



Global supply chain risk management strategies

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Abstract

Purpose – Global supply chains are more risky than domestic supply chains due to numerous links interconnecting a wide network of firms. These links are prone to disruptions, bankruptcies, breakdowns, macroeconomic and political changes, and disasters leading to higher risks and making risk management difficult. The purpose of this paper is to explore the phenomenon of risk management and risk management strategies in global supply chains.

Design/methodology/approach – This paper is based on an extensive literature review and a qualitative study comprising 14 in-depth interviews and a focus group meeting with senior supply chain executives.

Findings – The study provides insights into the applicability of six risk management strategies with respect to environmental conditions and the role of three moderators.

Research limitations/implications – The model is developed in a global manufacturing supply chain context. It should be tested in other contexts and with other methods to provide generalizability. The study takes a much needed step toward building a theory of risk management in global supply chains, which opens important future research directions.

Practical implications – This research provides direction to managers for choosing risk management strategies based on the global supply chain environment. Moderators have practical implications for global supply chain managers.

Originality/value – The paper addresses an identified gap in the literature for selecting risk management strategies in global supply chains. It employs grounded theory, a methodology appropriate for theory-building, to explore a phenomenon with an inadequate theoretical base.

Keywords Risk management, Supply chain management, International business

Paper type Research paper

Introduction

Global supply chains are a source of competitive advantage. Global configurations of firms provide access to cheap labor and raw materials, better financing opportunities, larger product markets, arbitrage opportunities, and additional inducements offered by host governments to attract foreign capital (AlHashim, 1980; Kogut and Kulatilaka, 1994). However, coupled with these benefits that entice firms to go global are the uncertainties and consequent risks that managers face in global supply chains. As Barry (2004) argues, “An enterprise may have lowest over-all costs in a stable world environment, but may also have the highest level of risk – if any one of the multiple gating factors kink up an elongated global supply chain!”

There is wide acknowledgement in the literature of the risks and uncertainties in global supply chains. Although risk management in multinational enterprises has been



examined (Baird and Thomas, 1985; Baird and Thomas, 1991; Carter and Vickery, 1989; Ghoshal, 1987; Kogut, 1985; Lessard and Lightstone, 1986; Miller, 1992), risk management was relegated to the background until recently when several researchers (Barry, 2004; Cavinato, 2004; Christopher and Lee, 2004; Giunipero and Eltantawy, 2004; Jüttner, 2005; Manuj and Mentzer, 2008; Norrman and Jansson, 2004; Spekman and Davis, 2004; Zsidisin, 2003a; Zsidisin *et al.*, 2004) revived an interest in risk management, particularly in global supply chains. Chopra and Sodhi (2004) contend that most companies develop plans to protect against recurrent low-impact risks in their supply chains. Many, however, ignore high-impact, low-likelihood risks. By understanding the variety and interconnectedness of supply chain risks, managers can tailor balanced, effective risk-reduction strategies for their companies. Hauser (2003) suggests that in today's increasingly complex environment, risk adjusted supply chain management can translate into improved financial performance and competitive advantage. In sum, understanding global supply chain risk management is important and a top priority for both academics and practitioners.

An initial review of the literature on risk management in supply chains led to the identification of three major gaps. First, no definition exists that adequately takes into account the unique dimensions of risk and risk management in a global supply chain. Rather, there are a multitude of definitions and conceptualizations, and therefore, confusion between terms such as risks, uncertainties, vulnerabilities, and sources of risks. Second, strategies to address risks warrant more attention (Jüttner, 2005). Although several studies provide a list of risk management strategies (Jüttner *et al.*, 2003), these studies do not address how managers select among them, i.e. the antecedents to global supply chain risk management strategies, and their consequences. Jüttner *et al.* (2003) suggest investigating risk management in different supply chains and developing strategies based on their environments. Third, there is limited research on moderators of the risk management process (Manuj and Mentzer, 2008).

In light of these gaps, the purpose of this paper is to take a step toward building a theory of global supply chain risk management strategies. A qualitative research design was chosen, as not much is known about the phenomenon. Based on the analysis of in-depth qualitative interviews using grounded theory methodology, a model of risk management strategies in global supply chains is developed. It is important to mention that the context in this qualitative study was manufacturing firms. Manufacturing firms can be considered the focus of product supply chains, and thus, a good starting point for initial development of supply chain theory. Expanding the theory to other contexts (such as other levels in the supply chain or for service providers) is left to future research.

This research makes three major contributions. A definition of supply chain risk is developed and four types of global supply chain risks are defined. In addition, the interaction of different risks in the global environment is explored. Second, a definition of risk management in a global supply chain context is developed. Rich descriptions of risk management strategies are provided and important antecedents to strategy selection are discussed. Third, three moderators in the process of risk management are explored, namely team composition, supply chain complexity management, and inter-organizational learning.

Methodology

The nature of the research problem should drive the choice of research strategy (Creswell, 1998; Denzin and Lincoln, 1998). Consistent with this philosophy and because of the lack of extant knowledge on the phenomenon, we employed grounded theory methodology. Grounded theory is a qualitative research methodology that allows the exploration of concepts, identification of relationships in raw data, and organization of concepts and the relationships into a theoretical scheme (Strauss and Corbin, 1998). Another advantage of grounded theory is the ability to handle complex phenomenon such as risk management because the methodology emphasizes the need for developing multiple concepts and their linkages in order to capture the central phenomenon. Insights from the grounded theory study and existing literature were used to develop the model presented in this paper.

Selecting participants who can provide meaningful data on multiple incidents is critical for grounded theory. To maximize the variations in the phenomenon, we interviewed managers involved in making and executing global supply chain decisions from a variety of manufacturing companies, including home appliances, electronic component suppliers, pharmaceuticals and over-the-counter products, office products, heavy equipment, and consumer goods. A varied group of managers holding different positions from different industries and firms with different sizes were recruited to look for similar incidents across multiple contexts. We included managers who had worked in several different companies and industries, as well as those who had worked with one organization over an extended period of time and witnessed the company move through several transformations.

The data in this paper come primarily from fourteen in-depth qualitative interviews with senior supply chain executives across eight companies. Apart from the interviews, we also conducted a focus group meeting involving seven senior executives of a global manufacturing firm. Five of these seven executives were later interviewed separately for this study and are a part of the 14 in-depth interviews. In total, the study had 16 unique participants.

The number and content of in-depth interviews was based on the concept of “theoretical sampling,” i.e. successive respondents were chosen based on the emerging theory. The initial participant sample was based on a participant’s interest in and experience with the phenomenon, job profiles, articulation skills, and willingness to participate in the research. Theoretical sampling ensures adequate representation of important themes. It is a process of data collection for generating theory whereby the analyst jointly collects, codes, and analyzes the data and decides what data to collect next and where to find them, in order to develop the theory as it emerges (Glaser, 1978). We started with broad open-ended questions which were followed by focused and directed questions as the interviews progressed within interviews and between successive interviews (Morrison *et al.*, 2002; Strauss and Corbin, 1998).

Interviews continued until “theoretical saturation” was reached – i.e. further interviews did not reveal any new information related to antecedents, risk management strategies, dimensions of risk, or moderators in the risk management process. In theory building, the objective is deep understanding from a few key informants (McCracken, 1988). Generalizing the findings is the purpose of theory-testing research (Mentzer and Flint, 1997), such as surveys, experiments, or simulation. Fourteen interviews are in line with the qualitative research

guidelines that eight or fewer informants often provide theoretical saturation (McCracken, 1988; Strauss and Corbin, 1998). We reached theoretical saturation in the 13th interview, which did not reveal anything significantly new. We conducted one more interview to confirm theoretical saturation. We found that the 13th and 14th interviews did not add much to our understanding of the phenomenon though the interviews did provide additional support for our constructs. Discovering commonalities between different respondents helped in getting to the core of the phenomenon. The constructs included in the model were discussed by multiple interviewees. Also, as suggested by the concept of “fit” (Table I), only those concepts mentioned by a participant were included that fit with the substantive area under investigation (Strauss and Corbin, 1990). All constructs included in the model were deliberated by the authors following repeated readings of the transcripts. Furthermore, the feedback from respondents on summaries of their interviews provided insights into whether a construct should be included.

