined in any depth. There has been a lack of conceptual and empirical research on information sharing, which limits the understanding of the dyadic business relationship and there has been no theoretical framework analysing export supply chain relationships. Thus, this paper attempts to present a review of the existing approaches to supply chain management that is associated with business involving export markets. This is with the purpose of identifying important issues and research gaps for further research and providing an initial conceptual framework. To do so, this research identifies four perspectives: supply chain management (e.g. Harland, 1996; Croom et al, 2000; Lambert and Cooper, 2000) relationship marketing theory (e.g. Wilson, 1995; Veludo et al., 2004; Eiriz and Wilson, 2006), network theory (e.g. Anderson et al., 1994; Lazzarini, 2001; Ritter, 2004) and transaction cost theory (e.g. Riordan and Williamson, 1985; Williamson, 2008). Amongst these perspectives, the researcher argues that supply chain management is used as the main theoretical background and thus has an ability to accommodate the three other perspectives.

The paper is structured as follows: the importance of supply chain management is explained, key theoretical perspectives (relationship, network, and transaction theories) and export performance in the literature are reviewed and propositions are formed; the methodology is illustrated, a discussion of the results follows; and the final section concludes.

2 SUPPLY CHAIN MANAGEMENT

Supply chain management can be defined as the management of upstream and downstream relationships with buyers and sellers in order to create value in the final market at less cost to the supply chain as a whole (Christopher, 1998). Most of the studies on supply chain management (Croom *et al.,* 2000; Lazzarini, 2001; Svensoon, 2002) have concluded that the lack of a universal definition of supply chain management is in part due to the approach of different researchers in developing the concept of supply chains. Such a multidisciplinary origin is reflected in the lack of holistic conceptual frameworks for the development of a perspective on supply chain management (Harland, 1996; Leonidou *et al.,* 2006). As a consequence, the schemes of interpretation of supply chain management are mostly partial with relatively poor findings that empirically validate the framework explaining the key themes and form of supply chain management, its buyer-seller relationships and its information sharing.

The academic literature underlines a more varied rationale as several studies link supply chain management to key perspectives such as relationship marketing theory (e.g. Wilson, 1995; Veludo *et al.,* 2004; Eiriz and Wilson, 2006), network theory (e.g. Anderson *et al.,* 1994; Lazzarini, 2001; Ritter, 2004), and transaction cost theory (e.g. Riordan and Williamson, 1985; Williamson, 2008). The literature suggests that the concept of supply chain management brings different focuses (e.g. Harland, 1996; Croom *et al,* 2000; Lazzarini, 2001; Eiriz and Wilson, 2006). For example, researchers may think of the relationship framework, which is built based on the dyadic relationship as the main unit to manage the flow of products and information. Others may link business relationships to networks. This issue refers to the set of relationships where a single relationship cannot work alone without connecting with other relationships. Another important notion is the focus on the transactions of the relationship that are grouped in one supply chain. Wilson (1996) argues that information sharing is one of the important aspects of supply chains for increasing profits and reducing costs, and must be investigated in more detail. Consequently, there is a demand for building a strong buyer-seller relationship to encourage the improvement of modern chains (Duffy *et al.,* 2008).

Supply chain management framework has become an important approach within management in developed countries since the 1990s. In the mid-1980s, transactions depended on arms-length agreements, whereas agreements in chain relationships were built on cooperation and information sharing in the 1990s (Hoyt and Huq, 2000). Consequently, the monetary value gained from the export of fresh fruit and vegetables to the European Union by developing countries increased by 24% between 2001 and 2005 (Jaffee, 2005). This is indicative of how the export supply chain plays a key role in managing flows of produce and information between buyers and sellers who are concerned with information sharing. More importantly, information sharing is a key strategy (Piercy *et al.,* 1997; Leonidou *et al.,* 2006), helping its members to make better decisions about strategic issues for better performance (Huang *et al.,* 2003).

The main problem motivating this research is that developing countries (e.g. Jordan) supply very limited fruit and vegetable exports to the European Union, where there are high profits and business continuities. The Jordanian exporter-producer relationships are unable to manage a high performance export chain. Retrospectively, there is a need to recommend and inform private and government sectors working in the export industry of fresh fruit and vegetables by understanding this issue from a holistic viewpoint. The novel focus is on an understanding of information sharing between the exporters and the producers in their relationships in order to improve the supply chain management from Jordan to the European Union.

In developing countries, the producers and exporters realise the importance of information sharing in supplying fresh fruit and vegetables to the European Union successfully. Modern fresh food-export supply chains can motivate the producers and the exporters to organise themselves in marketing groups. This is in order to develop sufficient volume for the necessary quality based on production, logistics and marketing information and connections with markets to access export markets with high profits. The researcher argues that supply chain management for export is built on the objectives of delivering products and services to the right customer, in the right quantity and at the right time in the export chain. Therefore, the researcher defines the concept of supply chain management as follows:

Supply chain management is a framework for creating relationships among the chain members, mainly the exporters and producers, who consider information sharing at the three levels of relationship, network and transaction dimensions, to reach the right customer, in the right quantity, and at the right time for better export performance.

Having discussed the above, however, previous research has not covered all the issues related to supply chain management, its concept and its export supply chain relationships, and information sharing has not been explored in detail. The previous research has not provided a holistic integration between relationships, networks and transaction in order to show supply chain management as a major approach. The previous research has not focused on agri-food export supply chain in detail. Therefore, this paper focuses on studying the exporter-producer relationship including key dimensions, along with exploring information sharing as being the main dimension. The main theoretical perspectives identified are the relationship, network and transaction perspectives, which are associated with information sharing in the context of export supply chain relationships in the fresh fruit and vegetable industry.

3 RELATIONSHIP MARKETING THEORY

Relationship marketing theory is a useful perspective offering explanations of several processes or dimensions (e.g. commitment and cooperation) that are significant in studying the interrelationships between certain phenomena of the buyer-seller relationship (Wilson, 1995), such as information sharing in supply chain management (Toften and Olsen, 2003). This theory can explain the exporter-producer relationship and its information sharing, offering explanations for the several streams in relationships, the dimensions in relationships, such as the rationale for, process of and structure of relationships.

Conceptual and empirical models often focus on different components of the relationship but use similar key theoretical dimensions to explain relationships (Wilson, 1995; Dash *et al.,* 2007). These dimensions include trust, commitment, communication, cooperation, collaboration, and information sharing. Tomkins (2001) explains that trust leads to increased information between firms in business. Trust and information sharing have a functional association that is more likely to be characterised over the life cycle of a positive relationship (Tomkins, 2001). Wilson (1995) defines commitment as the desire to continue the relationship. Commitment is developed in the more mature stage of relationships after trust is developed in the early stage (Wilson, 1995).

Cooperation is a key dimension to forming partnerships in order to ensure that both parties can gain benefits (Wilson, 1995). Cooperative ways enable both parties to supply fruit and vegetables in the required quantities and of the required quality to the target markets (Shaw and Gibbs, 1995). Collaboration is when two or more chain members work together to create a competitive advantage (Simatupang and Sridharan, 2002). Communication is a necessary human activity, which supports relationships between parties (Veludo *et al.,* 2004;) for creating rich knowledge. Information sharing encourages commitment and cooperation and helps the buyer and seller through the adaptation of processes (Kalafatis, 2000; Andersen, 2006). Furthermore, providing the right information between chain parties gives them the opportunity to review the credibility of the other party (Dash *et al.,* 2007).

Generally, most of the studies' authors (e.g. Wilson 1995; Piercy *et al.*, 1997; Eiriz and Wilson, 2006; Hsu *et al.*, 2008) use these dimensions to form different views on the relationship perspective. In most of the studies, the definitions explain a relationship as a link of benefits and processes for both individuals and firms engaging in several streams such as networks, exchange, governance, exporting and supply chain management to improve relationships and performance. These dimensions are processes in the relationship, which work as conditions to create better achievements and sharing of information for the firms. Based on the explanations above, the business relationship is considered as a key unit in the export supply chain. Therefore, the researcher defines the relationship concept as the following:

A relationship is a set of processes (e.g. commitment and information sharing) between an exporter and a producer who share a rationale for the relationship and networks in order to improve export performance in the transactional export supply chain.

Table 1 summarises previous studies that have applied the relationship perspective. The previous research has not covered all the issues related to relationships, and information sharing has not been explored in detail. A few studies (e.g. Kwon and Suh, 2004; Leonidou *et al.*, 2006) have explored important dimensions such as information sharing in the supply chain relationship but these studies have also failed to empirically contribute to examining information sharing in an advanced way. Most of the empirical studies (e.g. Dorsch *et al.*, 1998; Wu *et al.*, 2004) have provided key findings that contribute to understanding how the different dimensions affect each other but few of them have examined the impact of these dimensions on export performance. A few studies (e.g. Parker *et al.*, 2006; Hsu *et al.*, 2008) have investigated the association between the different relationship dimensions, information sharing and export performance to understand the supply chain relationship in the context of supply chain management. However, these studies have not empirically provided a holistic view related to information sharing and the interrelationships were indirect in the association. Most of the previous research has analysed one side of the dyadic supply chain relationships, which limited the full-understanding of relationship research. A few of the studies (e.g. Parker *et al.*, 2006) have examined both sides but they have not provided detailed empirical work related to relationships.

In fact, the above discussion on buyer-seller relationships leads to a key research question: "How do key relationship dimensions have impacts on information sharing in the export supply chain relationship?" This research attempts to provide insights into the high-order dimensions (e.g. trust and commitment), focusing on information sharing. Therefore, the researcher suggests the following proposition:

Proposition 1: Relationship dimensions (e.g. trust, commitment, cooperation, collaboration and communication) between the dyadic actors (exporter and producer) have an impact on information sharing in the exporter-producer relationship.

Table 1: Key Previous Research Related to Relationship Marketing Theory

Author	Type of Research	Key Factors (Dimensions) and Concepts	Key findings
Wilson (1995)	Conceptual research	Trust, commitment, bonds, cooperation, quality, mutual goals, satisfaction and technology adoption.	A relationship concept definition was improved and operationalized and the study described development processes.
Toften & Olsen (2003)	Conceptual research	Export information, export performance, and business success.	Export information use and export performance are influenced by knowledge and learning factors. Information use has positive impact on firm success.
Wu et al. (2004)	Empirical research	Trust, commitment, power, investment, dependence, continuity, and chain integration	The level of investment, dependence, trust, power and continuity to supply chain partners will enhance commitment and, consequently, the integration of the supply chain management.
Lages et al. (2005)	Empirical research	Relationship quality, long-term relationship, information sharing, commitment, satisfaction, and export performance.	A better relationship quality results in a greater amount of information sharing, commitment, orientation, and satisfaction with the exporter-importer relationship in the UK.
Parker et al. (2006)	Empirical research	Information sharing, commitment application, quality, and decision-making.	Perceived equality, continuous supply, quality, control and commitment are benefits in dealing directly in relationships. Information sharing importance for decision making in fresh products.

4 NETWORK THEORY

Network theory provides a useful framework for analysis of a business situation, and it adds a new level of complexity to understanding the relationship perspective (Jarillo, 1988; Möller and Halinen, 1999; Croom *et al,* 2000). Network relations create information sharing that enables buyers and sellers to have access to resources and knowledge beyond their abilities, leading to long-term relationships (Mikkola, 2008). This approach is a structure formed by the main dimensions (e.g. activities, resources and actors) that connect a set of relationships. Therefore, alongside information sharing, the network perspective will also be studied as it enables the analysis of export chain relationships. A business network is a set of relationships that are connected, showing firms' identity, process and functions that contribute to explaining a dyadic relationship (Anderson *et al.*, 1994; Ritter, 2004).

Actors is an essential function within relationships that are required to form meaningful network structures, in which the network must have activities and the resources required to carry out those activities (McLoughlin and Horan, 2002). In the export business, actors connect with each other socially to bring various beneficial types of producers, retailers and consumers together within regional fruit and vegetable networks (Lazzarini *et al.,* 2001; Koops *et al.*, 2002) and establish a network position (Turnbull *et al.,* 1996). Activities and resources are two strategic relationship functions in a network (Anderson *et al.,* 1994). These functions are meaningful in the conceptualisation of the marketing network, which is an important value in analysing a business (Möller and Halinen, 1999). However, actors control activities that are built by relationships with other parties in the network and are influenced by resources, which are exchanged to coordinate chain activities.

Anderson *et al.* (1994) state that functions carried out within relationships must be viewed as part of a network. They also state that relationships are connected to establish networks, which have direct and indirect connections with other relationships. Most of the previous studies state that relationship functions such as activities, resources and processes must be managed in a network in order to establish interactions for better benefits and long-term relationships. This is where networks are a set of relationships among constellations of actors (Jarillo, 1988; Bardach, 1994; Jarzo, 2000; Ritter, 2004) and these relationships make connections with each other to provide the functions of benefits and exchange processes of their business and others' for better performance. The researcher provides a definition of the network concept:

A network is a set of relationships among firms aiming to establish connections based on relationship functions (e.g. activities, resources and actors) to support information sharing for better performance in the export supply chain.

Table 2 summarises the previous studies that have applied the network perspective. Most of the studies have not covered all the issues related to networks' impact on dyadic relationships, and information sharing has not been explored as an important concept. A few studies (e.g. Halinen *et al.,* 1999) have examined information sharing in the supply chain relationship, but their empirical work was not in-depth. Most of the empirical studies (e.g. Ritter, 1999; Wilkinson and Young, 2002) have provided findings that contribute to understanding how the network dimensions affect each other but few of them have investigated the dimensions' impact on export performance. Most of the previous research has not examined the two sides of the relationship in network research, which limits the full understanding of the relationship work in the network. Consequently, this paper highlights a research question, which is "How do key network dimensions have impacts on information sharing in the dyadic relationship?" The researcher seeks to examine the effects of networks in business relationships and identifies the factors (e.g. activities, resources and actor position) that influence the relationships, focusing on information sharing.

Proposition 2: Network dimensions (e.g. activities, resources and actors) between the dyadic actors (exporter and producer) and the network actors have an impact on information sharing in the exporter-producer relationship.

Table 2: Key Previous Research Related to Network Theory

Author	Type of Research	Key Factors (Dimensions) and Concepts	Key findings
Ritter (1999)	Empirical research	Network competences, resource availability, human resource management, activities, communication structure and culture	Network competence is embedded within the whole company. Resource availability is a precondition for the development of competence. Network orientation of human resources, communication structure and corporate culture are positively associated with competence.
Möller & Halinen (1999)	Empirical research	Network, actor and buyer-seller relationship.	A network theory provides well-developed conceptual tools for analyzing the networks and network management issues.
Koops et al. (2002)	Empirical research	Resources, change processes, strategic changes and collaboration.	Resources have an effect on the product and process in food industry. Supplier and customer collaboration were not found to have any moderating effects.
Wilkinson & Young (2002)	Empirical research	Network, actor, firm performance, complexity, planning and strategies.	A network perspective leads to the identification of additional causal factors explaining firm and relationship behaviour and performance.
Mikkola (2008)	Empirical research	Market relations, power, economic activities, actors, network relations, and coordination.	A coordinative structural mode of socially overlaid networks is identified for fresh product chains.

5 TRANSACTION COST THEORY

Transaction cost theory's basic premise is that the cost of doing transactions could be too high under certain conditions (Grover and Malhotra, 2003). Transaction cost theory is an economic approach (Williamson, 2008) and reflects different types of transaction costs (e.g. coordination, contracting deals and information sharing) (Eiriz and Wilson, 2006). Thus, this economic perspective needs to take into account the economic rationality of supply chain relationships. This perspective provides explanations for transaction dimensions (e.g. asset specificity, uncertainty and frequency) between firms and their relationships (Williamson, 1995; Spraakman, 1997). Transaction cost theory explains how information advantage in a relationship is enjoyable and beneficial for firms (Williamson, 1995) and information sharing in business is a transaction cost (Eiriz and Wilson, 2006). Transaction cost theory contributes to the study of supply chain relationships and networks, and the efficiency of economic activities.

In transaction cost theory, the unit of analysis is the transaction used to describe the economic activity and the governance structures in business relationships (Riordan and Williamson, 1985). Transaction cost theory explains that transaction costs include coordination, monitoring, contracting deals, opportunistic behaviour risk and information sharing (Williamson, 1995). Williamson (1988b) defines a transaction as a basic unit of analysis in organisational structure rather than production, one where the main dimensions of transaction cost theory are asset specificity, uncertainty and frequency. The behavioural assumptions are bounded rationality and opportunism, which forces firms to make self-enforcing promises to behave responsibly in terms of increasing their profit (Williamson, 1995). Bounded rationality is accepting the limits of the human ability to process information comprehensively (Williamson, 1988b). Transaction cost theory views bounded rationality as a problem under conditions of uncertainty, which make it difficult to fully specify the conditions surrounding an exchange, thereby causing an economic problem (Grover and Malhotra, 2003). Opportunism is defined as *"self-interest seeking with guile"* by a human actor in business relationships (Williamson, 1985, 255). *"This does not imply that all those involved in transactions act opportunistically all of the time, rather, it recognizes that the risk of opportunism is often present"* (Hobbs, 1996, p.17). In his subsequent work, Williamson (1985, p. 47) describes guile as *"lying, stealing, cheating, and calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse."*

Three dimensions describe a transaction: asset specificity, uncertainty and frequency (Williamson, 1985). Asset specificity is a basic unit of analysis, which is the most important dimension in the transaction (Riordan and Williamson, 1985). *"Asset specificity arises when one partner to an exchange of a firm has invested resources specific to that exchange which have little or no value in an alternative use"* (Hobbs, 1996, p17). This dimension is a transactional factor of special interest (Williamson, 1981) and refers to the transferability of assets that support a given transaction cost, which are mainly in the form of human specificity (e.g. employee training) or physical specificity (e.g. investment in equipment) (Williamson 1985). Williamson (1985) describes two other types of asset specificity: site specificity (parties' relationships to minimise transportation and inventory costs), and dedicated assets (referring to substantial investments that would not have been made outside a particular transaction).

Uncertainty is linked to economic reasons and transacting behaviour are the two reasons related to uncertainty and both result in extra costs between parties (Bourlakis and Bourlakis, 2005). The existence of uncertainty makes writing and contracts complicated since the environment shifts in unforeseen ways (Spraakman, 1997). In the food supply chain, the transaction costs are because of uncertainty due to limited information, opportunism, frequency of transactions and incompleteness of contracts (Poole *et al.,* 1998). Under conditions of uncertainty, information cannot be derived regarding future states, where probabilistically generated information and interpretive ambiguity will exist in business.

Frequency could be called large-scale production, and setup costs and reputation effects are two aspects of frequency (Williamson, 2008). Only when the potential demand is large is it worthwhile to invest in specialised assets and have frequent transactions. If markets were small, such investments would not be worthwhile. According to Bourlakis and Bourlakis (2005), this relates to the frequency with which transactions between the firms occur, and whether high asset specificity firms should contract out.

This perspective works, depending on its basic unit of analysis, with the following features (Williamson, 1985, 1995): a) the basic unit of analysis is the transaction, b) asset specificity, uncertainty and frequency are the critical dimensions of transaction cost theory, which are essential for transactions, and c) the governance structure, such as relationships and the market that each structure has, differs for both cost and competence. The importance of the transaction role is shown in various studies, and it becomes more important when it is studied for business transactions of a business relationship in a network for better information sharing and achievement. Thus, the researcher defines the transaction concept as:

A transaction is a basic unit of analysis in a relationship, whose dimensions (e.g. asset specificity, uncertainty and frequency) affect actors' relationships, changing costs and information sharing for better export performance in their export supply chain.

In Table 3, there is much previous research related to the transaction perspective that is important to understand the transaction between the chain members. In the previous research, most of the studies have been theoretical or conceptual research and few studies (e.g. Williamson, 1988a; Ruben *et al*., 2007) have considered empirical work. In the present research, there is a need to understand this perspective in more depth in order to describe transactions between firms and their relationships, and the dimensions that affect transactions, including information sharing and export performance. The researcher argues in favour of studying transaction cost theory as a complementary perspective to the other two perspectives above. This is an attempt to explore the supply chain relationship from different approaches whose dimensions can have important influences on the buyers and the sellers sharing different benefits and information. In fact, there have been conceptual overlaps between the different dimensions of the three perspectives and previous research has not linked these dimensions to their perspectives. Therefore, this paper raises a third question, which is "How do key transaction dimensions have impacts on information sharing in the export supply chain relationship?" Hence, the following proposition is suggested:

Proposition 3: Transaction dimensions (e.g. asset specificity, uncertainty and frequency) in the export supply chain have an impact on information sharing in the exporter-producer relationship.

Table 3: Key Previous Research Related to Transaction Cost Theory

Research	Method	Key Factors (Dimensions) and Concepts	Key findings
Williamson (1971)	Theoretical research	Vertical integration, contract, information exchange and risks	Integration requires powers of internal organization. Firms resort to internalization because of economies of information exchange.
Williamson (1988a)	Empirical research	Contracts, opportunism, bonds, asset specificity, uncertainty, frequency, organization process and analysis, and innovation.	The transaction is the basic unit of analysis. The critical dimensions are asset specificity, uncertainty and frequency with respect to which transactions differ.
Poole et al. (1998)	Empirical research	Marketing orientation, transaction costs, contracts, uncertainty and information sources.	Producers can be grouped according to their marketing orientation. -Marketing factors and the negotiated price are determinants of the terms of the transaction. Information sources are very important to fresh product suppliers.
Schmitz (2006)	Empirical research	Symmetric information and information gathering.	Parties always agree on collaboration if symmetric information is available. information gathering is not always a purely strategic activity.
Williamson (2008)	Conceptual research	Contracting; transaction costs, human actors, outsourcing, organization and supply chain management	The study describes the contract approach to economic organization, the operationalization of transaction perspective, outsourcing levels, and qualifications to the foregoing.

6 EXPORT PERFORMANCE

Considerable attention has been paid to the export performance (e.g. Aksoy and Kaynak, 1993; Katsikeas *et al.,* 2000; Katsikeas *et al.,* 2008). However, despite the previous research efforts in understanding the importance of export performance, this paper is characterised by helping in developing a new approach to supply chain management for export. It is an attempt to link supply and demand sides based on the influence of information sharing on export performance. As a result, this research claims that export performance is a process by which it is possible to evaluate the overall business of both the buyer and the seller in their relationship. A variety of financial and non-financial criteria are important in providing the information necessary for decision makers to plan, control and direct the activities of the firm (Cousins *et al*., 2008).

Exporting fresh fruit and vegetables with a successful supply export chain is important for the exporter-producer relationships in Jordan, where only a few exporters are able to implement high quality standards and delivery requirements to the European Union. According to Cousins *et al.* (2008, p.242), *"the buyer-seller relationship must be evaluated, not just the dimensions of performance, but financial dimensions as well".* The following table illustrates two types of performance criteria that are indicated in the literature:

Table 4: Performance Criteria of Buyer-Seller Relationship

Criteria	Representative Research
Financial Performance	
-Profitability	-Styles &Ambler (1994); Dyer (1996); Zou & Stan (1998); Katsikeas et al. (2008)
-Costs	- Dyer (1996); Hsu et al. (2008); Trienekens et al. (2008)
-Sales growth	-Ambler et al. (1999); Matanda & Schroder (2002); Trienekens et al. (2008)
-Market share	-Styles & Ambler (1994); Robertson & Chetty (2000); Hsu et al. (2008)
-Return on investment	-Trienekens et al. (2008); Hsu et al. (2008)
Non-Financial Performance	
-Satisfaction	-Wilson (1995); Batt (2003); Leonidou et al. (2006); Dash et al. (2007).
-Relationship quality	-Dyer (1996); Dorsch et al. (1998); Roy et al. (2004); Trienekens et al. (2008); Hsu et al. (2008)
-Continuation	-Fontenot & Wilson (1997); Lages et al. (2005); Trienekens et al. (2008); Hsu et al. (2008)
-Market diversification	-Aksoy & Kaynak (1993); Robertson & Chetty (2000)

Financial criteria of performance are export sales growth, export profitability, export sales intensity and market share (Styles and Ambler, 1994; Ambler *et al.*, 1999; Katsikeas *et al.*, 2008) in addition to costs (Dyer, 1996; Hsu *et al.*, 2008). Robertson and Chetty (2000) suggest that export intensity, growth and profitability are three economic factors that measure performance. Trienekens *et al.* (2008) argue that the economic measures of performance for the fresh products business are efficiency (profitability and logistics costs), return on investment, return on sales. Zou and Stan (1998) argue that export sales and profits are probably the most frequently used financial factor.

Non-financial criteria of performance are: satisfaction (Wilson, 1995; Fontenot and Wilson, 1997; Batt, 2003; Dash et al., 2007), relationship continuation (Lages et al., 2005), relationship quality (Roy et al., 2004; Lages et al., 2005), market diversification (Robertson and Chetty, 2000) and the rate of new product introduction. Robertson and Chetty (2000) also include non-financial measures such as the firm's perception of overall performance derived from past and current events and future projected progression.

Having discussed the export performance, this research provides some scope for supply chain relationship associated information sharing in order to explore and understand the possible association between information sharing and export performance in detail. The financial and non-financial performance criteria identified are general factors and basis and they need to be refined further in future research. This leads to a research question that should be considered in this research. This question is "How does information sharing have an impact on export performance in the export supply chain relationship?" Therefore, the researcher proposes the following:

Proposition 4: Information sharing in the exporter-producer relationship has an impact on export performance of the dyadic actors in the export supply chain.

7 METHODOLOGY

This research follows a phenomenological approach to conceptual framework building. The use of this approach depends on analyzing theories and combining their dimensions to build up the highlighted conceptual framework. This is based on the rationale that supply chain relationships include not only relationship theory but also network and transaction theories; it thus offers a more integrated way of looking at the research problem (e.g. Harland, 1996; Croom *et al.*, 2000; Lazzarini, 2001; Moberg *et al.*, 2002; Eiriz and Wilson, 2006; Duffy *et al.*, 2008). This contribution will offer a distinctive and valuable understanding of the dyadic exporter-producer relationships with a holistic view and analysis.

The review and analysis of existing literature resulted in a conceptual framework to model the dyadic producer-exporter relationship. The researcher addresses the key gaps identified in the previous research and the key propositions suggested in the sections above for this research. The gaps are expressed as broad and open research issues (Yin, 1994, p. 21), and the propositions reflecting these gaps will be used as a guide in the data collection and analysis, focusing on the research phenomenon (Perry, 1998, p.791). The main focus is on identifying these gaps, and therefore future research will attempt to contribute to solving them.

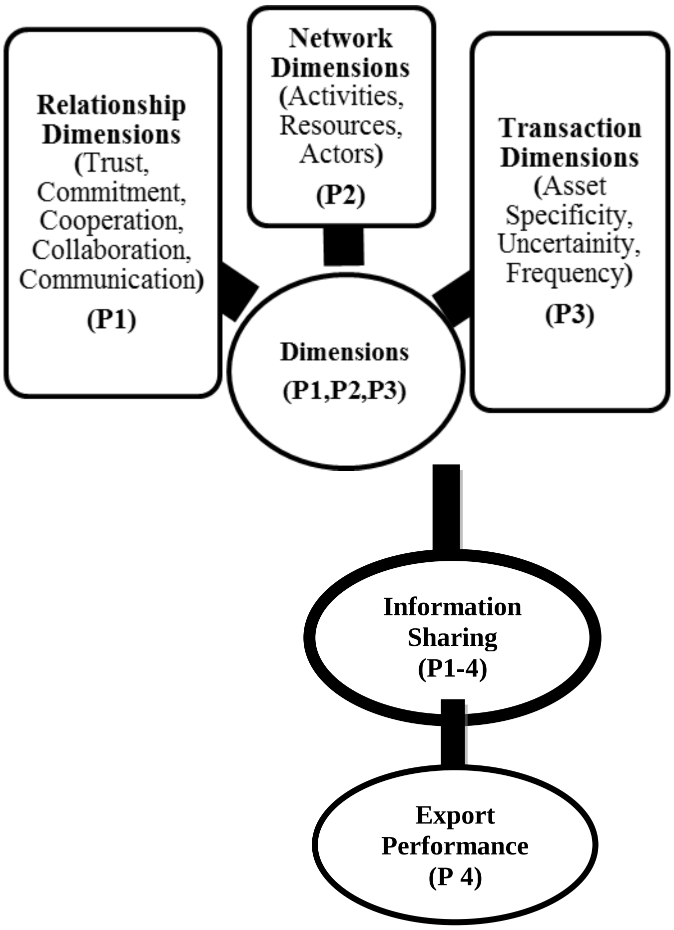
In summary, there has been a lack of conceptual and empirical research on information sharing, which limits the understanding of the dyadic business relationship, and offers no conceptual framework. In contrast, for phenomenon-driven research questions, the researcher has to frame the study in terms of the importance of the phenomenon and the lack of plausible existing theory (Eisenhardt and Graebner, 2007, p.26).

8 TOWARDS A CONCEPTUAL FRAMEWORK

Drawing on the different arguments and discussion above, the current research provides the initial conceptual framework of supply chain management and links it to the propositions (Figure 1**)**. This is in order to support the data collection and analysis in future research. Whilst higher level dimensions have been given great consideration within the context of the supply chain, there are many other factors that influence the exporter-producer relationship, the most important of which is information sharing. This paper presents a possible association of these factors for both sides of the export-producer relationship in the supply chain management and identifies factors that could be important in distinguishing the best relationships.

Therefore, a number of substantive, theoretical and methodological issues are still opportunities that remain for future research. This paper highlights them for future research in order to attempt contributing to solving them. These propositions are suggested to bring a focus on future empirical work related to three themes: relationship, network and transaction dimensions; information sharing; and export performance. It is argued that there is a need to establish a theoretical link between the three themes. There was a conceptual overlap between many of the dimensions of the three relevant perspectives (relationship marketing theory, network theory and transaction cost theory), to be used in a unified empirical study. Because many factors have impacts on the determination of information sharing, attempts to identify associations with any single factor, such as the cooperation dimension, may not have been totally successful. Therefore, to avoid this problem and to establish possible credible links between the three themes, key dimensions of the three perspectives are newly combined to introduce antecedents for information sharing, which affects export performance in supply chain management.

Figure 1: Conceptual Framework of Supply Chain Management



9 CONCLUSION AND CONTRIBUTION

The paper has reviewed the key empirical studies related to the factors of the supply chain relationship within supply chain management. Previous research related to supply chain management and marketing research and relationships, networks and transactions has been reviewed and then classified based on the use of three theoretical perspectives. This is in order to have a pre-developed (initial) conceptual framework for supply chain management associated with the information sharing phenomenon to guide future research. The research needs to identify a set of key factors and attempts to clarify them in order to develop a unified empirical study.

Therefore, this paper has sought to establish possible credible links between the three themes: dimensions of the three perspectives; information sharing; export performance in supply chain management. The researcher argues that combining the three perspectives will allow the development of a theoretical framework for supply chain management as the main perspective, in order to understand the dyadic exporter-producer relationship. This framework can work as an appropriate approach for analysing the totality of the relationship. This is based on the rationale that supply chain relationships include not only the relationship system but also network and transaction systems; it thus makes possible a more integrated way of looking at research supply chain management (e.g. Harland, 1996; Fontenot &Wilson, 1997; Croom *et al.*, 2000; Lazzarini, 2001; Moberg *et al.*, 2002; Leonidou *et al.*, 2006; Eiriz & Wilson, 2006; Duffy et al., 2008). This contribution will offer a distinctive understanding of the dyadic exporter-producer relationships with a holistic view. This research also encourages policy makers to be more aware of the importance of business relationships in export supply chain management. This paper provides policy makers with a unique conceptual framework that captures the processes needed to reach an improved export supply chain management based on a link between the different relationship, network and transaction dimensions; information sharing; and export performance as a strategic agri-food policy.

