An Agency Theory Investigation of Supply Risk Management

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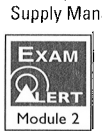
SUMMARY

Managing supply risk is an essential element of the overall supply management task. As the complexity of risk management has increased, responsiveness seems dominated by varying the level of inventory and using multiple supply sources as means of creating buffers. This research uses the framework of agency theory in managing supplier behaviors as a means to reduce supply risk and the impact of detrimental events. Empirical results indicate that purchasing organizations address various sources of supply risk by implementing management techniques that reduce the likelihood that detrimental events will occur. Firm size, purchases as a percentage of sales, and industry characteristics were also found to influence the manner in which supplier behaviors are managed.



INTRODUCTION

Every organization needs to acquire goods and services in order to carry out its mission and goals. Varying degrees of risk are associated with obtaining these inputs. An unplanned event may occur in their acquisition, delivery, and use that can negatively affect a firm's ability to serve its own customers. Supply risk is defined as the probability that such an event will occur and the resulting detrimental consequence on the purchasing firm.

Some degree of supply risk exists in every business organization. If contingency plans are not made to manage risk, the occurrence of a negative incident can have an immediate damaging effect on the purchasing firm. In order to understand how purchasing organizations address risk, this study creates and empirically tests a model of purchasing and supply management's involvement in supply risk management, using the agency theory perspective.

Organizations face numerous sources of risk with inbound supply. Risk can differ in type from supplier to supplier, in the duration of the risk, and in the degree of impact the good or service at risk has on the purchasing firm (Steele and Court 1996). Common methods employed to manage supply risk include inventory management (Lee and Billington 1993; Lee, Padmanabhan, and Whang 1997; Starr and Miller 1962) and the use of multiple sources (Anupindi and Akella 1993; Newman 1989; Tullous and Utecht 1992). These techniques shield an organization from the effects of supply risk due to uncertainty by creating a "buffer" from the detrimental incidents that can occur.

In contrast to buffering the effects of risk, the purchasing organization may also attempt to reduce or eliminate the source of risk. Cyert and March (1963) asserted, "Firms will devise and negotiate an environment so as to eliminate the uncertainty." The researchers believe the goal of completely eliminating supply risk is unrealistic, but the goal of reducing the probability of a detrimental event is achievable. Therefore, supply risk management consists of purchasing organization efforts that reduce the probability

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of occurrence and/or the impact that detrimental supply events have on the firm. Because the context for managing supply risk involves a principal (purchasing organization) and agents (suppliers), an appropriate theoretical perspective for studying supply risk management is agency theory.

LITERATURE REVIEW AND THEORY DEVELOPMENT

The following section establishes a theoretical foundation for studying supply risk management. This section begins with an introduction to agency theory. Next, a description of potential supply risk sources is presented. A discussion of behavior-based and buffer-oriented supply risk management methods follows. The literature review and theory development section concludes with hypotheses that will be tested.

Agency Theory

Agency theory is concerned with the study of problems that arise when one party, the principal, delegates work to another party, the agent (Eisenhardt 1989; Lassar and Kerr 1996). The unit of analysis is the metaphor of a contract between the agent and the principal. Previous studies employing agency theory as the theoretical framework have used "coordination efforts" (Celly and Frazier 1996), "control" (Anderson and Oliver 1987), and "management" (McMillan 1990) as the unit of analysis. In this research, the purchasing organization is the principal and the supplier is the agent. Variables that influence the contract between the principal and the agent include information systems, outcome uncertainty, risk aversion, goal conflict, programmability, outcome measures, and relationship length (Eisenhardt 1989). In examining supply risk, this study adopts the efforts of the purchasing organization to manage suppliers as the unit of analysis.

The management of risk can be categorized by outcome- and behavior-based contracts (Choi and Liker 1995; Eisenhardt 1989; Lassar and Kerr 1996). In the context of inbound supply, outcome-based management efforts reflect the extent that purchasing organizations emphasize results. Complete reliance on outcome-based efforts signifies an exclusive concern with bottomline results, regardless of how suppliers achieve them (Choi and Liker 1995). As uncertainty becomes insignificant, an agency theory perspective supports outcome-based supply risk management efforts as appropriate (Eisenhardt 1989). Supply is more efficiently managed without unnecessary intervention into supplier operations on the part of the purchasing organization.

The literature supports that one way to achieve the desired outcome of reducing the impact of detrimental supply events without intervening with supplier operations is through the use of buffers. Although not explicit in agency theory, buffers are used to shield the organization from the negative effects of a damaging event (Newman, Hanna, and Maffei 1993; Pagell and Krause 1999). The use of buffers provides a short-term solution to problems of supply risk, and focuses predominately on outcomes by reducing the impact of supply risk events. Extensive use of buffers may be cost prohibitive to the purchasing organization in the long run due to increased inventories, potential obsolescence, and reduced opportunities to enjoy the economies of scale available from a reduced supply base.

When supply uncertainty becomes a significant factor, the application of agency theory suggests that the purchasing organization embrace management efforts that reduce the probability and/or impact of a detrimental event on the firm. The appropriate risk reduction strategies can be categorized as behavior-based management efforts or buffer-oriented methods to shield the organization from detrimental events.