All interviews but one were recorded and transcribed verbatim. Detailed notes were taken for one interview participant who refused recording his/her interview. The interview transcriptions were analyzed using the ATLAS.Ti software. The grounded theory methodology of systematic organization and constant comparison of data within and between interviews using open, axial, selective coding was followed.

In view of the fact that the authors have a good understanding of the extant literature on risk management, a conscious attempt was made to keep this knowledge away from the ongoing research to prevent the interference of this knowledge. The primary researchers wrote down all they knew or believed to be true about the phenomenon of risk management. This made the researchers aware of their

Criteria (and explanation)	Step(s) taken
Credibility (extent to which the results appear to be acceptable representations of the data)	Participants reviewed the findings and provided feedback
Transferability (extent to which the findings from one study in one context will apply to other contexts)	Participants chosen based on theoretical sampling Diverse sample representing variations in type of industry, responsibilities, position level, and company size
Dependability (extent to which the findings are unique to time and place; the stability or consistency of explanations)	Participants reflected as far back as 15-20 years Core categories existed across industries
Confirmability (extent to which interpretations are the result of the participants and the phenomenon as opposed to researcher biases)	Documenting all personal knowledge of phenomenon to keep presuppositions away and journal-keeping to record personal viewpoints Findings supported by quotes All findings reviewed by both researchers
Integrity (extent to which interpretations are influenced by misinformation or evasions by participants)	Confidentiality assurance to participants Non-threatening interviews by researcher trained in qualitative research

Sources: Adapted from Flint and Mentzer (2000) and Flint *et al.* (2002)

Table I.
Evaluation criteria

preconceived theoretical notions about the phenomena. This list was used during the drafting of the interview protocol to make sure the presuppositions were not forced into the interview questions. This list was also referred to repeatedly during data analysis to ensure that insights were coming from the data and not artifacts of preconceived notions. Wherever appropriate, Glaser's (1978) advice was followed to use the literature as another source of data and was incorporated into the findings from the qualitative study.

The interview protocol is presented in the Appendix. A list of criteria for evaluating qualitative research and our efforts to maintain rigor are presented in Table I. The criterion for "credibility" needs particular mention. Each interviewee was provided a copy of the transcript of his/her interview. All significant comments from the interviewees were incorporated into the data analysis. At the end of each interview, the interviewer summarized the major points from the interview and gave the interviewee an opportunity to provide feedback. All interviewees had some comments at this stage that were duly noted/recorded and incorporated during data analysis. Lastly, all interviewees received a summary of the overall findings across all interviews and provided feedback. This feedback was used to fine-tune the findings.

Refining the concept of risk

The interviews revealed multiple interpretations of risk. One senior executive in a leading home appliance manufacturing firm said:

Risks are all those things that keep you away from the perfect path and perfect outcomes and (you) got to be able to translate (risks) into dollars somehow.

Another manager remarked, "Unintended outcomes, you know, is the risk." These and several other definitions provided by supply chain managers are consistent with the literature that suggests two components of risk:

- (1) potential losses (if the risk is realized, what losses will result and what is the significance of the consequences of the losses (Harland *et al.*, 2003; Manuj and Mentzer, 2008; Mitchell, 1995)); and
- (2) likelihood of those losses (the probability of the occurrence of an event that leads to realization of the risk).

Therefore, risk is the expected outcome of an uncertain event, i.e. uncertain events lead to the existence of risks. We call these uncertain events "risk events." While probability and impact of losses are the most commonly discussed dimensions of risk, two more risk dimensions (speed and frequency) are important in global supply chains. The quote below illustrates the consequences of slow discovery of a risk event (defective capacitors) coupled with a three-month pipeline:

We're three levels down into the supply chain here and we design the (circuit) board, we get it contract manufactured (in China), and sometimes we're buying the components, sometimes the contract manufacturer is buying the components. But a component supplier, their process for making capacitors went out of control. Capacitors got integrated into our boards and you know, months later, unfortunately, in this case, you're finding field failures because, it wasn't immediate failure, it was a *failure over time*. So, even though all the reliability work had been

done on this and it was in the field and working great, now you get three months of supply all of a sudden, which is a huge number, in the field, where now we have problems.

Speed of risk can be divided into the rate at which the event leading to loss happens, the rate at which losses happen, and how quickly the risk event is discovered. Coupled with increased lead times, lead time variability, physical distances from sources of risk, and lesser control over the supply chain, speed increases the magnitude of global supply chains problems.

Frequency is a measure of how often a similar kind of risk event happens. The following manager speculates on high frequency (too much) of an actual risk event:

What if you had something that was a functional failure? I mean if you made a mistake so that it (the product) could catch fire and burn down a house, and that's happened. So it could put an entire company at risk for survival if too much of that happened.

Similarly, another manager suggested a one-time big-volume loss due to a quality defect may be tolerable and correctable, but frequent small-volume quality defects leading to higher supply and demand risks can lead to a company losing its reputation and even going out of business.

Literature on quality control suggests two categories of factors affecting the adoption of quality tools: internal factors such as user-friendliness, usefulness, time, monetary cost, flexibility and popularity of the tools, and external factors such as project nature, organization, industries and culture (Thia *et al.*, 2005). Introduction and development of a formal process for quality improvement may be hindered by a failure to plan effectively, failure to establish objectives for quality improvement activities, inadequate internal and external measurement criteria, lack of thought given to the analysis and presentation of quality improvement progress, and workforce resistance to some of the measurements (Newall and Dale, 1991). Speed and frequency together determine the losses that happen per unit of time. This conceptualization is similar to failure mode and effects analysis, often used in engineering design analysis to identify and rank potential failure modes of a design or manufacturing process, and to determine its effect on other components of the product or process in order to document and prioritize improvement actions (Sankar and Prabhu, 2001). Thus, risk in a global supply chain context is defined as the distribution of performance outcomes of interest expressed in terms of losses, probability, speed of event, speed of losses, the time for detection of the events, and frequency. The distribution of outcomes results from risk events. If there were no risk events, the exact outcome rather than a distribution would be known a priori. A manager said, "Risk would be those factors which, I would say, impair your ability to be successful." In terms of the definition of risk presented above, these factors are "adverse events" and not being successful refers to not being able to closely match desired outcomes.

Risks in global supply chains

The literature suggests four categories of risks: supply, demand, operational, and security risks (Christopher and Peck, 2004; Manuj and Mentzer, 2008). Borrowing from the definition of supply risk provided by Zsidisin (2003b) and building upon it using the definition of risk developed above and insights from the interviews, supply risk is the distribution of outcomes related to adverse events in inbound supply that affect the ability of the focal firm to meet customer demand (in terms of both quantity and quality)

within anticipated costs and time, or causes threats to customer life and safety. Operations risk is the distribution of outcomes related to adverse events within the firm that affect a firm's internal ability to produce goods and services, quality and timeliness of production, and/or profitability. Demand risk is the distribution of outcomes related to adverse events in the outbound flows that affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the customer. Security risk is the distribution of outcomes related to adverse events that threaten human resources, operations integrity, and information systems; and may lead to outcomes such as freight breaches, stolen data or proprietary knowledge, vandalism, crime, and sabotage.

In another widely used classification, Ghoshal (1987) classifies risks as:

- macroeconomic risks associated with significant economic shifts in wage rates, interest rates, exchange rates, and prices;
- policy risks associated with unexpected actions of national governments;
- competitive risks associated with uncertainty about competitor activities in foreign markets; and
- resource risks associated with unanticipated differences in resource requirements in foreign markets.

