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Supply Chain Risk Management: A Review of the Empirical Research

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Abstract

Global supply chains today are subject to a variety of risks which makes supply chain risk management a critical topic. One research gap identified by Sodhi, Son and Tang (2011) on the topic of supply chain risk management (SCRM) is the lack of empirical research. This paper will review existing empirical research about SCRM. Articles utilizing structural equation modeling (SEM) will also be identified and reviewed along with other empirical articles.

Introduction

Definitions of supply chain risk and supply chain disruptions are helpful to provide a context for the importance of supply chain risk management research. One frequently cited definition of supply chain risk describes it as a "variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective value" (Jüttner, Peck, and Christopher, 2003). Supply chain risk is often associated with supply chain disruptions. A supply chain disruption

has been described as having "a certain probability of occurrence and is characterized both by its severity and by its direct and indirect effects. Since the resulting detriment is usually a function of time, supply chain disruptions involve time pressure, implying that decisions for mitigation must be made swiftly. … Depending on its severity, other terms might be applied, such as, glitch, disturbance, accident, disaster, or crisis" (Wagner & Bode, 2008, p. 310).

Another commonly used term is supply chain vulnerability. Chapman et al. (2002) define supply chain vulnerability as: "an exposure to serious disturbance, arising from risks within the supply-chain as well as risks external to the supply-chain." They also suggest that risks result from "lack of visibility, lack of 'ownership', self-imposed 'chaos', the misapplication of Just-in-Time practices and inaccurate forecasts" (Chapman et al., 2002). The authors also assert that "the complexity of today's typical supply-chain networks, … brings with it higher levels of risk and hence vulnerability" (Chapman et al., 2002).

With these definitions as a background, SCRM is an emerging research topic which has grown in interest over the last ten years. Given the relative newness of this topic area, the research is very diverse with many competing viewpoints. It is also not unusual that the topic has been addressed conceptually more often than empirically.

"Despite the proliferation of SCM literature, there have been few, if any, studies to develop measurement scales of SCM-related concepts. The role of scientific inquiry is to establish the relationships among the constructs of the theory, some of which must be related to observable data (Churchill, 1999). In other words, without operationalizing the SCM-related constructs, we

cannot further advance scientific knowledge of the phenomenon, nor promote the successful application of SCM in practice. Mentzer et al. (2001), therefore, called for empirical research to test the structure of SCM" (Min & Mentzer, 2004). The above comments are directed at the SCM literature in general but the same comments can easily be applied to the SCRM literature. To better understand SCRM, more research is needed which operationalizes SCRM constructs and utilizes empirical methods to investigate the relationships among those SCRM constructs.

Recent research by Sodhi, Son and Tang (2011) identified three major gaps in supply chain risk management (SCRM) research:

1. The definition gap – lack of agreement on the definition of SCRM
2. A process gap – inadequate coverage of response to risk incidents; and
3. A methodology gap – inadequate use of empirical methods.

The motivation for this paper can be seen in the assertion by Min and Mentzer (2004) and in the third research gap identified by Sodhi, Son and Tang (2011). This paper will identify and document the existing empirical research about SCRM. We will also propose additional avenues for future empirical research on the topic of SCRM.

Research Questions

Our goal is to address the following research questions through the development of this paper: What are the leading empirical articles on supply chain risk management (SCRM)? And, how can we use this information to guide future empirical research on the topic of SCRM?

Identifying the Literature

As a first step, a search was conducted utilizing "Google Scholar" and the phrase "supply chain risk management and empirical research". From the search results, the top fifty articles were selected for further investigation. Each article was screened for appropriateness as it relates to the specific focus of our research here. Other articles were identified through a related research effort which contained listings of empirical research that we could draw from to include here (i.e. Rao & Goldsby, 2009; Sodhi, Son & Tang, 2011).

For the second step, searches were conducted utilizing "Google Scholar" for specific authors' names which were identified in the first step. From the search results, individual articles were selected for further review. Each article was again screened for appropriateness as it relates to our research here. The search results were also reviewed to avoid duplication of articles appearing in multiple search results.

As a final step, a search was conducted utilizing "Google Scholar –advanced search" and the phrases "supply chain risk management", "structural equation modeling" and "empirical." From the search results, the top thirty articles were selected for further review.