Behavior-based management efforts focus on processes, emphasizing "tasks and activities" that lead to a reduction in supply risk (Eisenhardt 1989; Logan 2000). The improvement of processes associated with inbound supply is long-term oriented. Efforts to manage suppliers require substantial human and financial resources and close communications in order to improve processes and, subsequently, reduce the chance that a risk event occurs (Celly and Frazier 1996).

The following section describes various sources of supply risk that exist in purchasing organizations, and how firms can use behavior-based and buffer-oriented techniques to manage that risk. A summary of risk sources and management techniques examined in this study can be found in Table I.

Supply Risk Sources

Inherent risk that affects inbound supply can stem from many sources. Five sources of supply risk investigated in this research are: (1) unanticipated changes in the volume requirements and mix of items needed (Lee and Billington 1993; Noordewier, John, and Nevin 1990; Walker and Weber 1984); (2) production or technological changes (Robertson and Gatignon 1998; Walker and Weber 1984); (3) price increases (Steele and Court 1996); (4) product unavailability (Kraljic 1983; Noordewier et al. 1990; Steele and Court 1996); and (5) product quality problems (Lee and Billington 1993). All of these risk sources can negatively affect inbound production inputs.

The risk associated with *volume and mix requirements changes* arises from fluctuations in customer demand for the purchasing firm's product (Noordewier et al. 1990; Walker and Weber 1984). The more distance between suppliers and the final consumer in the supply chain, the more these demand changes are compounded (Fine 1998; Lee, Padmanabhan, and Whang 1997). This phenomenon is also known as the bullwhip effect. Possible outcomes of customer demand changes include stockouts when suppliers cannot meet escalating demands, or increased inventory in the supply chain when customer requirements are decreased.

Technological change risk comprises improvements in technology that render current technology and development efforts obsolete (Robertson and Gatignon 1998). The inability of suppliers to stay abreast of technological changes may have a detrimental effect on costs, competitiveness of products in the market, and leadtimes. Purchasing organizations must rely on suppliers' abilities to remain capable and efficient in their production processes through continuous improvement efforts. Continuous improvement efforts may yield changes that reduce suppliers' total costs and, subsequently, reduce the total cost of the purchasing firm's final products or services.

Quality problems, price increases, and *product unavailability* are three other supply risk sources. Quality-related risks can include the failure of suppliers to maintain capital equipment, damage that occurs in transit, and lack of supplier training in quality principles and techniques. The prices paid to suppliers can change because of market changes such as the price paid for supplier inputs and currency fluctuations (Carter and Vickery 1989) if the supplier is located overseas, or has one or more of its key suppliers located abroad. Product availability risk can arise from shipping, transportation, or distribution methods and leadtime (Noordewier et al. 1990; Steele and Court 1996).

Table I

PRIOR RESEARCH ON SUPPLY RISK

Variable	Definition	Reference
Supply Risk Sources		
Inability to handle volume demand changes	Demand fluctuations in quantity and type for a component or service	Walker and Weber (1984); Noordewier et al. (1990); Lee et al. (1997)
Failures to make delivery requirements	Methods to distribute, handle, and transport inputs	Lee and Billington (1993); Noordewier et al. (1990)
Cannot provide competitive pricing	The ability to lower the price for the same good or service	Steele and Court (1996); Yahya-Zadeh (1998)
Technologically behind competitors	The frequency of new ideas and emerging technology	Kraljic (1983); Noordewier et al. (1990); Steele and Court (1996)
Inability to meet quality requirements	The ability of suppliers to conform to specifications	Lee and Billington (1993)
Behavior-Based Management		
Supplier certification	Identifying suppliers' abilities to meet quality, cost, service, and delivery requirements	Lockhart and Ettkin (1993); Larson and Kulchitsky (1998)
Implement quality management programs	Implementing programs to improve the abilities and activities of suppliers to satisfy the quality needs of the purchasing firm	Choi and Liker (1995)
Develop target costing with suppliers	Setting a planned selling price and subtracting the desired profit, marketing, and distributing costs, leaving the required manufacturing and procurement costs	Newman and McKeller (1995); Ellram (1999)
Supplier development	Efforts of the purchasing organization to improve a supplier's performance and/or capabilities	Krause (1999); Hartley and Choi (1996); Watts and Hahn (1993)
Buffer-Oriented Management		
Safety stock	Additional stock or items for products, supporting activities, and customer service held internally	Lee and Billington (1993); Newman, Hanna, and Maffei (1993)
Using multiple supply sources	Procurement of a good or service from more than one independent source	Anupindi and Akella (1993); Mitchell (1995); Newman (1989); Tullous and Utecht (1992)
Requiring suppliers to hold inventory	Additional stock or items for products, supporting activities, and customer service held at the supplier's firm	Lee and Billington (1993); Newman, Hanna, and Maffei (1993)

Behavior-Based Management Techniques

A behavior-based focus addresses supplier processes rather than simply outcomes (Anderson and Oliver 1987). Agents (suppliers) are evaluated on their behaviors, which then have an effect on outcomes. When there is some degree of supply risk, behavior-based management efforts initiated by the purchasing organization better align suppliers' objectives with those of the buyer's (Anderson and Oliver 1987). Improved information sharing, monitoring the progress and actions of suppliers, and closer relationships with suppliers are part of a behavior-based orientation. These approaches also reduce the purchasing firm's risk of moral hazard (lack of supplier effort) and adverse selection (inaccurate assessment of supplier abilities), as discussed in agency theory (Eisenhardt 1989). Four management techniques that serve to align the goals of suppliers with the purchasing organization and that focus on supplier behaviors/processes are supplier certification, quality management programs, target costing, and supplier development.