Present theory has been extended by offering a central proposition that specific dimensions of relationships, networks and transactions are the key antecedents of information sharing, which in turn influences export performance in supply chain management. Future research should attempt to answer three research questions. First, how do the relationship, network and transaction dimensions have an impact on information sharing? Second, how is information sharing evaluated in the dyadic relationship? Third, how does information sharing have an impact on export performance? It is the aim to examine and validate a conceptual framework for export supply chain management that can offer fruitful insights and contributions for supply chain management and its buyer-seller relationships.

REFERENCES

Ambler, T. and Styles, C. (2000) 'The future of relational research in international marketing: constructs and conduits', *International Marketing Review,* 17 (6), pp. 492-508.

Ambler, T., Styles, C. and Xiucun, W. (1999) 'The effect of channel relationships and guanxi on the performance of inter-province export ventures in the people's republic of China', International. *Journal of Research in Marketing*,16, pp.75–87.

Anderson, J.C., Hakansson, H. and Johanson, J. (1994) 'Dyadic business relationships within a business network context', *Journal of marketing,* 58 (4), pp.1-15.

Archer, N. P. (2006) 'Supply chains and the enterprise', *Journal of Enterprise Information Management,* 19 (3), pp. 241-245

Ballou, R.H., Gilbert, S.M. and Mukherjee, A. (2000) 'New managerial challenges from supply chain opportunities', *Industrial Marketing Management,* 29, pp.7-18.

Bardach, E. (1994) '*Can Network Theory Illuminate Interagency Collaboration?',* Workshop on Network Analysis and Innovations in Public Programs, Sept. 29-Oct. 1, 1994: held at LaFollette Institute of Public Affairs, University of Wisconsin-Madison.

Batt, P.J. (2003) 'Building trust between growers and market agents', *Supply Chain Management: An International Journal,* 8 (1), pp.65-78.

Bradley F., Meyer R. and Gao, Y. (2006) 'Use of supplier-customer relationships by SMEs to enter foreign markets', *Industrial Marketing Management,* 35, pp.652 – 665.

Brennan, R., and Turnbull, P.W., (1999) 'Adaptive behavior in buyer–supplier relationships', *Industrial Marketing Management,* 28, pp. 481–495.

Cadilhon, J.J., Fearne, A.P., Moustier, P. and Poole, N.D. (2003), 'Modelling vegetable marketing systems in south east asia: phenomenological insights from vietnam', *Supply chain Management: An International Journal Volume*, 8 (5), pp. 427-441.

Christopher, M. (1998) *Logistics and supply chain management: strategies for reducing cost and improving service*. 2nd edn. London: Financial Times Publishing.

Cousins, P.D., Lawson, B. and Squire, B. (2008) 'Performance measurement in strategic buyer-supplier relationships: the mediating role of socialization mechanisms', *International journal of Operations & Production Management*, 28 (3), pp. 238-258.

Croom, S., Romano P. and Giannakis M. (2000) 'Supply chain management: an analytical framework for critical literature review', *European Journal of Purchasing & Supply Management,* 6, pp.67 – 83.

Dash, S., Bruning, E.D. and Guin, K.K. (2007) 'Antecedents of long-term buyer-seller relationships: a cross cultural integration', *Academy of Marketing Science Review,* 11, pp. 1-28.

Dorsch, M.J., Swanson, S.R. and Kelley, S.W. (1998) 'The role of relationship quality in the stratification of vendors as perceived by customers', *Journal of the Academy of Marketing Science,* 26 (2), pp. 128-142

Duffy R. S. (2008) 'Towards a better understanding of partnership attributes: an exploratory analysis of relationship type classification', *Industrial Marketing Management*, 37, pp.228 – 244.

Dyer, J. H. (1997) 'Effective inter-firm collaboration: how firms minimize transaction cost and maximize transaction value', *Strategic Management Journal*, 18, pp.553 – 556.

Eisenhardt, K. and Graebner, M. (2007) 'Theory Building from Cases: Opportunities and Challenges', *Academy of Management Journal*, 50 (1), pp. 25-32.

Eiriz V. and Wilson D. (2006) 'Research in relationship marketing: antecedents, traditions and integration', *European Journal of Marketing,* 40 (3/4), pp. 275-291.

Grover, V. and Malhotra, M.K. (2003) 'Transaction cost framework in operations and supply chain management research: theory and measurement', *Journal of Operations Management,* 21, pp.457–473.

Hadaya, P. and Cassivi, L. (2007) 'The role of joint collaboration planning actions in a demand-driven supply chain', *Industrial Management & Data Systems,* 107 (7), pp. 954-978.

Halinen, A, Salmi, A. And Havila, V. (1999) 'From dyadic change to changing business networks: an analytical framework', *Journal of Management Studies,* 36 (6), pp. 779-794.

Harland C. M. (1996) 'Supply chain management: relationships, chains and networks', *British Journal of Management,* 7, Special Issue**.**

Hoyt, J. and Huq, F. (2000) 'From arms length to collaborative relationships in the supply chain: An evolutionary process', *International journal of physical distribution and logistics management,* 30, (9), p. 750-764.

Hsu, C.C., Kannan, V.R., Tan, K.C. and Leong, K.C. (2008) 'Information sharing, buyer-supplier relationships, and firm performance A multi-region analysis', *International Journal of PhysicalDistribution & Logistics Management,* 38, (4) pp. 296-310.

Humphrey, J. and Schmitz, H. (2001) 'Governance in Global Value Chains', *IDS Working Paper,* 32 (3), pp.1-35.

Humphrey, J. (2005) *Shaping Value Chains for Development: Global Value Chains in Agribusiness.* Paper Commissioned by the German Federal Ministry for Economic Co-operation and Development.pp.1-70.

Jarillo, J.C. (1988) 'On strategic networks', *Strategic Management Journal,* 9 (1), pp. 31-41.

Jarosz, L. (2000) 'Understanding agri-food networks as social relations', *Agriculture and Human Values,*17, pp. 279–283.

Katsikeas , C.S., Piercy, N.F. and Ioannidis, C. (1996) 'Determinants of export performance in a European context', *European Journal of Marketing,* 30 (4), pp. 6-35.

Katsikeas, C.S., Leonidou, L.C. and Morgan, N.A. (2000) 'Firm-level export performance assessment: review, evaluation, and development', *Journal of the Academy of Marketing Science,* 28, pp. 493 -511.

Koops, S., Mollenkopf, D. and Zwart, T. (2002) 'Food supply chains: are efficiency and responsiveness mutually exclusive?', *Chain and network science,* 2 (1), pp. 7-17.

Kwon, I.W.G. and Suh, T. (2004) 'Factors affecting the level of trust and commitment in supply chain relationships', *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply,* pp. 4-14.

Lazzarini S. G., Chaddad F. R. and Cook M. L. (2001) 'Integrating supply chain and network analysis: the study of netchains', *Journal on Chain and Network Science,* 1 (1), pp.7 – 22.

Lages, C., Lages, C.R. and Lages, L.F. (2005) 'The RELQUAL scale: a measure of relationship quality in export market ventures', *Journal of Business Research,* 58, pp.1040– 1048.

Lambert, D.M. and Cooper, M.C. (2000) 'Issues in supply chain management', *Industrial Marketing Management,* 29, pp. 65-83.

Lau, H.C.W. and Lee, W.B. (2000) 'On a responsive supply chain information system', I*nternational Journal of Physical Distribution & Logistics Management,* 30 (7/8), pp. 598-610.

Leonidou, L.C, Palihawadana, D. and Theodosiou, M. (2006) 'An integrated model of the behavioural dimensions of industrial buyer-seller relationships', *European Journal of Marketing*, 40 (1/2), pp. 145-173.

McLoughlin, D. and Horan, C. (2002) 'Markets-as-networks: notes on a unique understanding', *Journal of Business Research*, 55(7), pp. 535-43.

Mikkola. M. (2008) 'Coordinative structures and development of food supply chains', *British Food Journa*l, 110 (2) pp. 189-205.

Moberg, C.R., Cutler, B.D., Gross, A., Speh, T.W. (2002) 'Identifying antecedents of information exchange within supply chains', *International Journal of Physical Distribution & Logistics Management*, 32 (9), pp.755-70.

Möller, K.K. and Halinen, A. (1999) 'Business relationships and networks: managerial challenge of network era', *Industrial Marketing Management,* 28, p. 413–427.

Narayandas, D. and Rangan, V.K. (2004) 'Building and sustaining buyer–seller relationships in mature industrial markets, *Journal of Marketing,* 68, pp.63–77.

Perry C. (1998), "Processes of a case study methodology for postgraduate research in marketing", *European Journal of Marketing*, Vol.32 No.9/10, pp.785 – 802.

Piercy N. F., Katsikeas C. S. and Cravens D. W. (1997) 'Examining the role of buyer-seller relationships in export performance', *Journal of World Business,* 23 (1), pp.73 – 86

Poole N. D., Del Campo Gomis F. J., Igual J. F. J. and Giménez F.V. (1998) ‘Formal contracts in fresh produce markets’, *Food Policy,* 23, pp.131 – 142

Riordan, M., and Williamson, O. (1985) ‘Asset specificity and economic organization’, *International Journal of Industrial Organization,* 3,pp. 365-78.

Ritter, T. (1999) ‘The networking company antecedents for coping with relationships and networks effectively’ *Industrial Marketing Management,* 28, pp. 467–479.

Ritter, T., Wilkinson, I.F. and Johnston, W.J. (2004) ‘Managing in complex business networks’, *Industrial Marketing Management,* 33, pp.175– 183.

Ritter T. and Gemünden H. G. (2004) ‘The impact of a company's business strategy on its technological competence, network competence and innovation success’, *Journal of Business Research,* 57 (5), pp.548 – 556.

Robertson, C. and Chetty, S.K. (2000) ‘A contingency-based approach to understanding export performance’, *International Business Review,* 9, pp. 211–235.

Roy, S. K., Sivakumar, and Wilkinson, I.F. (2004) ‘Innovation generation in supply chain relationships: a conceptual model and research propositions’, *Journal of the Academy of Marketing Science*, 32 (1), pp 61-79.

Ruben, R., Boselie, D.M. and Lu, H. (2007) ‘Vegetables procurement by Asian supermarkets: a transaction cost approach’, *Supply Chain Management: An International Journal*, 12 (1), pp. 60-8.

Sanzo, M. J., Santos, M. L.,Va´zquez, R., A ´ lvarez, L. I. (2003) ‘The effect of market orientation on buyer–seller relationship satisfaction’, *Industrial Marketing Management*, 32, pp. 327– 345

Schmitz, P. W. (2006) ‘Information gathering and the property rights approach’, *The American Economic Review,* 96(1), pp.422-434.

Shaw, S.A. and Gibbs, J. (1995) ‘Retailer-supplier relationships and the evolution of marketing: two food industry case studies’, *International journal of retail and distribution management’,* 23, (7), p.7-16.

Simatupang, T.S. and Sridharan, R. (2005) ‘The collaboration index: a measure for supply chain collaboration’, International *Journal of Physical Distribution & Logistics Management,* 35(1), pp. 44-62.

Styles C. and Ambler T. (1994) ‘Successful export practice: the UK experience’, *International Marketing Review,* 11 (6), pp. 23 – 47

Spraakman, G. (1997) ‘Transaction cost economics: a theory for internal audit’, *Managerial Auditing Journal,* 12 (7), pp.323-330.

Svensson, G. (2002) ‘The theoretical foundation of supply chain management. A functionalist theory of marketing’, *International Journal of Physical Distribution & Logistics Management*, 32 (9), pp.734–54.

Toften K. and Olsen S. O. (2003) ‘Export market information use, organizational knowledge and firm performance: a conceptual framework’, *Industrial Marketing Review*, 20 (1), pp.95–110.

Tomkins, C. (2001) ‘Interdependencies, trust and information in relationships, alliances and networks’, *Accounting, Organizations and Society*, 26 (2),pp.161−191.

Turnbull, P., Ford, D. and Cunningham, M. (1996) ‘Interaction, relationships and networks in business markets: an evolving perspective’, *Journal of business and industrial marketing,* 11 (3/4), pp. 44–62.

Van-Der-Vorst, J. G.A.J., Carlos A. da Silva, C. A. and Trienekens, J. H. (2007) *Agro-industrial supply chain management: concepts and applications*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, ISBN 978-92-5-105831-2, pp.1–55.

Veludo, M., Macbeth, D.K. and Purchase, S. (2004) ‘Partnering and relationships within an international network context’, *International Marketing Review,* 21, (2), pp. 142–157.

Wilson, D.T. (1995) ‘An Integrated Model of Buyer-Seller Relationships’, *Journal of the Academy of Marketing Science,*23 (4), pp.335-345.

Wilson N. (1996) ‘The supply chains of perishable products in northern Europe’, *British Food Journal,* 98 (6), pp.9 – 15.

Wilkinson, I. And Young, L. (2002) ‘On cooperating firms, relations and networks’, *Journal of Business Research*, 55, pp. 123– 132.

Williamson, O. E. (2008) ‘Outsourcing transaction cost and supply chain management’, *Journal of Supply Chain Management,* 44 (2), pp.5 – 15.

Williamson, O.E. (2002) ‘The theory of the firm as governance structure: from choice to contract’, *Journal of Economic Perspectives*, 16, pp. 171-195.

Williamson, O. E. (2000) 'The new institutional economics: taking stock, looking ahead', *Journal of Economic Literature*, 38(3), pp. 595–613.

Williamson, O.E. (1999) 'Strategy research: governance and competence perspectives', *Strategic Management Journal,* 20, pp.1087–1108.

Williamson, O.E. (1998) 'The institutions of governance', *The American Economic Review,* 88 (2), pp.75-79.

Williamson, O.E. (1995) 'Hierarchies, markets and power in the economy strategy', *Industrial and Corporate Chang,* 4 (1), pp.21–49.

Williamson, O. E. (1988a) 'Corporate finance and corporate governance', *Journal of Finance*, 43, pp.567 – 91.

Williamson, O. E. (1988b) 'The logic of economic organization', *Jouknal of Law, Economics, and Organization,* 4 (l), pp.65-98.

Williamson, O. E. (1985) *The Economic Institutions of Capitalism.* New York: Free Press.

Williamson, O. E. (1981) 'The economics of organization: the transaction cost approach', *American Journal of Sociology,* 87, pp.548 – 77.

Williamson, O. E. (1971) 'The vertical integration of production: market failure considerations', *American Economic Review,* 61 (2), pp.112 – 23.

Wu, W-Y., Chiag, C-Y.,Wu, Y-J. and Tu, H-J. (2004) 'The influencing factors of commitment and business integration on supply chain management', *Industrial Management and Data Systems*,104 (4), pp.322 – 333.

Zou, S. and Stan, S. (1998) 'The determinants of export performance: a review of the empirical literature between 1987 and 1997', *International Marketing Review,* 15,(5), pp. 333-356.

Yin, R. (1994), Case study research: Design and methods, (2nd.), Thousand Oaks, CA: Sage Publishing.

Int. Journal of Business Science and Applied Management, Volume 6, Issue 3, 2011

Supply chain risk management: review, classification and future research directions

Piyush Singhal
Dept. of Mechanical Engineering, GLA University, Mathura, India
17 Km Stone, NH-2 Mathura-Delhi Highway, P.O. Chaumuhan
Mathura-281406, UP, India
Telephone: +919412624713
Email: piyushsinghal2003@gmail.com

Gopal Agarwal
Dept. of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, India
J.L.N. Marg, Jaipur, 302017, Rajasthan, India
Telephone: +91- 141-2529087
Email: agarwal.drg@gmail.com

Murali Lal Mittal
Dept. of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, India
J.L.N. Marg, Jaipur, 302017, Rajasthan, India
Telephone: +91- 141-2529087
Email: mlmittal.mnit@gmail.com

Abstract

In order to be more efficient, firms have adopted strategies such as outsourcing, global partnerships and lean practices. Although such strategies have tremendous abilities to improve the efficiencies but simultaneously they make the firms vulnerable to market uncertainties, dependencies and disruptions. Moreover, natural calamities and manmade crises have also put negative impact on strategic, operational and tactical performance of supply chains. These factors have triggered the interest of academia and industry to consider the risk issues as prime concerns. To capture the more fine-grained elements of diversified risk issues related to the supply chain we employ a multi-layered top town taxonomy to classify and codify the literature and put forward the probable dimensions for future research. We further study the pool of SCRM literature focusing on coordination, decision making and sector-wise SCRM implementation issues and derive relevant propositions.

Keywords: supply chain risk management, risk, uncertainty, literature review

1 INTRODUCTION

Supply Chain Management (SCM) as a discipline has witnessed a tremendous growth during the last two decades. This growth has been noticed in terms of modelling and analysing various issues arising due to the development of complex networks amongst different organizations not only within countries but also across the globe. These issues are mainly related to designing, planning and coordinating the material, information, and money flows across the supply chains. But owing to increasing dynamism and uncertainty in the business environment risk issues are becoming key concerns to the organizations. The risks in supply chains arise mainly due to (i) operational fluctuations such as variability in supply, demand uncertainties, and price variability (Juttner, 2005; Christopher and Lee, 2004) (ii) natural events such as earthquakes, cyclones, epidemics and (iii) manmade crises such as terrorist attacks, unethical business practices and economic recessions (Kleindorfer and Saad, 2005). Further cultural, infrastructural and political differences and the trend towards strategies such as outsourcing, single-sourcing and lean practices have also made the supply chain vulnerable to risks (Juttner et al., 2003; Varma et al., 2007; Meixell and Gargeya, 2005).

Effective management of risks is becoming the focal concern of the firms to survive and thrive in a competitive business environment. Thus the supply chain risk management (SCRM) has emerged as a natural extension of supply chain management with the prime objective of identifying the potential sources of risks and suggesting suitable action plans to mitigate them. But developing an effective SCRM program is always a critical task and requires skills and expertise in multiple areas. Considerable work has been reported in the SCRM literature dealing with issues with qualitative and quantitative approaches. Several earlier attempts, however, have also been made by researchers to review the dimensions of risks and their impact on supply chain functioning. Tang (2006a) reviewed the literature dealing with quantitative models having strategies to manage the risks at the operational and strategic level by addressing the risk issues of such functional aspects of the supply chain as demand management, supply management and product management. Vanany et al. (2009) studied the SCRM literature based on unit of analysis and risk management processes. Rao and Goldsy (2009) elaborated the taxonomy of risk sources and a categorization scheme. Further to identify the key enablers and inhibiters of risk management practices Tang and Musa (2010) employed the bibliometric method of citation and co-citation and also assessed the potential sources of risk to enhance the understanding of the SCRM literature. Dailun (2004) provided the basic framework of risk management but was more influenced by financial risk management approaches. Industrial trends and practices that cause risks and business turbulence are also considered without reviewing their empirical linkages (Narasimhan and Talliri, 2009; Trkman and McCormak, 2009).

It is observed that the literature on SCRM is growing exponentially with diversified issues, approaches and purposes but most of the work is still found to be isolated and appears to be fragmented. Most of the earlier reviews found the missing elements and suggested guidelines to overcome them. However, our review differs in purpose, as we seek to assess how well the risk spectrum is explored considering the perceptive elements of risk definitions, categorizations, structural elements of the supply chain and implementation phases of SCRM. To provide deeper insights we suggest a multi-layered top-down taxonomy including risk factors, elements and attributes. We further unify the domain of the SCRM literature that consolidates and refines the available knowledge and practices. We also develop the codification scheme (Appendix), which could help practitioners not only to use classifications but also for retrieval of information for various quantitative and qualitative analyses.

The remainder of the paper is organized as follows: Section2 provides a review methodology, outcomes of preliminary investigations and a description of the taxonomy used in the study. Section3 outlines the qualitative and quantitative analysis of the literature, employing the proposed taxonomy. Section4 represents the managerial implications and challenges, focusing on coordination and decision making issues under business risks and also considering SCRM implementation issues for specific sectors. Section5 includes the closing remarks, identifies gaps in the research and proposes future research directions.

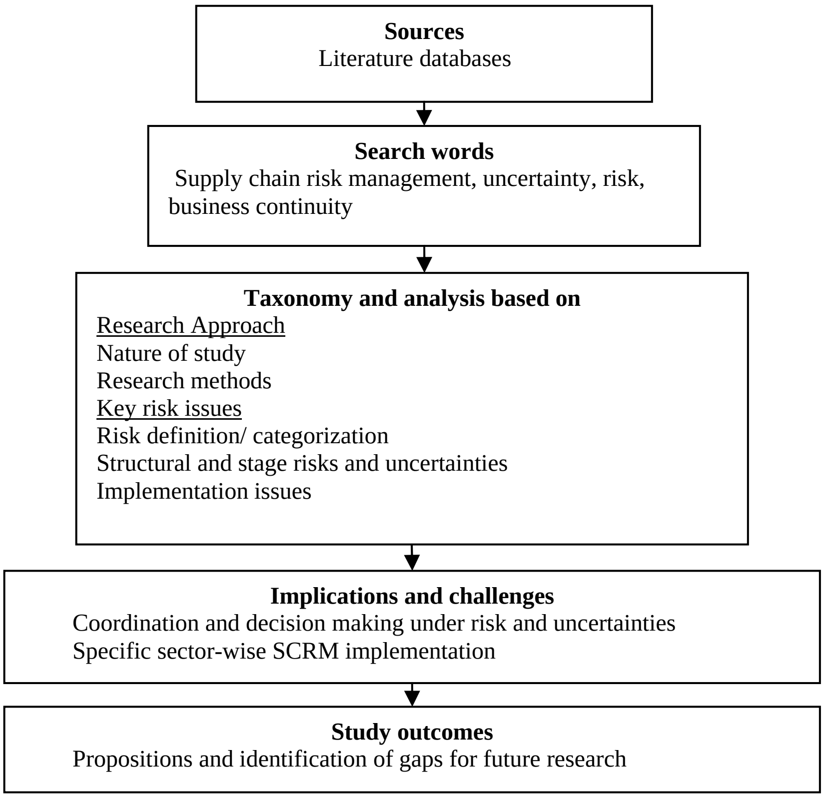
2 REVIEW METHODOLOGY AND PRELIMINARY FINDINGS

In this review, we focus on the SCRM literature and search the on-line library databases with the key words: supply chain risk management, uncertainty, risk and business continuity (Figure 1). The search was further narrowed down by a key focus on the papers addressing the following issues:

- Spectrum of supply chain risks with their significance
- Contribution of various research methodologies to managing the supply chain risks
- Issues primarily related to description and implementation of SCRM

This review includes 114 research papers taken from refereed journals published during the last fifteen years, from 1996 to 2010. The journals included in the review: *Computers and Chemical Engineering; Computers in Industry; European Journal of Operational Research; Expert Systems With Applications; International Journal of Agile Systems and Management; International Journal of Logistics Research and Applications; International Journal of Risk Assessment and Management; International Journal of Physical Distribution and Logistics Management; International Journal of Production Economics; Journal of Operations Management; Omega (The International Journal of Management Science); Supply Chain Management: An International Journal; The International Journal of Logistics Management; The Journal of Supply Chain Management.*

Figure1: Review methodology



2.1 Temporal trends in SCRM

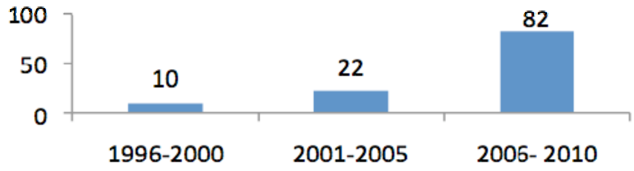
In order to view the periodic growth in the area of SCRM, the papers are divided into three time blocks each of five years duration. Figure 2 shows the number of papers in each period. Some key insights observed are presented below in Table 1:

- The papers dealing with supply chain risk issues appear in a variety of journals of different tracks such as management sciences/operational research, business management and systems engineering, indicating the multidimensionality of risk issues.
- More than 70% of papers included in the review were published during the last five years, indicating the growing importance of SCRM.

Table 1: Temporal trends of SCRM study

Period	**1996-2000**	**2001-2005**	**2006 onwards**
Trends in SCRM study	Risk definitions and investigation for focal firm perspectives usually influenced by financial risk analysis	Consideration of global risk issues, Investigation of operational parameters such as inventory policies, demand and supply, Capacity planning	Cross country relationship issues, Issues related to information sharing and security, Focus on brand image and comprehensive supply chain risk management program, Agility and resilience issues

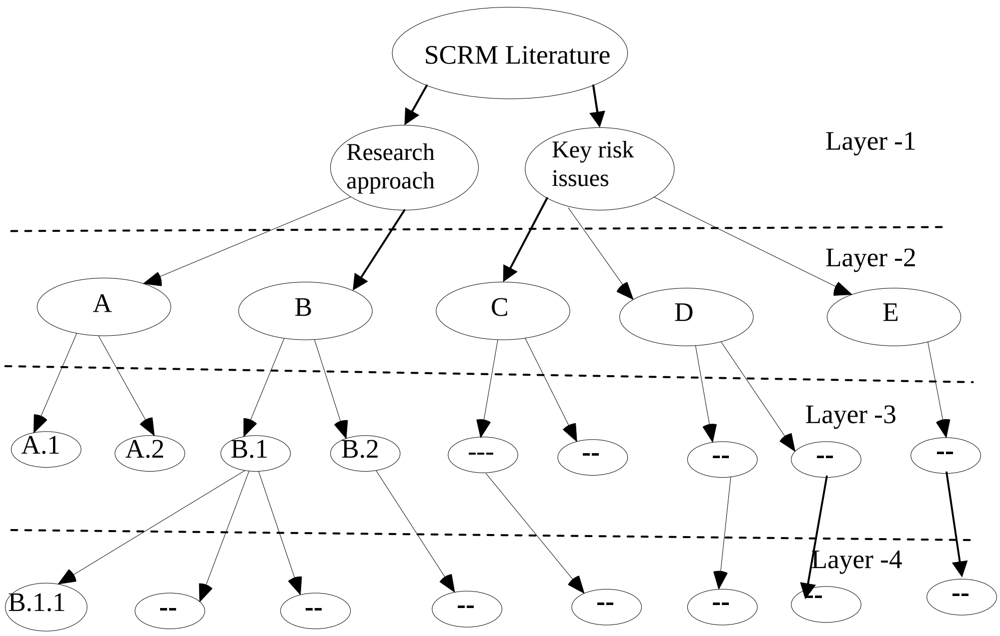
Figure 2: Publications in groups of five years



2.2 Details of Taxonomy and its relevance to SCRM

The proposed taxonomy and its classification factors have great relevance to describing and understanding the multi perspectives and complex risk issues. A multi-layered top-down structure is proposed to classify the SCRM literature and to encapsulate various research perspectives (Figure 3). To analyse the research efforts in the field of SCRM two criteria are considered: (i) research approach, (ii) exploration of key risk issues. Further to the research approach point of view, we consider the literature based on the nature of the study (A) and research methods (B) adopted to address the issues. Under exploration of risk issues we put specific emphasis on the exploration of supply chain risk elements in terms of risk definition/ classification criteria (C), risk related to structural elements of the supply chain (D) and issues related to the level of SCRM implementation (E). Each factor is further classified on the basis of the most discriminating elements followed by identification of the attributes of each subclass. Referring to the taxonomy, a logical identification code is also assigned to each factor, element and attribute, which can indicate the logical linkage among them (Appendix). In the next subsection we will discuss the classification criteria, their finer elements and their relevance to SCRM.

Figure 3: Top-town classification approach to SCRM literature



Research approach

A. Nature of study
A.1 Positive approach
A.2 Normative approach
B. Research Methods
B.1 Conceptual
B.1.1 Basic Theory
B.1.2 Theory Enhancement/Applied theory
B.1.3 Literature review/ Taxonomy developments
B.2 Empirical methods
B.2.1 Case Studies
B.2.2 Survey based statistical designs
B.2.3 Combined approach
B.3 Analytical
B.3.1 Risk Modelling
B.3.1.1 Modelling Type
B.3.1.1.1 Mathematical
B.3.1.1.2 Simulation
B.3.1.1.3 Multi agent
B.3.1.2 Model settings
B.3.1.2.1 Linear problem settings
B.3.1.2.2 Integer problem settings
B.3.1.2.3 Dynamic problem settings
B.3.1.2.4 Stochastic problem settings

Exploration of risk issues

C. Approach to defining/classifying Supply chain risk
C.1 Related to operational characteristics
C.2 Related to market characteristics
C.3 Related to business characteristics
C.4 Related to product characteristics
C.5 Miscellaneous
D. Risk issues related to structural elements of supply chain
D.1 Supplier(s) to manufacturer(s) relationship issues (Upstream issues)
D.1.1 Coordination and information issues
D.1.2 Supply system design issues
D.1.3 General issues
D.2 Manufacturer to buyer(s) relationship issues (Downstream issues)
D.2.1 Market volatility and demand fluctuations issues
D.2.2 Coordination under demand disruptions
E. Level of implementation of risk management approach
E.1 Risk identification approaches
E.1.1 Common listings
E.1.2 Taxonomy based risk identification
E.1.3 Scenario based
E.1.4 Objective based process mapping
E.2 Risk assessment and quantification approaches
E.2.1 Assessing the risk sources and exposure
E.2.2 Risk characterization
E.3 Risk mitigation approaches
E.3.1 Shaper
E.3.2 Acceptor
E.3.3 Recovery

2.2.1 Research approach

Nature of study (A)

In the proposed taxonomy the nature of the study (A) is considered to depict the motives of the study. As we know SCRM is an exponentially growing area of research, the exploration of literature with the nature of study perspective identifies the way by which the study contributes to the literature. It indicates whether the study is conducted to describe risk issues and propose solutions with due analysis or, as in some cases, if researchers prescribe solutions based on their experience and expertise. As the risk perceptions are multi-dimensional and elusive it will be interesting to explore the nature of the study adopted in the extant literature.

The nature of the study of the papers is analysed using the Malhotra and Grover (1998) scheme by categorizing them as having a positive research approach (A.1) or a normative research approach (A.2). Papers that attempt to describe, explain, investigate and predict the current supply chain risk issues and practices with various perspectives are considered as positive research. On the other hand, approaches that deal with the issues in a prescriptive manner where the author suggest(s) what an individual should do in a particular risk situation are termed normative. In normative research the author usually recommends the guiding framework and suggestions based on their experience and expertise in a particular field.

Research methods (B)

The next important element in the research approach is the research method, which represents the researcher's choice to follow the route to address the research objectives. Initially we follow the Wacker (1998) scheme and categorize the studies as conceptual, analytical and empirical. But owing to the fact that risk management has largely been adopted by practitioners and researchers from the last decade onwards, we require more detailed classification schemes to explore the underpinnings of risk management. Moreover, numerous emerging techniques, methodologies and approaches are involved to address the complex and entwined risk issues, which require a systematic framework to unify them under a relevant and logical classification scheme.

Focusing on this crucial need for comprehensive classification, we have fine-grained the classification by categorizing the conceptual study as basic theory (B.1.1), theory enhancement (B.1.2) and literature reviews/ taxonomy developments (B.1.3). Empirical studies are categorized based on the method of data collection and analysis such as case studies (B.2.1), survey based statistical design (B.2.2) and combination of both (B.2.3).