The risk events most salient to the global supply chain managers interviewed were currency, transit time variability, forecasts, quality, safety, business disruption, survival, inventory (and tools) ownership, culture, dependency and opportunism, oil price fluctuation, and risk events affecting suppliers and customers. All these risk events have supply chain research support (Birou and Fawcett, 1993; Cho and Kang, 2001; Chopra and Sodhi, 2004; Fisher, 1997; Hult, 1997; Johnson, 2001; Spekman and Davis, 2004; Zsidisin, 2003a; Zsidisin and Ellram, 2003). Table II presents the definitions of risk events, along with supporting interview quotes.

An interesting insight from the study was that different risk events in global supply chains are linked to each other in complex patterns with one risk leading to another, or influencing the outcome of other risks. Although such inter-linkages are also present in domestic supply chains, their unpredictability and impact increases in global supply chains. The quote below – where the manager compares domestic versus China sourcing – illustrates the linkages between risk events related to transit time, cycle time, and forecasting:

So there's the forecast error issue, too, over a long lead times. And the forecast error multiplies exponentially as you extend the lead time. I mean you're trying to forecast, it's like trying to forecast the weather tomorrow versus next month. You can do it tomorrow. You have no idea what's going to happen next month. That's the situation here, too. So you have this huge risk of forecasting incorrectly and it happens over and over. So what happens is companies tend to overreact. They run into a supply shortage and they add in a whole bunch of inventory so it won't happen to them again, and then they realize, oh my gosh, I've got a year's supply here of product. Now we need to shut down the factory. By the time they shut it down they're in a shortage again. So they go through this big pendulum swing between shortage and out of stock versus excessive inventory.

The above quote also reflects the challenge of determining optimal order quantities, optimal production quantities, safety stock levels, and other inventory policies that

Risk events	Definition	Quotes from interviews
Currency	Changes in exchange rates	When you're dealing with international trade, certainly introduce the currency risk
Transit time	Mean and variability of time spent in transit including transportation time and port clearance	"The problem with these long supply lines is they're also highly variable. I mean, it's not just the mean, it's the standard deviation of cycle time."
Forecast	Errors in predicting demand leading to stock-outs or excess stock	"There's the forecast error issue, too, over a long lead times (of global supply chains). And, you know, the forecast error multiplies exponentially as you extend the lead time."
Quality	Defective, damaged, or wrong product, components or materials; differences across multiple sites	"the assumption is that quality is a given, but, the reality of it is, you do have quality difference between suppliers because, you have variation across people as far as who's doing the audit and you don't necessarily have the same guy doing every audit everywhere around the world, so, you know there's difference there."
Safety	Products causing safety hazards	"the problem is that when these suppliers are half a world away from you, they don't necessarily are used to operating with the same quality and the same safety standards as we adhere to over decades because quality and safety standards have been developed in the US over decades and, and they have become almost natural to domestic suppliers. But look at people in the East, they are just starting up factories. I mean, they don't have that history."
Business disruption	Inability to produce goods or sell to customers	"I always used to put in my analyses some money for air freight. I would assume that eventually we're going to encounter a disruption"
Survival	Firm going out of business/bankrupt	"And what if you're outsourcing some component and right safety standards weren't exactly (followed), or right testing wasn't done and you bring in a component that starts burning down people's houses, I mean, can you imagine the lawsuits? So it could put an entire company at risk for survival"

(continued)

Table II. Risk events

Table II.

Risk events	Definition	Quotes from interviews
Inventory and tools ownership	Confusion and/or dispute over inventory ownership; dispute over use and IP of tools provided by one partner	<p>"It's not unusual for (company name) to actually supply or own the tooling that make the parts. What do you do if you own a tool in China and all of a sudden you want to buy from Thailand or Indonesia or Mexico? Do you move the tooling? The tool is built in China and you pay for it, it goes to the supplier and then you say, you're, you're charging too much. We're going to build it somewhere else. We want our tool. Will they let you have your tool? How long will it take to go through the courts and get your tool and you need parts now?"</p> <p>"With both those points of reference (two different companies where this participant worked), I'll say, (there are) common risk elements. One is language and culture barriers. You have to work, probably, a lot harder at overcoming some of those than a lot of people anticipate."</p> <p>"I need some flexibility and I can't have the risk of only being with one... If I absolutely know I'm dependent on you, then I lose some kind of leverage."</p> <p>"So many different things you have to, have to be concerned with when you start looking at risk. Transportation costs increases because of oil, I mean, oil has a big impact. We're seeing it now."</p>
Culture	Inadequate knowledge about people, culture, and language	
Dependency and opportunism	A supplier's or a customer's ability to act opportunistically	
Oil price increase	Changes in oil price	

significantly affect global supply chain performance both in terms of costs and profitability. There is a rich stream of literature that includes a variety of models for effectively managing inventories under various conditions (Talluri *et al.*, 2004; Simchi-Levi and Zhao, 2005; Wang and Hill, 2006). Another manager also discussed the interconnectivity of risks:

Costs are going up; booking ships is becoming more and more difficult. There are delays at the Port of sometimes two or three weeks. That in turn is driving up safety stock, and fuel surcharges are driving up transportation costs.

Figure 1 graphically shows the interactions between different types of risks, along with risk event examples. Supply, operational, and demand risks affect each other and are embedded in the context of “other risks.” The risk events listed under each heading are not exhaustive but only representative of each category. “Other” risks are beyond the direct control of any entity in the supply chain, aggravate the impact of other risk events, and include currency fluctuations, wage rate shifts, and events that compromise the security of the supply chain. It is also important to note that an outcome for one firm in the supply chain may be a “risk event” for another firm. For example, a supplier going out of business is an outcome for the supplier and a risk event for the customer firm.

A model of global supply chain risk management strategies

Based on the interviews, we developed a model of global supply chain risk management strategies (Figure 2). We propose that three factors affect the selection of

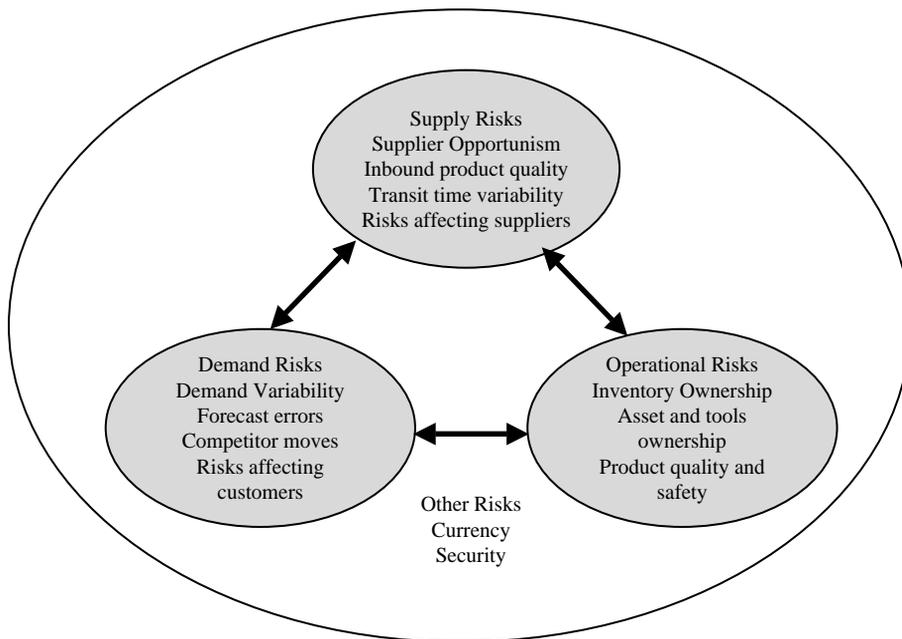


Figure 1.
Risks in global supply
chains

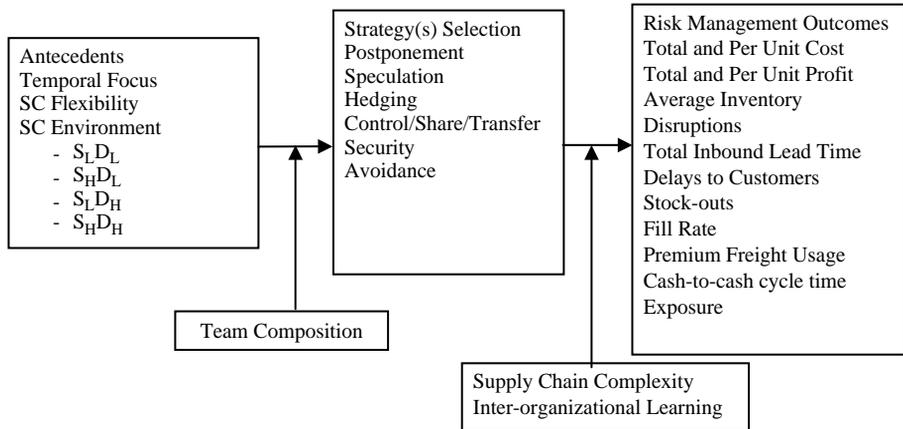


Figure 2.
A model of global supply chain risk management strategies

a risk management strategy, namely temporal focus, supply chain flexibility, and supply chain environment. The links between the antecedents and strategy selection are moderated by team composition. The selected strategy affects the risk management outcomes, and two factors – complexity of the supply chain and extent of inter-organizational learning – moderate this link.

