Ann Oper Res
DOI 10.1007/s10479-017-2452-0

Understanding risk management for intentional supply chain disruptions: risk detection, risk mitigation, and risk recovery

Scott DuHadway[1] · **Steven Carnovale**[1] · **Benjamin Hazen**[2]

Abstract Strategies to mitigate supply chain risk tend to treat disruptive events as homogenous, despite having different causes and requiring different risk management strategies. We develop a framework to understand effective risk management strategies by considering whether a disruption was caused by an intentional or inadvertent act and whether the source of the disruption was endogenous or exogenous to the supply chain. Based on exploring evidence from risk management strategies for specific disruptions, we find that risk detection is important for both intentional and inadvertent disruptions, while effective risk management practices differ in terms of risk mitigation (relational versus process based approaches) and risk recovery (restructuring versus resilience). The resultant theory-based framework provides a new theoretical perspective on supply chain disruptions and posits that understanding intent and the source of the disruption is critical for appropriate risk management strategies.

Keywords Disaster recovery · Behavioral supply chain management · Risk management · Supplier management · Organizational information processing theory

1 Introduction

Significant emphasis has been placed on the impact of disasters affecting the supply chain, and ensuing effects on operational performance [e.g., Prasad et al. (2016), Wang et al. (2014)]. In fact, scholars suggest "supply chain disruptions and the associated operational and financial

✉ Benjamin Hazen
Benjamin.hazen@live.com

Scott DuHadway
duhadway@pdx.edu

Steven Carnovale
Steven.carnovale@pdx.edu

[1] School of Business Administration, Portland State University, Portland, OR, USA

[2] Department of Operational Sciences, Air Force Institute of Technology, Dayton, OH, USA

Published online: 02 March 2017

risks represent the most pressing concern facing firms that compete in today's global marketplace" (Craighead et al. 2007:131). Generally, supply chain risk has been characterized as "the likelihood of an adverse and unexpected event that can occur and either directly or indirectly result in a supply chain disruption" (Garvey et al. 2015:619). It is worth noting the distinction between disruption and risk. Whereas disruptions are typically manifestations of supply chain risks; risk can be present without a disruption occurring. In the context of supply chain risk management though, research generally focuses on a 'plan for the worst, hope for the best' approach to managing disruptions (Kleindorfer and Saad 2005), as well as strategies to manage disruptions once they have occurred (Braunscheidel and Suresh 2009).

In the literature on disaster response and risk management, the focus has been primarily on managing disruptions in terms of detecting, mitigating the effect of, and recovering from a stoppage of the physical flow of goods. This emphasis on the physical flow of goods for disruptions has provided a beneficial understanding of how to identify and recover from disruptions which are caused by inadvertent behavior (i.e., non-intentional, accidental, and unpremeditated causes) such as quality failures, supplier bankruptcy, or natural disasters. However, strategies for managing disruptions can be substantively different when the behavioral cause of the disruption is intentional (i.e., opportunistic, purposive, or pre-meditated causes). For example, storing excess inventory to protect against a disruption would alleviate the impact of a supply chain disruption in the case of a natural disaster, but would exacerbate the negative impact of a disruption if the cause were due to fraudulent product quality from a supplier. Extending the understanding of disruptions to include relational risk associated with intentional behavior can have on disruptions can yield valuable insight for better risk management.

Disruption impacts in a highly time-sensitive supply chain (i.e., one related to disaster relief operations) can be more problematic than a traditional supply chain. Disruptions due to intentional or inadvertent behavior can have substantively different outcomes in terms of the impact on disaster relief operations since intentional disruptions in this context are particularly wicked, and both inadvertent (e.g., poor management of funds, poor planning) and intentional disruptions (e.g., theft, fraud, bribery) occur. To this end, the risk of intentional disruptions such as security threats to supply chains might be exacerbated in places with limited infrastructure such as where disaster relief occurs. By exploring the intent behind a disruption and the source of the risk, this paper's resultant classification scheme provides many practical and theoretical implications for understanding the operational impact of risk management strategies, allowing for more efficiently targeted risk management strategies.

The purpose of this paper is to explore and identify how the intent behind the behavior leading to a disruption can substantively change optimal risk management strategies in terms of three critical risk management areas: risk detection, risk mitigation, and disruption recovery. This paper contributes in three important ways. First, we provide a theoretical underpinning for supply chain disruption literature. Second, we develop a framework for understanding the varied nature of disruptions when taking into account both the intentional aspect of behavior leading to a disruption, as well as the source of the disruption. Third, we present how understanding the intent behind the disruption can substantively change appropriate risk detection, mitigation, and risk recovery strategies and identify how risk mitigation and risk recovery require different risk management approaches when the cause is intentional rather than inadvertent. By exploring the concept of behavioral intent underpinning a disruption, valuable insights that better develop the understanding of risk management strategies are discussed and presented.

1.1 Motivation

Strategies to manage disruption risks such as the potential for opportunistic behavior (Babich and Tang 2012), regional natural disasters (Lu et al. 2015), or international terrorism (Sheffi 2001) will differ based on the causes of and nature of the disruption. It is necessary to understand both how disruptions can be dissimilar and to provide a context for understanding which disruptions are similar to one another.