Supplier certification is awarded to suppliers that consistently meet predetermined quality, cost, delivery, financial, and volume objectives (Cox and Blackstone 1998). Certification frequently reduces the need for the purchasing organization to conduct time-consuming and expensive inspections of incoming goods or services (Larson and Kulchitsky 1998; Lockhart and Ettkin 1993). In the certification process, the purchasing organization obtains a wealth of information on suppliers' performance, as well as ensuring that the supplier has the capability to provide incoming goods and services. Since behaviors that meet certification criteria are largely standardized, suppliers' behaviors become more closely aligned with those of the purchasing organization. Alignment that improves supplier processes can lead to greater levels of performance, quality, and lower costs (Larson and Kulchitsky 1998).

The *implementation of quality management programs* in suppliers' facilities attempts to address the purchasing organization's quality requirements. The implementation of these programs improves the abilities and activities of the supplier to satisfy the quality needs and expectations of the purchasing firm. Empirical tests have shown that process-oriented quality management is more effective than outcome- or results-oriented quality management (Choi and Liker 1995). While these findings were focused on the internal operations of organizations, they can also be applied to the relationships between buying and supplying firms.

Target costing is also classified as a behavior-based approach to risk management. The development of target costing with suppliers can require significant two-way discussion and negotiation (Newman and McKeller 1995). The purchasing organization must share information on anticipated sales and production scheduling. The supplier works with the purchasing organization to determine ways to "drive cost out" of its products or services. Improved communication regarding costs provides the purchasing organization greater understanding of the supplier's cost structure and cost drivers. Target costing, therefore, closely aligns the goals of the supplier with those of the purchasing firm (Ellram 1999).

Supplier development refers to the efforts of a purchasing organization to improve a supplier's performance and/or capabilities so that the supplier can meet the purchasing organization's short- and/or long-term supply needs (Hartley and Choi 1996; Krause 1999; Krause and Ellram 1997). The purpose of supplier development includes creating and maintaining a network of competent suppliers (Watts and Hahn 1993); reducing costs (Hartley and Choi 1996); upgrading suppliers' technical, quality, and delivery capabilities; and fostering ongoing improvements (Watts and Hahn 1993). Supplier development activities performed by the purchasing organization can consist of providing feedback on supplier performance, raising performance expectations, educating and training supplier personnel, recognizing suppliers, placing engineering or other personnel from the purchasing firm on the supplier's premises, and directing investing capital in the supplier (Krause and Ellram 1997).

Buffer-Oriented Techniques

Buffers are an outcome-based approach to dealing with risk. Rather than reduce the likelihood of a detrimental event, firms employ buffers to reduce the detrimental effects of supply risk events. Inventory serves as a buffer for product unavailability. Buffer inventory may be held either by the purchasing firm or by suppliers, or both. The use of multiple suppliers for the same item also serves as a buffer against supply risk. If one supplier fails, other sources are available to compensate for the shortfalls. Each of these methods is presented in greater depth below.

Managing inventory to buffer supply risk has been studied by numerous researchers (Lee and Billington 1993; Lee, Padmanabhan, and Whang 1997; Starr and Miller 1962). Supply risk can be greatly reduced by the use of *internal safety stock*. Safety stock is particularly effective if the inventory is located in, or in close proximity to, production facilities. However, by its very nature, safety stock increases internal costs for storage space, potential obsolescence, and capital investment in inventory (Lee and Billington 1993). Onsite safety stocks provide an additional measure of protection from risk. This is in contrast to requiring suppliers to hold finished goods inventory, which carries the added uncertainty associated with transportation. Internal safety stocks place an additional burden on the purchasing firm to manage a greater level of internal inventory.

Supply risk can also be managed by requiring suppliers to hold finished goods inventory. With *supplier-managed inventory*, the supplier takes responsibility for the management and storage of inventory. However, the cost of the

supplier's investment in finished goods inventory will often be passed on to the purchasing firm in the form of a higher price.

Multiple sourcing may also reduce supply risk by utilizing one or more active alternative sources available. The use of multiple sources is often considered a means to create a more competitive supply environment and to reduce the risks of supply disruption and price escalation (Tullous and Utecht 1992). Excessive control, potential opportunism, and lack of technological innovation from a single source have also been argued as reasons for using multiple suppliers (Newman 1989).

HYPOTHESES

Based on a review of agency theory, it is hypothesized that as supply risk options become more prevalent, purchasing organizations will align their suppliers' goals to match their own goals through behavior-based management efforts. As described by Eisenhardt (1989), agency theory addresses problems that arise when the goals of the principal and the agent conflict, and it is difficult for the principal to verify what the agent is doing. Agency theory is also concerned with the issue of risk sharing between the two parties. The focus of the theory is in determining the most appropriate contract (management technique) between the principal and the agent. Researchers have hypothesized and tested risk from sources such as demand volume fluctuation being positively related to behavior-based management efforts, and negatively related to outcome-based efforts (Celly and Frazier 1996; Eisenhardt 1989). However, there have been very few studies focused on supply risk management through reducing the sources of supply risk.