Antecedents

Appropriate strategies are contextual and structured based on the characteristics of the situation. This entails recognizing the factors motivating the choice of a particular strategy for a given situation. Three factors affect the selection of a risk management strategy: temporal focus, supply chain flexibility, and supply chain environment.

Temporal focus. A short-term focus leads to adoption of strategies that provide immediate results and involve lower investments, and vice versa. Risk management is a continual process that involves long-term dedication of supply chain members (Giunipero and Eltantawy, 2004). Our findings suggest that a short-term focus does not necessarily suggest an absence of risk management, but a significantly lower importance to managing risks.

Consistent with the literature, the qualitative study suggests that performance metrics are an important determinant of the temporal perspective of managers (Mentzer and Firman, 1994):

[...] it's not that they (supply chain managers) don't want to (include risks in analyses). It's not that they don't know they should look at risk. But I think they don't because of the pressures they're under, the goals that they have to meet for the year. They probably figure, hey look, it's a low probability, probably won't happen and, frankly, my boss isn't asking me to look at it. So, why should I be a hero and miss my objectives? It's the right thing to do but they aren't rewarded for doing it. Maybe that's at the heart of this, is no one is compensated or incented in their day to day job to look at and evaluate the risks properly.

As the above quote suggests, if the reward system rewards only those who achieve their objectives irrespective of due attention to risks, then managers will strive to

achieve objectives at the cost of disproportionate risks. For example, in one company in the qualitative study, the major objectives are cutting costs, cutting inventory, and improving in-stock product availability. Risk management is perceived as something that slows down the process of achieving these company objectives. A typical off-shore target is to achieve X million dollars of component off-shoring in Y years. The managers of this firm inevitably compromise on risk issues. For the procurement team in this company, the proper supplier selection process is expected to take two years, whereas, usually the company starts sourcing from a new supplier within six months. The pressure to quickly start off-shoring, primarily due to short-term focus of bonus incentives, led to inadequate quality check of second tier suppliers. One such supplier supplied defective wires to the contract manufacturer and the wire got integrated into a range of appliances. The defective wire caused the appliances to malfunction. The cost to fix this quality lapse included replacement of defective appliances, including installation costs, reworking the existing appliances stocked at different levels in the supply chain, and reworking the goods in the three-week long (ocean) pipeline as they arrived. The losses amounted to about 15 percent of the company's bottom-line profit and equal to the anticipated savings from off-shore production for three years. Although the development of specific performance metrics is beyond the scope of this paper, it is certainly an area ripe for future research.

Flexibility. Upton (1994) defines flexibility as “the ability to change or react with little penalty in time, effort, cost or performance.” In uncertain supply and demand markets, a more flexible supply chain can exercise its options faster than its competitors:

[...] you need to have the flexibility to do whatever operations you need to do, wherever you need to do them and source whatever you need from wherever you can get it best. In the model that we apply today, we literally kind of pick up and move operations. It's a very inflexible move. We kind of replicate the same highly integrated, supply base and manufacturing process, just in a lower wage, lower supply base cost location. So wherever our competition follows us, there is no advantage. And, if there are currency fluctuations or wage increases, we're stuck. There's nowhere to go because we're in the same (inflexible) model that we were in before.

Flexibility is important in global supply chains because it plays a facilitating role in the coordination process and provides a unique ability to help firms manage the high levels of environmental and operating uncertainty inherent in global operations. Firms that achieve higher levels of flexibility significantly outperform their less flexible counterparts (Fawcett *et al.*, 1996). Flexibility positively impacts not only the firm's ability to extend its global reach but also its ability to enhance comparative performance relative to leading industry competitors. In sum, supply chain flexibility provides an inherent capacity to respond to emerging circumstances that cannot be fully anticipated in the planning cycle (Welch and Welch, 1996). For example, a global firm chose to assemble and sell air conditioners in India rather than manufacture them in India. They kit them in another country, and then ship the kits to India. The reason – different states in India have different tax advantages for business operations. So, one year, it might be most advantageous to assemble air conditioners in one state, and the next year it might be better to assemble in another state.

However, there is a caveat. Flexibility comes at a cost, is not necessarily useful in all cases, and thus, should be determined by the level of risks faced by the supply chain.

Nembhard *et al.* (2005) developed a supply chain model in which a manufacturing firm can have the flexibility to select different suppliers, plant locations, and market regions. Using a real options approach, they estimate the value of flexibility and determine the optimum strategy to manage flexibility under currency exchange rate uncertainty. They show that if the time lag between the decision and option implementation is not considered, the value of the operational flexibility can be significantly overestimated. More flexible firms have more strategic risk management options available to them. In sum, since flexibility helps a firm reallocate resources quickly and smoothly in response to change (Buckley and Casson, 1998), it is valuable for supply chains that face high demand or supply risks.

Supply chain environment. The qualitative study revealed that supply chain managers are typically concerned with risks on the supply and demand sides of the supply chain. It is not that they ignore operations risk, but (as the quote below illustrates) typically operations risk management resides in other departments such as corporate risk or finance, and is “covered” by buying insurance or hedging foreign exchange exposure. This study, therefore, focuses on supply and demand risks:

I’m the Assistant Treasurer of Risk Management and I have a small staff of four. And, one of our principle products and services is the insurance procurement that we buy for our global operations.

The qualitative study revealed that managers identified supply and demand risks they faced and linked strategies to these risks. It is interesting to note that although managers were aware of appropriate strategies for an environment, the most appropriate strategies were not always adopted because of factors such as performance metrics, supply chain flexibility, and team composition (discussed later). However, the general theme was that a supply chain that adopts and invests in strategies for managing the types of risks it faces should do better than supply chains that mismatch the type of risks faced and the risk management strategy selected.

This notion of matching strategies to the environment is similar to the concept of fit in the strategy literature, which suggests that a resource’s capacity to generate profits or to prevent losses depends, to a large extent, on the fit of a given strategy to the external environment (Amit and Schoemaker, 1993; Porter, 1991; Wernerfelt and Karnani, 1987). This is similar to suggestions of matching the type of supply chain to demand uncertainties faced by the supply chain (Fisher, 1997).

Based on our qualitative study, we adopt the classification developed by Lee (2002) to develop a 2×2 matrix of supply chain environment, based upon supply and demand risks. Table III cells denote the environments facing supply chains in terms of the levels of supply and demand risks. “S_LD_L” denotes low supply and low demand

Demand risks	Supply risks	
	Low	High
Low	S _L D _L	S _H D _L
High	S _L D _H	S _H D _H

Source: Lee (2002)

Table III.
Types of supply chain environments

risks, “S_LD_H” denotes low supply and high demand risks, “S_HD_L” denotes high supply and low demand risks, and “S_HD_H” denotes high supply and high demand risks.

Although we found evidence of importance of all antecedents, the environment facing the supply chain emerged as most important, primarily because supply and demand risks are outside the scope of the firm and require supply-chain wide attention. Therefore, in this paper we focus on the effects of supply chain environment on strategy selection. Further exploration of temporal focus and flexibility is left to future research.