Research has taken two general approaches for expanding the understanding of disruptions: broad research that treat disruptions as largely homogenous events (i.e., Azad et al. 2013; Xu et al. 2016) to suggest generally applied risk management strategies (Christopher and Peck 2004; Craighead et al. 2007; de Matta 2016; Tang 2006) and focused research which addresses a specific type of disruption such as international terrorism (Sheffi 2001), uncertain lead times (Kouvelis and Li 2008), and supply chain security (Véronneau and Roy 2014). While both of these approaches are valuable and have yielded insights into research and practice, one key aspect of disruptions, which has been largely absent in research, is the intent behind the event causing the disruption, which is often assumed to be inadvertent or accidental. We seek to bridge the gap between the broad-based research that identifies general strategies for managing disruptions and the focused research which identifies strategies for managing specific disruptions by developing a classification scheme which identifies how the cause of a disruption can impact risk management in terms of risk detection, risk mitigation, and risk recovery strategies.

The lack of emphasis on risk management strategies that takes into account the intent behind a disruption leaves a gap in the risk management literature that can expose firms to risks due to intentional disruptions that are not appropriately managed. Examples of disruptions that do not fit well within the current frameworks include, but are not limited to, fraudulent quality substitutions, intentional contractual breaches, state- or regime-backed attempts to disrupt certain operations, terrorism activities where the purpose is to disrupt the flow of goods or information, competitor-driven disruptions, or government-caused disruptions.

For example, consider the supply chain disruption experienced by Mattel in 2007 when toys were discovered containing lead-based paint. Mattel at the time was known for strict quality controls and had built a testing laboratory to monitor the levels of lead in the paint being used at the supplier's factory, which nevertheless ended up responsible for the lead paint crisis (Woo 2008). Mattel had made reasonable efforts to guarantee quality from their supplier and to prevent a disruption due to lead-based paint entering the supply chain unintentionally. However, these efforts were insufficient example because their supplier intentionally went around their safeguards to use lead-based paint as an opportunistic cost cutting measure. Despite having appropriate controls in place to prevent accidental or inadvertent quality failures, Mattel did not have appropriate protections against the intentional and opportunistic behavior by their supplier that used lead-based paint in producing products for Mattel. This is an example of an intentional disruption that occurs within a supply chain. Other examples of intentional disruptions can occur due to causes from outside of the supply chain as well. Apple and Samsung have been involved in numerous litigation battles which were designed to prevent the production and distribution of a product (Bartz 2013).

Each of these scenarios led to a disruption in the flow of goods but requires significantly different strategies to manage the risk. Despite having sufficient safeguards within a supply chain to protect against disruptions due to accidental or unplanned mistakes, companies can still be exposed to disruptions from intentional behavior. For firms to adequately prepare for and react to disruptions, it is critical to understand how the nature of the disruptive event can impact the appropriate strategies for supply chain risk management.

2 Literature and theory review

Below, we review two primary bodies of literature in order to theoretically ground intentional risk behavior. First, we review extant research surrounding supply chain risk and the management thereof. Next, we review related research on organizational information processing theory (OIPT). These two sections lay the groundwork for the proposed framework and propositions.

2.1 Supply chain risk and disruption management

Increasingly, the antecedents to supply chain disruptions are becoming more varied and frequent in nature (Narasimhan and Talluri 2009). Additionally, both the frequency and magnitude of risks faced by supply chains is also on the rise (Blackhurst et al. 2005). Disruptions have been shown to play a critical role in determining company value (Hendricks and Singhal 2003, 2005), and managing these risks is a major focus of firms. In a 2012 survey, 73% of companies reported at least one supply chain disruption in 2012, with an average of five disruptive events (Business Continuity Institute 2012) . Natural disasters, political upheavals, and quality failures continue to make the need to understand disruptions more salient.

In the supply chain literature, disruptions are often treated as homogenous regardless of the nature of the disruption. For example, Sheffi and Rice Jr (2005) discuss the disruptive event as "the tornado hits, the bomb explodes, a supplier goes out of business, or the union begins a wildcat strike." Although each of these cases is similar in that there is a disruption to the physical flow of goods, the prevention mechanisms, mitigation strategies, and recovery plans for each of these disruptions will likely vary. As such, we propose that the ability to distinguish between disruptions based on the characteristics of the disruption is a critical aspect of risk management that the literature has failed to address fully.

To expand the framework for addressing supply chain disruptions, there are many existing classification tools regarding risk management that merit analysis. These fall into two broad categories: (1) classifications relating to the source of risk, and (2) classifications regarding the factors impacting the antecedents to and recovery from supply chain disruptions. We discuss these classifications in the following two paragraphs.

Multiple classifications exist which focus on identifying various sources of risk. These tools classify the sources of risk in a variety of ways including: environmental, network, and organizational risks (Jüttner et al. 2003); specific sources of risk and cost of mitigation strategies (Chopra and Sodhi 2004); supply, demand, or operational risks (Manuj and Mentzer 2008); environmental, industry, organizational, problem-specific, and decision maker risk (Rao and Goldsby 2009); and network propagated risk (Garvey et al. 2015). Each of these different classifications of risk can be further expanded to include the degree of risk associated with both their frequency and their magnitude (Blackhurst et al. 2005; Norrman and Jansson 2004; Sheffi and Rice Jr 2005).