This study proposes that buying and supplying firms are usually two distinct organizations that have some degree of cooperation, but can have partial goal conflict. Risk in the supply of goods and services can arise from several sources, as previously discussed. However, it is very difficult to transfer that risk to the "agent" or supplier organization through outcome-based management efforts. For example, if a buyer threatens a supplier with termination for performance failure, the purchasing firm still requires those incoming products or services. Thus, as risk associated with supply increases, one appropriate strategy for managing it is through behavior-based management.

Another management strategy that may be used to counteract the effects of supply risk is the use of buffers. Buffers that include additional inventories and contingency plans are tools used frequently by the U.S. military to reduce risks associated with supply (Pagonis 1992). Differently from the military, private business organizations have the objective of making profits. An emphasis solely on maintaining buffers to manage supply risk can have detrimental effects on a business firm's profitability due to the capital devoted to inventories and increased transaction costs associated with managing multiple suppliers for the same purchases.

In this study, it is hypothesized that purchasing organizations will utilize both behavior-based and buffer-oriented techniques to manage the sources of supply risk. Behavior-based techniques are separated from buffer management in order to understand how the use of these techniques might vary based upon the risk source. Formally, the hypotheses tested in this research are:

H1: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived degree of supply risk sources.

Supply risk can originate from numerous sources. The five sources of supply risk investigated in this research consist of unanticipated changes in the volume requirements and mix of items needed, production or technological changes, price increases, product unavailability, and product quality problems.

H1a: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived risk from unanticipated changes in the volume requirements and mix of items needed.

H1b: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived risk from production or technological changes.

H1c: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived risk from price increases.

H1d: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived risk from product unavailability.

H1e: The extent to which purchasing organizations are involved in managing supply risk using behavior-based techniques is positively related to the perceived risk from product quality problems.

Purchasing organizations can also manage supply risk by constructing buffers that reduce the effects that detrimental supply events have on their firm. Therefore:

H2: The extent to which purchasing organizations are involved in managing supply risk using buffer-oriented techniques is positively related to the perceived degree of supply risk sources.

As previously discussed, supply risk emanates from various sources. Five subhypotheses examined in this study of managing supply risk with buffers consist of:

H2a: The extent to which purchasing organizations are involved in managing supply risk

using buffer-oriented techniques is positively related to the perceived risk from unanticipated changes in the volume requirements and mix of items needed.

H2b: The extent to which purchasing organizations are involved in managing supply risk using buffer-oriented techniques is positively related to the perceived risk from production or technological changes.

H2c: The extent to which purchasing organizations are involved in managing supply risk using buffer-oriented techniques is positively related to the perceived risk from price increases.

H2d: The extent to which purchasing organizations are involved in managing supply risk using buffer-oriented techniques is positively related to the perceived risk from product unavailability.

H2e: The extent to which purchasing organizations are involved in managing supply risk using buffer-oriented techniques is positively related to the perceived risk from product quality problems.

Control Variables

In addition to the specific hypotheses stated above, three control variables were investigated for their effect on supply risk management. Flynn, Sakakibara, Schroeder, Bates, and Flynn (1990) argued that firm size and industry effects often have an influence on organization practices. Firm size can influence the extent to which purchasing organizations manage supplier behaviors. Techniques that reduce the likelihood of supply risk from occurring, such as developing and certifying suppliers, often require significant human and financial resources by the purchasing firm. For example, firms such as John Deere & Company employ 80 engineers that work solely on supplier development efforts (Nelson 2000). Smaller firms may not have the resources to dedicate extensive involvement in risk reduction techniques such as supplier development. However, buffer-oriented techniques such as inventory management and the active use of multiple suppliers can be used by large and small firms to manage supply risk, since they do not usually require as many resources to implement. To control for firm size, the self-reported firm's total number of employees and its annual sales were normalized and included in the regression models.

An indicator variable was also created for industry effects segregated into firms that have either a manufacturing or service focus in their operations. Purchasing personnel in service firms may not have extensive involvement in managing supply risk as compared with manufacturing-focused firms because detrimental supply events may not have as significant of a potential for disrupting operations.

A third control variable considered in this research is the number of purchases that are considered strategic to the purchasing firm's competitive position and corporate success. When these items and services can significantly affect the success of the purchasing firm, there will be a greater tendency for purchasing organizations to implement techniques that reduce the risk associated with obtaining those items. In addition, since not all risk can be eliminated in the exchange between supplier and purchasing organizations, additional techniques may need to be implemented by purchasing organizations to eliminate the impact that supply risk can have on the firms.

RESEARCH METHOD

The researchers implemented a survey instrument to test the relationship between supply risk sources and techniques to manage that risk. This section begins with a description of how the survey instrument was developed. Next, characteristics of the survey respondents are presented followed by a discussion of the distribution of the survey instrument.

Survey Instrument Development

The primary method used to gather data for this research was a mail survey. Construct development closely followed the recommended procedure for one-time, cross-sectional data collection by Churchill (1979). A questionnaire was developed based on a review of the literature. Practitioners and academics possessing general business, purchasing and research expertise extensively reviewed the initial survey instrument. The survey was modified and pretested on several purchasing executives and academics before it was finalized.