It is recognized that analytical approaches have been widely developed during the last decade and it is becoming difficult to discriminate and classify them as they have a number of derived and common elements. However, attempts are made in this study to classify the efforts of researchers adopting analytical methods. We found that researchers adopt various approaches to develop the analytical models to assess the risks and their impacts. We first consider the factor of risk modelling (B.3.1) and further classify this with two elements: model type (B.3.1.1) and model settings (B.3.1.2). Various model mechanisms are available in the literature: in the risk management perspective we consider them as mathematical (B.3.1.1.1), simulation based (B.3.1.1.2) and multi-agent based (B.3.1.1.3). The second critical element of the analytical approach is the problem setting, which depends upon the nature of the study and scope and domain of the research problem. We consider these as linear problems setting (B.3.1.2.1), integer problem setting (B.3.1.2.2), dynamic problem setting (B.3.1.2.3) and stochastic problem setting (B.3.1.2.4).

2.2.2 Exploration of risk issues

Approach to defining/classifying Supply chain risk (C)

The terms 'risk' 'uncertainty' 'disruption' and 'disaster' are frequently and interchangeably used in supply chains to describe the perceptions and interpretations of individuals and organizations. A general interpretation of risk is influenced by the negative consequences of variation in expected outcomes, their impact and likelihoods (March and Shapira, 1987). Risk events are also studied with core supply chain activities and investigated with common business practices. Christopher and Peck (2004) relate the risks with the vulnerability and likelihood of being lost or damaged. Interruptions to the flow of information, material and finance from the original supplier to the end user which cause a mismatch between demand and supply are also considered as risks (Juttner et al., 2003).

In line with the definitions discussed above and to relate the risks with supply chain functional aspects we categorize the orientation of risk definitions related to operational characteristics (C.1), market characteristics (C.2), business/strategic characteristics (C.3), product characteristics (C.4) and others (C.5). Table 2 shows the risk characteristics and features in each of the categories.

Table 2: Risk definition criterion and description

Classification code	Risk definition criterion	Definition description/Characteristics	Risk issues
C.1	Related to operational characteristics	Operational features of supply chain which mismatch demand and supply or even disrupt the functioning of supply chain and interrupt the flow of material, product and information	Supply disruptions, demand uncertainties, machine/system failures, improper planning and execution, information and security risks
C.2	Related to market characteristics	Market fluctuations which cannot be predicted precisely and change their nature, impact and occurrence over time.	Price variability, customer behavior and expectations, competitor moves, exchange rates, environmental risks and disasters
C.3	Related to business/strategic characteristics	Specific characteristics of business, sector, their strategies and environment which cause an undesired event to happen and negatively affect the supply chain performance	adverse effects of strategies such as outsourcing, single sourcing, lean manufacturing, improper supply network design, forecasting errors, lack of coordination and information sharing
C.4	Related to product characteristics	Features related to the specific nature of products which make the supply chain vulnerable to risk and uncertainties	Short product life cycles, complexity in product design and manufacturing, desire for variety of products, need for multifunctional products
C.5	Miscellaneous	Various other characteristics can also be considered which may fit in the above mentioned category or can be studied separately	political risks, credibility risks brand image risk, social risks, ecological risks etc

Risk issues related to structural elements of the supply chain (D)

Supply chain structures are complex networks of different players (including lower tier suppliers to the end customer) established with core objectives to minimize the costs, maximize the value and explore new markets through effectively managed relationships among members (Hallikas et al., 2002; Blackhurst et al., 2007; Trkman and McCormack, 2009; Tuncel and Alpan, 2010).Though networking is a way to take advantage of collaboration and partnership amongst various supply chain players, it becomes a source as well as a medium through which risks are generated and propagated to the entire network.

To capture the structural dimension of the supply chain risks we classify the literature for the perspectives of upstream (D.1) and downstream (D.2). We also study the literature with a single focal firm point of view but observe that most of the risk issues related to a single firm are more relevant in a dyadic frame. Therefore we prefer to analyse the risk issues from a relational point of view in the form of dyads. To provide deeper insights into the upstream risks we further classify them considering the elements of supply system design: number of suppliers (single/multiple sourcing), location of suppliers (local/global sourcing) and coordination and information sharing and thus divide the literature into supply system design (D.1.1) and coordination and information sharing (D.1.2). Other issues such as supplier behaviour, traits etc. are considered under the general issues category (D.1.3).

Downstream risks usually relate to the fluctuations in demand, volatile market conditions, customer behaviour, technological changes and shorter product life cycles. At one end these risks are associated with the physical distribution and product flow towards the downstream side and on the other hand they are related to forecasting issues (Szwejczewski, et al., 2008). These risks are usually the outcome of a mismatch between actual demand and projected demand resulting in a demand and supply mismatch throughout the supply chain. We focus on two discriminating elements and classify the demand issues as market volatility and demand fluctuation (D.2.1) and coordination and information sharing (D.2.2).

Level of implementation of risk management approach (E)

Implementation of supply chain risk management is an extremely critical task requiring a sound knowledge of business functions, market trends and financial and infrastructural status of the organization as well as the entire supply chain. Implementation of SCRM generally requires three steps given as: identifying the potential risks to the organization (E.1), assessing the risks and aftermaths (E.2) and adopting suitable risk managing strategies (E.3). A hierarchy exists between these phases and the higher phase subsumes the lower phase (Dailun, 2004).

Risk identification is an important first step in any risk management effort. Numerous approaches have been proposed to identify the risks in supply chains, classified as: the common listing approach (E.1.1), where analysis of historical events is utilized to gain insight into future risks; taxonomy based approaches (E1.2),which provide a consistent framework to elicit and organize risk identification activities related to various business functions; scenario analysis (E.1.3), in which key risk factors and their effects on supply chain performance are analysed to develop a risk profile, making it easy to develop contingency plans at the operational level; risk mapping (E.1.4), with the capability of exposing the vulnerability of supply chains to potential risk before their occurrence.

Assessing the risks qualitatively or quantitatively is an essential task after the risk identification. When sufficient past data and expertise is available quantification of risks is meaningful, otherwise qualitative methods are more appropriate. We categorize the methods as assessing the risk sources (E.2.1) and risk characterization (E.2.2), with the latter being more rigorous. Assessing the sources and exposure (E.2.1) is effective when limited past data is available. The sources of risks and exposure are evaluated and subjectively indexed/ranked based on the assessor's perspective and experience. Risk characterization (E.2.2) provides a broader framework for risk assessment, grouping and prioritizing employing analytical models.

Various strategic and operational risk management stances are reported in the literature. We classify them as the shaper (E3.1), accepter (E3.2) and recovery approach (E3.3). In the shaper approach attempts are made to shape (reduce the impact and frequency) the uncertainty factors without changing the existing settings of the supply chain, while in the accepter approach risks are accepted and supply chains are reinvestigated and redesigned. Recovery strategies mainly support quick recovery mechanisms after severe damage in the supply chains.

3 ANALYSIS OF RESULTS AND DISCUSSION WITH PROPOSED TAXONOMY

We explore the literature and review the selected papers using the above discussed taxonomy. To develop a holistic view of SCRM efforts we included studies in practically all key demographical regions including Europe, Asia and the US. A combination of qualitative and quantitative approaches is adopted to describe the SCRM issues in the literature. The qualitative contents of the papers are provided in tables showing the issues discussed in the paper and also the approach adopted to address them. The quantitative exploration is presented in a table 3 and 2333 showing relative contributions of various classes and sub-classes under particular themes.

Table 3: Contribution of papers as per research approach

Classification Factor	Sub Classification	%Contribution	Sub Classification	%Contribution
Nature of study (A)	Positive (A.1)	91	……..	
	Normative (A.2)	9		
Research Method (B)	Conceptual (B.1	39	Basic Theory (B.1.1)	32
			Theory Enhancement (B.1.2)	54
			Literature reviews/ taxonomy development (B.1.3)	14
	Empirical (B.2)	26	Case Studies (B.2.1)	28
			Survey based statistical designs (B.2.2)	52
			Combined approach (B.2.3)	20
	Analytical (B.3)	35	……..	

3.1 Observations on research approach

3.1.1 Nature of study (A)

We first review the papers focusing on the nature of the study and approach adopted. We found that an ample amount of work has been done but still it seems to be in a nascent state due to the paucity of normative studies. It is noted that more research initiatives have been taken with a positive approach (91%) than normative research (Table-3). The low proportion of normative research (9%) exhibits the under-preparedness of research attempts to proffer precise and specific prescriptions to industries and academia.

3.1.2 Research methods (B)

Interestingly we found that even after the decade long period the contribution of conceptual research is highest, about 39%, followed by empirical (26%) and analytical, 35% (Table-3). This finding suggests that the field of SCRM is still emerging and requires theoretical support to develop practical frameworks. Analytical approaches have also made a major contribution to assessing and characterizing the risk issues. But the feeble acceptance of these models in actual practices point out the need for more empirical studies to explore the critical underpinning elements and relationships of the risk appetite of firms, their propensity and financial status.

Conceptual Study (B.1)

To provide the finer details, conceptual papers are further classified and it is observed that during 1996 to 2001 most of the papers focused on theoretical aspects related to risk issues, usually inspired by financial risk theories. But later on, catastrophic incidents such as the earthquake in Taiwan (2000), which severely damaged the supply base of the semiconductor industry, the Tsunami in Asia in 2005 that caused losses of more than $17 billion, Hurricane Katrina, which destroyed ports, railways, highways and communication networks and led to a significant drop in the US economy in 2006;terrorist attacks in the US and many Asian and European countries and many more motivated the researchers to redefine the risk issues for business continuity and devise mechanisms for quick recovery after disruptions. Thus agility, resilience and flexibility in supply chains have become the core agenda for research. This has increased the contribution to the applied theory of SCRM, dealing with contemporary and upcoming issues (Table-3).

Table-3 shows that theory is enhancing rapidly in the field of SCRM. Researchers are forming deeper insights and delving into critical SCRM aspects. Analysis also indicates that the field of SCRM is expanding but the attempts are still very small to review the prevalent literature. Thus more reviews are required to unify the various research efforts and explore the latent dimensions of risk management to support the global SCRM efforts significantly. The qualitative description of the issues addressed in papers, their approach and classification code is provided in Table 4.

Table 4: Description of conceptual research methods with risk issues discussed and classification code

Classification code	Theoretical Approach	Moves to manage uncertainties	Description of issues and papers
B.1.1	Fundamental supply chain and risk issues	Discuss the basic risk issues	Metrics and performance measurement for risks (Lawrence et al., 1996; Smeltzer and Sifered, 1998; Steven and Ronald, 1999; Sislian and Satir, 2000; Ritchie and Brindley, 2007), Risk management for practitioner perspectives (Hallikas et al., 2002; Finch, 2004; Yang et al., 2004; Juttner et al., 2003; Ojala and Hallikas, 2006), Risk definitions and classifications, risk constructs (Tang, 2006b; Kersten et al.,2007;Berg et al., 2008; Bailey and Francis, 2008; Trkman and McCormack, 2009)
B.1.2	Risk management theory enhancement	Propose theoretical models and frameworks to manage risk issues	Collaboration for responsiveness and customer satisfaction level (Christopher and Lee, 2004;Christopher and Peck, 2004; Jeng, 2004; Forme et al., 2007), Intangible issues of supply chain risks, behavioral aspects of risk (Ketzenberg et al., 2007; Kim and Park, 2008; Brun et al., 2006), Strategic and structural alignment issues (Giunipero and Eltantawy, 2004; Cigolini and Rossi, 2006; Peck, 2006; Khan and Burnes, 2007; Tapiero and Grando, 2008; Ritchie et al., 2008; Dani and Ranganathan, 2008), Value and risk identification and assessment in an advanced planning and scheduling system (Hung and Sungmin, 2008; Kenett and Raphaeli, 2008; Neiger et al., 2009, Szwejczewski, et al., 2008), Disruption risk management (Norrman and Jansson, 2004; Kleindorfer and Saad, 2005; Narasimhan and Talleri, 2009; Michael and Nallan, 2009), Robust strategies for risk mitigation (Tang, 2006b)

B.1.3	Literature review and taxonomies	Classify the risks, uncertainties and associated issues to unify the disjointed supply chain management literature	Classification of quantitative models dealing with risks and uncertainties(Tang, 2006), Classifications of risks (Dailun, 2004; Rao and Goldsby, 2009), Classification of literature considering unit of analysis, research methods etc as a classification factor (Vanany et al., 2009),Consideration of intangible and behavioral aspects of risk issues (Ponomarov and Holcomb, 2009), Focus on flow risks and developments (Tang and Musa, 2010)

Empirical study (B.2)

We include the papers that used empirical approaches with surveys followed by statistical designs and structured case studies. Many papers are also noted that have a combination of both methods for quantitative and qualitative analysis. The empirical approaches have been used to establish the relationships amongst latent supply chain issues such as short supplies, supplier characteristics, demand variability, erratic behavior of customers, risk propensity (Blackhurst et al., 2005; Shockley and Ellis, 2006; Bailey and Francis, 2008).These methods refine the level of understanding of risks, which further helps in taking strategic and operational decisions (Devraj et al., 2007; Sanders, 2008). It is recognized that survey based statistical designs are the most adopted approach in empirical studies (52%) to develop the relationship models. But in the SCRM literature case-studies also have increasing acceptability to develop more specific qualitative and quantitative models. Table 5 presents a description of the issues and moves to manage the risk in certain empirical papers.

Table 5: Description of empirical research methods with risk issues discussed and classification code

Classification code	Empirical Approach	Moves to manage uncertainties	Description of issues and papers
B.2.1	Case Studies	Investigation of specific cases	Value and risk assessment (Brun et al., 2006; Ojala and Hallikas, 2006), Perception of risks (Finch, 2004; Zhao et al., 2008),Managing information flow (Khan and Greaves, 2008 ; Bailey and Francis, 2008 ; Oke and Gopalakrishnan, 2009)
B.2.2	Survey based statistical design	Establish correlations for supply chain performance and risks	Investigation of outsourcing decisions (Lambros and Socrates, 1999), Investigation of the supply risk construct and integration (Shockley and Ellis, 2006 ;Wagner and Bode, 2006; Harland et al., 2007), Issues related to practitioner point of view(Juttner, 2005), Agency theory in risk management (Zsidisin and Ellaram, 2003), Effect of disruption on stock price performance (Hendricks and Singhal, 2005), Devaraj et al., 2007; Lee et al., 2007; Haan et al., 2007), Agility and flexibility in supply chain (Khan andGreaves, 2008;Braunscheidel and Suresh, 2008; Sodhi andTang, 2009)
B.2.3	Combined approach	Establishing the signifiacnt relationships for specific cases	Disruptions in supply chains (Blackhurst et al., 2005; Jiang et al., 2007), Risk and information sharing issues (Zhou & Benton Jr., 2007 ;Kocabasoglu et al., 2007; buyer perception of supply risks(Ellis et al.,2010)

Analytical study (B.3)

In order to plan and coordinate in a risk environment, quantification of risk and analytical modelling is required. Based on the modelling approach we categorize the literature into mathematical (B.3.1.1.1), simulation (B.3.1.1.2) and agent based methods (B.3.1.1.3) for a variety of settings such as linear (B.3.1.2.1), integer (B.3.1.2.2), dynamic (B.3.1.2.3) and stochastic (B.3.1.2.4). Table 5 lists the details of the papers and issues explored using analytical approaches.

The simple analytical approach to quantify and rank the risks is the Analytical Hierarchy Process (AHP) with linear problem settings in a multi attribute decision model. It reduces the complex decision problem into a series of one to one comparisons followed by synthesis of results based on a hierarchical structure (Korpela et al., 2002; Gaudenzi and Borghesi, 2006; Levary, 2008). However, the subjectivity involved in AHP has always been a matter of concern.

Owing to the very nature of the risk, the stochastic models are more accepted in supply chains to model risk issues, varying from strategic to operational levels (Beamon, 1998). The uncertainty associated with variables is tackled mainly with three approaches. First, standard distributions are used in which continuous probability distributions are assigned for decision variables. Second, when continuous distribution is not feasible, discrete finite scenarios are established considering various combinations of uncertain parameters. Third, there are fuzzy approaches, where uncertainties in decision parameters are considered as fuzzy numbers and membership functions (Chen and Lee, 2004; Mele et al., 2007). Underlying complexities and impractical assumptions limit the utility of mathematical modelling. Moreover, in some cases the explicit relationships between decision variables are difficult to model. In such situations, simulation techniques provide an alternative approach to analysing the supply chains by constructing an artificial environment within which the dynamic behavior of the risks can be assessed. Various risk mitigation strategies and tradeoffs are tested in a simulated environment with seasonality, level of information sharing, service level, net profit etc as simulation parameters (Labeau et al., 2000; Jammernegg and Reiner, 2007; Sohn and Lim, 2008; Thomas and David, 2008).

The simulation models also have certain limitations, such as the models can only be run with previously defined conditions and there are limited capabilities to design the system parameter itself (Swaminathan et al., 1998; Ohbyung et al., 2007). To overcome these shortcomings, multi-agent approaches, supported by advanced computational methods, have been introduced. In these approaches the problem is modeled as agent elements (supplier, manufacturer, distributor etc), control elements (inventory control, scheduling, logistics and transportation etc) and their interaction protocols (Swaminathan et al., 1998; Mele et al., 2007). These approaches are better than individual programs as they combine the various autonomous agents/programs in one platform. Various strategic and operational issues such as collaboration under demand and supply uncertainties, the role of information sharing, inventory levels, robust and optimal designs are investigated and managerial inferences are drawn by researchers (Chatzidimitriou et al., 2007; Mele et al., 2007; Ohbyung et al., 2007).

Table 6: Description of analytical research methods with risk issues discussed and classification code

Classification code	Analytical Approach	Moves to manage uncertainties	Description of issues and papers
B.3.1.1.1/ B.3.1.2.1	Mathematical (linear settings)AHP	Evaluating the risk ranks	Risk quantification using multi decision criteria (Korpela et al., 2002; Levary,2008;Teresa et al., 2006)
B.3.1.1.1/ B.3.1.2.2	Mathematical Stochastic Models (probability distributions and Scenario settings)	Quantification of risk using mean variance analysis	Quantifying the risk and performance attitude (Choi et al.,2008), Supplier failure risks (Lee, 2008)
B.3.1.1.1/ B.3.1.2.4		Uncertainty quantification with fuzzy sets	Evaluating the performance of the supply chain using fuzzy sets for uncertain parameters(Chen and Lee, 2004; Wang and Shu, 2007); Moghadam et al., 2008; Li and Kuo, 2008)
B.3.1.1.1/ B.3.1.2.4		Planning under uncertainties	Mid-term planning models (Gupta and Maranas,2003), Managing inventory levels and profit margins, strategies mix to minimize the effect of order variations, decomposing the problem to profit maximization and risk minimization objectives (Escudero et al., 1999; Kut and Zheng, 2003), Integrating risk management and B2B tools (Aggarwal and Ganeshan, 2007, Risk assessment in global chains, sourcing decisions under disruptions (Goh et al., 2007; Stephen et al., 2007; Boute et al., 2007; Ouyang, 2007; Hong and Sung, 2008;Haisheng et al., 2009, Bogataj and Bagataj, 2006)
B.3.1.1.1/ B.3.1.2.4		Coordination under uncertainties	Investigating the coordination strategies under production cost deviation and demand disruptions (Thomas and Griffin, 1996; Mantrala and Raman, 1999; Xiao et al., 2007), Quantifying coordinated decisions (Hsiesh and Cheng, 2008; Demirkan and Cheng, 2008)
B.3.1.1.2/ B.3.1.2.4	Simulation	Planning under uncertainties	Planning and controlling the inventory and supplier selection (Moghadam et al., 2008; Jammernegg and Reiner, 2007), inventory and capacity coordination (Liston et al., 2007), planning outsourcing, assessing risks and relations to inventory levels(Thomas and David, 2008)

B.3.1.1.2/ B.3.1.2.4		Coordination under uncertainties	forecasting of demand distortion in case of lack of information sharing(Meilin and Jingxian,2007; Carbonneau et al.,2008)
B.3.1.1.2/ B.3.1.2.4		Structuring of network under uncertainties	Design and restructuring of production/distribution networks (Mele et al.,2007)
B.3.1.1.2/ B.3.1.2.2		Information policies and forecasting methods for risk mitigation	Performance of supply chain with various information sharing levels (Lau et al.,2004), coordination between inventory and ordering (Sohn and Lim, 2008)
B.3.1.1.3/ B.3.1.2.4	Multi-agent systems	Robust mechanism	trading in dynamic and uncertain environments (Chatzidimitriou et al., 2008)
B.3.1.1.3/ B.3.1.2.2		Collaborations under uncertainties	Investigation of collaborations for maximum efficiency under demand and supply uncertainties (Ohbyung et al., 2008), Decision and implementation of risk management (Giannaikis and Louis, 2010)

3.2 Observations on exploration on risk issues

Literature is further reviewed to explore the risk issues addressed and contribution to various classification factors and presented in table 7.

Table 7: Contribution of papers as per risk issues explored

Classification Factor	**Sub classification**	**% contribution**	**Sub classification**	**%contribution**
Approach to defining/ classifying Supply chain risk (C)	Related to operational characteristic(C.1)	31	……...	
	Related to market characteristic(C.2)	25		
	Related to business characteristic (C.3)	19		
	Related to product characteristic (C.4)	13		
	Miscellaneous issues (C.5)	12		
Risk issues related to structural elements of supply chain (D)	Supplier(s) to manufacturer(s) relationship issues (Upstream issues) (D.1)	56	Coordination and information issues (D.1.1)	44
			Supply system design issues (D.1.2)	36
			General issues (D.1.3)	20
	Manufacturer to buyer(s) relationship issues (Downstream issues) (D.2)	44	Market volatility and demand fluctuations issues (D.2.1)	63.5
			Coordination under demand disruptions (D.2.2)	36.5
Level of implementation of risk management approach (E)	Risk identification approaches (E.1)	…….	Common listings (E.1.1)	27
			Taxonomy based risk identification (E.1.2)	20
			Scenario based (E.1.3)	30
			Objective based process mapping (E1.4)	23
	Risk assessment and quantification approaches (E.2)	…….	Assessing the risk sources and exposure (E.2.1)	45
			Risk characterization (E.2.2)	55
	Risk mitigation approaches (E.3)	…….	Shaper (E.3.1)	15
			Acceptor (E.3.2)	45
			Recovery (E.3.3)	40

3.2.1 Approach to defining/classifying Supply chain risk (C)

Employing the classification of risk definition criteria, table 7 shows that the operational characteristics (C.1) (e.g. demand-supply mismatch) are used to a greater extent (31%), followed by the market characteristic (C.2) (25%). The specific business features, strategies and their effects on the supply chain (C.3) have also been used in defining the risks (19%). In a business world where customers' expectations regarding products and services are changing, product centric orientation is a paramount consideration. Various definitions of risks, focusing on product characteristics (C.4) such as the product life cycle, functional features, variety, and the technical complexities involved are also gaining acceptance gradually (13%). Apart from this many more influencing features such as political, legal and financial issues (C.5) have also been used by some authors (13%). Table 8 provides the qualitative details of issues considered for risk classification in various papers.

Table 8: Details of papers on risk definition criteria with classification code

Classification Code	Risk issues/sources	Papers
C.1	Infrastructural, transport, communication, design, quality, cost, availability, manufacturability, health and safety, natural hazards, terrorism and political instability	Mason-Jones et al. (1998), Zsidisin et al. (2000), Kersten et al. (2007) Klerndorfer and Saad (2005), Faisal et al. (2006), Faisal et al. (2007), Boin et al. (2010)
C.2	Changing market conditions, customer expectations, product yields, quality, process time	Ritchie and Brindley (2007), Wong and Arlbjorn (2008), Serbanescu (2007), Mele et al. (2007)
C.3	Focus on efficiency rather than effectiveness, globalization of supply chains, trends of outsourcing, reduction of supplier base, Lack of trust, Inaccurate information sharing and asymmetry in power and dependency	Juttner et al. (2003), Finch (2004), Ojala and Hallikas (2006)
C.4	Product complexity and serviceability	Levary (2008), Knemeyer et al.(2009), Szwejczewski, et al. (2008)
C.5	Operational contingencies, Legal risks, political risk	Jiang et al. (2009), Manuj and Mentzer (2008)

3.2.2 Issues related to structural elements of the supply chain (D)

It is observed that researchers have focused on the risk issues on both sides of the supply chains but upstream issues get more attention, as shown in table 7, with a 56% contribution. This suggests that supply chains are more vulnerable to supply side risks. The downstream issues also make a significant contribution (44%), which shows that market uncertainties, demand fluctuations and associated risk issues are also well addressed by researchers. Table 9 shows the details and codes of papers representing upstream and downstream risk issues.

Upstream issues (D.1)

Upstream risks are associated with procurement and are considered to be threats to supply assurance, the possibility of improper supplier selection, increased company liabilities and uncertainty in supply lead time (Smeltzer and Sifered, 1998; Sislian and Satir, 2000; Meixell and Gargeya, 2005). It is observed that about 56% of the related papers focus on upstream risks. The key issues of supply risks are found to be related to supply system design (number of suppliers (single/multiple sourcing)), location of suppliers (local/global sourcing) and supplier’s agility, flexibility, delivery reliability and infrastructural strength and coordination and information sharing, which we covered in our classification. Analysis of the literature focusing on supply risks shows that information sharing and coordination issues (D.1.1) have been paid the highest attention (44%) followed by the supply system design issues (D.1.2) (36%) (Table7).

Downstream issues (D.2)

We focus on two discriminating elements and classify the demand issues as market volatility and demand fluctuation (D.2.1) and coordination and information sharing (D.2.2). Coordination and information sharing amongst wholesalers, dealers, and retailers and shorter planning horizons are some of the measures suggested in the literature to manage demand side risks (Gupta and Maranas, 2003; Chen and Lee, 2004; Boute et al., 2007; Stephan et al., 2007). There have also been proposals to investigate the level of information sharing from a security point of view and adopt trust based mechanisms under volatile market conditions (Xiao et al., 2007). As mention in table 7 issues related to demand and order variability have been considered more (63.5%) in the literature than coordination and information sharing issues (36.5%) to manage downstream risks.

Table 9: Details of papers dealing with the structural element of risks with classification code

Classification code	Structural position of supply chain	Description of issues and papers
D.1.1	Up-stream issues	Number of suppliers, and location related issues (Teresa et al., 2006; Abbas et al., 2006; Moghadam et al., 2007; Lee, 2008; Aggarwal and Ganeshan, 2007; Li-ping Liu et al., 2007; Goankar and Viswanadham, 2004; Haisheng et al., 2009)
D1.2		Relationship and coordination issues on supply side (Hallikas and Virolainen, 2002; Levary, 2008; Sarkar and Mohapatra, 2009; Ojala and Hallikas, 2006; Trkman and McCormack, 2009)
D.1.3		Responsibilities and reliability of suppliers (Giunipero, and Eltantawy, 2004; Jeng , 2004; Thomas and David, 2008)
D.2.1	Down- stream issues	Demand variability and market uncertainties (Mantrala and Raman, 1999; Gupta and Maranas, 2003; Kut and Zheng, 2003; Chen and Lee, 2004; Donk and Vaart, 2005; Boute et al, 2007; Neureuther and Kenyon, 2008)
D.2.2		Coordination under demand disruptions, Profits and service levels (Xiao et al., 2007; Meilin and Jingxian, 2007; Chatzidimitriou et al., 2008; Ohbyung et al., 2007; Sohn and Lim, 2008; Hsieh and Cheng, 2008)

3.2.3 Issues related to implementation of Supply chain risk management (E)

Various levels of SCRM implementation are analysed: identifying and classifying potential risks to the organization (E.1), assessing the risks and aftermaths (E.2) and adopting suitable risk managing strategies (E.3).

Risk identification (E.1)

The literature reflects various approaches to identifying the risks which we have categorized, as noted earlier in our taxonomy. Table 7 indicates that scenario based approaches (E.1.3) are most accepted (30%) in the literature because of their ability to predict the impact of risks. Their accuracy, however, depends on the ability and vision of the person setting the scenarios. Listing methods (E.1.1) are also common (27%) due to their simplicity. Objective based mapping (E.1.4) has also been used. It is difficult to prepare an exhaustive mapping but once completed it provides a very effective and accurate tool to understand the sources and drivers of risk. This method is gaining acceptance for specific supply chains (23%). Taxonomy based approaches (E.1.2) are usually influenced by the existing literature and practices to establish detailed and systematic risk classification schemes. As the risk management practices and related literature is growing and becoming more refined, the acceptability of this approach is expected to grow.

Risk assessment and quantification approaches (E.2)

As indicated in table 7 risk characterization (E.2.2) is more common (55%) followed by assessing the sources and risk exposure (E.2.1) (45%). The analytical approaches are not widely accepted firstly, due to their complexity and the requirement of expertise to implement them and secondly, existing methods are yet not capable of quantifying the elusive and dynamic nature of risk.

Risk mitigation approaches

Various strategic and operational risk management schemes are classified: the shaper (E3.1), accepter (E3.2) and recovery approach (E3.3). When past knowledge and experience related to market uncertainties are available, shaper strategies are found to be better. With this stance efforts are made to avoid the risks by dropping the risk prone market, customer or supplier. Contractual agreements are also in practice to minimize the risk intensity. To control the severity of risk, stocking an excess buffer and safety stocks are also a common phenomenon.

If the risk events are unavoidable, accepter strategies are adopted, in which supply chain visibility and coordination is improved and supply networks are redesigned, considering risks as a prime concern (Berge et. al., 2008). A variety of strategies such as supplier selection, number of suppliers, coordination architecture and level of information sharing, accepting the risks and uncertainties (Moghadam et al.,2007; Mantrala and Raman, 1999; Gupta and Maranas,2003; Boute et al., 2007; Neureuther and Kenyon, 2008) have been suggested in the literature. After 9/11 (the terrorist attack in the US) and a series of natural disasters, recovery strategies are increasingly considered by researchers. Continuity management and development of quick recovery plans are becoming a focal research area. Flexibility, agility, knowledge management, information sharing and horizontal/vertical integration are the key issues that are investigated form the point of view of recovery (Norrman and Jansson, 2004; Peck, 2006; Dani and Rangnathan, 2008; Braunscheidel and Suresh, 2008). Table 7 shows that accepter approach is the mostly widely considered one in the literature to design risk management strategies (45%) followed by the recovery approach (40%). Shaper approaches are not as commonly discussed as the other approaches (15%).

4 MANAGERIAL IMPLICATIONS AND CHALLENGES

The detailed classification scheme is further explored with two very significant factors representing the challenges to the adoption of SCRM: first, the coordination and decision making in uncertain business environments and second the implementation issues of SCRM for various sectors.