There are several classifications that focus on events immediately surrounding a disruption, focusing on either the antecedents of, or the reaction to, a disruptive event. For example, (Durach et al. 2015) present a framework for the antecedents to intra- and inter-organizational robustness in terms of both avoiding and resisting disruptions. Braunscheidel and Suresh (2009) discuss the antecedents to supply chain agility for a supply chain to better manage disruption risk. Such antecedent-based disruption classifications are useful in that they provide a good understanding of the risks associated with a disruption occurring, while recovery disruption classifications are useful for when the inevitable disruption does occur. For example, Tang (2006) presents nine strategies for employing robust supply chain man-

agement practices to recover better from supply chain disruptions. Recovery based disruption literature focuses on managing the impact of a disruption once it has happened. These typologies provide a useful lens into appropriate behavior for reducing the impact of a disruption through planning and forethought.

Taken together, extant literature on the categorization of risk management provides a proactive view on what *may* happen, and how to recover from a disruption, but does not address how the nature of the disruption can change the preventative, or reactionary behavior, despite disruptions occurring due to substantively different causes.

Exogenous/Endogenous Disruptions. To better understand how to manage disruptions, it is critical to understand the nature of the disruption itself. The current literature has ample information on what causes disruptions as well as useful theoretical models to explain behavior surrounding the disruption event, primarily focused on either before or after an event. Disruptions can be viewed from different levels of analysis—either impacting individual firms, specific supply chains, or multiple independent firms. We focus our analysis in this paper on disruptions that impact a firm, but are due to events that occur from within the supply chain of the firm (endogenous) or events that occur from outside of the supply chain (exogenous). Here, we examine the differences between exogenous and endogenous disruptions.

We define an exogenous disruption as one that occurs due to behavior from outside of the supply chain, while an endogenous disruption is one that occurs due to behavior from within the supply chain. The current literature has mainly focused on exogenous disruptions to a supply chain, likely because of how apparent the impacts of a large-scale disruption are to multiple firms. For example, the Japanese tsunami had significant implications for numerous businesses (MacKenzie et al. 2012), leading to additional research focusing on exogenous risks to a supply chain. Additionally, the threat of terrorist attacks has led to further research on exogenous risks for a supply chain (Sheffi 2001). The impacts from exogenous disruptions tend to affect multiple firms across various industries. Given this large effect, there is a significant amount of literature that has focused on recognizing and managing risk levels for disruptions that are due to such factors. Accordingly, there are a number of tools that exist for measuring the risks associated with exogenous disruptions (e.g. Garvey et al. 2015). Research has suggested multiple approaches for managing endogenous risks such as supplier audits (Giunipero and Aly Eltantawy 2004), volume flexibility (Braunscheidel and Suresh 2009), and contractual controls (Choi et al. 2004).

Intentional/Inadvertent Disruptions. While the external/internal dichotomy presented above is crucial to understanding the antecedents of disruptive events and how to manage them, this understanding should be viewed in the context of intent. The term 'intentional disruption' refers to a disruption that occurs due to purposeful behavior by the source of the disruption. This can arise endogenously, such as when suppliers deliberately decide to use inferior quality goods or intentionally fail to deliver certain goods as promised. It can also be due to exogenous factors, such as attempts from competitors or terrorists, to disrupt the flow of products in a firm's supply chain. Although the overarching goal of the intentional behavior might not be to cause a disruption, an intentional disruption occurs when the outcome of a specific intentional behavior leads to a disruptive event. Thus it includes behaviors such as 'self-interest seeking with guile', such as that suggested by Williamson (1985) in his definition of opportunistic behavior, as well as behaviors that are specifically targeted to cause a disruption. Because an intentional disruption is due to an intentional act from another party, it completely changes the dynamics of appropriate preventative and reactive behaviors, making the current understanding of disruptions insufficient in classifying different types of disruptions and for prescribing appropriate risk management strategies.

Consider the following selected risks faced by Analog Devices as discussed in their 10k report (Annual Report 2014):

> "We are involved in frequent litigation, including claims regarding intellectual property rights, which could be costly to bring or defend and could require us to redesign products or pay significant royalties… we could be forced either to redesign or to stop production of products incorporating that intellectual property, and our operating results could be materially and adversely affected. We may be unable to adequately protect our proprietary intellectual property rights, which may limit our ability to compete effectively. A significant disruption in, or breach in security of, our information technology systems could materially and adversely affect our business or reputation."

These threats clearly identify the risk of a significant financial impact due to intentional acts within the supply chain, which can lead to a disruption. It is our position that disruptions due to risks such as these are substantively different from disruptions due to inadvertent behavior and require different risk management approaches.

Inadvertent disruptions are disruptions that occur without an active decision directly leading to a disruption. These can include natural factors such as environmental disasters or economic disruptions. Quality problems can occur either as an inadvertent disruption (poor quality controls) or as an intentional disruption (fraudulent quality). Understanding whether or not the disruption is caused by an intentional or an inadvertent act has major implications for handling the disruption as it can significantly impact the relationship.