Sample Characteristics

Purchasing professionals associated with the Institute for Supply Management™ (ISM) were the target sample for this study because of their intimate knowledge of purchasing and supply management practices. ISM provided the researchers with a database of 2,300 purchasing professionals with positions at the director level or higher that were ISM members or had attended ISM-sponsored events. This survey was sent to a random sample of 1,000 individuals from the original database of 2,300. Excerpts of the survey can be found in Appendices A and B.

Distribution of the Survey Instrument

The surveys were distributed using a modified version of Dillman's Tailored Design Method (2000). The first mailing was sent to the sample of 1,000 purchasing professionals. A reminder postcard followed the initial mailing approximately 10 days later. A second mailing was sent to non-respondents two weeks after the postcard. Follow-up phone calls were made to all survey non-respondents, beginning a few days after the first mailing, through approximately one week after the second mailing. Of the 1,000 surveys that were mailed, 76 surveys were returned as unusable due to incorrect addresses, change of employment, or incomplete responses. A total of 261 usable surveys were returned, resulting in an effective response rate of 28 percent.

DATA ANALYSIS

The data analysis in this research consisted of constructing two regression models to discover how purchasing firms manage supply risk. The researchers first tested for non-response bias. Exploratory factor analyses and reliability tests were then conducted to purify the constructs. Finally, two regression models were run to examine the relationship between supply risk sources and its management with the use of behavior-based and buffer-oriented techniques, controlling for the effects of firm size, industry, and strategic purchases as a percentage of sales.

Non-Response Bias

Non-response bias is always a threat to survey research, even with high response rates. One common test for non-response bias is to compare the data of early and late respondents. As discussed by Armstrong and Overton (1977), late respondents are more likely to respond to the survey questions like non-respondents. A multivariate t-test was computed for all questions, comparing the first wave of respondents with the second wave of surveys, and provided strong statistical evidence that non-response bias was not present (Hotelling-Lawley Trace=1.819; p=0.435).

Exploratory Factor Analysis and Reliability Tests

An Exploratory Factor Analysis (EFA) was first conducted on the data measuring the management of supply risk sources. Factors for supply risk management were extracted using principal component analysis, followed by a varimax (orthogonal) rotation. The factor analysis for supply risk management techniques had two eigenvalues greater than one, suggesting the presence of two constructs. Items with a loading of 0.50 or greater for a factor, and less than 0.40 for the other factors, were retained (Hair, Anderson, Tatham, and Black 1995). Individual question responses were then summed for their respective constructs.

Reliability analysis was done to test the variance of random measurement errors among the questions within the aforementioned factors using coefficient α to test for internal consistency of the factors (Hair et al. 1995). Reliability is a necessary, though insufficient condition, for construct validity (Churchill 1979). The reliability coefficients can be found in Table II. The coefficient score for behavior-based and buffer-oriented techniques had coefficient scores greater than 0.70, which is considered sufficient for construct measurement (Hair et al. 1995).

The first factor, classified as behavior-based techniques, found in Table II, consisted of four items. The items *supplier certification, implementation of quality management programs, development of target costing*, and *supplier development* all measure techniques used by the purchasing organization to reduce the chance that supply risk occurs. The second factor had three items that included *safety stock planning, using multiple sources for the same item*, and *requiring suppliers to hold inventory* as techniques used to reduce the consequences of supply risk. This second factor was labeled "buffer-oriented techniques." Descriptive statistics for these items and supply risk sources can be found in Table III.

Table II

FACTOR ANALYSIS

Survey Item	Factor Pattern	
	Behavior-Based Management	Buffer-Oriented Management
Supplier certification	**0.548**	0.047
Implementation of quality management programs	**0.843**	0.076
Development of target costing	**0.581**	0.292
Supplier development	**0.622**	0.334
Safety stock planning	0.108	**0.633**
Using multiple sources for the same item	0.266	**0.545**
Requiring suppliers to hold inventory	0.090	**0.835**
Eigenvalue	2.96	1.41
% of variance explained	42.33	20.11
Coefficient α	0.76	0.78

Table III

DESCRIPTIVE STATISTICS

Item	Mean	s.d.	n
Risk Sources			
Volume specified	4.79	0.54	260
Timely, accurate deliveries	4.84	0.48	260
Offer competitive prices	4.75	0.54	260
Technological advances	4.18	0.82	260
Quality standards	4.85	0.43	260
Behavior-Based Management			
Supplier certification	3.25	1.25	258
Quality management programs	3.30	1.11	258
Target costing	3.30	1.31	256
Supplier development	3.58	1.01	257
Buffer-Oriented Management			
Safety stock	3.42	1.10	257
Multiple sourcing	3.84	0.94	258
Holding inventory	3.96	1.01	257

Regression Analysis

Two multiple linear regression analyses were performed to examine the purchasing organization's involvement

in supply risk management. The first regression analysis tested how the five supply risk sources are related to behavior-based management techniques. The second examined how supply risk sources are related to implementing buffer-oriented techniques. Firm size, industry, and the percentage of strategic purchases variables were included as the first block of independent variables in each of the regression models. The second block of variables consisting of the five supply risk sources was then included in each of the two regression models using stepwise elimination. A check of the residuals and variance inflation factors indicated that heteroscedasticity and multicollinearity were not threats to the model (Hair et al. 1995).