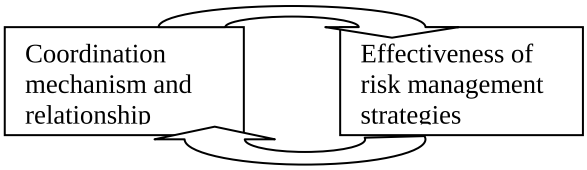


Figure 3: Linkage of coordination mechanism and effectiveness of risk management strategies

4.1 Coordination and decision making in an uncertain business environment

The literature reflects the fact that coordination strategies are established in supply chains at operational and strategic levels for synchronization of the inventory, logistics and production, employing information sharing as a tool for timely, relevant and accurate decision making (Sahin and Robinson, 2002). But in a changing business environment the paradigm has shifted and organizations are more inclined to integrate and review coordination strategies to reduce unexpected and undesired events throughout the network for better management of dependencies (Mele et al., 2007). Thus it will be interesting to study the decision making and coordination strategies with supply chain risk perspectives. In a competitive business environment coordination and collaboration is becoming the prime concern but criticality arises to make tradeoffs between the level and type of coordination and associated risks. A fundamental framework suggesting business integration is discussed by Kleindorfer and Saad (2005), including the strategies to reduce the impact and frequencies of disrupting elements. But theoretical treatment limits its application to the initial levels. Forme et al. (2007) have proposed an improved framework for business collaboration with two models, namely the collaboration characterization model (CCM) and the collaboration oriented performance model (COP). As far as the COP model is concerned they consider flexibility, reactivity, quality and lead times as a measure of performance index with various collaboration levels. They found that at the design and development level collaboration is high but at the operational level more efforts are required to compete in a demand driven market. Inclusion of supply, internal and financial risks can make these models more effective and acceptable.

Market volatility, shorter product life, uncertain demand is also considered by researchers while studying the coordination strategies at the operational and strategic level (Brun et al., 2006). They further assess the level of information sharing considering the value and risk in the supply chain. Donk and Vaart (2005) also studied the integration and collaboration issues with their empirical investigation with one supplier and their five buyers of a different nature. They found that shared resources in supply chains limit the possibility of integration. Their framework helps to set a level of integration in a particular risk and resource sharing situations. On a similar line of action Ojala and Hallikas (2006) touched on the investment risks in networking with the help of the case of two industrial original equipment manufacturers and nine of their suppliers, including from the electronics and metal sectors. Considering the network structure related risks and focusing on the investment decisions in networking in a buyer dominated environment they suggest four themes of investment decisions: investment specificity, investment pace, investment size and the possibility of wrong decisions. They found that the reliability of information plays a significant role in investment decisions. It is realized that more fine-grained models are now required to find the hidden complexities of the decision making process and coordination in the context of business risks and uncertainties.

As suggested in the literature, coordination strategies can be reviewed under the influence of two managerial decision making environments: centralized and decentralized. In a centralized decision making environment the focal concern of the managers is to align the marketing and operational management objectives to improve the relationship between supply chain members (Demirken and Cheng, 2008; Donk and Vaart, 2005; Hallikas and Virolainen, 2005). Managers are always assertive in order to develop strategic protocols for coordination among various members for sustainable relationships. The critical challenge faced by the managers in a centralized decision making environment is that the firm which leads the supply chain and has the power to take strategic decisions defines the risks with their own perspective and characterizes the risk impacts with their own appetite. It is further argued that they have the tendency to bear minimum risk and transfer it to other players, resulting in imbalances in the whole supply chain, which strain the entire supply networks.

Decentralized supply chains can be viewed in a different way and considered as an aggregate body of various discrete entities, where coordination exists, not more than inter-firm or dyadic level. It is observed that most of the decentralized supply chains suffer from uneven power distribution and conflicting risk perceptions and attitudes that limit the performance of the individual risk management strategies of various members. Managers can handle this challenge by addressing three prime issues in centralized as well as decentralized decision making environments: First, as we discussed above, the risk is multidimensional and multi-perspective in nature it could be better to identify and define the risk and its elements not only at the firm level but jointly at the supply chain level, including lower tier suppliers to the end customer. Many times it becomes impractical to consider long chain analysis in strategic decision making, in this case, at least, dyadic relationships should be considered for initial listing of risks and their quantification schemes. Second, in cases where the members have their own risk perceptions and strategic stances and plan to mitigate them, sincere managerial efforts are essential for strategic alignment of multiple perceptions and incorporation of a common minimum program. Third, managers should encourage the tendency to share the appropriate risk by linking it with profit sharing and investment of funds in supply chains. Thus suitable coordination mechanisms, including resource as well as risk sharing structures and level of control can resolve the issues of centralized and decentralized supply chains under risk and uncertainties to a large extent.

On reviewing the risk management literature, it has been found that most of the studies dealing with risk and uncertainties sufficiently cover issues like demand and supply disruptions, network design and multilevel inventory studies but the role of coordination mechanisms under diversified risk situations have not been thoroughly addressed. Supply chain coordination provides the means to understand and analyse the supply chain as a set of dependencies in the form of physical flow and information flow. Appropriate coordination in the supply chain can also reduce uncertainty in networks and strengthen the networks to perform better in existing risks and uncertainties. It is also argued that coping with uncertain situations should be the prime motive of coordination mechanisms. From the above discussion we conclude that integration and coordination among supply chain partners is a prerequisite for an effective risk management program and, furthermore, existing coordination mechanisms should be revisited considering the perceived risks and uncertainties (Figure 15). This discussion has helped us to synthesize two coupled propositions. These propositions can be examined and investigated empirically in various business environments.

P-1 Strong relationships and appropriate coordination mechanisms among partners improve the effectiveness of risk management strategies.

P-2 Existing coordination strategies can be more effective if revisited and revised, considering perceived risks and uncertainties.

4.2 SCRM for various sectors

We further explore the literature with the theme of implementing SRCM in diversified sectors and the practical implications. Disparity among supply chain partners, limited visibility and conflicting risk perspectives are key barriers to the implementation of SCRM at the supply chain level. Further it is argued that common SCRM strategies cannot be effective for diversified industrial sectors as the notion of risks, challenges, barriers and facilitators may vary with the nature, size and type of industry (Finch, 2004; Juttner, 2005). To explore this fact we study the diversified risk issues and preferences of certain industrial sectors.

Managing the supply chains of high-tech industries such as semiconductors, computer hardware and other electronic components is becoming challenging due to current business trends towards shorter product lifecycles, ever-changing customer demand, expanding product variety, and globalization. In high-tech industries, technology is changing rapidly, resulting in higher costs of obsolescence compared to other industries (Kut and Zheng, 2003; Jeng, 2004). Accurate forecasting, information sharing and integration among the supply chain players are urgently needed for this sector to manage the market volatility and price variability. Thus a specific SCRM program including dynamic risk factors will be more effective for such conditions.

Chemical and process industries have different situations. This sector is more vulnerable to safety and hazard issues; the efforts in this area are primarily focused on reduction of operational risks in the form of accidents, machine failures and supply disturbance which can propagate throughout the supply chain (Kleindorfer and Saad, 2005; Donk and Vaart, 2005). An SCRM program focusing on operational features and safety issues will be more relevant for this sector.

The automobile and machine components sector has been found to be plagued with high costs, reducing profit margins and accelerating competition. The focus of SCRM strategies is to redesign supply networks considering specific business risk issues and to investigate trade-offs between efficiency and responsiveness in the known/anticipated business risks environment (Moghadam et al., 2008; Carbonneau et al., 2008).

Diversified product requirements, changing customer tastes, stiff competition and distribution problems are the marked features of the textile industry (Forme et al., 2007; Brun et al., 2006). For the textile sector SCRM should strive to develop strategies to optimally manage the production capacity, workforce level and storage space, considering customer preferences, flexibility, reactivity, quality and lead times as the performance measure.

Food companies are continuously reviewing their business models in a changing business environment. Sustainability is becoming a key concern for this sector. Safety hazards such as contamination, biological risks, genetic risks and natural disasters, distribution and packaging losses, inappropriate contingency plans are the key challenges of this sector (Hong and Sung, 2008). In this sector SCRM primarily focusing to minimizing the wastage through proper distribution, storage and packaging in a collaborative environment, but food supply chain elements are still loosely linked and require more transparent and integrative models.

The above discussion reveals that different industrial sectors have diversified risk issues, priorities and needs. It could be interesting to explore this proposition empirically and identify the commonalities and differences among different sectors regarding risk issues to form clusters and develop specific risk mitigation strategies for clusters.

P-3 A common SRCM program may not be effective for different supply chains and specific SCRM strategies for specific sectors and industries are required.

Table 10: Risk issues and risk management for specific industries/supply chains

Industry / Sector type	Risk issues & sources	Risk mitigation approach	Papers
Electronics components/systems			
Semi-conductor	Supply and demand uncertainties	Correlating external demand to the supply lead time variability	Kut and Zheng (2003), Jeng (2004)
Electronic devices	Network risks in a buyer dominated environment	Assessing information risk & reliability	Ojala and Hallikas (2006)
PC manufacturing	Inbound risk identification &classification	Prototype model based on lit. reviews	Wu . et al. (2006)
Telecommunication	Internal and network risks	Trade-off between capacity and inventory management	Jammernegg and Reiner (2007)
Electronics	Outsourcing risks with contract costing	outsourcing with control costing	Liston et al. (2007)
DDR/RAM manufacturer	Demand variability with seasonality multi-generation products	Combination of forecasting method and level of information sharing	Sohn and Lim(2008)
Process			
Chemical	Accidents and disruptions	Integration to reduce impact and frequency of risks	Kleindorfer and Saad (2005)
Chemical	Supply, demand and internal uncertainties	Risk calculation	Li Ping Liu et al. (2007)
Pigments as raw materials	Variation in product specifications and volumes	Suggesting different integration with various uncertainty levels	Donk and Vaart (2005)
Textile/Fashion			
Fashion products	Demand variability with product variety	Assessment of value and risks	Brun et al. (2006)
Textile	Collaboration Risks under high demand variability	Developing collaboration performance indexes such as key success factors & key performance factors	Forme et al. (2007)
Textile	Demand uncertainties	Production loading plans using uncertainty data	Stephan et al. (2007)
Miscellaneous			
Machine tools	Supply risks	Risk control with optimal inventories	Moghadam et al. (2005)
Foundries	Demand disruptions	soft computing methods for forecasting	Carbonneau et al. (2008)
Agriculture	Supply risks, product decomposition	Improved auction model	Hong and Sung (2008)
Automobile spare parts	Demand variability	Suggesting better forecasting methods and inventory management	Li and Kuo (2008)
Food, beverage and meat	Demand amplification due to information mismatch	Collaborative partnership to manage demand and information flow	Cigolili and Rossi (2006), Baily and Francis (2008)

5 REVIEW FINDINGS, EXPLORATION OF GAPS AND AVENUES FOR FUTURE RESEARCH

SCRM is an exponentially growing area of research encompassing multidisciplinary and multidimensional aspects of risks. As the body of SCRM literature involves complex and entwined issues, a systematic taxonomy could make a great contribution. To delve into the supply chain risk issues we presented a multi-layered top-down classification scheme. In the first layer we considered the research approach and exploration of risk issues; in the second layer we examined the nature of the study, research methods, orientation of risk definitions, structural elements and the level of implementation; in the third layer the key discriminating elements of each factor were considered and were further categorized into detailed attributes. Apart from this, we have used a logical codification scheme employing an alphanumeric code which can assist in quantitative and qualitative analysis. We have further explored the literature with two very important and practical dimensions of the study, namely coordination and decision making in an uncertain business environment and implementation of SCRM for various sectors. The outcomes of these analyses have been presented in the form of propositions. In addition to describing the contributions of the researchers, this study also provided new insights for practical aspects of SCRM.

The conclusions of this study have illustrated the importance of adopting a broader view and scope of coordination strategies in the context of effective implementation of SCRM. It has been argued that understanding the emerging techniques, including conceptual, analytical and empirical approaches with all the proposed elements, enable us to tackle better the managerial challenges involved in addressing the risk issues. This kind of broader view is specifically needed in relation to the kind of managerial challenges faced by a company operating as a focal firm and having more power in supply chains. As this study has illustrated, it is not enough to concentrate on developing and sharpening the risk mitigation strategies focusing on one side of the supply chain and practices. Rather, the company needs to understand and try to influence the entire supply chain, or more importantly, the nature and progression of the flows across the various interfaces. The broadening of the scope of SCRM from a company’s internal processes towards the inclusion of external issues is thus an important managerial challenge.

The review reveals various insights and gaps in the SCRM literature. On comparison of the nature of the study it is observed that even though the literature has a plethora of work the contribution of prescriptive studies is significantly lower, which justifies the need for more focused and specific studies, acceptable to industry. We noticed that the contribution of conceptual studies to SCRM has been higher than that of empirical and analytical studies. This finding highlights the fact that, as risk management studies are still in a nascent state, conceptual and theoretical up-grading is still essential to improve the level of understanding of complex risk issues to provide the strands of effective empirical and analytical studies. It has also been noted that SCRM is accepted in multiple research fields and the literature reflects a huge variety of works with diversified themes, issues and approach. The literature reports very few reviews covering the width and depth of the field. Moreover, as we found that the area is still emerging, more reviews are needed encompassing the changing trends in methodology, approach and finer elements of risk issues with various perspectives. Thus attempts have been made in this study to cover the prevalent literature dealing with current research methods to address the risk issues.

The analysis of orientation of risk definitions suggests that operational aspects related to the demand supply mismatch and interruption of information, funds or material flow are the most utilized factors to define and classify risks. Market orientation factors such as customer expectations, market fluctuations, price variability, competitor moves etc. are also found to be significant to characterize the risk issues. Strategic decision elements such as outsourcing, single sourcing, degree of leanness in manufacturing, level and type of coordination and information sharing etc. are also issues of concern but are still not addressed as much as the operational elements. Moreover, product features such as life cycle, functionality and complexity in design have not been adequately explored to define the risk characteristics. Thus, including product and strategic perspectives to define the risks could improve the effectiveness of risk management mechanisms.

On exploration of the structural dimensions of the supply chain it was observed that researchers emphasize supply side risks more than the demand side. The optimal number of suppliers, delivery reliability, optimal size of deliveries, relationships and coordination are the key elements that influence the risk management strategies, but in a changing scenario customer related elements such as demand fluctuations and customer behaviour should also be included to improve the agility and responsiveness of the supply chain. The implementation of a risk management program shows that scenario based methods are more common due to their comprehensiveness to identify the risks, followed by listing methods due to their simplicity. Risk characterization techniques were found to be more accepted but are still not effective to quantify the elusive and dynamic nature of risks. Further, on investigation of risk management strategic stances we found that the acceptor stance with redesign of supply networks is more common than hitting the cause of risk and reshaping the uncertainty sources. After a series of natural and manmade disruptive events recovery strategies are also being developed with the prime notion of robustness and resilience.

It has been noted that empirical studies primarily analyse the supply chain, investigating the impact of various risk factors on performance determinants, information sharing, collaboration, and e-business practices. The implications of strategic moves such as outsourcing and lean practices have also been investigated with specific case studies and survey based statistical analysis. However, as we know the risk issues have strong perceptive elements and human and organizational behaviour plays a decisive role in managing the risk situations, behavioural elements such as human/organization risk propensity can be integrated with the conventional risks models to get more realistic solutions. Moreover, the role of various personality traits, context and experience can also be incorporated in risk management models. Thus empirical studies investigating behavioural, technical as well as commercial aspects and their role in decision making will be more relevant to develop better risk management models.

The literature reflects the dramatic growth in mathematical modelling to analyse the risk issues. Initially the problems were addressed with linear models but later on stochastic modelling, and multi-agent approaches have been employed more to analyse the risk issues under simulated environments using artificial intelligence tools. To deal with supply chain risk issues these models require further improvements. The literature reports various mathematical models developed to assist planning under uncertainties with number of impractical assumptions such as known probability distributions and linearization in relationships, which reduce the acceptability of the model for real life situations. Thus inclusion of deeper risk issues can improve the effectiveness of mathematical models to a large extent.

It is also necessary to develop coordination strategies considering the actual conditions such as non-ideal members and heterogeneous risk sharing attitudes. Many times managers have to analyse trade-offs considering the factors which contradict each other such as redundancy and efficiency. Methods and mechanisms are still required to analyse these trade-offs in a dynamic business environment with a risk perspective.

We have unified the study and analysed it for coordination strategies under different decision making environments and implementation issues of SCRM for various sectors. The coordination strategies have been studied with two decision making scenarios namely centralized and decentralized systems. In a centralized decision making environment the level of coordination and information sharing among various players is found to be better but it is also observed that the firms leading the supply chain have the tendency to transfer the risks to smaller players. However, in a decentralized decision making environment, coordination is found only at the inter-firm level, which causes conflicting risk perceptions and practices to manage them. Based on the discussion it can be said that coordination among various partners and appropriate level of information sharing is essential to improve the overall effectiveness of risk management strategies. Study further reflects the fact that different industries and sectors have different business environments, opportunities and limitations thus a common risk management framework may not be effective, that causes the need for specific SCRMs for diversified industries and sectors.

Thus by employing a detailed taxonomy we have investigated the prevalent SCRM literature focusing on the research methods adopted and exploration of the risk issues from definition to implementation phases and specific industry needs and we believe that the trend of growing interest in the field of SCRM will continue and new avenues will open from the strategic to the operation level with inclusion of new developments in technology, computing techniques and managerial concerns to effectively manage the risk issues.

APPENDIX: A LIST OF PAPERS WITH CLASSIFICATION CODE

Papers/articles	Classification Code	Papers/articles	Classification Code
Lawrence et al.,1996	A(1)B(1.1)C(5)E(3.1)	Li-ping Liu et al., 2007	A(2)B(1.2)D(1.1)
Thomas and Griffin, 1996	A(1)B(.3.1.1.1/B.3.1.2.4)D(1.2)	Liston et al., 2007	A(1)B(.3.1.1.2/B.3.1.2.4) D(2.2)
Mason-Jones et al., 1998	A(1)B(1.1)C(1)	Mele et al., 2007	A(1)B(.3.1.1.2/B.3.1.2.4) C(2)D(2.2)
Smeltzer and Sifered, 1998	A(1)B(1.1)C91)D(1.2)E(1.1)	Meilin and Jingxian, 2007	A(1)B(.3.1.1.2/B.3.1.2.4) D(2.2)
Escudero et al., 1999	A(1)B(.3.1.1.1/B.3.1.2.2)E(1.1)	Ouyang, 2007	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.2)E(3.3)
Lambros and Socrates,1999	A(1)B(2.2)C(3)D(1.2)	Ritchie and Brindley, 2007	A(1)B(1.1)C(2)E(3.2)
Mantrala and Raman, 1999	A(1)B(.3.1.1.1/B.3.1.2.4)D(2.1)E(2.1)	Serbanescu, 2007	A(1)B(2.2)C(2)E(1.2)
Steven and Ronald, 1999	A(1)B(1.1)C(1)E(2.1)	Stephen et al., 2007	A(1)B(.3.1.1.1/B.3.1.2.2) C(1)E(1.1)
Sislian and Satir,2000	A(1)B(1.1)C(5)	Wang and Shu, 2007	A(1)B(.3.1.1.1/B.3.1.2.2) E(3.1)
Zsidisin et al., 2000	A(1)B(1.1)C(1)	Xiao et al., 2007	A(1)B(.3.1.1.1/B.3.1.2.4) D(2.2)E(2.1)
Hallikas et al., 2002	A(1)B(1.1)C(2)D(1.1)E(3.2)	Zhou and Benton Jr, 2007	A(1)B(2.3)C(5)D(1.2)
Korpela et al., 2002	A(1)B(.3.1.1.1/B.3.1.2.1)	Bailey and Francis, 2008	A(1)B(1.1)D(2.1)
Gupta and Maranas, 2003	A(1)B(.3.1.1.1/B.3.1.2.2) D(2.1)E(1.3)	Berg et al., 2008	A(1)B(1.1)E(3.2)
Juttner et al., 2003	A(1)B(1.1)C(3)E(3.2)	Braunscheidel and Suresh,2008	A(1)B(2.2)C(1)E(3.3)
Kut and Zheng, 2003	A(1)B(.3.1.1.1/B.3.1.2.2) D(2.1)E(1.1)	Carbonneau et al.,2008	A(1)B(.3.1.1.2/B.3.1.2.4) D(2.2)
Zsidisin and Ellaram,2003	A(1)B(2.2)E(3.2)	Chatzidimitriou et al., 2008	A(1)B(.3.1.1.3/B.3.1.2.4) D(2.2
Chen and Lee, 2004	A(1)B(.3.1.1.1/B.3.1.2.2) D(2.1)E(3.2)	Choi et al., 2008	A(1)B(.3.1.1.1/B.3.1.2.2) E(2.1)
Christopher and Lee,2004	A(1)B(1.2)D(1.3)E(3.2)	Dani and Ranganathan,2008	A(1)B(1.2)E(1.3)
Christopher and Peck,2004	A(1)B(1.2)D(1.3)	Demirkan and Cheng, 2008	A(1)B(.3.1.1.1/B.3.1.2.4) D(1.2)
Dailun, 2004	A(1)B(2.3)	Hong and Sung, 2008	A(1)B(.3.1.1.1/B.3.1.2.2) C(1)D(1.1)E(1.3)
Finch,2004	A(1)B(1.1)C(3)	Hsiesh and Cheng, 2008	A(1)B(.3.1.1.1/B.3.1.2.4) D(2.2)E(2.1)
Giuniperoand Eltantawy, 2004	A(2)B(1.2)C(2)D(1.2)E(2.1)	Hung and Sungmin,2008	A(2)B(1.2)C(3)E(3.2)
Goankar andViswanadham, 2004	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(2.2)	Kenett and Raphaeli,2008	A(1)B(1.2)C(5)E(3.1)
Jeng,2004	A(1)B(1.2)D(1.3)	Khan and Greaves, 2008	A(2)B(2.1)C(3)E(3.2)
Lau et al.,2004	A(1)B(.3.1.1.2/B.3.1.2.2) D(1.1)	Kim and Park,2008	A(1)B(1.2)C(5)
Norrman and Jansson,2004	A(1)B(1.2)E(3.3)	Lee, 2008	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(2.2)
Yang et al., 2004	A(1)B(1.1)D(2.1)	Levary, 2008	A(1)B(.3.1.1.1/B.3.1.2.1) C(4)D(1.2)
Blackhurst et al.,2005	A(1)B(2.2)C(1)E(3.3)	Li and Kuo, 2008	A(1)B(.3.1.1.1/B.3.1.2.2) C(2)E(3.2)
Donk and Vaart, 2005	A(1)B(2.3)D(2.1)	Manuj and Mentzer, 2008	A(1)B(1.2)C(5)E(3.2)
Hendricks and Singhal, 2005	A(1)B(2.2)C(5)	Moghadam et al., 2008	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(2.2)
Juttner, 2005	A(1)B(2.2)C(1)E(3.2)	Neureuther and Kenyon, 2008	A(1)B(2.2)C(2)D(2.1)
Kleindorfer and Saad, 2005	A(1)B(1.2)C(1)	Ohbyung et al., 2008	A(1)B(.3.1.1.3/B.3.1.2.2) D(2.2)
Abbas et al., 2006	A(1)B(1.1)D(1.1)	Ritchie and Brindley,2008	A(1)B(1.2)C(3)E(3.2)
Bogataj and Bagataj, 2006	A(1)B(.3.1.1.1/B.3.1.2.2) C(5)E(2.1)	Sohn and Lim, 2008	A(1)B(.3.1.1.2/B.3.1.2.2) C(4)D(2.2)

Brun et al., 2006	A(1)B(1.2)C(1)E(1.1)	Szwejczewski et al., 2008	A(1)B(1.2)C(4)E(2.1)
Cigolini and Rossi, 2006	A(1)B(1.2)D(1.1)	Tapiero and Grando,2008	A(1)B(1.2)C(5)
Faisal et al., 2006	A(1)B(2.1)C(1)	Thomas and David, 2008	A(1)B(.3.1.1.2/B.3.1.2.4) D(1.3)
Gaudenzi and Borghesi, 2006	A(1)B(.3.1.1.1/3.1.2.1)C(3) E(2.2)	Wong and Arlbjorn, 2008	A(1)B(2.2)C(2)E(3.3)
Ojala and Hallikas, 2006	A(1)B(1.1)C(3)D(1.2)	Zhao et al., 2008	A(2)B(2.1)C(1)
Peck, 2006	A(1)B(1.2)E(3.3)	Zsidisin et al., 2008	A(2)B(2.2)C(3)E(3.2)
Shockley and Ellis,2006	A(1)B(2.2)C(1)D(1.1)	Haisheng et al., 2009	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)
Tang, 2006	A(1)B(1.3)	Jiang et al., 2009	A(1)B(1.2)C(5)
Tang, 2006b	A(1)B(1.1)E(3.3)	Knemeyer et al.,2009	A(1)B(1.2)C(4)E(3.3)
Wu. et al., 2006	A(1)B(.3.1.1.1/B.3.1.2.1) C(1)D(1.1)	Michael and Nallan,2009	A(1)B(1.2)C(1)E(3.3)
WagnerandBode,2006	A(1)B(2.2)C(3)D(1.1)	Narasimhan and Talleri,2009	A(1)B(1.2)C(5)E(3.1)
Aggarwal and Ganeshan, 2007	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(2.2)	Neiger et al. ,2009	A(1)B(1.2)E(1.1)
Blackhurst et al.,2007	A(1)B(2.3)C(1)D(1.2) E(3.1)	Oke and Gopalakrishnan, 2009	A(2)B(2.1)C(3)
Boute et al., 2007	A(1)B(.3.1.1.1/B.3.1.2.2) D(2.1)E(2.1)	Ponomarov and Holcomb, 2009	A(1)B(1.3)
Devaraj et al.,2007	A(2)B(2.2)C(3)	Rao and Goldsby , 2009	A(1)B(1.3)
Faisal et al., 2007	A(1)B(2.1)C(5)E(3.2)	Sarkar and Mohapatra, 2009	A(1)B(.3.1.1.2/B.3.1.2.2) D(1.2)
Forme et al., 2007	A(2)B(1.2)	Sodhi and Tang, 2009	A(1)B(2.2)C(2)D(2.1)
Goh et al., 2007	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(3.2)	Trkman and McCormack,2009	A(1)B(1.1)D(1.2)E(3.3)
Haan et al.,2007	A(1)B(2.2)C(2)	Vanany et al.,2009	A(1)B(1.3)
Harland et al.,2007	A(1)B(2.2)C(5)E(3.1)	Boin et al., 2010	A(1)B(1.2)C(3)E(3.2)
Jammernegg and Reiner,2007	A(1)B(.3.1.1.2/B.3.1.2.4) C(1)D(2.2)	Giannaikis and Louis, 2010	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(2.2)
Kersten et al.,2007	A(1)B(1.1)C(1)	Ellis et al., 2010	A(1)B(2.2)C(1)E(3.3)
		Tuncel and Alpan, 2010	A(1)B(.3.1.1.2/B.3.1.2.4) C(1)D(2.2
Ketzenberg et al.,2007	A(1)B(1.2)C(5)	Tang and Musa, 2010	A(1)B(1.3)C(1)
Khan and Burnes,2007	A(1)B(1.2)E(3.2)	Wanger and Neshat, 2010	A(1)B(.3.1.1.1/B.3.1.2.2) D(1.1)E(3.2)
Kocabasoglu et al., 2007	A(1)B(2.2)C(1)E(3.2)	Wuand Olson, 2010	A(1)B(1.2)C(5)
Lee et al., 2007	A(2)B(2.2)D(1.1)		

REFERENCES

Abbas, F., Marvin, A. and Mehmet, K. (2006), "Perspectives on Global Supply Chain Supply-Side Risk Management", PICMET 2006 Proceedings, 9-13 July, Istanbul, Turkey, pp. 2732-2740.

Aggarwal, P. and Ganeshan, R. (2007), "Using risk-management tools on B2Bs: An exploratory investigation", Int. J. Production Economics, vol. 108, no. 1-2, pp. 2-7.

Bailey, K. and Francis, M. (2008), "Managing information flows for improved value chain performance", Int. J. Production Economics, vol. 111, no. 1, pp. 2-12.

Beamon, B.M. (1998), "Supply chain design and analysis: models and methods", Int. J. Production Economics, vol. 55, no. 3, pp. 281-294.

Berg, E., Knudsen, D. and Norrman, A. (2008), "Assessing performance of supply chain risk management programmes: a tentative approach", International Journal of Risk Assessment and Management ,Vol. 9, no. 3, pp. 288-310.

Blackhurst, J., Craighead, C.W., Elkins, D. and Handfield, R.B. (2005), "An empirically derived agenda of critical research issues for managing supply- chain disruptions", International Journal of Production Research, vol. 43, no. 19, pp. 4067-4081.

Blackhurst, J., Wu, T. and O'grady, P. (2007), "A network-based decision tool to model uncertainty in supplychain operations", Production Planning and Control, vol. 18, no. 6, pp. 526-535.

Bogataj, D. and Bagataj, M. (2006), "Measuring the supply chain risk and vulnerability in frequency space". Int. J. Production Economics, vol. 108, pp. 291-301.

Boin, A., Kelle, P. and Whybark, D.C. (2010), "Resilient supply chains for extreme situations: outlining a new field of study", Int. J. Production Economics, vol. 126, no. 1, pp. 1-6.

Boute, R.N., Disney, S.M., Lambrecht, M.R. and Houdt, B.V. (2007), "An integrated production and inventory model to dampen upstream demand variability in the supply chain", European Journal of Operational Research, vol. 178, no. 1, pp. 121-142.

Braunscheidel, M.J. and Suresh, N.C. (2008), "The organizational antecedents of a firm's supply chain agility for risk mitigation and response", Journal of Operations Management, vol. 27, no. 2, pp. 119-140.

Brun, A., Caridi, M., Salama, K.F. and Ravelli, I. (2006), "Value and risk assessment of supply chain management improvement projects". Int. J. Production Economics, vol. 99, no. 2 pp. 186-201.

Carbonneau, R., Laframboise, K. and Vahidov, R. (2008), "Application of machine learning techniques for supply chain demand forecasting", European Journal of Operational Research, vol. 184, no. 3, pp. 1140-1154.

Choi, T.M., Li, D., Yan, H. and Chiu, C.H. (2008), "Channel coordination in supply chains with agents having mean-variance objectives", Omega (The International Journal of Management Science), vol. 36, no. 4,pp. 565-576.

Chatzidimitriou, K.C., Syneonidis, A.L., Kontogounis, I. and Mitkas, P.A. (2008), "Agent Mertacor: A robust design for dealing with uncertainty and variation in SCM environments", Expert System with Applications, vol. 35, no. 3, pp. 591-603.

Chen, C.L. and Lee, W.C. (2004), "Multi objective optimization of multi-echelon supply chain networks with uncertain demands and prices", Computers and Chemical Engineering, Vol. 28, no. 6-7, pp. 1131-1144.

Christopher, M. and Lee, H. (2004), "Mitigating supply chain risk through improved confidence",International Journal of Physical Distribution and Logistics Management, vol. 34,no. 5, pp. 388-396.

Christopher, M. and Peck, H. (2004), "Building the resilient supply chain", The International Journal of Logistic Management, vol. 15, no. 2, pp.1-13.

Cigolini, R. and Rossi, T. (2006), "A note on supply risk and inventory outsourcing", Production Planning and Control, vol. 17, no. 4, pp. 424-437.

Dani, S. and Ranganathan, R. (2008), "Agility and supply chain uncertainty: a scenario planning perspective",International Journal of Agile Systems and Management, Vol. 3, no. 3/4, pp. 178 - 191.

Dailun, S.H.I. (2004), "A review of enterprise supply chain risk management", Journal of System Science and System Engineering, vol. 3, no. 2, pp. 219-244.

Demirkan, H. and Cheng, H.K. (2008), "The risk and information sharing of application services supply chain", European Journal of Operational Research, vol. 187, no. 3, pp. 765-784.