Analyzing disruptions from the perspective of intentional/inadvertent is a helpful approach because understanding the motivation behind a possible disruption may improve resource allocation for risk mitigation strategies. Intentionally caused disruptions are a fundamental source of risk that has not been comprehensively investigated, despite being a concern for firms. The events involving intentional disruptions, such as those discussed by AIG, also frequently occur within the smartphone industry, which has been involved in a perpetual patent war between the major producers of smartphones. Between 2011 and 2015, over 30 lawsuits were been filed between Apple and Samsung alone (Nam et al. 2015). Based on the literature described above, we present a classification scheme of causes for disruptive events.

2.1.1 Operational classification of disruptions

Force Majeure Disruption. A Force Majeure disruption is one that is due to non-deliberate events that occur outside of the supply chain, from inadvertent and exogenous causes. These events disrupt the flow of materials within a supply chain due to external forces that are not deliberate and not focused on a single firm. Inadvertent exogenous disruptions might include disruptions such as those due to natural disasters, disruptions due to economic instability, political instability, port closures, or terrorism. Force Majeure disruptions are the most well-developed disruption within the disruption literature as it is often the one that receives the most attention both from the general media and the academic journals.

Performance Failure. A Performance Failure disruption is due to an inadvertent act that occurs within the supply chain. While these are not intentional, they can still be quite damaging and indicate a significant problem within the supply chain. Performance Failure disruptions can be attributed to poor supply chain management. These non-intentional acts still result in a disruption of the supply chain. Examples can include poor quality, routing or delivery failures, fires or accidents, or supplier bankruptcy. These disruptions can be either minor or major depending on the spread and the cause of the disruption within the supply chain.

Targeted Strike. Targeted Strike is a disruption category that has not been fully addressed in the current literature. A Targeted Strike disruption is one that is caused by deliberate behaviors from outside of the supply chain. They are from intentional and exogenous causes and can include things such as competitor driven disruptions, protests by activists or external groups, targeted terrorism, government intervention such as litigation that impacts production, electronic attacks, or theft. These disruptions occur from outside of the supply chain but are targeted towards a particular firm or supply chain. For example, in 2000, protesters banded together to protest and blockade oil refineries and fuel deposits, leading to a major disruption of the petroleum supply chain in the UK (Doherty et al. 2003). Competitors can also be the source of a disruptive event. One deliberate strategy is to raise competitor costs or engage in group boycotting where a firm pressures its suppliers to behave unfavorably towards other buyers (Salop and Scheffman 1983). Another strategy is to use litigation to increase competitor costs and delay or halt production of similar competitor products, as seen in the case between Mattel and Bratz (Chang 2011) when Mattel sued Bratz to halt production of a competing product and with the aforementioned constant litigation battles between Apple and Samsung in the smartphone market (Bartz 2013).

Inside Job. Inside Job disruptions are those that are a result of intentional actions from one of the supply chain members. These are deliberate actions within a supply chain and might include things such as fraudulent behavior between organizations (such as the earlier example of Mattel's supplier deliberately circumventing the lead paint testing process), theft, contract violations, strikes from within the supply chain, or different forms of opportunistic behavior such as deliberately using inferior goods or counterfeit products. These cases can be considered as inter-organizational fraud and have received limited attention within the

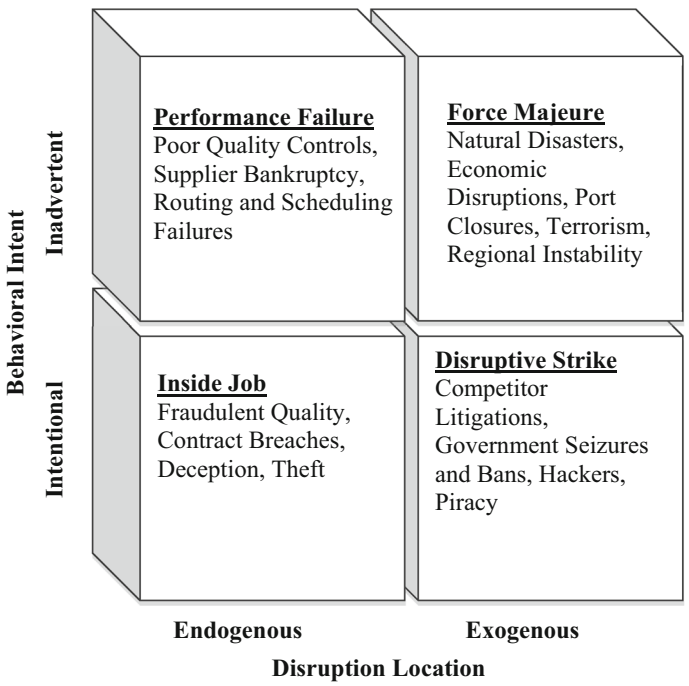

Fig. 1 Classification of disruptive events

disruption literature. Figure 1 summarizes this classification and presents some examples of disruptions that fall into each classification.