Identifying the Empirical Research about SCRM

Two articles were identified which provided partial lists of empirical research studies so we begin with a list of those articles and extend the list with articles identified through additional searches. Rao and Goldsby (2009) evaluate the literature as they develop a proposed typology

for SCRM. They list twelve (12) articles which they identify as being empirical. Table 1 lists the articles identified in the Rao and Goldsby (2009) article:

Table 1. Articles Identified by Rao and Goldsby (2009)

Author(s) (Year)	Type of Empirical Study	Comments
Blackhurst et al. (2005)	Qualitative	Visibility and capacity management
Craighead et al. (2007)	Qualitative	Propostions relating SC Disruptions to SC Design
Finch (2004)	Secondary	Networking with smaller firms contributed to SC Risk
Hendricks & Singhal (2003)	Secondary	SC Glitches result in negative stock impact and loss of shareholder value
Hendricks & Singhal (2005a)	Secondary	Slow recovery in stock value after SC glitches
Johnson (2001)	Qualitative	Lessons to manage risk based on actual toy industry events
Jüttner et al. (2003)	Qualitative	Identify four segments for future research
Kleindorfer & Saad (2005)	Secondary	Analyzes data from U.S. Chemical Industry and SC disruptions
Manuj & Mentzer (2008a)	Qualitative	Evaluates SCRM strategies using grounded theory
Perry (2007)	Qualitative	Framework for natural disaster recovery based on interviews with logistics managers
Zsidisin et al. (2004)	Qualitative	Purchasing organizations can assess supply risk through supplier quality issues
Zsidisin et al. (2000)	Qualitative	Purchasing organizations and creation of contingency plans

Sodhi, Son and Tang (2011) identify a lack of empirical research on SCRM as one of three research gaps. The gaps they identify are: "(1) a definition gap – there is no clear consensus on the definition of SCRM"; "2) a process gap – there is lack of research on an important aspect of the risk management process, namely, the response to supply chain risk incidents; and (3) a methodology gap – there is a shortage of empirical research in the area of SCRM" (Sodhi, Son and Tang, 2011). In Tables 2 and 3 we list the research identified by Sodhi, Son and Tang (2011) which is divided into two categories – quantitative empirical and qualitative empirical.

Table 2. Articles Identified by Sodhi, Son and Tang (2011) as 'Quantitative' Empirical

Author(s) (Year)	Type of Empirical Study
Hendricks & Singhal (2003)	Quantitative
Hendricks & Singhal (2005a)	Quantitative
Hendricks & Singhal (2005b)	Quantitative
Kleindorfer & Saad (2005)	Quantitative
Wagner & Bode (2008)	Quantitative
Braunscheidel & Suresh (2009)	Quantitative
Jiang et al. (2009)	Quantitative
Ellis et al. (2010)	Quantitative

Table 3. Articles Identified by Sodhi, Son and Tang (2011) as 'Qualitative' Empirical

Author(s) (Year)	Type of Empirical Study
Treleven and Schweikart (1988)	Qualitative
Johnson (2001)	Qualitative
Norrman and Jansson (2004)	Qualitative
Zsidisin et al. (2004)	Qualitative
Blackhurst et al. (2005)	Qualitative
Brun et al. (2006)	Qualitative
Gaudenzi and Borghesi (2006)	Qualitative
Sodhi and Lee (2007)	Qualitative
Manuj & Mentzer (2008a)	Qualitative

For the purposes of this paper we will now focus on just those articles that are "quantitative" empirical studies. Drawing from the lists of Quantitative (or Secondary) Empirical studies in the two articles referenced above (Sodhi, Son & Tang, 2011; Rao & Goldsby, 2009) we have a total of nine articles. There are three articles which appear in both lists, one "Secondary" article that is unique in the Rao and Goldsby (2009) list and five articles that appear only in the Sodhi, Son & Tang (2011) list. From the search and evaluation for this paper we add another 11 articles to the list of "quantitative" empirical studies bringing the total to 20. The articles that we add can be seen in Table 4:

Table 4. Additional Articles Identified for this Paper

Author(s) (Year)	Type of Empirical Study
de Koster et al. (2011)	Quantitative
Gray et al. (2011)	Quantitative
Hora et al. (2011)	Quantitative
Rao et al. (2011)	Quantitative
Speier et al. (2011)	Multi-method; Quantitative
Hendricks, Singhal & Zhang (2009)	Quantitative
Hendricks & Singhal (2009)	Quantitative
Hendricks & Singhal (2008)	Quantitative
Schoenherr et al. (2008)	Secondary
Wagner & Bode (2006)	Quantitative
Jüttner (2005)	Quantitative

The remainder of the evaluation in this paper will again focus on just the 20 articles identified as being "quantitative" empirical studies which are shown in Table 5.