Devaraj, S., Krajewski, L. and Jerry, C.W. (2007), "Impact of eBusiness technologies on operational performance: The role of production information integration in the supply chain", Journal of Operations Management, vol. 25, no. 6, pp. 1199-1216.

Donk, D.P. and Vaart, T. (2005), "A case of shared resources, uncertainty and supply chain integration in the process industry", Int. J. Production Economics, vol. 96, no. 1, pp. 97-108.

Ellies,S.C., Henery R.M. and Shockley, J. (2010), "Buyer perceptions of supply disruption risk: A behavioral view and empirical assessment", Journal of Operations Management, vol. 28, no. 1, pp. 34-46.

Escudero, L.F., Galindo, E., Garcia, G., Gomez, E. and Sabau, V. (1999), "Schumann, a modeling framework for supply chain management under uncertainty", European Journal of Operational Research, vol. 119, no. 1, pp. 14-34.

Faisal, M.N., Banwet, D.K. and Shankar, R. (2007), "Information risks management in supply chains: an assessment and mitigation framework", Journal of Enterprise Information Management, vol. 20, no. 6, pp. 677-699.

Faisal, M.N., Banwet, D.K. and Shankar, R. (2006), "Supply chain risk mitigation: modeling the enablers", Business Process Management, Vol. 12, no. 4, pp. 535-552.

Finch, P. (2004), "Supply chain risk management: case study", Supply chain Management: An International Journal, vol. 3, no. 2, pp 183-196.

Forme, F.G.L., Genoulaz, V.B. and Campagne, J.P. (2007), "A framework to analyze collaborative performance", Computer in Industry, vol. 58, no. 7, pp. 687-697.

Gaudenzi, B. and Borghesi, A. (2006), “Managing risks in supply chain using AHP method”, The International Journal of Logistics Management, vol. 17, no. 1,pp. 114-136.

Giannakis, M. and Louis, M. (2011), “A multi-agent based framework for supply chain risk management”, Journal of Purchasing and Supply Management, vol. 17, no. 1, pp. 23-31.

Giunipero, L.C. and Eltantawy, R.A. (2004), “Securing the upstream supply chain: A risk management approach”, International Journal of Physical Distribution and Logistics Management, vol. 34, no. 9, pp. 698- 713.

Goankar, R. and Viswanadham, N. (2004), “AConceptual and Analytical Framework for the Management of Risk in Supply Chains”, Proceedings of the IEEE, International Conference on Robotics and Automation, New Orleans, LA. pp. 2699-2704.

Goh, M., Joseph, Y.S. L. and Meng, F. (2007), “A Stochastic model for risk management in global supply chain networks”, European Journal of Operational Research, vol. 182, no. 1, pp. 164-173.

Gupta, A.and Maranas, C.D. (2003), “Managing demand uncertainty in supply chain planning”. Computers and Chemical Engineering, vol. 27, no. 8-9, pp. 1219-1227.

Haan, J., Moron, D.K. and Placzek, E. (2007), “Logistic management and firm size; a survey among Polish small and medium enterprises”, Int. J. Production Economics, vol. 108, no. 1-2, pp. 119-126.

Haisheng, Y., Amy, Z. and Lindu, Z. (2009), “ Single or dual sourcing: decision-making in the presence of supply chain disruption risks”,Omega (The International Journal of Management Science), vol. 37, no. 4, pp. 788-800.

Hallikas, J. and Virolainen, V.M. (2005), “Supply Networks and Risk Management: A Dyadic Case Study”, Technology Business Research Center, Lappeenranta , Finland.

Hallikas, J., Virolainen, V.M. and Tuominen, M. (2002), “Risk analysis and assessment in network environments: A dyadic case study”, Int. J. Production Economics, vol. 78, no.1, pp. 45-55.

Harland, C.M., Caldwell, N.D., Powell, P. and Zheng, J. (2007), “Barriers to supply chain information integration: SMEs adrift of eLands”, Journal of Operations Management, vol. 25, no. 6, pp. 1234-1254.

Hendricks, K.B. and Singhal, V.R. (2005), “An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm”, Production and Operations Management, vol. 14, no. 1, pp. 35-52.

Hong, G.H. and Sung, H.H. (2008), “Evaluating supply partner’s capability for seasonal products using machine learning techniques”, Computer and Industrial Engineering, vol. 54, no. 4, pp. 721-736.

Hsieh, C.C. and Cheng, H.W. (2008), “Capacity allocation, ordering and pricing decisions in a supply chain with demand and supply uncertainties”, European Journal of Operational Research, vol. 184, no. 2, pp. 667-684.

Hung, K.T. and Sungmin R.(2008), “Changing risk preferences in supply chain inventory decisions”, Production Planning and Control, vol. 19, no. 8, pp. 770-780.

Jammernegg, W. and Reiner, G. (2007), “Performance improvement of supply chain process by coordinated inventory and capacity management”, Int. J. Production Economics, vol. 108, no. 2, pp. 183-190.

Jeng, J.T. (2004), “Supply Chain Risk Management”. IEEE Semiconductor Manufacturing Workshop Proceedings, pp. 139-140.

Jiang, B., Baker, R.C. and Frazier, G.V. (2009), “An analysis of job dissatisfaction and turnover to reduce global supply chain risk: Evidence from China”. Journal of Operations Management, vol. 27, no. 2, pp. 169-184.

Juttner, U. (2005), “Supply chain risk management: understanding the business requirements from practitioners perspective”, The International Journal of Logistics Management, vol. 16, no. 1, pp. 120-141.

Juttner, U., Peck, H. and Christopher, M. (2003), **“**Supply chain risk management: outlining an agenda for future research”, International Journal of Logistics Research and Applications, vol. 6, no. 4, pp. 197-210.

Kenett, R.S. and Raphaeli, O. (2008), “Multivariate methods in enterprise system implementation, risk management and change management”,International Journal of Risk Assessment and Management, vol. 9, pp. 258-276.

Kersten, W., Hohrath, P. and Boger, M. (2007), “An Empirical Approach to Supply Chain Risk Management: Development of Strategic Framework”. Technology, pp. 1-20, available at pomsmeetings.org

Ketzenberg, M.E., Rosenzwig, E.D., Marucheck, A.E. and Metters, R.D. (2007), “A framework for value of information in inventory replenishment”, European Journal of Operational Research, vol. 182, no. 3, pp. 1230-1250.

Khan, O. and Greaves, Y.C. (2008), "Mitigating supply chain risk through improved agility: lessons from a UK retailer", International Journal of Agile Systems and Management, vol. 3, no. ¾, pp. 263 - 281.

Khan, O. and Burnes, B. (2007), "Risk and supply chain management: creating a research agenda", The International Journal of Logistics Management, vol. 18, no. 2, pp. 197-216.

Kim, S.W. and Park, S. (2008), "Development of three-echelon SC model to optimize coordination costs", European Journal of Operational Research, vol. 184,no. 3, pp. 1044-1061.

Kleindorfer, P.R. and Saad, G. H.(2005), "Managing Disruption Risks in Supply Chains", Production and Operations Management, vol. 14, no. 1, pp. 53-68.

Knemeyer, A.M., Walter, Z. and Cuneyt, E. (2009), "Proactive planning for catastrophic events in supply chains",Journal of Operations Management, vol. 27, no. 2, pp. 141-153.

Kocabasoglu, C., Prahinski, C. and Klassen, R.D. (2007), "Linking forward and reverse supply chain investments: The role of business uncertainty", Journal of Operations Management, vol. 25, no. 6, pp. 1141-1160.

Korpela, J., Kylaheiko, K., Lehmusvaara, A. and Tuominen, M. (2002), "An Analytical approach to production capacity allocation and supply chain design", Int. J. Production Economics, vol. 78, no. 2, pp. 187-195.

Kut, C.S. and Zheng, X. (2003), "Impact of supplier's lead time and forecast demand updating on retailer's order quantity variability in a two-level supply chain", Int. J. Production Economics, vol. 86, no. 2, pp. 169-179.

Labeau, P.E., Smidt, C. and Swaminathan, S. (2000), "Dynamic reliability: towards an integrated platform for probabilistic risk assessment", Reliability Engineering and System Safety, vol. 68, pp. 219–254.

Lau, J.S.K., Huang, G.Q. and Mak, K.L. (2004), "Impact of information sharing on inventory replenishment in divergent supply chains", International Journal of Production Research, vol. 42, no. 5, pp. 919-942.

Lambros, L. and Socrates, M. (1999), "An Empirical Investigation of Outsourcing Decisions", The Journal of Supply Chain Management, vol. 35, no. 1, pp. 33-41.

Lawrence, T. B., Velimis, M., Picardal, C. and Iftekharuddin, K. (1996), **"**Risk Management and System Engineering Discipline", IEEE Aerospace and Electronics Conference Proceedings, vol.2, pp.829-835.

Lee, T.Y.S. (2008), "Supply Chain Risk Management", Int. J. Information and Decision Sciences, Vol. 1, No. 1 pp. 98-114.

Lee, C.W., Kwon, I.W.G. and Severance, D. (2007), "Relationship between supply chain performance and degree of linkage among supplier, internal integration and customer", Supply Chain Management: An International Journal, vol. 12, no. 6, pp. 444-452.

Levary, R.R. (2008), "Using the analytic hierarchy process to rank foreign suppliers based on supply risks", Computers and Industrial Engineering, vol. 55, no. 2, pp. 535-542.

Li, S.G. and Kuo, X. (2008), "The inventory management system for automobile spare parts in a central warehouse", Expert System with Application, vol. 34, no. 2, pp. 1144-1153.

Li-ping Liu, Jian-hua Ji, Hai-long Yu, Ji-ling Hu and Ti-jun Fan. (2007), "Supply chain risk management in Chinese process industries", IEEE Int. Conference on Wireless Communication, Networking and Mobile Computing Proceedings, pp. 4923-4925.

Liston, P., Byrne, J., Byrne, P.J. and Heavey, C. (2007), "Contract costing in outsourcing enterprises: Exploring the benefits of discrete event simulation", Int. J. Production Economics, vol. 110, no. 2, pp. 97-114.

Malhotra, M. K., and Grover, V. (1998), "An assessment of survey research in POM: from constructs to theory", Journal of Operations Management, vol. 16, no. 4,pp. 407-425.

Mantrala, M.K. and Raman, K. (1999), "Demand uncertainty and supplier's returns policies for a multi-store style-good retailer",European Journal of Operational Research, vol. 115, no. 2, pp. 270-284.

Manuj, I. and Mentzer, J.T. (2008), "Global supply chain risk management strategies", International Journal of Physical Distribution and Logistics Management, vol. 38, no. 3, pp. 192-223.

March, J.G. and Shapira, Z. (1987), "Managerial perspective on risk and risk taking", Management Science, vol. 33, no. 11, pp. 1404 -1418.

Mason-Jones, Rachel and Towill, D. (1998), "Shrinking the supply chain uncertainty cycle", Control, pp.17-22.

Meilin, H. and Jingxian, C. (2007), "Managing Operational Risk in Supply Chain", IEEE Int. Conference on Wireless Communication, Networking and Mobile Computing Proceedings, pp. 4919-4922.

Meixell, M.J. and Gargeya, V. B. (2005), "Global supply chain: A literature review and critique", Transportation Research Part E, vol. 41, no. 6, pp. 531-550.

Mele, F.D., Guillen, G., Espuna, A. and Puigjaner, L. (2007), "An agent based approach for supply chain retrofitting under uncertainty", Computer and Chemical Engineering, vol. 31, no. 6, pp. 722-735.

Michael J. B. and Nallan C. S. (2009), "The organizational antecedents of a firm's supply chain agility for risk mitigation and response",Journal of Operations Management, vol. 27, no. 2, pp. 119-140.

Moghadam, M.R.S., Afsar, A. and Sohrabi, B. (2008), "Inventory lot-sizing with supplier selection using hybrid intelligent algorithm", Applied Soft Computing, vol. 8, no. 4, pp. 1523-1529.

Narasimhan, R. and Talleri, S. (2009), "Perspectives on risk management in supply chains", Journal of Operations Management, vol. 27, no. 2, pp. 114-118.

Neigar, D., Rotaru, K. and Churilov, L. (2009), "Supply chain risk identification with value- focused process engineering", Journal of Operations Management vol. 27, no. 2, pp. 154-168.

Neureuther, B.D. and Kenyon, G. (2008), "A Model for Evaluating Supply Chain Risk", POMS 19th Annual Conference, La Jolla, California, USA.

Norrman, A. and Jansson, U. (2004), "Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident", Int. J. Physical Distribution logistic Management, vol. 34, no. 5, pp. 434-456.

Ohbyung, K., Ghi, P.I. and Lee, K.C. (2007), "MACE-SCM: A multi-agent and case based reasoning collaboration mechanism for supply chain management under supply and uncertainties", Expert Systems with Applications, vol. 33, no. 3, pp. 690-705.

Ojala, M. and Hallikas, J. (2006), "Investment decision-making in supplier networks: Management of Risk", Int. J. Production Economics, vol. 104, no. 1, pp. 201-213.

Oke, A. and Gopalakrishnan, M. (2009), "Managing disruptions in supply chains: A case study of a retail supply chain",Int. J. Production Economics, vol. 118, no. 1, pp. 168-174.

Ouyang, Y. (2007), "The effect of information sharing on supply chain stability and the bullwhip effect", European Journal of Operational Research, vol. 182, no. 3, pp. 1107-1121.

Peck, H. (2006), "Reconciling supply chain vulnerability, risk and supply chain management", International Journal of Logistics Research and Applications, vol. 9, no. 2, pp. 127-142.

Ponomaroy, S.Y. and Holcomb, M.C. (2009), "Understanding the concept of supply chain resilience", The Int. J of Logistics Management, vol. 20, pp. 124-143.

Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", The Int. J. of Logistics Management, vol. 20, no. 1, pp. 97-123.

Ritchie, B. and Brindley, C. (2007), "Supply chain risk management and performance: A guiding framework for future development", International Journal of Operations and Production Management, vol. 27, no. 3, pp. 303-322.

Ritchie, B., Brindley, C.S. and Armstrong, N. (2008), "Risk assessment and relationship management: practical approach to supply chain risk management",International Journal of Agile Systems and Management, vol. 3, no. ¾, pp. 228-247.

Sahin, F. and Robinson, E. P. (2002), "Flow coordination and information sharing in supply chains: review, implications, and directions for future research", Decision Sciences, vol. 33, no. 4, pp. 505-536.

Sanders, N.R. (2008), "Pattern of information technology use: The impact of buyer-supplier coordination and performance", Journal of Operations Management, vol. 26, no. 3, pp. 349-367.

Sarkar, A. and Mohapatra, P.K.J. (2009), "Determining the optimal size of supply base with the consideration of risks of supply disruptions", Int. J. Production Economics, vol. 119, no. 1, pp. 122-135.

Serbanescu, D. (2007), "Sensitivity and uncertainties issues in the Integrated PRA studies", International Journal of Risk Assessment and Management, vol. 2, no. 1/2, pp. 31-56.

Sislian, E. and Satir, A. (2000), "Strategic Sourcing: A Framework and a Case Study", The Journal of Supply Chain Management, vol. 36, no. 3, pp. 4-11.

Shokley, J. and Ellis, S.C. (2006), "Measuring the supply risk construct: An exploratory study", Clemson University, Clemson, USA.

Smeltzer, L.R. and Siferd, S.P. (1998), "Proactive supply management: The management of risk", The Journal of Supply Chain Management, vol. 34, no. 1, pp. 38-45.

Sodhi, M. S. and Tang, C. S. (2009), "Modeling supply-chain planning under demand uncertainty using stochastic programming: A survey motivated by asset–liability management", Int. J. Production Economics, vol. 121, no. 2, pp. 728-738.

Sohn, S.Y. and Lim, M. (2008), “The effect of forecasting and information sharing in SCM for multi-generation products”, European Journal of Operational Research, vol. 186, no. 1, pp. 276-287.

Stephen, C.H.L., Sally, O.S.T., Ng, W.L. and Yue, W. (2007), “A robust optimization model for multi-site production planning problem in an uncertain environment”, European Journal of Operational Research, vol. 181, no. 1, pp.224-238.

Steven, R. T. and Ronald, D. W. (1999), “Integrating Risk Assessment into Management Systems”, 24" International Electronics Manufacturing Symposium October 18-20, 1999, Austin, Texas.

Swaminathan, J. M., Smith, S.F. and Zadeh, N.M. (1998), “Modelling supply chain dynamics: A multi-agent approach”, Decision Sciences, vol. 29, no. 3, pp. 607-632.

Szwejczewski, M., Mitchell, R. and Lemke, F. (2008), “Risk measurement and management during new product development: an exploratory study”,International Journal of Risk Assessment and Management, vol. 9, no. 3, pp. 277-287.

Tang, C.S. (2006a), “Perspective in supply chain risk management”, Int. J. Production Economics, vol. 103, no. 3, pp. 451-488.

Tang, C.S. (2006b), “Robust Strategies for mitigating supply chain disruptions”, International Journal of Logistics Research and Applications, vol. 9, no.1, pp. 33-45.

Tang, O. and Musa, S. N. (2010), “Identifying risk issues and research advancements in supply chain risk management”, Int. J. Production Economics, vol. 133, no. 1, pp. 25-34

Tapiero, C.S. and Grando, A. (2008), “Risks and supply chains”, International Journal of Risk Assessment and Management, vol. 9, no. 3, pp. 199-212.

Thomas, D. J. and Griffin, P.M. (1996), “Coordinated supply chain management”, European Journal of Operational Research, vol. 94, no. 1, pp.1-15.

Thomas, K. and David, C. (2008), “The risk of second tier suppliers in serial supply chains: Implications for order policies and distributor autonomy”, European Journal of Operational Research, vol. 186, no. 3, pp. 1158-1174.

Trkman, P. and McCormack, K. (2009), **“**Supply chain risk in turbulent environments—A conceptual model for managing supply chain network risk”, Int. J. Production Economics, vol. 119, no. 2, pp. 247-258.

Tuncel, G. and Alpan, G. (2010), “Risk assessment and management for networks: A case study”, Computer in Industry, vol. 61, no. 3, pp. 250-259.

Vanany, I., Zailani, S. and Pujawan, N. (2009), “Supply chain risk management: literature review and future research”, International Journal of Information systems and Supply Chain management, vol. 2, no. 1, pp. 16-33.

Varma, V.A. Reklaitis, G.V., Blau, G.E. and Pekny, J.F. (2007), “Enterprise –wide modeling and optimization – An overview of emerging research challenges and opportunities”, Computers and Chemical Engineering, vol. 31, no. 6, pp. 692-711.

Wacker, J.G. (1998), “A definition of theory: research guidelines for different theory-building research methods in operations management”, Journal of Operations Management, vol. 16, no. 4, pp. 361-385.

Wagner, S.M. and Bode, C. (2006), “An empirical investigation in to supply chain vulnerability”, J. Purchasing and Supply Management, vol. 12, pp. 301-312.

Wagner, S.M. and Neshat, N. (2010), “Assessing the vulnerability of supply chains using graph theory”, Int. J. Production Economics, vol. 126, pp. 121-129.

Wang, J. and Shu, Y.F. (2007), “A possibilistic decision model for new product supply chain design”, European Journal of Operational Research, vol. 177, no. 2, pp. 1044-1061.

Wong, C. Y. and Arlbjorn J. S. (2008), “Managing uncertainty in a supply chain reengineering project towards agility”, International Journal of Agile Systems and Management, vol.3, no. ¾, pp. 282-305

Wu, D.D. and Olson, D.L. (2010), “Risk issues in operations: ‘methods and tools’”, Production planning and Control, vol. 20 no. 4, pp. 293-294.

Wu, T., Blackhurst, J. and Chidambaram, V. (2006), “A model of inbound supply chain analysis”, Computers in Industry, vol. 57, no. 4, pp. 350-365.

Xiao, T., Xiangtong, Q. and Gang, Y. (2007), “Coordination of supply chain after demand disruptions when retailers compete”, Int. J. Production Economics, vol. 109, no. 2, pp. 162-179.

Yang, B., Burns, N.D. and Backhouse, C. J. (2004), “Management of uncertainty through postponement”, International Journal of Production Research, vol. 42, no. 6, pp. 1049-1064.

Zhou, H. and Benton Jr., W.C. (2007), “Supply chain practice and information sharing”, Journal of Operations Management, vol. 25, no. 6, pp. 1348-1365.

Zhao, X., Huo, B., Flynn, B.B. and Yeung, J.H.Y. (2008), “The impact of power relationship commitment on the integration between manufacturers and customers in the supply chain”, Journal of Operations Management, vol. 26, no. 3, pp. 368-288.

Zsidisin, G., Panelli, A. and Upton, R. (2000), “Purchasing organizational involvement in risk assessment, contingency plans and risk management: an exploratory survey”, Supply Chain Management: An International Journal, vol. 5, no. 4, pp. 187-198.

Zsidisin, G.A. (2003), “Managerial Perceptions of Supply Risk”, The Journal of Supply Chain Management, vol. 39, no. 1, pp.14-26.

Zsidisin, G.A. and Ellaram, L.M. (2003), “An agency theory investigation of supply risk management”, The Journal of Supply Chain Management, vol. 39, no. 3, pp. 15-27.

Zsidisin G.A., Wanger, S.M., Melnyk, S.A., Ragatz, G.L. and Burns, L.A. (2008), “Supply risk perceptions and practices: An explorative comparison of German and US supply management professionals”, Int. J. Technology and Management, vol. 8, no. 4, pp. 401-419.

Int. Journal of Business Science and Applied Management, Volume 6, Issue 3, 2011

The institutional determinants of CEO compensation: An international empirical evidence

Habib Jouber
Lartige, Faculty of Economic, Sciences & Management, University of Sfax
Airport Road, P.O Box 1088, Sfax 3018, Tunisia
Telephone: +216 96672732
Email: habib.jouber@yahoo.com

Hamadi Fakhfakh
Lartige, Faculty of Economic, Sciences & Management, University of Sfax
Airport Road, P.O Box 1088, Sfax 3018, Tunisia
Telephone: +216 98657007
Email: hamadi.fakhfakh@fsegs.rnu.tn

Abstract

Corporate governance literature suggests that the relationship between CEO effort and outcomes such as firm performance is highly uncertain due to the influence of numerous organizational and environmental contingencies that are outside CEOs' control. The major focus of this study is to determine whether institutional factors explain cross-sectional differences in CEO pay structure and sensitivity to performance and luck. Thus, we address three ultimate questions; Are CEOs rewarded for luck? Does institutional features matter for CEO pay for luck? How do systematic incentive effect is sensitive to luck's nature? Ordinary Least Squares (OLS) and Instrumental Variables (I.V.) estimations based on a sample of 300 publicly traded firms covering four countries from the Anglo-American and Euro-Continental corporate governance models between 2004 and 2008 show that the answers to the two first questions are a surrounding yes. Robustness check tests relying to the third question provide evidence that pay for luck is asymmetric. That is, executives are rewarded for good luck but they are safe of bad luck.

Keywords: CEO compensation, performance, institutional factors, luck, corporate governance

Acknowledgement: The authors would like to thank the associate editor and two anonymous reviewers for their in-depth and insightful comments that shaped the paper. The authors also appreciate research assistance from LARTIGE laboratory members

1 INTRODUCTION

At the heart of the issue of the managerial compensation's impact on shareholder value is the conflict of interests between corporate shareholders and managers. The assumption is that compensation contracts may resolve or alleviate these conflicts (Jensen and Meckling, 1976). Existing research on this issue is based primarily on the optimal contracting theory. Under this theory, CEO performance-based compensation helps tying the CEO's personal wealth to his firm's stock price and, hence casting doubts on the possibilities that CEOs take self-serving actions to harm shareholders. That is, management rewards should motivate executives to take real actions that increase firm value. This view asserts however, that executives are rewarded only for firm-specific performance's improvements and that executive pay is the outcome of market mechanisms. Or, it is commonly known that contractible performance measures capture the interaction between both specific and systematic incentives (Holmstrom, 1979). With this in mind, one could rationalize this evidence in terms of the principal's disability to draw conclusions about the level of skills or effort the agent exerted. Such disability occurs because a real portion of firm performance may be due to something over which executives have no control, such as, for example macroeconomic trends or input and output price movements (Feriozzi, 2011). Thus, a serious problem facing a shareholder is to determine how much of the firm performance is due to luck and how much is due to skill. This is in fact the crux of Bertrand and Mullainathan's (2001) pay for luck hypothesis. This hypothesis has been spun under the auspice that CEO pay responds as much to a lucky dollar as to a general dollar. Supporting this hypothesis, controlling for CEO pay economic determinants, and using two instruments for luck, we define two types of CEO performance based incentive effect; a lucky (systematic) incentive effect which corresponds to implicit impacts of exogenous events on corporate profitability, and a purely (specific) incentive effect which reflects human skills and efforts. Consequently, we appoint pay for luck and pay for performance to design pay sensitivity respectively to each effect.

Finding pay for luck is not new. However, relatively little is known about how pay depends on its nature that is; are CEOs rewarded for good luck as for bad luck? We show that the answer to this question is a surrounding no. Besides, although a growing stream of research has linked many financial decisions to institutional settings, few are the works that have highlighted how the institutional environment affects the structure of management compensation and its sensitivity to luck. We aim to fill this gap in knowledge by examining how CEO based performance grants relate to luck and institutional factors. To ascertain the validity of such factors' impacts on the systematic incentive effect, we consider the differences made between the Euro-continental and the Anglo-American corporate governance models regarding the law enforcement level, the degree of investors' right protection, and the corporate governance system's quality.

The remainder of this paper is organized as follow. In the next section, we briefly review research related to executive pay and specify our hypotheses regarding potential effects of institutional factors on executive pay. The section thereafter describes the data sources and the methodology that we use. Section 4 describes robustness checks, while Section 5 concludes.

2 THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

2.1 CEO pay theoretical foundations

There is a growing body of literature on CEO performance-based pay. There is, moreover, a large consensus that the economics of executive remuneration contracts are normally understood in the context of a principal-agent relationship whereby the manager experiences different incentives to the owner (Jensen and Meckling, 1976; Gregory-Smith, 2011). We can split the recent related studies into to two groups. The first group combines works that admit the orthodox (optimal contracting) of the agency approach to assess whether CEO pay is set by the board to wait on shareholders. Supporting the premises of the hegemony (self-serving) theory, the second group list together researches that argued that observed compensation contract deviate from the optimum and that this deviation is contingent on systematic firm performance primarily driven by exogenous market and industry related factors[1].

Amongst the first set of theoretical and empirical advancements in the understanding of the management based performance rewards' impacts on shareholder value, numerous studies have pointed out that observed compensations are optimally determined and respond likely to agency concerns. Measuring the magnitude of the pay-performance correlation has been the standard for good number of these researches for testing the ability of incentive contracts to enhance corporate profitability. The seminal representative study is that of Jensen and Murphy (1990). Whereas the authors have failed to find strong evidence of a pay response to performance[2], rival

[1] There are evidences that CEO pay is strongly and positively related to such factors. Researchers supporting these evidences have coined this relationship as relative performance evaluation, pay for luck, pay for sector performance, etc (Bertrand and Mullainathan, 2001; Garvey and Milbourn, 2003; 2006; Gopalan *et al*., 2010; Hoffmann and Pfeil, 2010).

[2] Jensen and Murphy (1990) find that the median wealth of a CEO rises by $3.25 when the value of the corporation increases by $1000 for a sample consisting of CEOs listed in the Forbes Executive Compensation Surveys.

studies conducted post the increase in equity based compensation of the 1990s find a much stronger relationship. These studies cover the U.S. (Hall and Liebman 1998; Core *et al*., 1999; Harford and Li, 2007; Zheng and Zhou, 2009; Jiménez-Angueira and Stuart, 2010, etc.), Canada (Zhou, 2000; Park *et al*., 2001; Craighead *et al*., 2004; Swan and Zhou, 2006; Chourou *et al*., 2008; Kalyta and Magnan, 2008; Geremia *et al*., 2010), France (Alcouffe and Alcouffe, 2000; Llense, 2010), the U.K. (Ozkan, 2009; Guest, 2009a; Conyon and Sadler, 2010; Voulgaris et *al*., 2010; Renneboog and Zaho, 2011), Allemande (Elston and Goldberg, 2003), Australia (Evans and Evans, 2001; Merhebi *et al*., 2006; Heaney *et al*., 2010), Japan (Abe *et al*., 2005; Kato and kubo, 2006), Chine (Conyon and He, 2011; Chen *et al*., 2011), Hong Kong (Cheung et *al*., 2005), Sweden (Oxelheim *et al*., 2010), Italy (Brunello et *al*., 2001), Denmark (Ericksson, 2000), Netherlands (Jansen *et al*., 2009), Slovenia (Gregoric *et al*., 2010), and Portugal (Fernandes, 2008).

A contrario, results from "neighbour" studies by Tosi *et al*. (2000) and Gabaix and Landier (2008) may seem surprising. The authors advocate that firm size accounts for more than 40% of the variance in total CEO pay while firm performance accounts for only less than 5% and that the 600% increase in CEO pay in US firms between 1980 and 2003 can be explained by the 600% increase in firm size.

The second set of works is consistent with the view that CEO pay outcome is far from being an agency problem solution and it may reflect an element of chance (Bertrand and Mullainathan, 2001) or managerial power (Bebchuk and Fried, 2003; 2004). This view goes further arguing that executives are rewarded for luck but not for performance. That is, CEOs seem to benefit from windfall earnings beyond their control. Bebchuk *et al*. (2006) argue this is likely to be most keenly observed in cases where pay sensitivity to macroeconomic influences is substantial. When this happen, pay arrangements are viewed as rewarding CEOs' failures rather than success. Consequently, modeling CEO compensation with reference to the principal-agent backgrounds may weaken or mislead shareholders' overcomes about reward for chance's dramatic impact on their wealth. Among researchers arguing against the assumptions that directors could resist the systematic influences and negotiate at arm's length with managers under the agency theory, we can mention Bertrand and Mullainathan (2001), Garvey and Milbourn (2003; 2006), Gopalan *et al*. (2010), Feriozzi (2011), Oyer (2004), Jiménez-Angueira and Stuart (2010), Chiu *et al*. (2011), Oxelheim *et al*. (2010), Oxelheim and Wihlborg (2003), and Oxelheim and Randoy (2005).

Bertrand and Mullainathan (2001) question the effectiveness of executive pay as an incentivizing mechanism. They show that pay for luck is as large as pay for general pay for performance; in other words, CEOs are rewarded as much to a lucky dollar as to a general dollar. Garvey and Milbourn (2003; 2006) argue that executives can set pay in their own interests; that is, they can enjoy pay for luck as well as pay for performance. Gopalan *et al*. (2010) and Chiu *et al*. (2011) point out that management can take advantage of lucky external events and dampen the effects of unlucky external events by taking strategic choices vis-à-vis the firm's performance relative to the industry's performance[3] or exchange rate and macroeconomic fluctuations. Oyer (2004) find that if managerial outside opportunities are positively related to wide industry movements, managers might receive a larger pay during an upswing simply because their participation constraints are more demanding. By considering implicit CEOs' incentives to avoid bankruptcy in a simple hidden action model, Feriozzi (2011) documents that luck cannot be filtered out of managerial pay. Jiménez-Angueira and Stuart (2010)'s study testing whether there is asymmetric use of IRPE and pay-for-luck that indicates CEO power over the compensation process suggests that CEO bonus compensation is more sensitive to industry-adjusted performance when the firm outperforms its industry benchmark and when the industry benchmark is positive. Oxelheim *et al*. (2010), Oxelheim and Wihlborg (2003), and Oxelheim and Randöy (2005) find macroeconomic influences on Swedish CEOs' compensation to be substantial.