2.2 Organizational Information Processing Theory

To date, research has been limited that grounds intentional risk behavior in an overarching theoretical construct. In this paper, we integrate Organizational Information Processing Theory (OIPT) as a means to explain how organizations can proactively respond to different types of disruptions.

At the heart of OIPT is the idea that organizations are faced with information that is marked by constant uncertainty and equivocality (Cegielski et al. 2012; Daft and Macintosh 1981), and thus require the employment of information processing capabilities that improve information quality and flow. Accordingly, OIPT presents an appropriate lens through which to examine supply chain disruptions which are difficult to predict, and are thus major sources of uncertainty (defined as the amount of information that needs to be gathered and interpreted) and equivocality (defined as the multiplicity of meaning that could be interpreted from information) (Daft and Macintosh 1981; Wu et al. 2013). The seminal article on the theory (Galbraith 1974) suggests that as uncertainty (equivocality) increases, the information processing requirements of the firm increase, and that firms should adopt capabilities to meet these requirements (Tushman and Nadler 1978). As information processing capabilities increase within the organization, they are better able to deal with uncertainty (equivocality) (Poole 1978; Wu et al. 2013).

This requirement for increased information processing is vital to the planning and mitigation strategies for supply chain risk. Previous studies have shown that as levels of uncertainty rise, so too will the magnitude of supply chain disruptions (Ellis et al. 2011). In response to increased uncertainty and the need for more robust information processing capabilities, firms will design structural mechanisms to meet these requirements. Firms that build these capabilities to specifically fit their unique information processing requirements will be more competitive than rival firms who are unable to engineer lesser degrees of fit (Hazen and Sankar 2015; Wu et al. 2013).

Tuggle and Gerwin (1980) suggested that firms choose their strategic orientation based on the information available to their decision makers and that their response to uncertainty impacts performance. Ito and Peterson (1986) demonstrated that information processing capabilities can facilitate boundary spanning and the firm's ability to navigate its network connections, which have been shown to increase firm performance (Carnovale and Yeniyurt 2015). Taken together, the recommendations of OIPT become particularly salient in the context of supply chain risk and disruption management, as one of the key steps advocated in this process is to determine and implement the right capabilities to use as controls (Pettit et al. 2010).

In addition to designing structural mechanisms to process and gather varied information, OIPT suggests that a firm's ability to formalize processes also aids in addressing uncertainty (Smith et al. 1991) and that structural designs alone are insufficient (Stevenson and Gilly 1991). Extending the theoretical boundaries of OIPT, Hult et al. (2004) suggested that the supply chain can act as a valuable information gathering and processing system and that formalized processes that improve information gathering can lead to better performance. To this end, Bode et al. (2011) examine supply chain disruptions from the standpoint of the firm being able to acquire and process information.

2.2.1 Connecting OIPT to disruptions

This study leverages the theoretical arguments from the aforementioned literature base to inform firms' risk detection, risk mitigation, and disaster recovery strategies. Below, we suggest a series of propositions that detail the implications of supply chain disruptions/risks when viewed through the lens of OIPT. The propositions serve to elucidate two overarching themes. First, the propositions will compare the implications of the disruption categorization laid out in Fig. 1. Next, the propositions serve to apply tenets of OIPT with respect to defining information processing requirements, developing information processing capabilities, and creating mechanisms that properly fit requirements to capabilities. Functions of these tenets are compared to three vital elements of managing supply chain disruptions/risks: (1) risk detection, (2) risk mitigation, and (3) risk recovery. Risk detection represents the phase of information processing that allows firms to appropriately prepare for a disruption. Risk mitigation represents the phase of organizational safeguards to follow in the case of a disruption and reduce the impact of a disruption once the disruption has occurred. Risk recovery represents the process of restoring or rebuilding a supply chain to its previous status.

3 Framework and propositions

Recall that above, we have categorized supply chain risk/disruptions in two ways. First, we suggested that risks deal with the likelihood of potentially negative affects to the firm and can be thought of, and have been studied as, either exogenous or endogenous to the firm. Disruptions, then, refer specifically to the manifestations of said risks. Next, we suggested that such risks/disruptions could also be thought of as either inadvertent or intentional. Finally, we juxtaposed the 2 (see Fig. 1), suggesting that when viewed together, a clearer picture of the implications of such a disruption emerges.

In order to understand the different implications of the framework presented in this paper, an overview of various supply chain risk management strategies is included and categorized along the dimensions of the disruption type following the endogenous/exogenous and intentional/inadvertent framework discussion above and the phases of risk management along the lines of risk detection, risk mitigation, and disruption recovery. This literature review is presented in Table 1 below. Using the literature explored in Table 1 in conjunction with the proposed framework, it is possible to identify the similarities and differences among suggested strategies between the different types of disruptions and the phases of risk management, which have previously been largely included in the same overall categorization of supply chain disruptions.

Using this approach identifies appropriate risk management strategies to manage specific types of disruption risk. This can be of benefit for risk management implementation, understanding the implications of previous literature on disruptions, and exploring the differentiable application of risk management strategies along the dimensions discussed in this paper. Based on the juxtaposition of the disruption framework of exogenous/endogenous and intentional/inadvertent, OIPT for managing uncertainty, and prior literature on disruption management, we develop the following set of propositions to elucidate how the different nature of disruptions can change both the impact of the disruption and the appropriate risk management strategies.