RESEARCH FINDINGS

An examination of both regression analyses, found in Table IV, indicates that significant relationships exist between supply risk sources and how that risk is managed. This section provides a summary discussion of the two hypotheses and control variables.

Hypothesis Testing

Hypothesis 1, which stated, "The extent to which purchasing organizations are involved in managing supply risk with behavior-based techniques is positively related to the perceived degree of supply risk sources," was partially supported. The empirical results of this study indicate that purchasing organizations do become increasingly involved in behavior-based management in response to threats of supply risk from the ability of suppliers to meet technological advances and quality standards. Improving supplier processes is one method to manage supply risk. Process improvement initiatives such as certifying suppliers, implementing quality management programs, developing suppliers, and engaging in target costing may reduce the degree of risk associated with inbound supply by minimizing the likelihood of their occurrence.

For example, Honda of America Manufacturing has a strong supplier development and certification process established with many of its suppliers (Nelson et al. 1998). Honda focuses on continuous process improvement of suppliers through evaluation in the areas of quality, cost, delivery, development speed, and management attitude. The emphasis on process improvement has had dramatic results on reducing the probability of supply risk occurrence. In 1997 alone, 122 suppliers had a perfect record for quality, and 229 suppliers achieved 100 percent on-time delivery (Nelson et al. 1998). The Honda example supports the notion that improving supplier processes is a proactive way to manage supply risk. In addition, behavior-based management techniques facilitate communication between the purchasing and supplier organizations. The improved dialogue allows two separate organizations to better understand each other's needs and abilities and to pursue similar goals. This research provides further evidence that risk reduction techniques become more important to firms as perceived supply risk increases.

Table IV

REGRESSION RESULTS

Variable	Unstandardized Coefficient	Standardized Coefficient		N	R^2	F	ΔR^2	F	VIF
Behavior-Based Management				220	0.155	7.843 **			
Coefficient	0.750								
Firm Size	0.170	0.168	**						1.028
% Strategic Purchases	0.005	0.133	*						1.017
Industry (Service)	-0.314	-0.164	**						1.022
Technology	0.190	0.176	**				0.047	11.682 **	1.105
Quality	0.333	0.158	*				0.023	5.715 *	1.105
Buffer-Oriented Management				220	0.021	1.544			
Coefficient	3.601								
Firm Size	0.035	0.037							1.008
% Strategic Purchases	0.004	0.099							1.003
Industry (Service)	-0.172	-0.099							1.010

* = significant at $p < 0.05$
** = significant at $p < 0.01$

Hypothesis 2, which stated, "The extent to which purchasing organizations are involved in managing supply risk sources with buffers is positively related to the perceived degree of supply risk sources," was not supported. The implementation of buffers is done regardless of the extent of perceived supply risk. Buffers, such as inventories, are idle assets that tie up capital, require resources such as storage space and material handling equipment, and present additional risk such as obsolescence. Likewise, using multiple suppliers for the same item(s) to reduce the effects of supply risk may decrease opportunities to achieve economies of scale and increase administrative costs associated with managing more suppliers.

Influence of Control Variables

The three control variables had a significant influence on the extent that purchasing organizations implement behavior-based techniques, but not on the extent that these firms utilize buffer-oriented techniques. Purchasing organizations whose firms primarily provide services were less involved in the management via behavior-based techniques as compared with manufacturing-focused firms. Carter, Carter, Monczka, Slaight, and Swan (1998) have reported that suppliers control as much as 70 percent of the final cost of many products. Purchasing's involvement in behavior-based management activities may be heightened in manufacturing firms due to the relatively high value of purchases as a percentage of the organization's overall costs. In comparison, purchasing organizations in service firms may not have as great a responsibility for affecting overall corporate profitability.

Firm size was also found to have a significant positive influence on the use of behavior-based techniques, but not on the implementation of buffer-oriented techniques. Purchasing's involvement in behavior-based activities with suppliers often requires investments in human and financial resources in order to improve processes. As larger firms often have a greater pool of resources than smaller organizations, it is consistent that they were found to engage in behavior-based management techniques that reduce the chance of supply risk occurrence. However, firm size did not effect purchasing's use of buffer-oriented techniques. One explanation for this finding is that because smaller organizations do not have the requisite resources to invest in process improvements that reduce uncertainty, those firms may instead view strategies that reduce the effects of supply risk as a good use of their limited assets.

The third control variable, strategic purchases as a percentage of sales, was also significantly related to behavior-based techniques but did not affect the extent of involvement in buffer-oriented techniques. Managing suppliers' behaviors becomes more important for purchases that are considered critical to an organization's success, while human and capital resources consumed by that management are not considered necessary for tactical purchases. Buffer-oriented strategies, however, may be appropriate for strategic as well as tactical purchases.