Risk management strategies

Based upon the definition of risk developed above, in-depth interviews, and building upon the existing literature (Norrman and Jansson, 2004; Jüttner *et al.*, 2003), the following definition of global supply chain risk management was developed:

Global supply chain risk management is the identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure – for supply chain outcomes that in turn lead to close matching of actual cost savings and profitability with those desired.

An interesting addition in this definition, which had been missing in the existing definitions, is “matching of actual cost savings and profitability targets with those desired.” As the quote below suggests, it may be possible to reduce adverse risk event outcomes in the short run but the long run cost is critical to the profitability of global supply chain ventures:

Well I think the number one thing people would do is just put inventory in the system. So that's one, one almost no-brain approach to dealing with risk, just have a layer of inventory on the system. Add 60 days more to inventory to deal with globally outsourced product. But, sixty days is enormous. I guess I have to do that in the short-term but in the long run my only hope is to try to get faster and more efficient [. . .] and the companies that are the fastest are going to really win because the others are going to be paralyzed.

Everything else remaining the same, faster (shorter cycle time) and higher efficiency should lead to higher profits. Another manager discussed the cost focus in his company in terms of profits:

Probably one of the biggest difference between the company I came from and this company. And I don't think it's unique to this company. The focus on cost is just unremarkable. We have, in a sense, in our industry, *cost reduced ourselves to profitability* over time.

Several outcomes are of interest in global supply chain risk management. Foremost, risk management should lead to closely matching the desired cost savings and profitability targets. Therefore, total supply chain cost and profit that account for both benefits and costs of risk management strategies are important outcomes that need to be measured to ascertain the effectiveness of a risk management strategy (Beamon, 1998). However, other measures of supply chain performance that are most likely to be impacted by global supply and demand uncertainties should also be included to evaluate a risk management strategy holistically. On the supply side, two outcomes of interest in global supply chains emphasized in the literature as well as by participants

in the qualitative study include supply disruptions (Chopra and Sodhi, 2004), and total inbound lead time (Fagan, 1991). On the demand side, the outcomes most emphasized include stock-outs (Chopra and Sodhi, 2004; Fisher, 1997), fill rates (Beamon, 1998; Chang and Makatsoris, 2001), lead times, and delays to customers (Chopra and Sodhi, 2004). Operational outcomes of interest in global supply chains include average inventory (Cho and Kang, 2001; Min and Zhou, 2002; Van der Zee and Van der Vorst, 2005; Zsidisin, 2003a), premium freight usage on both the inbound and outbound side, cash-to-cash cycle time (Min and Zhou, 2002), and exposure (Miller, 1992). While other outcomes are self-explanatory, exposure has been defined as the number of different types of risk events that occur in a given time period. All risk-related outcomes are of interest in global supply chains. However, the propositions offered in this study are based on total net profit as it encompasses several other outcomes such as total cost (which in turn includes inventory costs, cost of delays to customers, stock-out costs, transportation cost), and total revenue.

We found evidence of six risk management strategies in the qualitative study also supported by the literature: postponement (Bucklin, 1965; Chiou *et al.*, 2002; Zinn and Bowersox, 1988), speculation (Bucklin, 1965), hedging, control/share/transfer (Achrol *et al.*, 1983; Agrawal and Seshadri, 2000; Cachon, 2004), security (Downey, 2004), and avoidance (Miller, 1992). Although explored in literature, they have not been explicitly linked to risk management in global supply chains. Using insights from the interviews, the following discussion provides descriptions of the six risk management strategies, and develops propositions on the appropriateness of each strategy under differing levels of global supply and demand risks.

Postponement. Postponement entails delaying the actual commitment of resources to maintain flexibility and delay incurring costs (Bucklin, 1965). Form postponement includes labeling, packaging, assembly, and manufacturing. Time postponement refers to the movement of goods from manufacturing plants only after customer orders are received (Zinn and Bowersox, 1988). The extent of form postponement depends on demand customization, component costs, product life cycle, and product modularity (Chiou *et al.*, 2002). The following quote illustrates the usefulness of postponement strategy:

Let's just say you architect your product into modules [...] and what it does, it separates the module production from the assembly of the product. Right now, we're highly integrated. Greasing the parts and building the product all happen at the same time. If you separate those through your architecture, you have tremendous flexibility. You can keep a factory open, because it is not really necessarily a factory anymore, to do assembly of your product close to where you need it, at your distribution center, that makes sense for how you distribute into the marketplace. But you can do module production, literally, anywhere. So you can now have the right partnerships, you can have a technology partnership, you can have a cost focus on pieces that make sense, modules that make sense to have a cost focus on. You can move assembly from location to location. You can move modules more easily because you understand how they're going to interact in the system as opposed to our interactions. We approach architecture in an integrated fashion today, the interactions are not always very clear.

A major problem faced by supply chains is how to justify the cost of form postponement. Form postponement requires a substantial investment in understanding product design (Van Hoek, 2001) and more effort as modular products are more difficult

to design than comparable interconnected systems (Baldwin and Clark, 1997). The existence of common or overlapping suppliers and customers in different supply chains may affect a firm's ability to invest in the postponement related facilities and training programs (Yang *et al.*, 2004). Any investment may provide a benefit for competitors, i.e. a source of opportunism, and hence increase transaction costs. With increasing interest in postponement (Yang *et al.*, 2004), measures have been developed to improve coordination through behavioral interdependence, and reduction in autonomy of coordinating organizations and thereby reducing behavioral uncertainty (Appelqvist and Gubi, 2005). Building on Perry (1991), who suggests the potential benefits of postponement depend on the uncertainty projected in the operating environment, it is argued that supply chains facing low demand uncertainty will not benefit as much from form postponement as supply chains facing high demand uncertainty. Therefore:

- P1.* Supply chains facing $S_L D_H$ and $S_H D_H$ environments are more likely to adopt form postponement strategies than those facing $S_L D_L$ and $S_H D_L$ environments.

We did not find evidence of time postponement strategies in our interviews. This is probably because distance and logistics constraints (e.g. availability of transportation options and delays at ports) make time postponement an expensive strategy in a global supply chain context. At most, a few executives mentioned the use of air to expedite freight. This was driven more as a fall-back option for contingencies than a well thought out postponement strategy. However, based on the literature, it is expected that flexible supply chains operating in high demand risk environments are more likely to adopt time postponement strategies.

An interesting observation in the qualitative study was a general sense of enthusiasm towards form postponement strategy. It appeared that an increasing trend toward off-shoring provided a motivation for form postponement. Yang *et al.* (2004) also argue that with increasing attention to mass customization, agile operations, and e-business strategies, there should be more interest in postponement; however, there has been an absence of empirical research supporting this implication. Since global supply chains face high risks, postponement becomes increasingly valuable as the proportion of off-shore components in the final product increases. Therefore, as a preliminary observation, we believe that as the proportion of off-shore components in the final product increases, the likelihood of a supply chain considering investment in form postponement will increase.

Speculation. Speculation (also called selective risk taking) is a demand-side risk management strategy that is the opposite of postponement (Bucklin, 1965). Bucklin (1965, p. 27), mentions that "the principle of speculation holds that changes in form, and the movement of goods to forward inventories, should be made at the earliest possible time in the marketing flow in order to reduce the costs of the marketing system." It includes such actions as forward placement of inventory in country markets, forward buying of finished goods or raw material inventory, and early commitment to the form of a product, all in anticipation of future demand. In the interviews, speculation emerged as the most commonly used strategy to address uncertainty in the business environment:

The total amount of initiatives (e.g. products, product lines, and markets) that you could potentially work on would far exceed that number (of initiatives that are realistically possible

because of resource constraints). So the difficult decisions were really to place your bets, so to speak, on the right horses. In other words, try to make sure you worked on the things that were really going to deliver the year end objectives because if they didn't it reflected on all of our evaluations, which is as a matter of fact reflected in our compensation.