Table 1 Risk Management Strategies and Disruption Types

Disruption Type	Definition	Examples	Risk detection	Risk reduction	Disruption recovery
Force majeure	Disruptions due to nondeliberate events that occur outside of the supply chain.	Natural disasters, economic disruptions, port closures, terrorism, political instability	Information sharing (Kleindorfer and Saad 2005; Sheffi 2001), TQM (Lee and Whang 2005), risk analysis and assessment (Shtub et al. 1994; Norrman and Jansson 2004; Raj Sinha et al. 2004)	Diversification, modularity in processes and pesign (Kleindorfer and Saad 2005), strategic inventory stockpiling (Sheffi 2001; Chopra and Sodhi 2004), risk pooling (Sheffi 2001). TQM (Lee and Whang 2005), reducing supply chain complexity (Manuj and Mentzer 2008)	Backup systems, contingency plans (Kleindorfer and Saad 2005; Finch 2004), volume flexibility, supply chain agility (Braunscheidel and Suresh 2009), redundant and responsive suppliers (Chopra and Sodhi 2004)
Targeted strike	Disruptions due to deliberate behaviors from sources outside the supply chain.	Competitor litigations, Government seizures and bans, hackers, targetted terrorism, theft, piracy	Supply chain level security assesment and management (Finch 2004), robustness determined by the weakest link in the supply chain for purposeful disruptions (Kunreuther and Heal 2003; Kleindorfer and Saad 2005)	Government regulation, supply chain security (Sullivan 2010), strategic supply chain design, simulated scenario planning (Kleindorfer and Saad 2005)	Multiple product lines, supply chain agility (Braunscheidel and Suresh 2009)
Performance failure	Disruptions due to an inadvertent act that occurs within the supply chain.	Poor quality controls, supplier bankruptcy, routing and scheduling failures, accidents	Supplier audits, supplier development (Giunipero and Aly Eltantawy 2004)	Inventory, Reliable suppliers (Tomlin 2006), risk management processes (Finch 2004)	Volume flexibility (Braunscheidel and Suresh 2009); multiple sourcing (Giunipero and Eltantawy 2003)
Inside job	Disruptions that are a result of intentional action from one of the supply chain members.	Fraudulent quality failures, contract Breaches, intellectual property theft, equipment or product theft, worker strikes	Supplier audits, supplier integration; proactive supply chain design (Finch 2004)	Contractual controls, trust, relational management, stick and defense licensing (Choi et al. 2004), Corporate Social Responsibility (Collier and Esteban 2007)	Exit or voice (Ping 1993), switching to alternate suppliers, relationship management

3.1 Impact of disruptions on firm performance

While disruptions, in general, tend to have an adverse impact on firm performance, endogenous disruptions can be particularly disastrous. Previous research has touched on the idea of looking at disruptions from a perspective of internal and external problems and found that disruptions that could be associated with internal problems had a worse negative impact on financial performance (Schmidt and Raman 2012). The following three arguments advance this claim.

First, an endogenous disruption suggests a fundamental issue within the supply chain that has not been resolved. A firm involved in an endogenous disruption might be viewed as worse at risk management as a firm that does not experience a similar disruption. Hendricks and Singhal (2005) demonstrate that disruptions can have a significant negative impact on firm finances, leading to abnormal stock returns of −40% on average with lasting consequences that reached into the year following the announcement of a disruption. An endogenous disruption can indicate a systematic issue within the supply chain that has not been resolved and will need to be fixed, which can be both costly and time-consuming.

Second, in addition to the problem being intrinsic to the supply chain, such endogenous disruptions are likely isolated to the firm and not experienced by competitors that do not share elements of their supply chains. Companies that are more resistant to disruptions have a competitive advantage in the market (Sheffi 2005). Extending that argument, an endogenous disruption that does not impact a competitor (i.e. delivery failures due to supply chain errors) will impact the disrupted firm more negatively than an exogenous disruption such as delivery failures due to a natural disaster which impacts a firm and their competitors. In the case of an exogenous disruption, it is more likely that competitors using a similar supply chain will face similar negative impacts. For example, the impacts from natural disasters, port closures, regional stability, government regulations, and so on are likely to impact many companies simultaneously, and thus relative performance would be less negatively impacted.