MANAGERIAL IMPLICATIONS

The research results indicate that purchasing organizations manage supply risk sources arising from potential technological and quality problems of suppliers by implementing techniques that focus on the behaviors of supplier organizations. Yates and Stone (1992) argued that two essential factors that influence supply risk are probability and effect. Risk is perceived to exist when there is a likelihood that a detrimental event can occur and that event has a significant associated outcome or cost. Based upon the empirical evidence presented in this research, purchasing organizations will more likely implement behavior-based management techniques to reduce the probability of a detrimental event occurring when they perceive a higher level of risk. Behavior-based management techniques include supply management activities such as certifying suppliers, implementing quality management programs, developing suppliers, and engaging in target costing. However, firms do not vary significantly on the extent to which they implement buffers to minimize the effects of supply risk on their organizations. Buffer-oriented techniques, which include using multiple supply sources, planning safety stock, and requiring suppliers to hold inventory, are implemented regardless of the degree of supply risk that is perceived. These research findings have several managerial implications for purchasing and supply management professionals in deciding how to best manage supply risk.

From an agency theory perspective, outcome-based management, such as buffer-oriented techniques, fits in situations where it is not worthwhile for the purchasing firm to engage in changing the supplier's behavior. The purchasing organization is focused on results: reducing the impact of detrimental supply occurrences. It is not concerned about the means to that end. This research found that use of buffers is a common approach among those organizations studied and is not related to the level of perceived supply risk. It is worth investigating why firms continue to rely on buffer-oriented techniques, which can be very expensive, even after they have implemented measures to reduce the likelihood of a detrimental supply event.

Behavior-based management techniques represent process improvements that provide purchasing and supply management professionals with tools to reduce the *probability* of a supply risk occurrence. For example, the certification of supplier firms ensures that their production processes, capacity levels, and quality procedures are able to meet purchasing firm requirements (Larson and Kulchitsky 1998). Developing target costs with suppliers confirms that the costs of components or services provided by supplier organizations fit within the framework of what customers are willing to pay for a product (Ellram 1996). Implementing quality management programs and developing suppliers prevents supply problems from occurring by ensuring that those supplier firms can meet the short- and/or long-term needs of the purchasing firm (Krause 1999).

From an agency theory perspective, behavior-based management techniques can facilitate (1) reducing information asymmetries, (2) aligning objectives, and (3) programming supplier activities. Each of these facets of agency theory is discussed with regard to how it reduces the likelihood of supply risk occurrence.

Reducing Information Asymmetries

Behavior-based management techniques allow purchasing organizations to obtain greater insights into strategic suppliers and their processes. Increased "transparency" of information between organizations leads to sharing of knowledge, increased collaborative abilities, and improved risk management for both supplying and purchasing firms (Lamming, Caldwell, Harrison, and Phillips 2001). As a result, the agency problems of moral hazard and adverse selection are minimized (Eisenhardt 1989). Moral hazard, in a supply management context, refers to the risk purchasing firms encounter from suppliers that do not put forth the agreed upon effort to meet customer demand. Adverse selection, on the other hand, involves the misrepresentation of a supplier's ability to meet customer requirements. Behavior-based techniques such as developing suppliers, certifying suppliers, and implementing quality management programs provide purchasing organizations greater information about supplier processes and capabilities. Information previously known only to the supplier firm now becomes available to its customer when that purchasing organization engages in supply risk management efforts that focus on reducing supply uncertainty.

Reducing the likelihood of supply risk occurrence can result in improved supplier performance. For example, when suppliers incorporate the latest technological advances in their operations, and adhere to specified quality standards, the cost of doing business with that supplier is significantly reduced. The total cost of suppliers due to delivery failures, inspection costs, product returns, and warranties is significantly reduced. Transaction costs are lowered in the exchange, resulting in overall improved supply chain performance in the dyad between purchasing firms and suppliers.

Aligning Objectives

The purpose of most business organizations is to increase the long-term profitability of their firms. From an agency theory perspective, goal alignment is positively associated with behavior-based management, and negatively related to outcome-based management (Eisenhardt 1989). The behavior-based techniques studied in this research facilitate the alignment and achievement of objectives of the supplier firm with that of its customer organization. For example, supplier development activities focus on improving supplier performance and capabilities to meet purchasing organization requirements (Hartley and Choi 1996; Krause 1999). Supplier development activities, such as educating and training supplier personnel and directly investing in supplier organizations, create "bilateral governance" structures (Heide and John 1990) that allow two distinct firms to reduce supply uncertainties. From the buyer-supplier relationship, the two firms can focus toward increasing their "share of the pie" of profits, focus on jointly creating greater efficiencies within interorganizational processes (Burt and Doyle 1993), and/or work in conjunction to increase the "size of the pie" of profits for both firms. Additional behavior-based techniques such as supplier certification and target costing have a similar purpose. Supplier certification provides the purchasing firm in-depth knowledge about the supplier firm, including information about its philosophies and capabilities. The certification process allows purchasing organizations to engage in long-term relationships with suppliers that it believes will contribute to their success. Target costing aligns the purchasing organization's goals with that of its supplier to ensure that the overall target price is met to meet the purchasing firm's customer's requirements.

The alignment of objectives contributes to improved risk management by having the supplier and purchasing firm work toward managing risk. When greater risk is perceived by purchasing organizations in areas such as falling behind in technology advancements and not adhering to quality standards and specifications, this research has found that purchasing professionals engage in behavior-based management techniques to a greater extent. Goal alignment between two distinct organizations results from engaging in these risk management activities.