In summary, it is striking to notice two interesting findings. First, as related literature mentioned, management rewards are sensitive to performance as well as to luck. Second, except of Oxelheim et *al*., (2010), all cited researches have focused on the U.S. setting. To make sure of the first finding's truth in other contexts, we propose our first hypothesis as follow:

Hypothesis 1: CEO pay is sensitive to firm's performance (specific incentive effect) as much as to luck (systematic incentive effect) even in non-U.S. countries.

2.2 Institutional features' impacts on management compensation structure and sensitivity to luck and performance

Drawing aspiration from La Porta *et al*.'s (1997) seminal models, a large stream of research has linked firm's financial decisions to institutional features. For example La Porta *et al*. (2000; 2006), Giannetti (2003), Bartram *et al*. (2009), Denis and McConnel (2003), Djankov et al. (2008) have established that legal characteristics affect presumably firm's decisions regarding dividend pay-out, capital structure, derivatives usage, financing, and ownership structure4. Nevertheless, issues on such features' impacts on management

[3] This is known as Relative Performance Evaluation (RPE).

[4] The reader is referred to Bryan *et al*. (2010) for a thorough review of legal system's effects on other firm's financial policies.

compensation design and international pay difference are scarce. To our knowledge, apart from Bryan et al. (2010; 2011), no other study has examined if or how institutional environment affects executive compensation. We extend Bryan et al.'s (2010; 2011) results by addressing whether law enforcement level, investors' right protection degree, and the corporate governance system's quality index are significant determinants of compensation structure and if international pay differences respond really to variations in these attributes' strength across countries. The following findings advocate why CEO compensation design and sensitivity to luck and performance are expected to depend on such attributes and differ across institutional environments.

2.3 Legal system

Legal rules commonly instituted at the national level or exercised within nations may contribute to between-countries management practices homogeneity (La Porta *et al*., 1997). Yet, cross national differences in legal systems may however breed within-countries corporate decisions heterogeneity. We base our hypothesis on the law and finance theory to explore the possibility that differences in national legal system can lead to differences in compensation structure. La Porta *et al*. (1997; 1998) provide undeniable evidence that most commercial law derives from one of two broad traditions: common law or civil law. The former is based on English tradition where laws are determined by judges. The latter relies more on statutes and comprehensive codes which are primarily articulated by legal scholars and governmental authorities. La Porta *et al*. (1998) contend that common law systems prevalent in Anglo-Saxon frameworks (such as U.S. and U.K.) provide significantly stronger protection shareholders' rights than do civil law ones (such as France). Greater protection of shareholders' rights protection has many financial and behavioural implications. First, La Porta *et al*. (2006) report that countries with stronger legal protection have more efficient stock markets, but smaller and narrower debt markets, make so much use of public equity, and rely more on equity based compensation to mitigate agency costs. Second, Ali and Hwang (2000) show a highly value relevance of accounting information amongst such countries that provides effective direct link between stock price and firm performance. Third, Bryan et *al*., (2010) point out that common law's nations are highly democratic and accept further compensation systems that reward individual talents and achievement. Fourth, Brenner and Schwalbach (2009, p. 3) argue that over the period 1995-2005, about 9 per cent to 10 per cent flaw of CEOs compensation in the common law countries have led to a positive pay gap relative to French civil law countries of about U.S. $150,000 per year. Accordingly, we hypothesize;

Hypothesis 2: In common law countries, CEO pay is more sensitive to firm's performance than to luck.

2.4 Shareholder rights protection

Under stronger shareholder rights, boards are more accountable for their actions. Shareholder rights are protected when shareholders are equipped with options that help them to more effectively exercise their control rights. These rights are enforced by public authorities such us courts or administrative agencies and differ presumably across jurisdictions. La Porta *et al*. (1997; 1998), Djankov *et al*. (2008), Spamann (2006), Brenner and Schwalbach (2009), and Bryan *et al*. (2010; 2011) have showed that shareholder protection is guaranteed within common law system nations. Bryan *et al*. (2010) have focused on how variation in shareholder rights protection affects managerial compensation structure. They found evidence that this institutional feature is the primary determinant of variation in equity mix for a sample of 381 non-US firms from 43 countries during the 1996-2000. Brenner and Schwalbach (2009) contend moreover, that the stronger anti-director rights of shareholders, the smaller is the risk-adjusted level of CEO pay. Still, they suggest that directors in countries with higher level of anti-director rights take their duty to achieve the best CEO compensation contract for shareholders more seriously. On the other hand, shareholder rights enforcement may encourage dutiful behaviour by executives and deter management self-serving practices. Hence, our third hypothesis reads as follows:

Hypothesis 3: CEO pay for performance (for luck) is positively (negatively) related to shareholder rights protection level.

2.5 Corporate governance quality

Several pundits have recognized the potential impact of corporate governance on firm's financial decisions and choices. Concerning CEOs pay decisions, there has been an admitted consensus regarding the positive link between corporate governance and managerial compensation design. For example, the extant literature has established that equity-based reward is related to compensation committee quality (Sun and Cahan, 2009; Gregory-Smith, 2011), board independence (Chourou *et al*., 2008; Ozkan, 2007; Faleye, 2011), institutional ownership (Hartzell and Starks, 2003; Gallagher *et al*., 2006), voluntary corporate disclosure (Beyer *et al*., 2010), compensation consultants (Murphy and Sandino, 2010; Cadman *et al*., 2010; Voulgaris *et al*., 2010), say on pay (Dew-Becker, 2009; Conyon and Sadler, 2010; Ferri and Maber, 2009). External aspects of corporate governance, such as regulatory environment or the market for CEO talent, influence also both the level and composition of executive compensation (Sapp, 2008; Geremia *et al*., 2010; Chalevas, 2011; Cremers and Grinstein, 2011). Internal and external corporate governance-related factors have moreover, effects on the association between CEOs pay and firm's performance. Related empirical literature is full of stories suggesting too low pay-performance sensitivity in presence of governance failures. In their influential papers, Bertrand and Mullainathan (2001) and Garvey and Milbourn (2003; 2006) find that in poorly governed firms[5], managers are not compensated in line with their performance; that is, they can enjoy pay for luck. Minnick *et al*. (2010) and Feriozzi (2011) contend however, that pay-for-performance sensitivity is higher within well governed firms. Supporting these assertions, we develop our fourth hypothesis as follow:

Hypothesis 4: Well governed firms reward their CEO more for performance than for luck.

3 RESEARCH DESIGN AND METHODOLOGY

In this section, we describe our data, provide our variables' outline, and ultimately lay out our empirical methodology.

3.1 Sample selection and data source

This study aims shed light on whether institutional environment features may influence CEO pay structure and efficiency. To reveal such influence, we consider the distinction made between the Anglo-American and Euro-Continental corporate governance models. Hence, we select a sample of U.S. and Canadian firms as to represent the former and a group of U.K. and French firms as to refer to the latter.

Our starting target sample covers a random group of 100 U.S. companies from S&P 500 index, all U.K. listed firms of the FTSE 100 index, all Canadian companies of TSX100 index, and all firms of SBF 120 index. The discarding procedure, either because of incomplete needed information for the period under analyses which covers years from 2004 to 2008, or because of insufficient number of observations per sector, left us with seventy-five firms in each country. All selected firms are shared out their corresponding industries using the Fama-French 12 industry classification[6].

Needed information is hand collected from various sources. For U.S. firms, data on executives' compensation, ownership structure, board and CEO characteristics are collected from DEF 14A proxy statement reports available on the SEC files and download from the EdgarScan's website (edgarscan.com). Financial and accounting firm's characteristics come from the 10K annual reports contained in the same database. For the Canadian firms set, data on CEO pay, ownership and corporate governance are provided by the firms' proxy circulars available from the System for Electronic Document Analysis and Retrieval (SEDAR) database. Data on French observations are exhausted from various sources such as the Expansion, the Financial Market Authority, and the Euronext websites. Data on the U.K. firms are exclusively collected from their websites[7]. Shareholder right protection indices are provided by the World Bank Doing Business (2008)'s report.

3.2 Variables selection and measurement

Our dependent variable is measured by the natural logarithm value of cash and equity-based compensation for the CEO. This logarithm procedure mitigates heteroskedasticity resulting from extreme skewness. Cash compensation is base salary and bonus. Equity-based compensation is computed as (stock price) × (the member of newly granted shares) + (stock price) × (option delta) × (the number of newly granted stock options).

We emphasize the effects of institutional factors on executives' compensation design and sensitivity to performance and luck. However, the management pay's academic and practitioner related literature has suggested a number of economic determinants for CEO compensation. Hence, we include a set of firm's (performance, size, growth opportunities, and specific risk) and CEO (managerial horizon, tenure, and ownership) characteristics to our models as additional explicative variables to facilitate the comparison of our results with previous studies. Table 1 provides a summary of the measurements for all the variables and their predicted signs in the regressions.

[5] Are firms with concentrated ownership structure, higher entrenched managers, smaller boards, and lower fraction of outside directors.

[6] The Fama/French 12 industry classification is: Consumer Non-durables, Consumer Durables, Manufacturing, Energy, Chemicals, Business Equipment, Telecommunications, Utilities, Shops, Healthcare, and Other. Authors' definitions for these groupings are accessible from Kenneth R. French's website http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data Library/det_12_ind_port.html. The distribution of the sample firms by industry is available from the authors.

[7] Since 2003, listed U.K. companies are required to establish a transparent disclosure for developing policies on executives' compensation and corporate issues allowing to more detailed analyses.

Table1: Variables definition and their predicted effects on executives' pay

Variable	Label	Predicted effect	Definition
CEOs compensation	COMP		Natural log of cash and equity-based compensation for CEO
Institutional factors			
Legal system's origin	LEG	+/-	Equal to 1 if common law, 0 otherwise
Shareholder right protection	SPI	+/-	Shareholder Protection Index from the world bank doing business (2008) report
Corporate governance quality	G-Ind	+/-	Corporate governance index*
Systematic chocks			
Firm's to industry relative performance variation	IRPE	+	Variation in the firm's economic performance relatively to mean industry's economic performance evaluation
Firm's to market relative performance variation	MRPE	+	Variation in the firm's economic performance relatively to mean market's economic performance evaluation
Firm and CEO characteristics			
Firm performance	PER	+	Total shareholder return TSR
Firm size	SIZE	+	Total assets in logarithm
Growth opportunities	GROW	+	Market to book ratio ((market value of equity+ book value of debt)/total assets)
Firm specific risk	RISQ	+	Total risk less systematic risk, where the latter is estimated using the market model
CEO tenure	TEN	-	Number of years since the CEO is in position
CEO ownership	OWN	-	% of common share owned by the CEO
CEO age	AGE	+	CEO age in years

*Note; * This index assigns a value of 1 if the firm meets the threshold level to each of these attributes; chairman and CEO positions are separated, nominating and compensation committees are composed solely of independent outsiders, board meet at least twice time annually, at least the CEO serves on the board of one of other public firms, board is controlled by more than 50% grey directors, and CEO don't serves as a member neither in the nominating committee, nor in the compensation committee.*

3.3 Models

To test the first hypothesis, we should estimate two sets of models. The first one allows us to estimate the general sensitivity of pay to performance whereas the second is used to estimate the sensitivity of pay to luck. The first model is an OLS regression with firm and time fixed effects and can be developed as follows:

$$COMP_{it} = \alpha + \beta*Perf_{it} + \chi_i + \gamma_t + \delta_x*X_{it} + \varepsilon_{it} \quad \text{(Eq.1)}$$

where $COMP_{it}$ is the CEO's cash and equity-based compensation in firm *i* at time *t*; $Perf_{it}$ is the total shareholder return; χ_i are firm fixed effects; γ_t are time fixed effects, X_{it} are firm, CEO and institutional characteristics, and β is an estimator to capture the (global) pay-performance link.

The second model helps estimating the sensitivity of pay to luck, that is unobserved chocks that may cause performance. The most popular way to deal with unobserved causality is to use an Instrumental Variables (I.V.) approach. To do so, we should identify a valid instrument for the performance measure and estimate model (1) using two-stage least squares (2SLS). Hence, we estimate as a first stage this equation:

$$Perf_{it}= \eta*Chock_{it} + \alpha_x X_{it} + y_i + z_t + e_{it} \quad \text{(Eq.2)}$$

where, $Chock_{it}$ represents the instrument for luck[8]. In the second stage, 2SLS estimates are obtained by regressing COMP on the predicted values of Perf, computed using the parameters from the first-stage regression:

$$COMP_{it}=\alpha+\beta_{luck}*P\hat{e}rf_{it}+\delta_f*F_{it}*P\hat{e}rf_{it}+ \chi_i + \gamma_t + \delta_x*X_{it} + \varepsilon_{it} \quad \text{(Eq.3)}$$

[8] There are two important characteristics that Chock must have to be a valid instrument. First, it should be sufficiently correlated with Perf, so we expect η≠0. Second, Chock should be uncorrelated with e, in other words, E[Chock, e] = 0. The insight here is that Chock should not have its own direct influence on COMP and therefore not be an omitted variable in Equation (1).

The estimated coefficient β_{luck} captures pay sensitivity to performance that comes from luck (incentive systematic effect), and F is a vector of the institutional factors. We include industry dummies per the Fama-French 12 industry classification to each of the three above models.

4 EMPIRICAL RESULTS AND ROBUSTNESS CHECKS

4.1 Descriptive statistics

Table 2 provides the descriptive statistics for the variables in the regression analysis. In panel A, we observe that the mean (median) cash and equity based compensation of the American and Canadian chief executive officers, is 6807.195 U.S. million dollars (5904.305 U.S. million dollars). These figures are much higher in comparison with their counterpart levels in France and U.K. The mean (median) French and British CEOs compensation is 3890.541 U.S. million dollars (2630.268 U.S. million dollars). The statistics show however, significant dissimilarities between the two sub-sample specially regarding the institutional features. On the one hand, it is noteworthy that the Anglo-American framework safeguards shareholder interests more than the Euro-Continental one. Panel A proves a mean (median) value of shareholder protection index of 6.01 (5.47). Panel B indicates however, values of 4.51 (4.06) which are remarkably lower. On the other hand, U.S. and Canadian settings show higher level of corporate governance indices when compared to their British and French peers. Moreover, American and Canadian firms are significantly much larger, exhibit higher growth opportunities levels, incur less specific risk, and perform well. Notably, French and British CEOs hold relatively much shares (23.3%) and have larger tenure (11 years). T-statistics for mean differences and Wilcoxon z-scores for median differences confirm these findings. In fact, univariate difference tests reveal highly significant T-statistics and z-statistics coefficients[9].

Pearson correlation matrices show significant pair wise correlations between some explanatory variables. First, the origin of legal system is highly positively correlated to CEO pay, to shareholder protection index as well as to governance index (panel A) suggesting that firms from common law countries use greater amount of cash and equity based compensation, provide greater protection of shareholder rights, and support well qualified corporate governance tools. Indeed, the significant correlation between these variables is noteworthy. These univariate links approve, a priori, Bryan *et al.*'s (2010, 2011) results of the legal system's positive impacts on the executive compensation's equity mix. Second, executive pay is positively correlated with firm size and performance showing that incentive policies are widely used in large and healthy firms. Two main reasons may explain this finding: (1) large firms are more likely to hire higher talented managers who can claim and justify higher compensation and (2) companies with higher performance may also offer higher executive compensation to further improve their performance**.** These correlations parallel the ones obtained by Conyon *et al*. (2010) who find that size and performance explain by about 37.7% and 28.1% of CEO incentives gap between large and small firms. Third, we don't record any association between management reward and CEO characteristics. Fourth, contrary to the U.S.-Canadian group of firms, we note from panel B that there is no significant link between executive compensation and any of the institutional factors. Unless, shareholder right protection and governance quality are highly correlated. We note moreover, a highly positive link between CEO ownership and top executives compensation within the British-French case. The other statistics are comparable to those obtained by similar researches dealing with the economic determinants of management incentives.

[9] For the sake of brevity, the results of these tests are not reported here. Nevertheless, they are available from the authors under request.

Table 2: Descriptive statistics and Pearson correlations

Variable	Mean	Median	1	2	3	4	5	6	7	8	9	10	11	12	13
Panel A: U.S.-Canadian sub-sample															
1.COMP	3.83	3.77	1												
2.LEG	1	-	**.18**	1											
3.SPI	6.01	5.47	**.36**	**.19**	1										
4.G-Ind	4.38	3.79	**.28**	**.11**	**.09**	1									
5.IRPE	0.103	0.07	.13	.02	.01	.03	1								
6.MRPE	0.141	0.103	.21	.01	.00	.03	**.31**	1							
7.PER	0.271	0.208	**.11**	.01	**.01**	**.07**	**.17**	.03	1						
8.SIZE	11.45	10.39	**.08**	.06	.04	.01	.10	.01	.07	1					
9.GROW	1.71	1.37	.1	.05	.01	.01	.02	.11	.10	.21	1				
10.RISQ	0.033	0.021	**.21**	.02	.01	.02	-.01	.00	.01	.05	.00	1			
11.TEN	9.816	8.039	.09	.01	**-.21**	-.16	.04	.01	.00	.01	.01	.01	1		
12.OWN	0.114	0.093	.01	.01	-.13	-.11	.01	.03	.00	.05	.01	-.1	**.20**	1	
13.AGE	57.97	54.62	.00	.01	.00	.05	.01	.03	.00	.01	.01	.00	**.11**	**.10**	1
Panel B: U.K.-French sub-sample															
1.COMP	3.59	3.42	1												
2.LEG	0.53	0.37	.01	1											
3.SPI	4.51	4.06	.01	.01	1										
4.G-Ind	4.09	3.37	.03	.00	**.11**	1									
5.IRPE	0.111	0.087	**.07**	.00	.09	.03	1								
6.MRPE	0.107	0.076	**.02**	.00	.03	.03	.09	1							
7.PER	0.173	0.161	.05	.01	.01	**.02**	.03	.07	1						
8.SIZE	8.39	8.07	.10	.01	.01	.01	.01	.02	**.05**	1					
9.GROW	1.19	0.093	.10	.00	.05	.01	.01	.01	.02	.01	1				
10.RISQ	0.051	0.037	.05	.04	.00	.00	-.01	-.1	.01	-.1	-.1	1			
11.TEN	11.101	9.037	.01	.01	-.01	**-.10**	.00	.00	.00	.01	.00	.00	1		
12.OWN	0.233	0.175	**.10**	.01	-.10	**-.01**	.00	.01	.01	.01	.01	-.1	**.01**	1	
13.AGE	59.13	56.83	.05	.01	.01	.01	.00	.01	.00	.01	.00	.01	**.05**	.1	1

This table presents the univariate analysis of the CEO's compensation as well as firms and institutional characteristics of our sub-samples. Panel A (B) shows results for U.S.-Canadian (U.K.-French) sub-sample. Pearson correlations for each sub-sample appear respectively below the principal diagonal of the correspondent panel. Variable descriptions and measurement are provided in Table 1. Bold numbers indicate significance at the 1% one-tailed level or better.

4.2 Regression results

The generalized and separated estimation results for the three sets of models are reported in Tables 3 and 4. Table 3 reports the results of our test of global sensitivity of pay to performance, where performance measure is the total shareholder return. The first column shows the results of estimating Eq. (1) using the overall observations. The second and the third columns point out results using sub-sample observations. Models (1a), (2a), and (3a) include the full independent variables whereas models (1b), (2b), and (3b) control only for performance and institutional factors. In all specifications, the coefficients for the firm's performance are significantly positive indicating that the incentive effect is supported. The magnitude of this effect ranges between 21% and 39% showing that shareholder wealth rises by nearly one quarter to one third points when the three highest paid top executives' cash and equity based compensation increases by one per cent point. This positive sensitivity of pay to performance is in line with optimal contracting orthodox of the agency approach. It is noteworthy that the performance's estimated coefficients are larger in the U.S.-Canadian specification suggesting that executives' incentives wait more on American and Canadian shareholders than on British and French ones. The coefficient for shareholder protection provides strong evidence of positive associations between the strength of investor rights and the relative use of incentive compensations. The hypothesized effect of law enforcement quality on executives' pay is exclusively hold for the U.S.-Canadian sub-sample. The sign and magnitude of this effect are similar to those reported by Bryan *et al*. (2010).

Corporate governance quality has also a significant positive impact on CEO compensation. This impact is notably larger in specifications (2b) and (3b). The coefficient for firm size is significantly positive confirming univariate analysis that executive pay is positively impacted by firm size. This coefficient is in turn greater than that of growth opportunities in all models. This difference indicates that although market-to-book ratio has a positive impact on pay, firm size has a relatively larger impact.

Concerning the remainder estimations, the coefficients for the CEO tenure and ownership are the most noteworthy. The regression estimates of model (3a) show a significant monotone association between the tenure in the CEO position and the top three executives' cash and equity based compensation. The coefficient is economically important (0.139) implying that an increase in the CEO's tenure by one year will increase executives' rewards by roughly 14%. This finding stands in line with the previous evidence of Nourayi and Mintz (2008). Moreover, the estimate for the CEO ownership is positive and statistically significant at the 1% level. This is may be consistent with the managerial power approach contending that powerful CEO may influences the pay process to his own interest.

To further thin the impact of contextual features on executives' pay, we include interactive variables that are equal to the shareholder wealth multiplied by each of the three institutional features, that is ($TSR_{it} \times LEG_{it}$), ($TSR_{it} \times SPI_{it}$), and ($TSR_{it} \times G\text{-}ind_{it}$). Unreported results keep constant the previous findings; all interactive terms are positive and statistically significant (notably for the full and U.S.-Canada sample based regressions).

Table 3: Results of OLS regression analysis of pay-to-performance sensitivity

Variable	Model (1): Full sample (N=1500)		Model (2): U.S.-Canadian subsample (N=750)		Model (3): U.K.-French subsample (N=750)	
	Model (1a)	Model (1b)	Model (2a)	Model (2b)	Model (3a)	Model (3b)
Intercept	0.058** (2.2)	0.027*** (2.65)	0.019*** (2.87)	0.024*** (3.06)	0.097** (2.49)	0.035*** (3.44)
Perf	0.388* (1.8)	0.37* (1.64)	0.251** (2.26)	0.299** (2.31)	0.217** (2.09)	0.236** (1.96)
LEG	0.021* (1.63)	0.03* (1.81)	0.105*** (3.01)	0.113*** (2.24)	0.044 (0.96)	0.053 (0.83)
SPI	0.018* (1.31)	0.021** (1.96)	0.037** (2.01)	0.041** (2.11)	0.022 (0.91)	0.026* (1.63)
G-Ind	0.011** (2.41)	0.016** (2.5)	0.027** (2.32)	0.031*** (2.73)	0.017* (1.89)	0.023** (2.56)
SIZE	0.105** (2.03)		0.211** (2.15)		0.177** (2.01)	
GROW	0.091* (1.87)		0.119** (1.96)		0.095* (1.83)	
RISQ	0.047 (0.91)		0.031* (1.81)		0.019 (1.1)	
TEN	-0.121* (-1.76)		-0.1 (1.27)		-0.139** (-1.96)	
OWN	-0.201 (-0.87)		-0.191* (-1.64)		0.217*** (2.87)	
AGE	0.091 (1.03)		0.085 (1.31)		0.107* (1.8)	
Adjusted R^2	0.301	0.498	0.393	0.579	0.377	0.435

*This table shows coefficients from the OLS full and separated regression of the CEO pay against shareholder return, firm and CEO characteristics, and institutional factors. Parameter estimates appear first and standard errors appear in parenthesis. All models include complete sets of time and industry dummy variables. Variables are as defined in Table 1. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% one tailed levels or better respectively.*

Table A of the Appendix summarizes estimation results of Eq. (2). Remind that the premise of this equation is to check firm performance sensitivity to exogenous systematic pressures. That is, we have to decompose the predicted performance into its 'real' part, which is taken cover of these pressures; and its 'problematic' part, which is potentially endogenous them. Two interesting observations emerge from the regression estimates where shareholder wealth is the dependent variable. First, we find that shareholder return is increasing in the firm's to industry relative economic performance evaluation and firm's to market relative economic performance variation. These interactions show that variations in both relative performance evaluations are strong instruments for unobservable chocks. Second, firms perform well when growth opportunities are positively expected, but worst when specific risk is higher and manager is powerful.

To test for the hypothesized systematic incentive effect, we perform the second stage of the instrumental variables (I.V.) technique. In this stage, 2SLS estimates are obtained by regressing executives' pay using the predictable changes in performance due to luck (Pêrf) computed from the first stage. Estimated results appear in Table 4. From this table, we remarkably note two striking findings. On the one hand, CEO compensation is positively sensitive to luck. The coefficients for shareholder adjusted return are significantly positive approving that managers are potentially rewarded for performance beyond their control. Hence, we support our first hypothesis. It is noteworthy, but not surprising, that firm adjusted performance coefficients are clearly much smaller in the U.S.-Canadian sub-sample based regressions showing that firms in these settings reward less for luck than do their peers in the U.K.-French frameworks. On the other hand, the coefficients for the interaction between adjusted performance and institutional variables are significantly negative meaning that contextual factors have moderate effects on the sensitivity of pay-to-luck. The coefficient for the legal system-adjusted shareholder return interaction term is (-0.194) suggesting that the systematic incentive effect may be mitigated by until one fifth point when law enforcement quality is sustained. Shareholder right protection and governance index exert also significant moderate effects on the pay sensitivity to luck. These effects are much conspicuous for the U.S.-Canadian subsample based regressions. Taken together, these results find straightforward evidence that systematic incentive effect is more moderate in well governed firms or in those providing strong protection of shareholder rights. This effect is moreover, less important within nations of common law system. Thus, we support our expectations regarding the impacts of the specific Anglo-American and Euro-Continental institutional features on CEO pay sensitivity to luck. Indeed, we rely on previous evidences of pay-for-luck (Bertrand and Mullainathan, 2001; Garvey and Milbourn, 2003; 2006) and pay-for- firm relative performance (Farmer *et al.*, 2010; Gopalan *et al.*, 2010; Jiménez-Angueira and Stuart, 2010).

Table 4: Results of 2SLS regression analysis of pay-to-luck sensitivity

Variable	Model (1): Full sample (N=1500)	Model (2): U.S.-Canadian subsample (N=750)	Model (3): U.K.-French subsample (N=750)
Intercept	0.029** (1.96)	0.031** (2.08)	0.047** (2.21)
Pêrf	0.317** (2.11)	0.273*** (2.6)	0.375** (2.31)
LEG* Pêrf	-0.117* (-1.73)	-0.194*** (-3.39)	-0.101* (-1.76)
SPI* Pêrf	-0.201** (-2.27)	-0.270*** (-2.96)	-0.159** (-1.96)
G-Ind* Pêrf	-0.187* (-1.89)	-0.237** (-2.01)	-0.212** (-2.27)
SIZE	0.513* (1.77)	0.308* (1.81)	0.271* (1.88)
GROW	0.317 (1.21)	0.405* (1.7)	0.273 (0.83)
RISQ	0.083 (1.01)	0.117* (1.72)	0.091 (0.82)
TEN	-0.076* (-1.8)	-0.095* (-1.89)	-0.107** (-2.11)
OWN	-0.069* (-1.71)	-0.053 (-0.48)	-0.097** (-2.31)
AGE	0.04 (0.57)	0.034 (1.33)	0.041* (1.73)
Adjusted R^2	0.371	0.596	0.479

*This table shows coefficients from the 2SLS full and separated regression of the CEO pay against shareholder adjusted return, firm and CEO characteristics, and firm performance-institutional factors interaction terms. Parameter estimates appear first and standard errors appear in parenthesis. All models include complete sets of time and industry dummy variables. Variables are as defined in Table 1. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% one tailed levels or better respectively.*

4.3 Sensibility analyses

To check for robustness of our results against the unspecified nature of luck, we refer the above tasks after controlling for the luck nature. Hence, we split each subsample into two groups of firms. We restrict the first group to just those observations for which the variation in the firm's to industry relative economic performance evaluation and/or the variation in the firm's to market economic performance evaluation is negative (bad luck). Similarly, we restrict the second group to just those observations for which the variation in these instruments is positive (good luck)[10]. We define $Perf^{(-)}$ and $Perf^{(+)}$ as to refer to the respectively impacts of these specifications on shareholder return. Check results are shown in Table 5. Such results could normally help us to test whether pay is similarly sensitive to good luck as to bad luck. We note from this table that the most coefficients of the $Perf^{(+)}$ variable are significantly positive showing that executives' pay rises presumably when systematic chocks are favourable. Moreover, we view that the pay-$Perf^{(+)}$ links are much reliable in the U.S.-Canadian sub-sample based estimations than in those ruled on the U.K.-French settings. Unless, the estimation outputs point out that pay-sensitivity to bad luck is statistically insignificant. Surprisingly, the coefficients for the $Perf^{(-)}$ variable are positive and significantly different from zero in both models meaning that there is no observable constraining significant effect of downward systematic pressures on CEOs payment. That is, managers are not penalized when the market is unfavourable. This finding meets Garvey and Milbourn's (2006) asymmetry pay-for-luck thesis which asserts a significantly less CEOs pay for luck when luck is down than when it is up.

The estimated interaction links provide strong support for the moderated impacts of the institutional variables on the systematic incentive effect when luck is positive. Unless, these absorbed impacts disappear when luck turns to be negative. The results for firm and CEO characteristics are presumably similar to those explored above and are conform to evidences of comparable studies.

[10] Separating each subsample into two groups has also the advantage of not constraining the coefficients on the performance control variables to be the same across the two groups of firms.

Table 5: Robustness check results

Variable	Model (1): U.S.-Canadian subsample (N=735)		Model (2): U.K.-French subsample (N=670)	
	Model (1a)	Model (1b)	Model (2a)	Model (2b)
Intercept	0.013* (1.87)	0.01** (1.99)	0.093* (1.83)	0.011* (1.78)
$Perf^{(+)}$	0.273** (2.13)		0.362*** (2.89)	
$Perf^{(+)}$*LEG	-0.175** (2.07)		-0.106 (1.18)	
$Perf^{(+)}$*SPI	-0.319*** (3.01)		-0.211* (1.81)	
$Perf^{(+)}$*G-Ind	-0.201** (1.96)		-0.167** (2.21)	
$Perf^{(-)}$		0.171** (2.37)		0.202** (2.04)
$Perf^{(-)}$*LEG		-0.071 (0.34)		-0.056 (0.51)
$Perf^{(-)}$*SPI		-0.101 (1.11)		-0.117 (0.48)
$Perf^{(-)}$*G-Ind		-0.19 (0.37)		-0.214 (1.01)
SIZE	0.316** (2.27)	0.271** (2.1)	0.219* (1.83)	0.231* (1.88)
GROW	0.121* (1.78)	0.103* (1.8)	0.107* (1.76)	0.095 (1.34)
RISQ	0.099* (1.88)	0.067* (1.81)	0.084** (2.31)	0.078** (2.2)
TEN	-0.074 (0.32)	-0.058* (1.78)	-0.077* (1.8)	-0.069* (1.86)
OWN	-0.091 (0.11)	-0.059 (1.21)	-0.071** (1.96)	-0.073** (2.03)
AGE	0.068* (1.73)	0.07 (1.35)	0.051* (1.83)	0.066* (1.88)
Adjusted R^2	0.561	0.483	0.601	0.535

*This table displays test sensibility results. $Perf^{(+)}$ measures the positive variation in the firm's to industry relative economic performance evaluation and/or the variation in the firm's to market economic performance evaluation. $Perf^{(-)}$ measures the positive variation in the firm's to industry relative economic performance evaluation and/or the variation in the firm's to market economic performance evaluation. Results on full sample estimations are suppressed for expositional convenience. Parameter estimates appear first, and standard errors appear in parenthesis. All models include complete sets of time and industry dummy variables. Variables are as defined in Table 1. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% one tailed levels or better respectively.*

5 CONCLUSION

The suitability of executive compensation and incentives continues by academics, media, and practitioners. Nonetheless, some affiliated questions remain unanswered. The premise of this paper is to address the followings; Are CEOs rewarded for luck? Do institutional features matter for CEOs pay for luck? How does systematic incentive effect sensitive to luck's nature?