Lastly, endogenous disruptions can act as a strong negative signal to key stakeholders, including customers, suppliers, and shareholders, which can lead to lower levels of demand, weaker negotiating power, and a lower valuation for a company. In the case of an exogenous disruption, such a signal is not as negative given that the disruption can be viewed as one that was externally caused, and thus is not an intrinsic failure to the firm. A disruption due to a natural disaster is less indicative of systematic challenges than a disruption due to failures within the supply chain. In looking at 500 disruptions, Schmidt and Raman (2012) found that disruptions associated with internal problems had a more negative impact on financial performance than disruptions associated with an external impact. Following these arguments, we present the following proposition:

Proposition 1 *The impact of a disruption on firm performance is more negative when the disruption is due to an endogenous rather than an exogenous cause.*

The costs associated with a disruption that are due to an intentional act from either within or external to the supply chain can be particularly impactful because they are often designed in a way to either cause as much damage or capture as much of the value from within the supply chain as possible. Because supply networks are driven by relationships among buyers, suppliers, and third parties, it is critical to distinguish between inadvertent and intentional disruptions. Despite the challenge of detecting this type of disruption, it is critical that the firms are aware of the risks to appropriately manage risks of intentional disruptions. One of the challenges for managing intentional disruptions is that the robustness of the supply chain is determined by the weakest link in the entire supply chain (Kleindorfer and Saad 2005;

Kunreuther and Heal 2003). As such, it might be outside of the detection and controlling reach of any one firm in the supply chain.

An inadvertently caused disruption can have major ramifications on firm performance, but often the penalties and costs are focused on replacing missing product or repairing a damaged supply chain. For example, Aston Martin experienced a disruption due to a supplier using counterfeit plastic material in the accelerator arms (Klayman 2014). The damage was extensive because it had permeated through the supply chain and became an external problem for Aston Martin, and likely will require finding a new supplier for the part rather than simply ordering additional materials due to the disruption. Responding to an intentional disruption might require a full redesign of the supply chain, either to find new trustworthy suppliers or to limit the risk of intentional interference from parties outside the supply chain. Based on this, we propose:

Proposition 2 *The impact of disruptions on firm performance is more negative when those disruptions are due to an intentional rather than an inadvertent cause.*

3.2 Risk detection

Risk detection is a critical component of risk mitigation strategies. Understanding how to best detect and anticipate risks can allow both prevention strategies and recovery strategies to be in place prior to a disruption occurring. Each of the different classifications has different risks that must be detected to produce adequate risk management strategies.

Force Majeure disruptions can be identified through risk awareness strategies such as information sharing (Kleindorfer and Saad 2005; Sheffi 2001), principles from TQM (Lee and Whang 2005), risk assessment strategies (Norrman and Jansson 2004), and identifying risk indicators (Zolkos 2003). These risk management strategies need to encompass the full supply chain as risks that suppliers face quickly become critical for a focal firm in the event of a natural disaster or another type of force majeure disruption.

Performance Failures can generally be monitored within a supply chain by supplier audits and supplier development (Giunipero and Aly Eltantawy 2004). These principles were well applied by Toyota in their supplier base to significant effect (Dyer and Nobeoka 2000), leading to a very low level of recalls for Toyota (Bates et al. 2007). There have been several movements towards quality and supplier management within the literature and industry, with both Total Quality Management and Lean as major influences on improving quality throughout a supply chain. Other strategies might include appropriate incentives in contracts or relational management. Supply chain visibility can provide a warning that something might occur before it becomes a major issue. Detecting and measuring the likelihood of a disruption occurring due to internal causes is challenging, although possible. Tracking information such as order fill rates, on-time deliveries, and quality can provide a reasonable indicator of unexpected failures within a supply chain that can lead to a disruption.

Targeted Strikes are a type of disruption that is very difficult to anticipate. For example, the recent advertising campaign by taco bell that deliberately targeted the McDonald's brand (Maureen 2014) would be difficult to anticipate. Other events can be equally challenging to predict, such as government seizure, theft, or piracy. Despite the challenge of detecting this type of disruption, it is critical that firms are aware of the risks as soon as possible so that contingency plans can be put in place regarding the outcome of the disruptive event. Some of the risk of a Targeted Strike could be detected and subsequently ameliorated with appropriate security assessment and management practices (Finch 2004). One critical aspect

of risk management for targeted strikes is that the robustness of the supply chain is determined by the weakest link in the entire supply chain (Kleindorfer and Saad 2005; Kunreuther and Heal 2003), and as such it is particularly critical for a firm to be aware of the risks that the entire supply chain is exposed to.

Inside Job disruptions are among the most difficult of disruptions to detect, as they are often the result of a supply chain partner who is seeking to hide or obfuscate their behavior deliberately. It is especially important to have strong supplier integration and audits to be aware of potential opportunistic behavior or problems before they lead to a disruption. Strong relational management practices can help a firm be aware of a possible intentional disruptive event, which can help to detect early cases of an Inside Job disruption.

Although the specific mechanisms to detect risk levels for each type of disruption differ based on the specific risk, the suggested strategies for risk detection for each of the four classifications are highly similar as they are focused on information sharing, visibility and integration with suppliers. The primary differentiation is that of using the information to detect a specific type of threat such as supply chain security threat, theft, quality, or supplier bankruptcy. The overall goals of the different specific mechanisms fall within the same general categories.