Table 5. Compiled List of Empirical Quantitative or Secondary Data Studies

Author(s) (Year)	Rao & Goldsby (2009)	Sodhi, Son & Tang (2011)	Identified in this paper
Finch (2004)	X		
Hendricks & Singhal (2003)	X	X	
Hendricks & Singhal (2005a)	X	X	
Hendricks & Singhal (2005b)		X	
Kleindorfer & Saad (2005)	X	X	
Wagner & Bode (2008)		X	
Braunscheidel & Suresh (2009)		X	
Jiang et al. (2009)		X	
Ellis et al. (2010)		X	
de Koster et al. (2011)			X
Gray et al. (2011)			X
Hora et al. (2011)			X
Rao et al. (2011)			X
Speier et al. (2011)			X
Hendricks, Singhal & Zhang (2009)			X
Hendricks & Singhal (2009)			X
Hendricks & Singhal (2008)			X
Schoenherr et al. (2008)			X
Wagner & Bode (2006)			X
Jüttner (2005)			X

Brief summary comments about the most recent articles are shown in Table 6. Summary comments for all other articles can be found in Table 7 on a following page.

Table 6. Empirical Study Elements in Recent Articles

Author(s) (Year)	Comments on Elements of Empirical Study
de Koster et al. (2011)	Antecedents of safety performance in warehouses; survey of 78 Dutch warehouse managers and 1033 warehouse employees; Hazard reducing systems and Safety-specific transformational leadership were main predictors of safety performance
Gray et al. (2011)	30 matched pairs of onshore and offshore drug manufacturing plants were evaluated; offshore plants operated with higher quality risk
Hora et al. (2011)	Identifies and tests key factors associated with 'time to recall' a product. Three main factors are identified based on the empirical results
Rao et al. (2011)	Online order glitches impact online customer shopping behavior along several dimensions – frequency and size of order as well as customer anxiety level
Speier et al. (2011)	Multi-method research which tests safety and security constructs; Quantitative survey and MANOVA used to evaluate data from the food industry; High risk products lead to greater sharing of information

Evaluation of Empirical Studies

From Table 6, we can see research that explores supply chain risks from a different perspective. The four empirical papers address the following issues:

- Supply chain design
- Offshore manufacturing risk
- Safety leadership in warehousing, and
- Product recall strategies

Among the quantitative studies, de Koster et al (2011) analyzed data from Dutch warehouses regarding safety initiatives to prevent accidents. Gray et al (2011) also conduct a quantitative study of offshore manufacturing risk in the pharmaceutical industry. In another quantitative

study, Hora et al (2011) investigate 500 product recalls between the years of 1993 and 2008. This expands the operationalization of "glitches" to include other situations.

Also in Volume 29 of JOM but not part of the special issue, Rao et al (2011) conduct a quantitative study that looks at "glitch magnitude" and the relationship with "future customer orders" and "customer order anxiety".

From Table 7, we can see that 'financial issues' have garnered the most attention of any single topic area related to supply chain risk management. The impact on shareholder value (and firm market capitalization) is the main topic addressed as evidenced in several articles by Hendricks and Singhal (2003, 2005a, 2005b, 2008, 2009) and Hendricks, Singhal and Zhang (2009). This makes the authors the most frequent contributors to the empirical research about SCRM. Their research relies on secondary data to address several related SCRM phenomena. Among these are the impact on stock price and the direct impact on stockholders that occurs as a result of a supply chain disruption event (Hendricks and Singhal 2003, 2005a, 2005b, 2008; Hendricks, et al. 2009). A subsequent topic looks at the length of recovery time for the stock's value after a disruptive event (2005a). A recent article looked at the impact of a different type of supply chain event – the announcement of "excess inventory" (Hendricks and Singhal 2009). The analysis of actual events and the impact on companies and their constituencies is an important contribution to the SCRM literature. This type of research to explore the impact of actual events should be extended into other supply chain/organizational segments where data can be related to SCRM constructs.