In speculation, decisions are made on anticipated customer demand. The resources in the supply chain need to be directed to those specific products and customers that provide the firm with a competitive advantage (Perry, 1991). By fixing the form of the finished goods at the earliest point, it is possible to gain economies of scale in production, procurement, and transportation, as well as lead to reduction in sorting costs. However, to ascertain the form of finished goods is more useful in low demand risk conditions. That is, speculation requires high-quality estimates of demand, which is possible under low demand uncertainty. An example of speculation is, in case of limited market research resources, to serve customers with similar demographics in culturally-similar countries rather than developing customized products for new markets. In speculating about cost-risk trade-offs, managers should typically be aware of the supply-demand and/or operating trade-offs associated with the options and choose to avoid unattractive options. Supply chains facing low demand uncertainty are better suited to achieve the benefits of speculation. Therefore:

- P2. Supply chains facing $S_L D_L$ and $S_H D_L$ environments are more likely to adopt a speculation strategy than supply chains facing $S_L D_H$ and $S_H D_H$ environments.

Hedging. Hedging is a supply side risk management strategy. In a global supply-chain context, hedging is undertaken by having a globally dispersed portfolio of suppliers and facilities such that a single event (like currency fluctuations or a natural disaster) will not affect all the entities at the same time and/or in the same magnitude. Managers in the study mentioned having “qualified back-up” suppliers in the USA because their supply chains are not in a position to accommodate even short-term disruptions. An example quote illustrates the impact of absence of a hedging strategy:

Company X got burned a number of times with currency fluctuations due to outsourced product. Euro has been strengthening, (and had) a dramatic impact on X's profitability; The import of that European product was very profitable, but a lot of profitability got wiped out due to the currency issues. I think there's a huge risk we face right now as they outsource more and more stuff to China, that the Yuan or the RMB, it's likely that's going to strengthen I would think. And that could wipe out a good chunk of the savings.

Hedging is an expensive strategy because it involves creating multiple options for decision variables. For example, dual sourcing can be used as a hedge against risks of quality, quantity, disruption, price, variability in performance, and opportunism (Berger *et al.*, 2004), but dual sourcing requires more investment than single sourcing. Another consideration in hedging is the requirement of similar levels of output in terms of quality and service across multiple facilities or supply chain partners. Hence, hedging yields maximum benefits where strong quality and process controls are in place. In sum, hedging requires high levels of investment, which is justified and more valuable only if a supply chain faces high supply risks. Therefore:

- P3. Supply chains facing $S_H D_L$ and $S_H D_H$ environments are more likely to adopt hedging as compared to supply chains facing $S_L D_L$ and $S_L D_H$ environments.

Control/share/transfer. The interviews suggest that control, share, or transfer of risks take the form of vertical integration, contracts, and agreements. Vertical integration increases the ability of a member of a supply chain to control processes, systems, methods, and decisions. Vertical integration may take the form of forward (downstream) or backward (upstream) integration, and is therefore, both a supply side and demand side risk management strategy. The literature suggests that integration may also be used to create entry or mobility barriers (Bucklin, 1965). Desirability of control and hence the level of integration also depend on the commitment of the focal firm to the target market. Vertical integration may increase control and reduce risks in a supply chain, but it changes variable costs into fixed costs.

Need for greater control leads to higher demand side integration (Anderson and Gatignon, 1986). Innovative products, such as proprietary products and high service requirement products, are more likely to be sold through forward integrated supply chains (Boedecker and Morgan, 1980). An example is biotechnology companies involved in drug discovery. These companies overcome the uncertainty and need for technology integration through acquisition and partnering strategies. Such strategies help biotechnology companies apply their technologies across a broad range of applications within the drug discovery supply chain to maximize opportunities for product development, thereby delivering competitive advantage through better speed, cost, quality and direction (Amir-Aslani and Negassi, 2006). Another example is that of banks and insurance companies that create innovative partnerships, buying stakes in other companies and forming strategic alliances to sell an increasingly wider and complex portfolio of financial products (Schroeder, 1998). On the supply side, some of the risks that provide incentive for backward integration are opportunism and asset specificity by the supplier, capacity constraints, and the supplier-buyer power balance (Achrol *et al.*, 1983; Ellram and Siferd, 1998; Williamson, 1979).

However, vertical integration ties up capital and reduces the flexibility of the supply chain to react to environmental changes. There is a growing trend toward supply and demand side disintegration, with firms focusing more on core competencies, and outsourcing non-critical activities. For example, in the global semiconductor industry, there is vertical separation of design, manufacture, equipment production and process development (Macher *et al.*, 2002). Several companies in our sample are engaged in manufacturing electronic components and products and electrical appliances are increasingly outsourcing and off-shoring manufacturing activities. An interesting example is one company in our sample that started as an electronic and electrical components and product manufacturing company. Today, it earns substantial revenue from managing the product-design and development process with completely outsourced contract manufacturing.

In such fragmented supply chains, benefits of control can also be obtained through virtual supply chain integration and supply chain collaboration. Writing specific contracts to share and transfer risks can be employed as an alternative to vertical integration. Sharing or transferring risks takes place through outsourcing and/or writing flexible contracts with clauses that account for possible changes in the environment and associated risks (Macneil, 1978). Sharing and transferring risk may take place in supply chains with either a short-term or a long-term focus.

We found no strong link between environment and the types and extent of control strategies. Therefore, an interesting research direction is to explore this link further. In terms of vertical integration only, we propose:

- P4. Supply chains facing $S_H D_L$ environment are more likely to adopt backward integration, supply chains facing $S_L D_H$ environments are more likely to adopt forward integration, and supply chains facing $S_H D_H$ environments are more likely to adopt both backward and forward integration.

Security. Global supply chain security encompasses information systems security, freight breaches, terrorism, vandalism, crime, and sabotage. Security strategy is aimed at increasing a supply chain's ability to sort out what is moving, and identify unusual or suspicious elements. Security strategy also encompasses working closely with government and port officials to proactively comply with regulations and avoid unnecessary delays at border-crossing points. Several government efforts such as the Container Security Initiative, the Customs Trade Partnership Against Terrorism (CTPAT), and the overarching operation safe commerce initiative provide directions to gradually enhance the security of global commerce (Downey, 2004).

Our study revealed that the direction for pursuing security strategies and several government guidelines (such as security criteria for Long Haul Highway Carriers in Mexico) are based on CTPAT. The US Customs and Border Protection web site (www.cbp.gov) provides several documents with guidelines to enhance the safety of the cargo entering the USA. The International Ship and Port Facility Code, introduced by the International Maritime Organization, came into effect in July 2004. It is a code agreed between the signatories on minimum security arrangements for ships, ports and coast guard agencies.

Many companies go beyond the statutory regulations to secure their supply chains. Almost all managers in the qualitative study reported concern for supply chain security and that they are taking proactive actions to secure their supply chains. Private initiatives mentioned by our participants included tracking and monitoring the integrity of cargo containers using RFID and GPS, usage of temper-proof seals, and working with port officials to understand and implement CTPAT guidelines. Managers facing all varieties of the supply and demand risks reported having more security checks in place because of going global and increasingly stringent regulations. Therefore, we propose:

- P5. All types of supply chains will increase the use of security strategies.

An important implication of this proposition is that supply chain managers need to include the costs of implementing security strategies with all other risk management strategies. Some strategies, such as vertical integration and avoidance, may reduce security strategy costs while others, such as transferring risks, may increase the cost of implementing security strategies.

Avoidance. The qualitative study pointed to the existence of two types of avoidance strategies. Avoidance strategy Type 1 is used when the risks associated with operating in a given product or geographical market, or working with particular suppliers or customers, is considered unacceptable. Miller (1992) suggests that avoidance takes the form of exiting through divestment of specialized assets, delay of entry into a market

or market segment, or participating only in low uncertainty markets. The following quote illustrates:

If it was all easy, then there's not much reward in assuming the risk. It is a risk/benefit trade off. We get benefit from moving to China through costs and we can quantify how much we think we can save by moving product to China, for example. But if that probability of risk times impact is greater than the benefit, then you make a conscious decision that that's probably not a good idea.