Programming Supplier Activities

Task programmability refers to the degree to which appropriate behaviors of suppliers can be specified in advance (Eisenhardt 1989). The rationale is that more programmed jobs or projects are easier to observe and evaluate. For example, it is easier to observe supplier performance and specify requirements in advance when purchasing firms provide detailed instructions for supplier performance achievement. Proactive purchasing activities such as supplier development and supplier certification provide such information to suppliers. When greater risk is perceived from sources such as technology and quality, behavior-based management techniques reduce the chance that risk occurs by programming supplier tasks, activities, and requirement standards.

CONCLUSIONS

Supply risk exists in every business organization, whether it is recognized and managed, or ignored. It is critical to an organization's success to understand the supply risk sources that exist and how to best manage that risk. A supplier's failure to deliver inbound purchased goods or services can have a detrimental effect throughout the purchasing firm and subsequently through the distribution channels that eventually reach the consumer. This section presents the

limitations of this research, the major findings, and suggests future research directions.

Limitations

One limitation of the study concerns the relationship influence between buying and supplying firms. Purchasing organizations may be limited in their influence to improve supplier processes if that supplier is not dependent upon them. In such circumstances, if there was a high degree of risk perceived by the purchasing organization in its dealings with a supplier who has more power (Cox 2001), the purchasing organization may instead increase its reliance on buffer-oriented management: the level of internal inventory, use of multiple supply sources, or even attempting to find a new supply source. Additional studies are needed to determine the effect of organizational influence on the nature of purchasing's involvement in supply risk management.

A second limitation of this study is that the mean values for the importance of supply risk sources were very high, with many of the supply risk dimensions considered as "important" to most of the respondents. However, as shown in Table III, there was variability within the responses used to evaluate the items that form the supply risk construct. If there were no variability, it would not be possible to observe a relationship between supply risk and purchasing's involvement in its management.

Major Findings

This study empirically tested one important aspect of supply chain channels: supply risk management. As supply risk sources become more prevalent, purchasing organizations are increasingly likely to implement behavior-based techniques that reduce information asymmetries, align organizational objectives, and program supplier activities. These findings are in line with the key premises of agency theory. In addition, the control variables of firm size and percentage of strategic purchases both have a significant positive influence on the extent that purchasing organizations implement behavior-based management techniques. There is also an industry effect, with firms in the manufacturing sector significantly more likely than firms in the service sector to implement behavior-based risk management techniques. It makes sense that as perceived risk increases, organizations are willing to invest in the more intensive, behavior-based risk reduction techniques rather than simply focusing on buffering the risk.

From an agency theory perspective, outcome-based management such as buffer techniques fit in situations where it is not worthwhile for the purchasing firm to invest in changing the supplier's behavior. The purchasing organization is focused on results: reducing the impact of detrimental supply occurrences. It is not concerned about the means to that end. This research found that use of buffers is a common approach among those organizations studied, and is not related to the level of perceived supply risk. This result could be due to the fact that the mean values for the importance of supply risk sources were relatively high among those studied. It is worth investigating why firms continue to rely on buffer techniques, which can be very expensive, even after they have implemented measures to reduce the likelihood of a detrimental supply event.

Directions for Future Research

Future research studies should examine the effects that the techniques used in managing supply risk sources have on reducing the frequency and consequences of detrimental supply events. The use of performance measures has been studied with a predominant focus on customers (see Haytko (1994) for a discussion of this research). Noordewier et al. (1990) measured supplier performance through inventory turnover, the percentage of on-time deliveries, and the percentage of acceptable products delivered under conditions of uncertainty. However, their study was based on a single commodity with no evaluation of the effect that these items had on the purchasing organization's ability to meet its customers' needs. It would be beneficial for future research to define variables measuring the effects of an incoming supply failure on purchasing firms and their supply channels. Such a study could investigate whether a relationship exists with purchasing's involvement in the behavior-based and buffer-oriented techniques presented in this study, and the frequency and severity of inbound supplier failures. Case studies could also provide insight into why purchasing firms continue to use outcome-based buffers in conjunction with behavior-based supply risk techniques. Research of this type could provide much needed prescriptive evidence for purchasing executives who wish to reduce the inherent risk in supply and, subsequently, improve products and service to their customers.

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Appendix A

EXCERPTS FROM QUESTIONNAIRE (SUPPLY RISK SOURCES)

How important is each of the following factors when PSM (Purchasing and Supply Management) evaluates the **performance and risk** associated with a supplier?	Never Important/ Not a Consideration		Sometimes Important		Always Important
Supplier's ability to provide products/services in the volume specified.					
Supplier's ability to make timely, accurate deliveries.					
Supplier's ability to offer competitive prices.					
Supplier's ability to incorporate the latest technological advances in their operations.					
Supplier's ability to adhere to specified quality standards and specifications.					

Appendix B

EXCERPTS FROM QUESTIONNAIRE (RISK MANAGEMENT TECHNIQUES)

To what extent is PSM involved in the following activities to address supplier risk and supplier management?	No Input/We Do NOT Engage in This Activity	Advisory Role	Team Member	Primary Decision Maker	Sole Decision Maker
Supplier certification.					
Implementation of quality management programs with suppliers.					
Development of target costing with suppliers.					
Supplier development.					
Establishing common platforms for products.					
Supply contingency plans.					
Safety stock planning.					
Using multiple sources for the same item(s).					
Requiring suppliers to hold inventory to meet your current needs.					