Table 7. Empirical Study Elements in the Literature

Author(s) (Year)	Comments on Elements of Empirical Study
Braunscheidel & Suresh (2009)	Survey of 4000 ISM members in top management positions; 218 usable responses were analyzed from 303 responses received; test of 12 hypothesized path coefficients; SEM model includes main factors influencing "Firm's Supply Chain Agility"; External Integration and External Flexibility were 1st and 2nd major antecedents of FSCA
Ellis et al. (2010)	3196 surveys distributed to purchasing professionals; 223 usable responses; test of nine hypotheses to evaluate relationships of several variables and probability of supply disruption or magnitude of supply disruption; CFA and SEM for analysis
Finch (2004)	Evaluates secondary published data about Information System interruptions caused by "natural disasters, accidents and deliberate acts"; evaluates a series of case studies; concludes that larger firms experience greater risk by networking and having small or medium enterprises (SMEs) as partners increased the risk exposure
Hendricks & Singhal (2003)	519 announcements from WSJ & DJNS from 1989 - 2000; glitches - primarily part shortages; test of five hypotheses
Hendricks & Singhal (2005a)	827 announcements from 1989 - 2000; production or shipping delays; test of five hypotheses
Hendricks & Singhal (2005b)	885 announcements from 1992 - 1999; production or shipping delays; test of four hypotheses related to performance metrics
Hendricks & Singhal (2008)	838 announcements from 1989 – 2001; loss of 10% of shareholder value
Hendricks & Singhal (2009)	276 announcements about excess inventory from 1990 – 2002; tests five hypotheses; 73% - 74% of sample firms experience negative stock market reaction of nearly 7%
Hendricks, Singhal & Zhang (2009)	307 supply chain disruptions from 1987 – 1998; new variables in hypotheses include 'operations slack', 'business diversification', 'geographic diversification', and 'level of vertical relatedness
Jiang et al. (2009)	634 usable responses from 3000 surveys distributed to Chinese migrant workers in manufacturing sector; logistic regression analyses; Labor Risk (job satisfaction), labor turnover & SC risk and other factors
Jüttner (2005)	Quantitative survey of 1700 Institute of Logistics members; 137 responses obtained; follow-up with focus groups; results indicate the risk assessment tools in use by logistics professionals
Kleindorfer & Saad (2005)	U.S. chemical industry events; 1,945 chemical-release accidents between 1995 and 1999 from the total population of 15,219 facilities; over $1 B for business interruption and other indirect costs
Schoenherr et al. (2008)	US Manufacturing Case study to empirically derive values for 17 risk factors related to outsourcing to China and Mexico; employs AHP to assess the risk factors
Wagner & Bode (2006)	Survey of 4,946 top-level executives; 760 usable responses; test of three hypotheses about supply chain vulnerability and demand-side risk, supply-side risk and catastrophic risk
Wagner & Bode (2008)	Survey of 4,946 top-level executives; 760 usable responses; test of five hypotheses about SC Risks and SC performance; support for two hypotheses – one for Demand-side risk and one for Supply-side risk

As described by Rao and Goldsby (2009), the use of secondary data is a dominant choice within the existing empirical research about SCRM. The use of secondary data can be seen in Finch (2004), Hendricks and Singhal (2003), Hendricks and Singhal (2005), Kleindorfer and Saad (2005). The entire set of Hendricks and Singhal papers (2003, 2005a, 2005b, 2008, 2009; Hendricks, et al. 2009) rely on secondary data to evaluate the financial impact that results from supply chain disruptions and supply chain glitches.

In an editorial in the *Journal of Operations Management (JOM)*, Boyer and Swink indicate that "Survey research is a common methodological approach in the fields of management and marketing, with well-established protocols that are summarized by Flynn et al. (1990) and many others. The question is not whether survey-based research is appropriate, but when is it appropriate?" (Boyer and Swink, 2008). As a result of the research by Flynn et al. (1990), in *JOM* "there has been a notable growth in empirical research generally, and in survey-based research in particular" (Boyer and Swink, 2008).

Given this trend in operations and supply chain management research, the inclusion of several articles which employ survey research to address issues related to SCRM is encouraging to see in our results here. This provides another avenue for conducting empirical research about SCRM. The use of survey research can be seen in the SCRM work by Wagner and Bode (2006; 2008), Jüttner (2005), Jiang et al. (2009), de Koster et al. (2011) and Speier et al. (2011) as primary example in this paper. The research by Wagner and Bode (2006; 2008) is notable for the size of the initial survey distribution (4,946) and also for the usable response (n = 760). Their research investigates several relationships between supply chain risks and supply chain performance.

From the initial five hypotheses, the survey results indicate strong support for two hypotheses – one for Demand-side risk and one for Supply-side risk (Wagner & Bode, 2008).

The following section will devote attention to a subset of survey research where the analysis technique employed is structural equation modeling (SEM).