By answering these questions, we attempt several contributions to the management pay literature. Our first contribution is to extend this literature by investigating still not sufficiently investigated research fields. To do so, we tackle the Anglo-American and the Euro-Continental corporate governance areas. Numerous contextual factors differ across these frameworks and may presumably explain the remarkable differences in executive pay between them. From these factors we select the legal system's origin, the shareholders' rights protection, and the corporate governance quality. Links between these features and firms' financial decisions have been largely studied. Nevertheless, their impacts on CEO pay structure and sensitivity to performance and systematic chocks are not still explored. Revealing these impacts forms our second contribution. Our last contribution is to approve the asymmetric character of the systematic incentive effect using instruments for luck not rounded up before.

Taken together, several results from the paper provide answers to the above questions and stand out as new or important. We find that the answers for to the two first questions are a surrounding yes. On the one hand, instrumental variables estimators show that the coefficients for the adjusted (to luck) shareholder return are significantly positive showing that CEOs, in both settings, are potentially rewarded for luck. That is, for systematic chocks beyond their control. Per sub-sample analysis clarify that Anglo-American managers benefit more from luck than their European peers. On the other hand, we provide evidence that the selected institutional factors are the primary determinants of pay intensity and sensitivity to performance and to luck. Especially, we find that CEO pay to performance elasticity is positively associated with the strength of shareholder rights, the quality of corporate governance tools, and the level of law enforcement. Pay to luck sensitivity is however, significantly strong within nations where these features are less sustained. Consequently, we support the two agency approach's orthodox previously claimed by Bertrand and Mullainathan (2001); well governed firms fit the predictions of the contracting view whereas, poorly governed ones fit those of the skimming view.

By discerning favourable exogenous chocks (good luck) from unfavourable ones (bad luck), we agree Garvey and Milbourn's (2006) and Gopalan *et al.*'s (2010) pay for luck asymmetry theses; executive are rewarded for good luck while they are insulated from bad luck. Or, otherwise, CEO pay-setting process involves 'carrots' (rewards for high performance), rather than 'sticks' (punishment for poor performance).

Even though our findings answer the above addressed questions, other CEO pay determinants are still to be decided. Further researches are needed in order to have a full understanding of some of these determinants.

As further directions, future studies should highlight the impacts of cultural, ethical, and political countries specific factors on the management compensation contracts design and efficiency.

APPENDIX

Table A: Results of the first stage of the instrumental variables (I.V.) estimation approach

Variable	Model (1): Full sample (N=1500)		Model (2): U.S.-Canadian subsample (N=750)		Model (3): U.K.-French subsample (N=750)	
	Model (1a)	Model (1b)	Model (2a)	Model (2b)	Model (3a)	Model (3b)
Intercept	0.068* (1.67)	0.051* (1.88)	0.077** (2.01)	0.056* (1.89)	0.039** (1.96)	0.045* (1.68)
IRPE		0.135*** (3.39)		0.71** (2.46)		0.644*** (3.14)
MRPE	0.41** (2.26)		0.56** (2.00)		0.77*** (2.88)	
SIZE	0.031 (1.01)	0.023 (0.86)	0.019* (1.81)	0.011* (1.89)	0.027 (1.33)	0.03* (2.11)
GROW	0.053 (1.22)	0.047* (1.88)	0.071** (1.96)	0.059** (2.11)	0.037* (1.89)	0.028* (1.9)
RISQ	-0.049* (1.81)	-0.031* (1.81)	-0.017** (1.96)	-0.022* (1.88)	-0.037** (2.07)	-0.044** (2.13)
TEN	0.001 (1.21)	0.001 (1.01)	0.01 (0.86)	0.018 (0.91)	0.022* (1.86)	0.019 (1.31)
OWN	-0.02* (1.87)	-0.017 (1.33)	-0.023* (1.8)	-0.027** (1.96)	-0.036*** (2.87)	-0.041*** (3.08)
AGE	-0.001 (0.83)	0.007 (0.76)	-0.011 (1.11)	-0.009 (0.53)	0.017 (1.01)	0.011 (1.27)
Adjusted R^2	0.173	0.131	0.27	0.249	0.314	0.298

*This table shows coefficients from the I.V. estimation of the firm performance sensitivity to luck due to unobserved chocks. Variation in the firm's to industry relative economic performance evaluation and variation in the firm's to market economic performance evaluation are used as instruments for luck. Dependent variable is shareholder total return. Parameter estimates appear first and standard errors appear in parenthesis. All models include complete sets of time and industry dummy variables. Variables are as defined in Table 1. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% one tailed levels or better respectively.*

REFERENCES

Abe, N., Gaston, N., & Kubo, K., (2005). Executive pay in Japan: the role of bank appointed monitors and the main bank relationship. *Japan and the World Economy*, 17, 371–394.

Alcouffe, A., & Alcouffe, C., (2000). Executive compensation setting practices in France. *Long Range Planning*, 33 (4), 527-543.

Ali, A., & Hwang, L., (2000). Country specific factors related to financial reporting and the value relevance of accounting data. *Journal of Accounting Research*, 38, 1-21.

Bartram, S., Brown, G., & Fehle, F., (2009). International evidence on financial derivatives usage. *Financial Management*, 38, 185-206.

Bebchuk, L.A., & Frield, J.M., (2003). Executive compensation as an agency problem. *Journal of Economic Perspective*, 17, 71-92.

Bebchuk, L.A., & Frield, J.M., (2004). Pay without performance; the unfulfilled promise of executive compensation. Harvard University Press.

Bebchuk, L.A., Grinstein, Y., & Peyer, U., (2006). Lucky CEOs. NBER Working Paper Series.

Bertrand, M., & Mullainathan, S., (2001). Are CEOs rewarded for luck? The ones without principals are. *The Quarterly Journal of Economics*, 116 (3), 901-932.

Beyer, A., Cohen, A., D., Lys, Z., T., & Walther, R., B., (2010). The financial reporting environment: Review of the recent literature. *Journal of Accounting and Economics*, in press.

Brenner, S., & Schwalbach, J., (2009). Legal institutions, board diligence, and top executive pay. *Corporate Governance: An International Review*, 17 (1), 1-12.

Brunello, G., Graziano, C., & Parigi, B., (2001). Executive compensation and firm performance in Italy. *International Journal of Industrial Organization*, 19 (1-2), 133-161.

Bryan, S., Nash, R., & Patel, A., (2010). How the legal system affects the equity mix in executive compensation. *Financial Management*, spring 2010, 393-418.

Bryan, S., Nash, R., & Patel, A., (2011). Law and executive compensation: a cross-country analysis. *Applied Corporate Finance*, 23 (1), 84-91.

Cadman, B., Carter, E., M., & Hillegeist, S., (2010). The incentives of compensation consultants and CEO pay. *Journal of Accounting and Economics*, 49, 263-280.

Chalevas, G., C., (2011). The effect of the mandatory adoption of corporate governance mechanisms on executive compensation. *The International Journal of Accounting*, 46, 138-174.

Chen, J., Ezzamel, M., & Cai, Z., (2011). Managerial power, tournament theory and executive pay in China. Working paper. Cardiff University.

Cheung, Y., Stouraitis, A., & Yong, A.W.S., (2005). Ownership concentration and executive compensation in closely held firms: evidence from Hong Kong. *Journal of Empirical Finance*, 12, 511-532.

Chiu, H., S., Oxelheim, L., & Wihlborg, C., (2011). Exchange rate and macroeconomic fluctuations as sources of luck in CEO compensation. SSRN working paper, abstract=1928959.

Chourou, L., Abaoub, E., & Saadi, S., (2008). The economic determinants of CEO stock options compensation. *Journal of Multinational Financial Management*, 18, 61-77.

Conyon, M., & He, L., (2011). Executive compensation and corporate governance in China. *Journal of Corporate Finance*, 17, 1158-1175.

Conyon, M., J., Peck, S., I., & Sadler, G., V., (2009). Compensation consultants and executive pay: Evidence from the United States and the United Kingdom. *Academy of Management Perspectives*, 23 (1), 43-55.

Conyon, M., & Sadler, G., (2010). Shareholder voting and directors' remuneration report legislation: say on pay in the UK. *Corporate Governance: An International Review*, (18) 4, 296-312.

Core, J., Holthausen, R., & Larcker, D., (1999). Corporate governance, chief executive officer compensation, and firm performance. *Journal of Financial Economics*, 51 (3), 371-406.

Craighead, J., Magnan, M., & Thorne, L., (2004). The impact of mandated disclosure on performance-based CEO compensation. *Contemporary Accounting Research*, 21 (2), 369–398.

Cremers, M., & Grinstein, Y., (2011). The Market for CEO Talent: Implications for CEO Compensation. SSRN Working paper, available at: http://ssrn.com/abstract=1108761.

Denis, D., & McConnell, J., (2003). International corporate governance. *Journal of Financial and Quantitative Analysis*, 1 (1), 1-36.

Dew-Becker, I., (2009). How Much Sunlight Does it Take to Disinfect a Boardroom? A Short History of Executive Compensation Regulation in America. *CESifo Economic Studies*, 55 (3-4), 434–457.

Djankov, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A., (2008). The law and economics of self-dealing. *Journal of Financial Economics*, 88, 430-465.

Elston, J. A., & Goldberg, L. G., (2003). Executive compensation and agency costs in Germany. *Journal of Banking and Finance*, 27, 1391-1410.

Eriksson, T., (2000). What determines managers pay? Evidences from Denmark. *Long Range Planning*, 33 (4), 544-559.

Evans, R., & Evans, J., (2001). The influence of non-executive director control and rewards on CEO remuneration: Australian evidence, working paper (Curtin University of Technology, Perth, WA).

Faleye, O., (2011). CEO directors, executive incentives, and corporate strategic initiatives. *The Journal of Financial Research*, 34 (2), 241-277.

Farmer, M., A., Alexandrou, G., & Archbold, S., (2010). New evidence of relative performance evaluation (RPE) in UK chief executive realized incentive compensation. Working paper, Kingston Business School.

Feriozzi, F., (2011). Paying for observable luck. *RAND Journal of Economics*, 42 (2), 387–415.

Fernandes, N., G., (2008). Board compensation and firm performance: the role of 'independent' board members. *Journal of Multinational Financial Management*, 18, 30-44.

Ferri, F., & Maber, D., A., (2009). Say on pay vote CEO compensation: Evidence from the UK. Harvard Business School and SSRN.

Gabaix, X., & Landier, A., (2008). Why has CEO pay increased so much? *Quarterly Journal of Economics*, 123, 49–100.

Gallagher, D., R., Smith, G., & Swan, P., (2006). Do institutional investors really monitor executive compensation? Mimeo.

Garvey, T., G., & Milbourn T., T., (2003). Incentive Compensation When Executives Can Hedge the Market: Evidence of Relative Performance Evaluation in the Cross Section. *Journal of Finance*, 58, 1557-1581.

Garvey, T., G., & Milbourn, T., T., (2006). Asymmetric benchmarking in compensation: executives are rewarded for good luck but not penalized for bad. *Journal of Financial Economics*, 82, 179-225.

Geremia, K., Carnaghan, C., & Nelson, T., (2010). Exploring changes in management compensation structure in Canada; evidence on consequences of requiring options expensing. Working paper, University of Lethbridge.

Giannetti, M., (2003). Do better institutions mitigate agency problems? Evidence from corporate finance choices. *Journal of Financial and Quantitative Analysis*, 38, 185-212.

Gopalan, R., Milbourn, T., & Song, F., (2010). Strategic Flexibility and the Optimality of Pay for Sector Performance. *Review of Financial Studies*, 23 (5), 2060–2098.

Gregoric, A., Polanec, S., & Slapnicar, S., (2010). Pay me right: reference values and executive compensation. *European Financial Management*, 16 (5), 778-804.

Gregory-Smith, I., (2011). Chief executive pay and remuneration committee independence. *Oxford Bulletin of Economics and Statistics*, 1-22.

Guest, M., P., (2009a). Board structure and executive pay: evidence from the UK. *Cambridge Journal of Economics*, 1-22.

Hall, B., & Liebman, J., (1998). Are CEOs really paid like bureaucrats? *Quarterly Journal of Economics*, 133, 653-691.

Harford, J., Li, K., (2007). Decoupling CEO wealth and firm performance: The case of acquiring CEOs. *Journal of Finance*, 62 (2) , 917-949.

Hartzell, J. C., & Starks, L. T., (2003). Institutional investors and executive compensation. *The Journal of Finance*, 58, 2351-2374.

Heaney, R.,Tawani, V., & Goodwin, J., (2010). Australian CEO Remuneration. *Economic Papers*, 29 (2), 109–127.

Hoffmann, F., & Pfeil, S., (2010). Reward for luck in a dynamic agency model. *The Revue of Financial Studies*, 23 (9), 3329-3345.

Holmstrom, B., (1979). Moral hazard and observability. *Bell Journal of Economics*, 10 (1), 74-91.

Jansen, P., E., Merchant, A., K., & Van der Stede, A., W., (2009). National differences in incentive compensation practices: the differing roles of financial performance measurement in the United States and the Netherlands. *Accounting, Organization and Society*, 34 (1), 58-84.

Jensen, M., & Murphy, K., (1990). Performance pay and top management incentives. *Journal of Political Economy*, 22 (2), 225-264.

Jensen, M.C., & Meckling, W., (1976). Theory of the firm: Managerial behavior, agency costs, and ownership structure. *Journal of Financial Economics*, 3 (4), 305-360.

Jiménez-Angueira, C., & Stuart, V., N., (2010). CEO Bonuses, Relative Performance Evaluation, and Pay-for-Luck. SSRN working paper, abstract= 1691154.

Kalyta, P., & Magnan, M., (2008).Stealth compensation: The case of supplemental executive retirement plans. *Journal of Accounting and Public Policy*, 27 (2), 101-194.

Kato, K., & Kubo, K., (2006). CEO Compensation and firm performance in Japan: Evidence from new panel data on individual CEO Pay. *Journal of the Japanese and International Economies*, 20, 1-19.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (2006). What works in securities laws? *Journal of Finance*, 61 (1), 1-32.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R., (1997). Legal determinants of external finance. *Journal of Finance*, 52 (3), 1131-1150.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R., (1998). Law and finance. *The Journal of Political Economy*, 106, 1113-1155.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R., (2000). Investor protection and corporate governance. *Journal of Financial Economics*, 58, 3-27.

Llense, F., (2010). French CEO's compensation: what is the cost of a mandatory upper limit? *CESifo Economic Studies*, Jun 56 (2), 165-191.

Merhebi, R., Pattenden, K., Swan, P., L., & Zhou, X., (2006). Australian Chief Executive Officer Remuneration: Pay and Performance. *Accounting and Finance*, 46, 481–97.

Minnick, K., Unal, H., & Yang, L., (2011). Pay for performance? CEO compensation and acquirer returns in BHCs. *The Review of Financial Studies*, 24 (2), 339-472.

Murphy, K., & Sandino, T., (2010). Executive pay and "independent" compensation consultants. *Journal of Accounting and Economics*, 49, 247-262.

Nourayi, M. M., & Mintz, M. S., (2008). Tenure, firm's performance, and CEO compensation. *Managerial Finance*, 34 (8), 524-536.

Oxelheim, L., & Randoy, T., (2005). The Anglo-American financial influence on CEO compensation in non-Anglo-American firms. *Journal of International Business Studies*, 36 (4), 470-483.

Oxelheim, L., & Wihlborg, C., (2003). Recognizing macroeconomic fluctuations in value based management. *Journal of Applied Corporate Finance*, 15 (4), 104-110.

Oxelheim, L., Wihlborg, C., & Zhang, J., (2010). How to Avoid Compensating CEO for Luck: The Case of Macroeconomic Fluctuations. IFN Working Paper No. 842.

Oyer, P., (2004). Why do firms use incentives that have no incentive effects? *Journal of Finance*, 59, 1619–1649.

Ozkan, N., (2007). Do corporate governance mechanisms influence CEO compensation? An empirical investigation of UK companies. *Journal of Multinational Financial Management*, 17 (5), 349-364.

Ozkan, N., (2009). CEO compensation and firm performance: an empirical investigation of UK panel data. *European Financial Management*, (12), 1-26.

Park, Y., Nelson, T., & Huson, M., (2001). Executive pay and the disclosure environment: Canadian evidence. *Journal of Financial Research*, 24 (3), 347-365.

Renneboog, L., & Zhao, Y., (2011). Us knows us in the UK: on directors networks and CEO compensation. *Journal of Corporate Finance*. Article in press.

Sapp, G., M., (2008). The impact of corporate governance on executive compensation. *European Financial Management*, 14 (4), 710-746.

Spamann, H., (2006). On the insignificance and/or endogeneity of La Porta et al.'s "anti director rights index" under consistent coding. Working paper n°7, Harvard Law School, Cambridge.

Sun, J., & Cahan, S., (2009). The effect of compensation committee quality on the association between CEO cash compensation and accounting performance. *Corporate Governance: An International Review*, 17 (2), 193-207.

Swan, P., & Zhou, X., (2006). Does executive compensation disclosure alter pay at the expense of incentives? Unpublished working paper, Australian School of Business UNSW and University of Hong Kong.

Tosi, H., Werner, S., Katz, J., & Gomez-Mejia, L., R., (2000). A meta-analysis of executive compensation studies. *Journal of Management*, (26), 301-339.

Voulgaris, G., Stathopoulos, K., & Walker, M., (2010). Compensation consultants and CEO pay: UK evidence. *Corporate Governance: An International Review*. Article in press.

Zheng, L., & Zhou, Z., (2009). The Effect of Executive Stock Options on Firm Performance: Evidence from retiring CEOs, SSRN working paper, abstract= 1426540.

Zhou, X., (2000). CEO pay, firm size, and corporate performance: evidence from Canada. *The Canadian Journal of Economics*, 33 (1), 213–251.

Int. Journal of Business Science and Applied Management, Volume 6, Issue 3, 2011

A comparison of push and pull production controls under machine breakdown

Joshua Prakash
School of Mechanical Engineering, Universiti Sains Malaysia
(USM), Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia
Telephone: +006017-3655113
Email: joshuaprakash@gmail.com

Chin Jeng Feng
School of Mechanical Engineering, Universiti Sains Malaysia
(USM), Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia
Telephone: +00604-5996365
Email: chinjengfeng@eng.usm.my

Abstract

Production control for high-mix production remains a complex issue. Common pull system replenishment generates large works-in-process (WIPs) for each part type, especially under breakdown. This paper attempts to solve this by presenting a production control that classifies parts into two categories. The performances of three production control mechanisms under breakdown are compared. The production control mechanisms in consideration are push, shared constant WIP (CONWIP), and parallel CONWIP. A full-factorial simulation experiment was conducted. ANOVA was performed to determine the significant effects of input factors. Response surface methodology was used to demonstrate the behavior of performance measures in terms of these significant input factors. The results prove that parallel CONWIP is superior over shared CONWIP in terms of the average flow time per part. If categorical dispatch rules are employed, parallel CONWIP outperforms shared CONWIP in terms of service level. With high card count, parallel CONWIP generally produces lower bottleneck utilizations while maintaining a low average flow time per part than shared CONWIP.

Keywords: push system, pull system, CONWIP, machine breakdown, multiple product types

Acknowledgement: The authors wish to acknowledge Universiti Sains Malaysia for the full financial support through the short term grant no. 6039031 and the Postgraduate Fellowship Scheme.

1 INTRODUCTION

In recent years, the use of pull systems has become increasingly prevalent in many industries to reduce WIP and other lean wastes directly or indirectly. There are many forms of pull systems, such as the single-stage kanban system, which has been thoroughly investigated through mathematical formulations and simulation studies. There are also reported industrial case studies of its applications over a long period. In comparison, constant WIP (CONWIP) systems are relatively less explored, particularly its behavioral peculiarity against emergent production challenges. One challenge faced by the CONWIP system is the production synchronization of multiple part types (Spearman, 1990). Ryan and Vorasayan (2005) proposed a method of allocating cards to each part type present in a part family, as opposed to sharing cards among part types. The simulation study revealed superior performance in terms of service level, but several flaws are overlooked. Finished goods inventory for each part type, irrespective of the consumption rate, yields higher holding cost. Setting WIP levels for each part type is unfavorable in a non-steady state environment.

Another challenge faced in CONWIP system studies is the inclusion of machine breakdown in performance comparison. With the exception of the study of Ozbayrak, Cagil, and Kubat (2004) where there are 35 part types, most literature on CONWIP systems that include breakdown only considers one part type. In reality, a particular product family employing CONWIP systems can be made up of several part types. Thus, although the superiority of the CONWIP system in the presence of breakdown is clear, this fact may not hold true if several part types are considered.

This paper compares the performance of one push system and two pull systems in a $D/D/1/\infty/\infty$ queue of a serial production line, with breakdown following a distribution and no setup. The two pull systems described are the shared and parallel CONWIP systems. The paper is organized as follows. Sections 2 provide literature a review on the push and pull systems, CONWIP system, and machine breakdown. Section 3 and 4 describes the methodology and model construction of the study respectively. Section 5 highlights the results obtained from the study. Section 6 provides the analysis of the results. Section 7 concludes the paper.

2 LITERATURE REVIEW

Production control mechanisms can be divided into two categories: push system and pull system. In the push system, production is initiated when demand is scheduled to individual workstations and parts are available for processing. In the pull system, production is initiated when finished goods/WIP inventory are withdrawn and parts are available for replenishment. The push system is more commonly employed in industries because it emerged long before the pull system did. However, although the push system has shown relative success in industries, errors in demand forecasting may cause excess/deficient finished goods/WIP inventory, and overutilization/underutilization of capacity in meeting the actual demand. Either way, unnecessary costs may be accrued. Several production planning tools associated with the push system are material requirement planning (MRP) and manufacturing resource planning (MRP II).

Around the same time that MRP and MRP II emerged, Japan was facing ordeals in developing its automotive industry. Lean manufacturing emerged as a solution, where complete waste elimination is the goal of the industry. One core principle of lean manufacturing is just-in-time. The pull system stems from this principle. A study conducted in the 1990s revealed the superiority of the pull over the push system. American and European industries were thus drawn to the pull system and its potential benefits. Womack, Jones, and Roos (1990) provided an excellent review on this shift in production control preference. Several notable benefits realized with the pull system include usage of actual demand in production and consideration of capacity utilization in setting WIP levels. In the long run, inventory costs are lowered.

One form of pull system that has gained wide acceptance from both academic and industry perspectives is the CONWIP system. CONWIP system was introduced by Spearman, Woodruff, and Hopp (1990). The basis of CONWIP system operation is that in order for parts to be admitted into the line, each part container should be attached with a card. When a container is consumed at the end of the line, the card attached to it is returned to the beginning of the line, and subsequently attached to a designated part container before being readmitted to the line. Thus, the consumed container is replenished upon completion of the designated part. Huang, Wang, and Ip (1998) compiled the notable benefits of the CONWIP system from previous studies.

One common ground in many studies on the CONWIP system is the determination of system parameter value(s) for a desired performance level. Hopp and Roof (1998) established a method known as statistical throughput control used to set WIP levels in production and assembly lines employing the CONWIP system based on a desired throughput level. Cao and Chen (2005) developed and solved a mathematical model to obtain optimal part assignment, part sequence, and lot size in production and assembly lines employing the CONWIP system. The performance measures used are setup time and work load balance. Framinan, Ruiz-Usano, and Leisten (2000) examined the effect of different dispatch rules in a five-station CONWIP system flow shop via simulation. The performance measures used are flow time, WIP level, and throughput.

Studies that compare production control mechanisms are also immense in quantity. Enns and Rogers (2008) compared the push and CONWIP systems in a simple, balanced production line. Mathematical modeling and simulation are used to evaluate the tradeoffs between throughput and inventory. Geraghty and Heavey (2004) compared hybrid push/pull and CONWIP systems via simulation. The conditions yielding optimal inventory and safety stock for the hybrid system are investigated. These conditions are in turn applied to the CONWIP system and their performances are compared. Khojasteh-Ghamari (2009) compared the kanban and CONWIP systems applied in an assembly system in terms of the WIP level and throughput. Framinan, Gonzalez, and Ruiz-Usano (2003) have highlighted other notable comparisons.

Most studies on the CONWIP system are solely from the academic perspective. This fact does not diminish the effectiveness of the CONWIP system because there are studies that discuss its industrial application, although few and far between. Spearman, Hopp, and Woodruff (1989) reported a CONWIP system in the process of installation by a large computer manufacturer. The background of the concept introduced in the factory and specific implementation issues such as throughput monitoring is discussed. Gilland (2002) introduced the CONWIP system in an Intel microprocessor factory. Several wafer release policies in cases with single and multiple bottlenecks are further analyzed via simulation.

The existence of multiple part types in production has been dealt with in several ways. In many cases, part types originating from a given product family possesses some form of common ground in production. This situation impedes independent operational control over each part type. Duri, Frein, and Di Mascolo (1995) investigated the presence of two part types in a facility operating via the kanban system. The machine utilization and mean waiting time are derived under varying processing order of products. Kenne, Boukas, and Gharbi (2003) investigated an FMS producing two part types via mathematical formulation. Numerical examples revealed the necessary level of WIP for each part type under varying breakdown and repair rates. Both these studies reveal the importance of addressing the influence of multiple part types in production; failure to do so may accrue unnecessary costs (Gharbi and Kenne, 2003).

Smalley (2009) proposed a method where part types are grouped based on their demand pattern. Each group operates via a common production control mechanism, but differs in the setting. Despite consideration of additional factors is required, the primary aim is to deal with environments where demand fluctuates. Although the proposed method describes works in an environment employing the kanban system, the method can be adopted in the CONWIP system. Most recently, Prakash, Chong, Mustafa, and Chin (2011) described the workings of such a system (termed parallel CONWIP system) in a three-product shared-machine facility with admittance of reworked parts. The results reveal the superiority of the said system. Some studies involve deciding on the WIP levels for various part types present. Ryan and Vorasayan (2005) allocated WIPs for each part type. Spearman (1990) as well as Ryan and Vorasayan (2005) provided two extremities in the allocation of WIP in a CONWIP system. In the former, the total WIP is cited; in the latter, the WIP for each part type is cited. In both cases, the WIP level set is independent of the demand pattern for each part type. A compromised solution meeting in the middle of these extremities is maintaining the WIP level for part types with frequent demand.

Many studies on the performance of shop floor assume 100% reliability in machines, which is far from reality. In fact, failure is a characteristic possessed by all entities on the shop floor related to production. Machine failure behavior is typically characterized by a bathtub curve (Lewis and Chen, 1994). With this behavior, machine failure, or rather, machine breakdown, may be represented by a distribution. Two parameters commonly addressed are the mean-time-to-failure (MTTF) and mean-time-to-repair (MTTR).

The impact of machine breakdown has been addressed in both push (Chung, 2003; Wazed, Ahmed, Yusoff, 2010) and CONWIP (Graves and Milne, 1997; Ozbayrak Cagil, and Kubat, 2004) systems. Several alternatives for dealing with machine breakdown have been proposed. Abboud (2001) compiled these alternatives from previous studies. Production in excess of demand is the essence of many of these alternatives. The difference between them lies in the point at which production stops and resumes. However, the main goal of any method employed is to prevent the machine prone to breakdown from becoming the bottleneck. The most well-known alternative in dealing with machine breakdown is preventive maintenance.

3 METHODOLOGY

This study is approached using discrete-event simulation. Control parameters selected are commonly used by management to influence the performances of production. The experimental design approach used is a full-factorial experimental design, whereby experiments are performed on all possible combinations of discrete values prescribed in the control parameters. The performance measures are collected after each simulation run. The model is constructed in WITNESS® 2008.

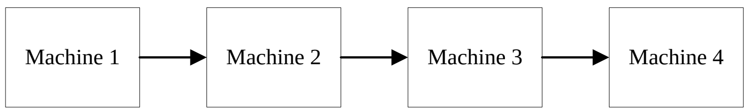
A multi-factor ANOVA is performed to determine the effects of the control parameters and their interactions on each performance measure. In addition, response surface methodology (RSM) based on Box and Wilson (1951), relates any significant effect found with the specified performance measure. A second-order polynomial that yields a high value of R^2 is selected in depicting the behavior of a model. Certain strategies are employed to make comparison between models possible. In most cases, two independent variables are present in an equation. Recommended by Montgomery (1997), the analysis can be simplified by setting one variable as constant.

Banks, Carson II, Nelson, and Nicol (2005) reported that one method of model verification is to examine model output for reasonableness. The behavior of each model is tested by changing the control values of one parameter at a time. The models are verified in two methods. First, the models are made deterministic and the results obtained from the initial simulation run are compared with ones generated from manual calculation. The models are fine-tuned until both results are matched. Second, the performances of the models are observed and compared with established general system behavior in found Groover (1987).

Model Description

The simulation model consists of four automated machines in a series, processing two categories of parts, namely high runner (HR) and low runner (LR). The model emulates a D/D/1/∞/∞ input queue with saturated demand. The inter-arrival and service times are deterministic for a single production line, with unlimited queue capacity and infinite population of potential arrivals. The HR consists of parts with frequent demand, whereas the LR comprises parts with infrequent demand. Each category has two part types: in total, HR_1, HR_2, LR_1, and LR_2. Each machine is separated by a buffer. Parts arrive at an inter-arrival time of eight hours. To avoid excessive WIP build-up, an additional constraint is introduced such that the total number of parts to be processed upon each inter-arrival time is fixed, as opposed to a fixed inter-arrival quantity. Each batch is made up of LS parts containing either HR or LR. The distribution of HR and LR at each arrival is defined by HRLR, which is the ratio of HR to LR. All parts proceed via the same route asynchronously, as shown in Figure 1.

Figure 1: Processing route of parts



Each machine follows a deterministic processing random outage case (DPRO), where processing times are deterministic, but machines are subjected to breakdown and repair following exponential distribution. The MTTF is commonly adopted as a parameter of choice in depicting breakdown; however, it has the flaw of breakdown occurring even when the machine is idle. This effect is magnified in the CONWIP system, where Spearman, Woodruff, Hopp (1990) highlighted that machines are periodically idle. To enable a fair mode of comparison against the push system, the parameter representing breakdown is the number of operations, BC. This variable indicates that a machine experiences breakdown as soon as BC operations are completed. All machines are assumed to be equally unreliable. Thus, MTTR has a fixed value.