Avoidance strategy Type 1 is geared toward driving overall probabilities associated with risk events of a decision to zero by ensuring that the risk does not exist. In avoiding risks, managers are aware of the supply-demand and/or operating trade-offs associated with the options and choose to avoid or drop some of these risks.

Avoidance strategy Type 2 takes the form of preempting adverse events. For example, in our interviews, we found that avoidance strategy for off-shoring quality issues consists of site audit and approval, and product audit and approval. Managers ensure that all participants are on a quality base line so that quality problems are avoided. However, they understand that although quality is a given, there are variations across people (including those who do the audits) and suppliers. The following quote is illustrative:

[...] make sure that you understand what all the risks are and the people are picking up on them and addressing them. Before we produce product in this facility it has to pass our audits and be approved and then you have to get the product approved there as well. So they have to build some sample product and send it to us and have some testing done, and approve it from that standpoint. So there's a site approval and a product approval that we go through before we fully approve any specific product out of a specific site.

In avoidance strategy Type 2, reducing the frequency and probability of a risk event is of concern. This usually arises when managers have no option but to venture into high uncertainty demand or supply markets. A review of the literature suggests that quality costs can primarily be divided into prevention, appraisal, and failure. Our participants suggested that quality-related costs for off-shore manufacturing can add up to a substantial part of a company's costs. Giakatis *et al.* (2001) provide a good review of the stream of literature focused on understanding the cost of quality. This literature stream can provide valuable guidance for managers seeking to better understand and apply quality control frameworks in a global manufacturing context.

Our interviews revealed that supply chains operating in all types of environments attempt to avoid risks within the constraints of acceptable returns such as revenue and profit targets. If a supply chain has an option to not enter a $S_H D_H$ environment but still meet targets, then it is more likely to adopt a Type 1 avoidance strategy. However, if a supply chain has no choice but to enter a $S_H D_H$ environment to achieve its targets, then it is more likely to adopt a Type 2 avoidance strategy. All types of supply chains adopt avoidance strategies to varying degrees, driven by the availability or non-availability of options. Therefore:

P6. Supply chains operating in all types of environment adopt avoidance strategies. Type 1 avoidance strategy is adopted when a supply chain has an option not to enter a high demand or supply risk environment. Type 2 avoidance strategy is adopted when a supply chain has no option but to enter a high demand and/or supply risk environment.

The moderating role of team composition

The first step in identifying risk typically starts when an opportunity to reduce costs or to increase revenues is recognized by a firm in the supply chain. This opportunity may be realized by sourcing from, producing in, or selling across the domestic market borders. Such decisions may be capital intensive and have major cost or strategic implications. This is because operational decisions related to inventory policies and levels, transportation contracts, and warehouse capacity and locations have to be linked with sourcing and marketing decisions to optimize supply chain operations. Therefore, such decisions cannot be easily reversed in the short run. The interviews support the contention that such decisions tend to be team-based:

One person might make the wrong decision four times out of a hundred. But a collaborative team will always make the right one [...] So the positive side is it allows executing at a high level. The negative side is that it takes time, more time than we would like. So if we're making a supply chain decision to make something in Mexico or in Asia or in Europe, it takes more people to be involved in making the right decision than if we're deciding to make it in Los Angeles, California.

Team members bring different perspectives to solving a problem. Hence, team composition becomes an important determinant of the quality of risk identification and management. However, for the team to effectively and efficiently reach a decision, it is important to understand the trade-offs and counteractive forces that may exist in a group. The following quote from a senior supply chain executive provides an example:

[...] in addition to supply chain we had procurement involvement, legal, customs, material control involved in decision making for off-shore procurement. Factory material control was a key player in this. They're the ones that are impacted. They're sitting there running the factories and if they don't have the parts they're the ones who feel the pain when the parts aren't there so they had a vested interest in doing everything they could to stop this project.

The interviews suggested the following important trade-offs and counteractive forces should be considered when determining the team composition for a global supply chain decision:

- members with stakes for and against the decision in question;
- members with risk-averse versus risk-taking attitudes;
- trade-offs between inclusion of members outside the organization, and the time and cost of such an effort. For example, involving supply chain members may pay off in the long run but may involve significant investment by the focal firm; and
- getting the most functionally proficient managers versus managers with long-term vision.

Because of the above factors, given the same antecedent conditions, the strategy selected will differ with different team composition. Therefore:

P7. Team composition affects the relationship between the antecedents and the strategy selected.

An important implication of this proposition is that who gets involved in decision making should depend on the kind of change. Three types of changes may accompany

global supply chain decisions that may affect the supply chain risks: consumer facing changes, changes in the source of components that provide the same functionality, and changes that affect operational capabilities. An example provided by a participant in the study illustrates. If a company changes the supplier of printed circuit boards (PCB) from a domestic supplier to an off-shore supplier, as long as the functionality is the same as before, marketing may not need to get involved. Hence, in this case, supply risks can be adequately handled by logistics and quality auditors. However, for these same PCBs, deciding on how to protect the proprietary software in the PCBs requires active involvement of product design specialists. Therefore, a different team composition is required for security risks.

Another example from the qualitative study is that of worldwide procurement of stainless steel that goes into home appliances. The refrigerator cannot look different than the dishwasher or stovetop in terms of finish and color. In this case, the marketing department is expected to be a part of the decision and to agree that the color and finish match to avert demand risks. Depending on the type of decision, the team composition most appropriate to reach effective decisions varies. Exploring team compositions for different types of global supply chain decisions is an interesting future research direction.

Supply chain performance

Given the definition of risk management in global supply chains, risk management strategies should lead to reduction in loss, probability, speed, frequency, and/or exposure of risk events and thereby improve the supply chain outcomes listed in Figure 2. Per the concept of fit discussed earlier, adopting a strategy that fits the propositions above should lead to better performance.

Moderators to risk management outcomes

The qualitative research suggests that complexity of the supply chain and the degree of inter-organizational learning in the supply chain moderate the relationship between the risk management strategies selected and risk management outcomes.

Supply chain complexity. Supply chains are composed of elements that have intricate, counterintuitive, and nonlinear links, and as a consequence, are both complex and adaptive (Choi and Hong, 2002). Supply chain complexity is an aggregate measure of the structure, type, and volume of interdependent activities, transactions, and processes in the supply chain. It also includes the information, constraints, and uncertainties under which these activities, transactions, and processes take place (Manuj and Sahin, 2005). The dimensions of complexity identified in literature include levels and tiers in a system (Choi and Hong, 2002); form of technology and nature of information processing (Vachon and Klassen, 2002); and volume and variety of logistics transactions, stock keeping units, number of supplying and distribution partners, number of countries involved, and origin-destination pair permutations (Rao and Young, 1994).

A manager suggested, “as you move internationally, the complexity goes up considerably.” Global supply chains drive up the level of complexity, which drives up the level of risks. When the level of complexity is uncontrolled, the system is less predictable. Therefore, reducing complexity should be a strategic goal for operations (Frizelle and Woodcock, 1995). There is evidence in the literature that less complex

supply chains are better able to manage supply risks (Wilding, 1998) and improve performance (Vachon and Klassen, 2002). Furthermore, lower complexity leads to better implementation of strategies by reducing issues such as confusion about ownership of inventory, bullwhip effect, and inertia (Wilding, 1998) and increases the predictability of the outcomes. Therefore:

- P8. Greater supply chain complexity lessens the relationship between supply chain risk strategies and risk-related outcomes.