Structural Equation Modeling

As mentioned above, another search of Google Scholar looked for the exact phrase for "structural equation modeling" (SEM), "supply chain risk management" and "empirical". The top 50 results from this search were reviewed and only four articles involving SEM actually addressed SCRM. That leaves 46 articles which may or may not use SEM but do not address SCRM explicitly.

In many research situations a number of the variables of interest are not easily observed. SEM is designed to be very effective for analyzing exactly those situations where latent variables are involved and where multiple variables are being studied to evaluate their effect on other observable variables. In the last few years supply chain management research has joined many other disciplines in the use of SEM (Monroe, 2008).

Two articles using SEM have already been identified in our list above and these are the more recent publications shown in Table 6, specifically Braunscheidel and Suresh (2009) and Ellis et al. (2010). Braunscheidel and Suresh (2009) develop a SEM model to test the relationships of factors contributing to the 'Firm's Supply Chain Agility' (FSCA). Their results indicate that

‘External Integration’ and ‘External Flexibility’ are the first and second major antecedents of FSCA. ‘Internal Integration’ was not as strongly correlated with FSCA. From their perspective, FSCA is a main construct for SCRM as a means for reducing risk.

Ellis et al. (2010) base their analysis on 223 responses from purchasing professionals on questions about the probability of supply disruption and the magnitude of supply disruption. They utilized confirmatory factor analysis (CFA) and SEM to evaluate the survey results. Four antecedents “have positive and significant effects on managers’ views of the magnitude of supply disruptions” (Ellis et al., 2011). They also report that the purchase of customized products did “not directly increase managers’ expectations of the probability of supply disruptions” (Ellis et al., 2011). Overall, the antecedents in their SEM model explained “27.4% of the variance in the magnitude of supply disruption” (Ellis et al., 2011).

One article among the top 50 that was not previously identified comes from Kocabasoglu et al. (2007). This article addresses “risk propensity” and “business uncertainty” as it relates to “reverse supply chain investments” and the authors do utilize SEM. The authors report “little evidence of a relationship between business uncertainty and RSC [reverse supply chain] investment” (Kocabasoglu et al. 2007). Despite their findings, clearly “business uncertainty” belongs in the discussion about SCRM.

An interesting finding among the top 50 articles from this search is the number of articles which do address “supply chain management practices” but do not use the word “risk” within their discussion. Many of these articles do address such issues as “information sharing”, “failure to

share information" and "information distribution" (Kannan and Tan, 2005; Benton and Maloni, 2005; Hult et al. 2007). While these articles do not use the term "risk" and they do not address SCRM directly, the SCM practices being described are indeed intended to address supply chain risk. SCRM researchers need to be aware of this research stream and then borrow and learn from it when appropriate.

Another article by Faisal et al. (2006) did address SCRM but did not use SEM. The article was judged to be "qualitative" and will be included in future work on "qualitative empirical" articles based on the use of "expert opinion" in the paper (Faisal et al. 2006).

Future Research

We concur with the observation by Sodhi, Son and Tang (2011) that there is a major research gap due to the lack of empirical research about SCRM. In another research stream, Prahinski and Kocabasoglu (2006) develop ten propositions for future empirical research in another segment of supply chain management – reverse supply chains. Giunipero & Eltantawy (2004) offer four propositions that address SCRM specifically but they focus only on the upstream or supply-side of the supply chain. Following these recommendations about other research topics, there are ample opportunities to develop propositions that will address the topic of SCRM in a more comprehensive manner.

The connection between supply chain performance and financial results makes the financial focus a natural choice for researchers. The financial impact has received the greatest attention among the empirical studies identified in this paper on the topic of SCRM. We suggest that there

is a need to apply empirical methods to the "material supply chain", the "informational supply chain" and the "relational supply chain". These topic areas will provide broader coverage of all aspects of the supply chain rather than focusing on the "financial supply chain" exclusively.

Limitations

For this paper the literature from the most recent ten year period has been utilized and the resulting set of articles is a limited sample but there is a high degree of confidence that it is a representative sample. Earlier empirical studies that address SCRM may have been omitted as a result of the timeframe boundary.

Recent publications were relied upon to help to identify the empirical studies of interest. The methods used focused on the top articles – those articles that are cited most frequently or rank highly due to reputation. These methods may have stopped short of finding additional empirical studies further down the list in the rankings. Given these limitations, this paper represents a snapshot of the empirical studies on SCRM rather than a comprehensive coverage of all the quantitative empirical studies.

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