Machine processing times do not follow a distribution primarily because such systems may have shifting bottlenecks, that is, different bottlenecks at each replication. Therefore, a deterministic processing time is more suitable because bottleneck utilization is of interest. Three production control strategies discussed in this paper include the push (P), shared CONWIP (SC), and parallel CONWIP (PC) systems. In the P system, batches are pushed to an available machine as long as a preceding buffer is not empty. In the SC system, one batch is admitted into the line when one CONWIP card is available. KC cards are shared between HR and LR batches. In the PC system, one HR batch is admitted into the line when one HR CONWIP card is available. The same applies to LR part batches. KCHR cards are shared between HR batches and KCLR between LR batches. Prakash, Chong, Mustafa, and Chin (2011) depicted diagrams describing the operation of each system.

Dispatch rules dynamically rank queues by computing batch priority indices (Bhaskaran and Pinedo, 1992). In this study, three dispatch rules are considered: first-in-first-out (FIFO), HR-LR (HL), and LR-HR (LH). FIFO is based on the arrival time, where batches of earlier arrival times are given higher priority. HL prioritizes HR over LR, and if more than one batch of a category is present, the FIFO rule is in place. LH follows HL, except that LR is prioritized over HR. The HL and LH rules apply only to the PC system due to the distinction made within the system. It is run for one shift a day, five days a week for over 10 weeks (1 440 000 s) with a warm-up period of two weeks (288 000 s). Table 1 summarizes the variable values of each control parameter used in the simulation.

Table 1: Control parameter variable values

Control parameter	Variable value
LS	50, 100, 150
HRLR	0.3, 0.5, 0.7
BC	10, 25, 40
KC	6, 10, 14
KCHR	3, 5, 7
KCLR	3, 5, 7

The performance measures of interest are the HR service level, LR service level, throughput, average flow time per part, and bottleneck utilization. These performance measures are selected because of their prevalent use in the industry and scientific studies. The WIP is not one of the performance measures of interest because according to Little (1961), WIP level can be estimated once throughput and average flow time per part are known.

When all machines are 100% reliable in a push system, the lead time of HR providing a 95% service level is set as the HR lead time for all models. The same applies for LR. This method of setting due dates is known as the endogenous due date setting (Cheng and Gupta, 1989), and takes into account information on an arriving job. In P-FIFO, a part is committed to the line as soon as it is pushed to the immediate upstream buffer of the first machine. In the SC-FIFO and PC variants, a part is committed to the line as soon as a card is attached to the order. The following annotations and mathematical expressions define each performance measure:

LT_{HR} = lead time of HR
LT_{LR} = lead time of LR
a_{iHR} = time when part *i* of category HR arrives
b_{iHR} = time when part *i* of category HR is committed
c_{iHR} = time when part *i* of category HR is shipped
d_{iHR} = due date of part *i* of category HR
a_{iLR} = time when part *i* of category LR arrives
b_{iLR} = time when part *i* of category LR is committed
c_{iLR} = time when part *i* of category LR is shipped
d_{iLR} = due date of part *i* of category LR
i = 1, 2, 3….
T_{wu} = warm-up period

Let f_{HR}=0, f_{LR}=0, g_{HR}=0 and g_{LR}=0 at the start of each simulation run

if $t \geq T_{wu}$
    $d_{iHR} = a_{iHR} + LT_{HR}$
    $d_{iLR} = a_{iLR} + LT_{LR}$
    if $c_{iHR} \leq d_{iHR}$
        $f_{HR} = f_{HR + 1}$
    else
        $g_{HR} = g_{HR + 1}$
    endif
    if $c_{iLR} \leq d_{iLR}$,
        $f_{LR} = f_{LR + 1}$
    else
        $g_{LR} = g_{LR + 1}$
    endif
endif

HR service level = $\dfrac{100 f_{HR}}{f_{HR} + g_{HR}}$

LR service level = $\dfrac{100 f_{LR}}{f_{LR} + g_{LR}}$

$$\text{Throughput} = \frac{f_{HR} + g_{HR} + f_{LR} + g_{LR}}{1440000 - 288000} = \frac{f_{HR} + g_{HR} + f_{LR} + g_{LR}}{1152000}$$

$$\text{Average flow time per part} = \frac{\sum_{i=1}^{f_{HR}+g_{HR}} (c_{i\,HR} - b_{i\,HR}) + \sum_{i=1}^{f_{LR}+g_{LR}} (c_{i\,LR} - b_{i\,LR})}{f_{HR} + g_{HR} + f_{LR} + g_{LR}}$$

$$\text{Bottleneck utilization} \approx \frac{100 \times 100(f_{HR} + g_{HR} + f_{LR} + g_{LR})}{1440000 - 288000} = \frac{f_{HR} + g_{HR} + f_{LR} + g_{LR}}{115.2}$$

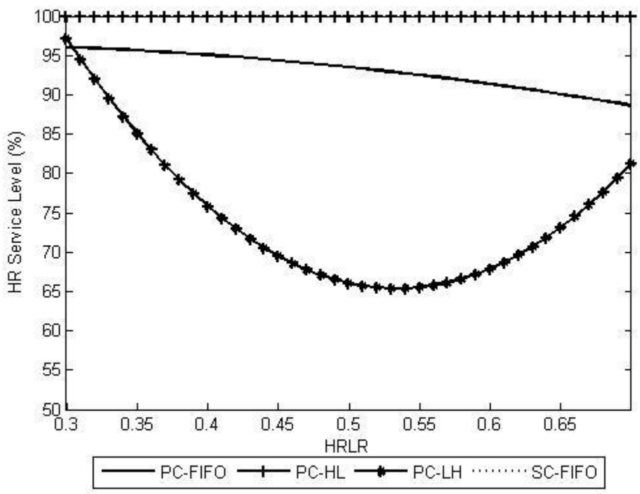
4 RESULTS

The ANOVA results of the three production controls are explained in this section. In all PC variants, all main factors pose effects on the performance measures of this study. Interactions of any two main effects are also significant. However, in PC-HL, interaction of KCLR with any remaining factors poses no effect on the performance measures of this study and LR approximates a push system behavior. A similar observation is obtained with PC-LH where HR approximates a push system behavior. In addition, interactions of higher order reveal negligible effect on the performance measures.

With regards to SC-FIFO, all performance measure in the study reveals no significant changes with respect to HRLR. This is due to the absence of assignment of cards between HR and LR orders. Likewise, within the context of interaction, interactions of HRLR with any remaining factors poses no significant effect on the performance measures of this study.

In P-FIFO the performance measures of this study are independent of changes in HRLR. This is consistent with a push system behavior where the only determinant is the lot size, and manipulation of this variable brings about significant changes in the aforementioned performance measures. However, the analysis also reveals that changes in BC bring no significant effect to HR and LR service level as well as average flow time per part. This is due to the sufficiently high WIP levels within the system such that the effect of breakdown is suppressed. As for interaction between factors, only changes in both BC and LS impose significant effect in the performance measures of this study.

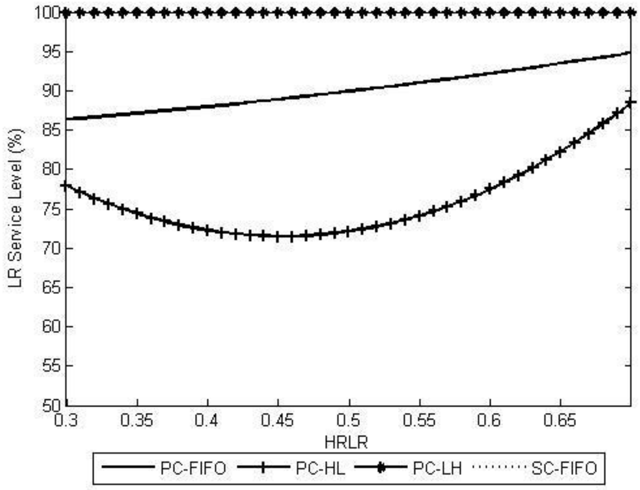
Figure 2: HR service level vs. HRLR for SC-FIFO, PC-FIFO, PC-HL, and PC-LH.



SC-FIFO overlaps with PC-HL

The HR service level of PC-HL is as good as that of SC-FIFO (Figure 2), maintaining 100% HR service level irrespective of HRLR. For PC-FIFO, although the HR service level is adequately high, it is still lower than that of SC-FIFO, and exhibits a decrease with HRLR. PC-LH has the lowest HR service level among all systems, and exhibits a minimum at approximately HRLR=0.5.

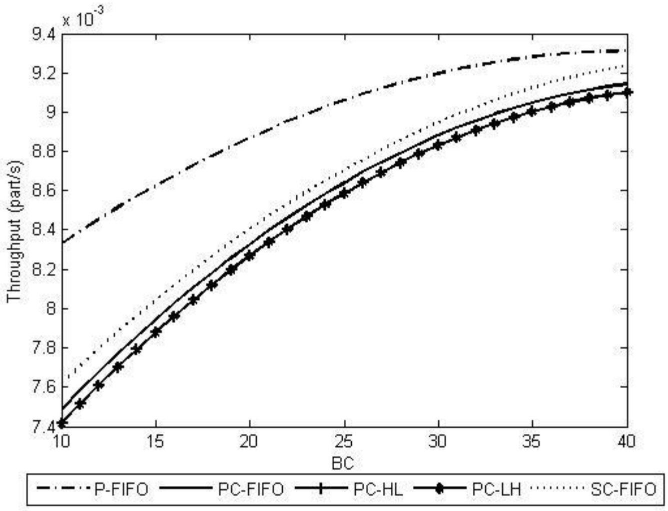
Figure 3: LR service level vs. HRLR for SC-FIFO, PC-FIFO, PC-HL, and PC-LH.



SC-FIFO overlaps with PC-LH

The LR service level of PC-LH is as good as that of SC-FIFO (Figure 3), maintaining 100% HR service level irrespective of HRLR. For PC-FIFO, although the HR service level is adequately high, it is still lower than that of SC-FIFO, and exhibits an increase with HRLR. PC-HL has the lowest HR service level among all systems, and exhibits a minimum at approximately HRLR=0.45. LR service level reflects a similar behavior to that of HR service level.

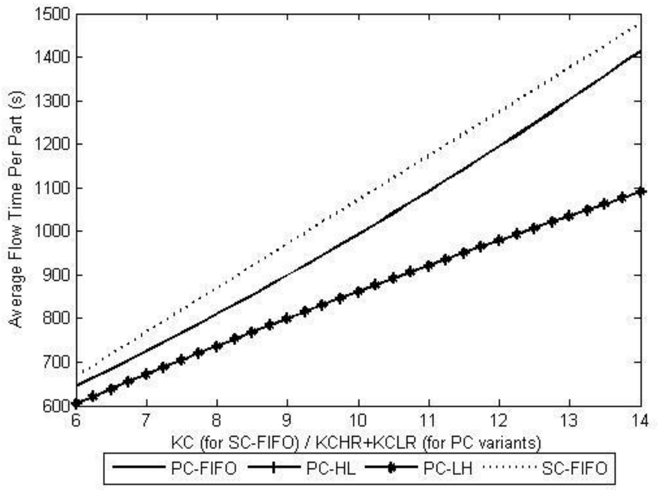
Figure 4: Throughput vs. BC for P-FIFO, PC-FIFO, PC-HL, PC-LH, and SC-FIFO



PC-HL overlaps with PC-LH

The throughput of P-FIFO is the highest compared to remaining systems (Figure 4). The throughput of PC-FIFO is slightly lower than SC-FIFO. With the HL and LH dispatch rules, throughput is suppressed even further. Throughput of all systems shows a decrease with increasing BC.

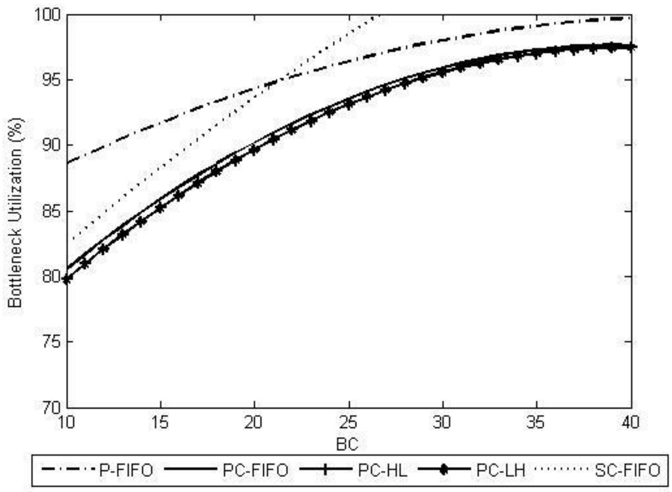
Figure 5: Average flow time per part vs. KC / KCHR+KCLR for SC-FIFO, PC-FIFO, PC-HL, and PC-LH.



PC-HL overlaps with PC-LH

The average flow time per part of SC-FIFO is the highest compared to remaining PC variants (Figure 5). PC-FIFO is slightly lower than this and the presence of HL and LH loading rules suppress the average flow time per part even further. The average flow time per part of all systems show an increase with increase in total number of CONWIP cards.

Figure 6: Bottleneck utilization vs. BC for SC-FIFO, PC-FIFO, PC-HL, and PC-LH.



PC-HL overlaps with PC-LH

The bottleneck utilization of all PC variants is constantly lower than those of P-FIFO and SC-FIFO (Figure 6). The bottleneck utilization of P-FIFO is the highest when BC lies between 10 and 20; beyond this range, the bottleneck utilization of SC-FIFO is the highest. The bottleneck utilization of all systems exhibits an increase with increasing BC.

5 DISCUSSION

In essence, between the SC and P systems, a larger proportion of parts in the former are able to meet the due date set while maintaining a low WIP level. This finding is consistent with that of JodlBauer and Huber (2008). The primary reason for this behavior is the limit placed on WIP in SC-FIFO. In P-FIFO, WIP accumulates at the immediate upstream buffer of the bottleneck; with higher breakdown rate, WIP accumulation is higher. This finding highlights one benefit of the SC over the P systems; in the presence of breakdown, the admittance of fresh parts is suppressed due to the absence of free cards. Although machine breakdown is in fact an unpredictable event, the occurrence of breakdown naturally controls fresh parts from being admitted into the line, in accordance with the number of cards present. The absence of this control mechanism in the event of breakdown, as in the P system, affects the service level.

The HR service levels in decreasing order are SC-FIFO and PC-HL, PC-FIFO and P-FIFO, and PC-LH. The allocation of cards between HR and LR may cause instances when cards of a particular category are not available for attachment to corresponding orders (noted among PC variants in Figure 2). This void can be manipulated to favor a given category if priority is given to parts of that category. However, this void does not occur with SC-FIFO. On a different note, with PC-LH, the HR service level is the lowest and exhibits a minimum. With increased HRLR up to the minimum point, the quantity of HR increases. The LH dispatch rule is sufficient to suppress the effect of increased HR volume. However, beyond this point, the HR service level increases, and as at any given instance, LR can be absent from a queue. Although PC-FIFO does not perform as well as SC-FIFO in terms of the service level, the practical simplicity of the categorical dispatch rules are sufficient to elevate the service level.

The LR service levels in decreasing order are SC-FIFO and PC-LH, PC-FIFO and P-FIFO, and PC-HL. Between the SC and PC systems, the former maintains its behavior as before, whereas the behavior of PC variants is the inverse. In Figure 3, the minimum point in the LR service level of PC-HL is explained as follows. At HRLR values lower than that at the minimum point, the effect of the HL dispatch rule coupled with increased HR volume has a negative effect on the LR service level. Beyond this point, although LR orders have the two said factors working against it, the LR service level increases. With a smaller volume of LR, there is lesser chance for a given LR order not to meet the specified due date.

The throughputs in decreasing order are P-FIFO, SC-FIFO, PC-FIFO, and PC-HL and PC-LH. Figure 4 shows that the throughput of P-FIFO remains highest as parts are constantly admitted into the line irrespective of downstream needs. P-FIFO, despite producing more parts, still yields a lower service level. Between the SC and PC systems, the WIP levels are limited by the number of cards present, hence the lower throughput. Throughputs of PC variants are lower than those of SC-FIFO, albeit only a small difference. This slight difference in throughput is sufficient evidence of the possible difference in the net WIP present in the line. This difference also indicates that although PC variants have the same total number of cards as in SC-FIFO, PC variants have more instances when cards are not in use, hence the lower service level than that in SC-FIFO.

The SC system has a lower and constant average flow time per part compared with the P system. This finding is consistent with that of Spearman and Zazanis (1992), who also compared the behavior of the SC and P systems. The average flow times per part in decreasing order are P-FIFO, SC-FIFO, PC-FIFO, and PC-HL and PC-LH. Any given part in P-FIFO spends a large proportion of time waiting for processing to begin. A lower average flow time per part corresponds to a larger lot size, and a larger lot size comes with increased WIP level. On the other hand, SC-FIFO exhibits a constant average flow time per part. With a larger lot size, each batch spends a longer time in processing, thereby delaying the cards from being freed and limiting the net WIP in the line. Lesser WIP queues indicate lesser waiting time.

Between the SC and PC systems, the summation KCHR and KCLR in PC variants at any given instance corresponds to the equivalent KC in SC-FIFO. In Figure 5, due to the absence of allocation between HR and LR in SC-FIFO, both categories have equal chances of obtaining a card. However, in PC-FIFO, a larger HRLR increases the average flow time per part, as more orders need to wait for HR cards in the line to be freed. This phenomenon causes the range of average flow time per part in PC-FIFO to be larger than that in SC-FIFO. This larger range also accounts for the lower average flow time per part in PC-FIFO. With HL and LH dispatch rules, this range is increased even further, constituting a lower average flow time per part. Although the flow time of the PC variant diminishes its predictability, as in the report of Spearman (1990) where an SC system flow time remains effectively constant, this feature can be seen as an advantage.

For PC variants, in the event of an influx of parts of a given category, categorical dispatch rules or introduction of additional cards favoring that category can be used to cater to this sudden change. Another option is the conversion of cards from an opposing category to the category of the influxed parts. In SC-FIFO, the only way to meet this requirement is by the introduction of additional cards, which increases the net WIP, hence the average flow time per part. From a different perspective, although PC variants generally yield a lower service level than SC-FIFO, its shorter average flow time per part can be taken advantage of. With advanced knowledge of flow time, a card can be freed earlier in a PC environment, thereby allowing jobs an early start.

With knowledge on the average flow time per part and throughput, the WIP level in each system can be deduced in accordance with Little's law (Little, 1961). The WIP levels in decreasing order are P-FIFO, SC-FIFO, PC-FIFO, and PC-HL and PC-LH. As pointed out by Karmarkar (1986), the number of cards used in a pull system does not indicate the net WIP present, but rather, sets an upper limit on the WIP level. This theory applies to the CONWIP system as well. As pointed out earlier, between the SC and PC systems, there are more instances in PC variants when cards are not in use. In the event of breakdown in a PC environment, these unused cards can be kept as reserves to allow for machine repair. In SC-FIFO, the reservation of WIP is more difficult to implement if all cards are present in the line.

The bottleneck utilizations in increasing order are PC-HL and PC-LH, PC-FIFO, and SC-FIFO and P-FIFO coinciding at a BC of approximately 25 (Figure 6). At smaller BC values, P-FIFO exhibits the highest bottleneck utilization. At higher BC values, SC-FIFO exhibits the highest bottleneck utilization. In SC-FIFO, with higher breakdown rate, fresh parts are controlled from entering the line, hence the lower bottleneck utilization. As aforementioned, PC variants exhibit the lowest bottleneck utilization due to the effect of allocation between HR and LR. The lower bottleneck utilization is sufficient indication that the introduction of additional cards to the system is still a valid option. Although higher utilization is generally more desirable for investment justification purposes, it may appear as a disadvantage in the event of influx of parts. In such a case, as in SC-FIFO, the introduction of additional cards may yield a lower service level with increased net WIP (where average flow time per part may increase), but this may not be possible as the bottleneck is at capacity.

Thus, an additional experiment is carried out to compare the performance of PC-FIFO and SC-FIFO at common values of bottleneck utilization. These common values are obtained are as follows: the number of cards in PC-FIFO is increased such that its behavior with respect to BC approximates that of SC-FIFO. The HR (Figure 7) and LR (Figure 8) service levels of the new PC-FIFO follows that of its predecessor. However, the average flow time per part of PC-FIFO increases at a lower gradient than SC-FIFO, as shown in Figure 9. Therefore, at a given value of bottleneck utilization and in systems with high number of cards, PC-FIFO is advantageous over SC-FIFO in terms of average flow time per part.

Figure 7: HR service level vs. HRLR for PC-FIFO (with increased bottleneck utilization) and SC-FIFO.

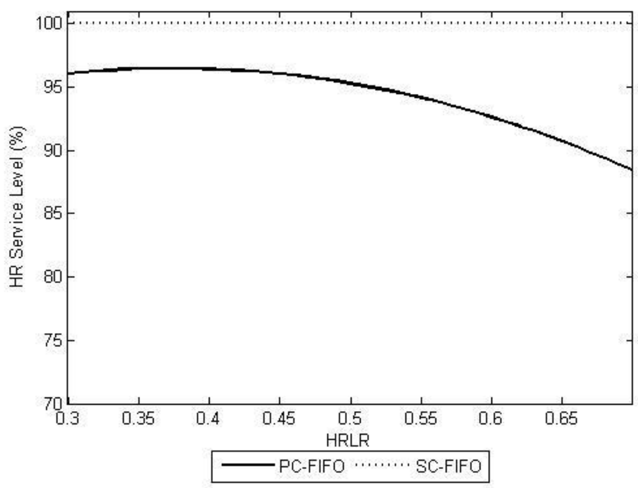


Figure 8: LR service level vs. HRLR for PC-FIFO (with increased bottleneck utilization) and SC-FIFO.

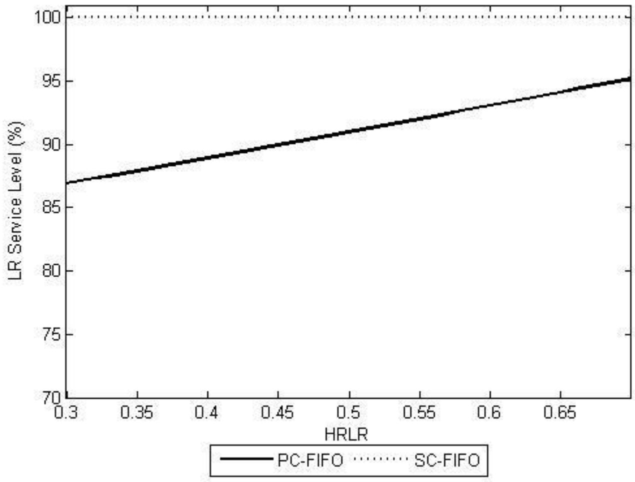
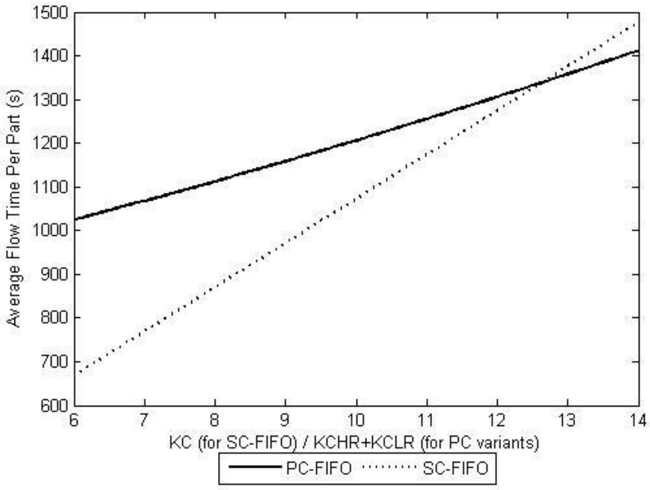


Figure 9: Average flow time per part vs. KC / KCHR+KCLR for PC-FIFO (with increased bottleneck utilization) and SC-FIFO.



6 CONCLUSION AND FURTHER RESEARCH

This paper compares the performance of the P, SC, and PC systems in the presence of breakdown. SC has the advantage of higher HR and LR service levels over PC systems. However, PC systems are superior over the SC system in terms of lower average flow time per part and lower bottleneck utilization. The P system is superior over the SC and PC systems only in terms of throughput.

The study is highly beneficial for flow shop production facilities intended to adopt high mix by providing alternative production planning and control systems notably using CONWIP. In such production environment, demands are obtained from different customers, consequently product life cycles are short and production volumes are significantly varied in time. The process generally consists of operations with heterogeneous groups of machines. Machine breakdown is common due to high speed processing as well as constant product change. In particular, the results reveal the advantages of parallel CONWIP systems in terms of average flow time per part irrespective of the fluctuating demand ratio of high runners and low runners. In comparison, a shared CONWIP system will require part sequencing in the backlog list to effectively accommodate sudden changes in these demands. In addition, a more volatile demand change may require rigorous shuffling of part sequencing in the backlog list. Aside from this, a recalculation of CONWIP card may be required. In parallel CONWIP systems, part sequencing is not required as categories of parts are predefined. Thus the backlog list may focus on efforts in determining suitable number of cards dedicated for high runner and low runner. In the long run, the burden placed on the scheduling system is alleviated.

The PC system is relatively new and thus possesses many unexplored options. The effect of categorical dispatch rules in the PC system shows better performance in terms of category service level and average flow time per part. However, the possibility of other dispatch rules commonly adopted in production floors may change the behavior of these performance measures. Studies on the effect of the machine setup on such a system can also be interesting because the setup time can have a wide range of values, depending on the industry of application. A larger setup time may constitute a larger deviation from the aforementioned behavior. The possibility of increasing the service level by releasing cards earlier than the completion of processing is also of interest. One final notable aspect of interest is the implementation procedure of such systems and how it differs from conventional CONWIP system implementation.

REFERENCES

Abboud, N. E. (2011). A discrete-time Markov production-inventory model with machine breakdowns. *Computers and Industrial Engineering*, *39*, 95-107.

Banks, J., Carson II, J. S., Nelson, B. L., & Nicol, D. M. (2005). *Discrete-Event System Simulation*. Englewood Cliffs, NJ: Prentice-Hall.

Bhaskaran, K., & Pinedo, M. (1992). *Handbook of Industrial Engineering*, edited by G. Salvendy. New York, NY: John Wiley.

Box, G. E. P., & Wilson, K. B. (1951). On the experimental attainment of optimum conditions. *Journal of the Royal Statistical Society, Series B (Methodological)*, *13*(1), 1-45.

Cao, D., & Chen, M. (2005). A mixed integer programming model for a two line CONWIP based production and assembly system. *International Journal of Production Economics*, *95*, 317-326.

Cheng, T. C. E., & Gupta, M. C. (1989). Survey of scheduling research involving due date determination decisions. *European Journal of Operational Research*, *38*, 156-166.

Chung, K. J. (2003). Approximations to production lot sizing with machine breakdowns. *Computers and Operations Research*, *30*, 1499-1507.

Duri, C., Frein, Y., & Di Mascolo, M. (1995). Performance evaluation of kanban multiple-product production systems. *Emerging Technologies and Factory Automation*, *3*, 557-566.

Enns, S. T., & Rogers, P. (2008). *Clarifying CONWIP versus push system behavior using simulation.* Proceedings of winter simulation conference, Miami, Florida, USA. Piscataway, New Jersey: IEEE Press, 1867-1872.

Framinan, J. M., Ruiz-Usano, R., & Leisten, R. (2000). Input control and dispatching rules in a dynamic CONWIP flow-shop. *International Journal of Production Research*, *38*(18), 4589-4598.

Framinan, J. M., Gonzalez, P. L., & Ruiz-Usano, R. (2003). The CONWIP production control system: review and research issues. *Production Planning and Control*, *14*, 255-265.

Geraghty, J., & Heavey, C. (2004). A comparison of hybrid push/pull and CONWIP/pull production inventory control policies. *International Journal of Production Economics*, *91*(1), 75-90.

Gharbi, A., & Kenne, J. P. (2003). Optimal production control problem in stochastic multiple-product multiple-machine manufacturing systems. *IIE Transactions*, *35*, 941-952.

Gilland, W. (2002). A simulation study comparing performance of CONWIP and bottleneck-based release rules. *Production Planning and Control*, *13*(2), 211–219.

Graves, R. J., & Milne, J. R. (1997). A new method for order release. *Production Planning and Control*, *8*(4), 332-342.

Groover, M. P. (1987). *Automation, Production Systems and Computer Integrated Manufacturing*. Englewood Cliffs, NJ: Prentice-Hall.

Hopp, W. J., & Roof, M. L. (1998). Setting WIP levels with Statistical Throughput Control (STC) in CONWIP production lines. *International Journal of Production Research*, *36*, 867-882.

Huang, M., Wang, D., & Ip, W. H. (1998). Simulation study of CONWIP for a cold rolling plant. *International Journal of Production Economics*, *54*(2), 257-266.

Jodlbauer, H., & Huber, A. (2007). Service-level performance of MRP, Kanban, CONWIP and DBR due to parameter stability and environmental robustness. *International Journal of Production Research*, *46*(8) 2179-2195.

Karmarkar, U. S. (1986). *Kanban systems*. Working Paper Series No.QM8612, Center for Manufacturing and Operations Management, The Graduate School of Management, The University of Rochester.

Kenne, J. P., Boukas, E. K., & Gharbi, A. (2003). Control of production and corrective maintenance rates in a multiple-machine, multiple-product manufacturing system. *Mathematical and Computer Modelling Journal*, *38*, 351–365.

Khojasteh-Ghamari, Y. (2009). A performance comparison between kanban and CONWIP controlled assembly systems. *Journal of Intelligent Manufacturing, 20*, 751-760.

Lewis, E. E., & Chen, H. C. (1994). Load-capacity interference theory and the bathtub curve. *IEEE Trans. Reliability*, *43*, 470-476.

Little, J. (1961). A Proof Of The Queueing Formula L = λW. *Operations Research*, *9*(2), 383-387.

Montgomery, D. C. (1997). Response surface methods and other approaches to process optimization. In: D. C. Montgomery. *Design and analysis of experiments* (pp. 427–510). New York: John Wiley and Sons.

Ozbayrak, M., Cagil, G., & Kubat, C. (2004). How successfully does JIT handle machine breakdowns in an automated manufacturing system? *Journal of Manufacturing Technology Management*, *15*(6), 479-494.

Prakash, J., Chong, M. Y., Mustafa, S. A., & Chin, J. F. (2011). Parallel CONWIP for a high-mix multi-stage production system with entrance of rework. *Journal of Production Research and Management*, *1*(2), 1-23.

Ryan, S. M., & Vorasayan, J. (2005). Allocating work in process in a multiple-product CONWIP system with lost sales. *International Journal of Production Research, 43,* 223-246.

Smalley, A. (2009). *Creating Level Pull*. Cambridge, MA: Lean Enterprise Institute.

Spearman, M. L., Hopp, W. J., & Woodruff, D. L. (1989). A hierarchical control architecture for Constant Work-in-Process (CONWIP) production systems. *Journal of Manufacturing and Operations Management, 2*, 147-171.

Spearman, M. L., Woodruff, D. L., & Hopp, W. J. (1990). CONWIP: a pull alternative to kanban. *International Journal of Production Research*, *28*(5), 879-894.

Spearman, M. L., & Zazanis, M. A. (1992). Push and pull production systems: Issues and comparisons. *Operational Research*, *40*, 521-532.

Wazed, M. A., Ahmed, S., & Yusoff, N. (2010). Impacts of common processes in multistage production system under machine breakdown and quality uncertainties. *African Journal of Business Management*, *4*(6), 979-986.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine That Changed the World: The Story of Lean Production*. New York: Harper Collins Publishers.