Inter-organizational learning. Organizational learning helps a firm develop its knowledge base (Holmqvist, 2003; Huber, 1991), and provides fresh insights into strategies, markets, and relationships (Hult *et al.*, 2000). Learning can also provide a platform for building dynamic capabilities (Teece *et al.*, 1997). However, in the current age of increasing fragmentation, it is not a single organization that implements a strategy but a set of institutions, agencies, and establishments that reside in multiple countries and are often independently owned. Therefore, the focus of learning shifts from within-organizations to between-organizations – i.e. inter-organizational learning. Inter-organizational learning is a process by which supply chain partners share and combine information and knowledge in creative ways that lead to enhanced supply chain outcomes:

There's value in institutional knowledge of a supplier that they have with us, we have with them, their technical capabilities, their quality systems. We like it best when the supplier stays with us but is competitive. If the question was how do you get them (suppliers) to move their assets (from Mexico to China), you really don't. But marketplace gets them to move their assets. They've got to make decision, do they make investments to be a global player or not. There is great value in that institutional knowledge. So that is really what we like to have happen.

Inter-organizational learning positively affects several performance measures in supply chains, such as reduction in cycle time (Hult *et al.*, 2002; Hult *et al.*, 2003), higher resilience (Comfort, 1994), higher levels of relationship commitment (Hult *et al.*, 2003), and increased flexibility, which consequently lead to a larger set of strategies from which to choose, as well as better implementation of selected strategies:

- P9. Greater inter-organizational learning strengthens the relationship between supply chain risk strategies and risk management outcomes.

Implications

Although important, risk management has not received enough attention (Jüttner *et al.*, 2003). Several strategies have been suggested, but there is little knowledge about the antecedents that lead to their adoption. This paper addresses this gap and presents a model of risk management strategies based on a qualitative study and weaves it into the existing literature. It is important to reassert here that, since the qualitative study was based on global manufacturing firms, the propositions developed in this paper hold only for participants of global manufacturing, and similar, supply chains. As mentioned earlier, the intent of qualitative study is to explore concepts based on thorough understanding of a few key informants (McCraken, 1988). The goal is not to generalize but to explore the full breadth of the phenomenon (Strauss and Corbin, 1998). Several research and managerial implications result from this effort.

Research implications

The first theoretical implication is the identification of antecedents to supply chain risk management strategies. Although the literature identifies several strategies for managing supply chain risks, it falls short in identifying when to use each strategy. This paper addresses the gap by identifying the most important antecedents to selection of risk management strategies and linking the antecedents to appropriate strategies. Future research should quantitatively explore the strength of these relationships and qualitatively explore whether more antecedents exist and their complex nature.

A second contribution is the exploration of the concept of risk in a global supply chain context. Several new dimensions of risk, namely speed and frequency, other than the popular dimensions of probability and losses have been identified and explored to explicate the concept of risk in global supply chains. Speed and frequency coupled with increased lead times, lead time variability, physical distances from sources of risk, and lesser control over the supply chain increase the magnitude of problems manifold in global supply chains as compared to domestic supply chains. These dimensions should serve the body of knowledge well in helping practitioners frame their global supply chain management risk strategies, and in helping future researchers better understand the nuances of global supply chain risk management.

An important insight is the moderating effect of team composition on the relationship between the selection of risk management strategies and its antecedents. Little work has been done to explain the nature of team composition in supply chains and, as such, this is a contribution to the body of knowledge. Moreover, how the various risk management strategies and their relationship with temporal focus and supply chain characteristics is affected by team composition suggests a whole program of research to examine the impact of team composition on various supply chain decisions.

We also identify and elaborate on two moderators of the strategy implementation-performance relationship – complexity and inter-organizational learning. The literature does not sufficiently address implementation issues after strategy selection, and this is a contribution of this paper. Many strategies fail in the implementation phase. For risk management strategies, managing complexity and leveraging inter-organizational learning can lead to better supply chain performance. Some complexity reduction measures mentioned by our participants in conjunction with risk management included stock keeping units rationalization, serving varied customers such as contract and retail stores through one integrated supply chain, and reducing number of suppliers. The other moderator is inter-organizational learning which can lead to faster and better implementation of a selected strategy. In addition, learning leads to increased flexibility that leads to more strategic options. Developing a step-by-step strategy implementation protocol is not the focus of this paper, but we describe two broad areas of focus in supply chains that moderate strategy implementation, which should help future researchers develop such a step-by-step protocol.

A limitation of this study is the sample consists exclusively of managers involved in making and executing supply chain decisions for their firms, with the exception of one manager who is involved with both in-house supply chain planning and for external clients. Although we reached theoretical saturation in our sample, very rich data were

provided by the manager who is involved with external clients. We believe that in-depth interviews with managers in 3PL firms, and those providing global supply chain solutions to external clients would provide additional insights, particularly concerning additional strategies for managing risks. Future research may also focus on linking the strategies to outcomes, i.e. if a particular risk management strategy is adopted, what outcomes are influenced the most.

An interesting research direction follows from a major concern expressed by several managers in our study. As discussed earlier, it is challenging to determine optimal order quantities, optimal production quantities, safety stock levels, and other inventory policies in global supply chains. A future research direction is to comparatively investigate multiple inventory policies in terms of cost and profitability.

Future research should also focus on refining and testing the model with qualitative and quantitative data across different industries and companies, including tier one or tier two suppliers, retail chains, and 3PL service providers. Further qualitative and quantitative empirical testing should reveal variations, if any, across multiple firms in a supply chain, industries, and cultures. On the quantitative side, survey research is appropriate as it emphasizes representative sampling, and seeks to maximize population generalizability thereby enhancing the external validity of research. The size, complexity, and stochastic nature of global supply chains also make computer-based simulation a useful methodology for future research.

Managerial implications

Although the lack of quantitative testing of the model at this point limits the managerial implications, there are still several implications for managers. First, managers should fully understand, at a minimum, the six risk management strategies discussed in this paper, namely postponement, speculation, hedging, control/share/transfer, security, and avoidance. No company or supply chain can afford to adopt one of these strategies for all global supply chains. Different global supply chain conditions (moderated by team composition) affect the appropriateness of the various strategies. Managers must understand the advantages and disadvantages of the various risk management strategies, and when they are appropriate. Managers should also consider the composition of risk management teams, in terms of functions and orientations represented, to assess and manage the myriad of global supply chain risks.

In light of heightened concerns for global supply chain safety and security, managers need to consider the costs of securing global supply chains in their decisions. Documenting the security strategies developed by managers is another useful and timely area of further research.

The risk management outcomes discussed in this paper also provide direction to managers in the performance metrics that should be developed to assess the success or failure of global supply chain risk management. It is certainly axiomatic that what is not measured cannot be managed. Further, what is measured incorrectly or under-measured will be mismanaged (Mentzer and Firman, 1994). Developing metrics that accurately and fully tap the impact of effectively managing risks in global supply chains will drive managers to take appropriate, well managed risks. This development is beyond the scope of this paper, but certainly holds considerable opportunities for managers and future research.

Finally, it is important for global supply chain managers to consider the degree of complexity in their various global supply chains, and the ability of their organizations to partially ameliorate this complexity by adopting inter-organizational learning processes. Although the exact nature of the impact of complexity and learning on performance outcomes still needs further research, managers can begin to adopt the strategies discussed and cited here.

Managers in our study repeatedly made comments about the fact that growth in outsourcing and off-shoring, increasingly demanding customers, geographical dispersion of supply chain, access to markets in emerging economies, and unanticipated events such as terrorist acts and natural disasters will lead to increased complexity, risks, and opportunities in global supply chains. Thus, this paper is an important initial step in developing models of global supply chain risk management strategies. The area is ripe with opportunity, both for future research and competitive advantage.

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Appendix. Interview protocol/guide (based on McCracken (1988))

Opening

- Introductions of interviewer and interview participant.
- Overview of purpose of the study.
- Confidentiality assurance.
- Permission to audiotape.

Demographic data

- Title of interview participants.
- Job history.
- Organizational structure.
- Background on organization, industry.

Lines of inquiry

- What are elements of risk?
- What is a risk management process?
- Steps in process.
- Tools and techniques.
- Strategies for risk management.
- Risk mitigation/contingency planning.
- Facilitators/impediments in the process.

Additional unplanned/floating prompts

- Describe.
- Tell me more about that.

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- Explain that in more detail.
 - Give me examples or tell me about a related incident.
 - How does that work?
 - Tell me about a time when that did not happen.

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