Proposition 3 (a-c)*: Although the specific mechanisms differ, Information Sharing (a), Supply Chain Visibility (b), and Supplier Integration (c) are effective risk detection approaches for all types of disruptions.*

3.3 Risk mitigation

The risks associated with Force Majeure disruptions can be reduced through supply chain design such as diversification or modularity in processes and design (Kleindorfer and Saad 2005), strategic inventory stockpiling (Chopra and Sodhi 2004), risk pooling (Sheffi 2001), principles from TQM (Lee and Whang 2005), or reducing supply chain complexity (Manuj and Mentzer 2008). Using the traditional classification of risk frequency and impact (Norrman and Jansson 2004), appropriate risk levels can be determined. Identifying general risk levels for Force Majeure disruptions and designing appropriate procedural safeguards and prevention mechanisms such as earthquake-proofing facilities, backup inventory or suppliers, and contingency plans can effectively reduce the impact of a disruption.

Reducing the risk of a Performance Failure disruption within a supply chain is manageable through setting up appropriate processes with a supply chain such as carrying safety stock and using reliable supplies (Tomlin 2006), using a list of approved or preferred suppliers who have been pre-certified to some degree of reliability (Gosling et al. 2010), or using a risk management process (Finch 2004) to identify and manage risk levels for inadvertent disruptions which occur within the supply chain.

Strategies for reducing the likelihood of a Targeted Strike are largely relational in nature. For example, stick and defense licensing which different types of relationships with regards to intellectual property controls can protect against certain types of intellectual property risks (Choi et al. 2004). Certain safeguards might be taken such as securing against theft (Sullivan 2010), but in general, there are limited actions that a firm can take to prevent a targeted disruption. Recognizing that the entire supply chain might be exposed in the case of a disruption and strategically developing a balanced supply chain that is not extremely dependent on the contribution from a single firm can alleviate some of the risk, but there is no simple solution to eliminate targeted disruptions. One suggested strategy to manage Targeted Strikes is that of role-playing possible scenarios to assess specific vulnerabilities (Kleindorfer and Saad 2005).

Additionally, it is important to recognize the role that government and regulatory environments have on managing a Targeted Strike disruption, as they might often be the first barriers to protect a company from malfeasance. Developing appropriate triadic relationships with governments or other organizations can help to reduce the threat of intentional disruptions.

Reducing the risk of Inside Jobs and other opportunistic behavior within the supply chain is more reliant on relationships than processes put in place. For example, consider the Mattel case discussed previously. Despite developing appropriate processes and checks, lead-based paint still entered the supply chain through deceptive behavior by their suppler. One possible approach might be that of Corporate Social Responsibility which can lead to higher levels of commitment and motivation (Collier and Esteban 2007). Effective relational governance mechanisms might include a combination of contractual controls, trust governance, or relational management approaches to reduce the risk of an Inside Job disruption.

Although many process-based risk approaches are very effective for traditional disruptions, such as modularity, strategic inventory, risk management processes, etc., they are not as effective for managing intentional disruption risk. In fact, in some cases, they might create additional exposure. Modularity increases the exposure, since if the base platform is compromised (either through litigation holds or intellectual property theft for example), everything else is placed at risk. Additionally, it means wider sharing of information, which can increase relational risk. Inventory can become a liability in the case of fraudulent quality issues, and risk management processes can't accurately predict relational behavior. Appropriate risk management strategies for intentional disruptions are relational-based approaches, rather than process-based approaches. Relational measures *can and do* reduce risk related to intentional disruptions. Relational governance, trust, and contracting controls can all be effective tools for managing relational risk. Based on this discussion, we propose the following two propositions regarding risk mitigations:

Proposition 4a *Risk mitigation efforts for inadvertent disruptions are effective when they are process-based approaches.*

Proposition 4b *Risk mitigation efforts for intentional disruptions are effective when they are relationship-based approaches.*

3.4 Disruption recovery

Disruption recovery for *Force Majeure* disruptions generally focus on having a supply chain that can quickly readjust to replace any lost inventories or production capabilities. Such approaches include backup systems and contingency plans (Finch 2004; Kleindorfer and Saad 2005), supply chain agility (Braunscheidel and Suresh 2009), or redundant and responsive suppliers (Chopra and Sodhi 2004). Each of these allows the company to survive the disruptive event and return to normal operations. Disruption recovery for Force Majeure disruptions includes consuming stockpiled inventory and changing to alternate supply sources for quickly recovering from a disruption. The alternative supply sources could either be internal production capabilities, secondary factories, or secondary suppliers to which demand can be rerouted. Because the disruption comes from outside of the supply chain's direct control, the supply chain typically does not need to be redesigned, although depending on the extent of the disruption, factories might need to be rebuilt as part of the recovery process.

Performance Failure disruptions can be managed through similar approaches, although the mitigation strategy would be more specific to the supplier that was responsible for the performance failure. Although in some cases it might require some restructuring if the supplier

is deemed insufficient, typically, appropriate safeguards can be reestablished with the same suppliers and the disruption can be managed. However, having volume flexibility (Braunscheidel and Suresh 2009) or multiple sourcing strategies (Giunipero and Aly Eltantawy 2004) can be of significant value. In more extreme cases of a Performance Failure disruption (such as a major automotive recall), it can be useful to have an efficient reverse supply chain that can enable a more efficient and faster recovery effort.

Targeted Strike disruptions are difficult to manage, largely because they have many different effects upon a supply chain. Depending on the nature of the Targeted Strike, recovery methods from other classifications might be possible. In the event of loss of goods from piracy or theft, replacing the lost goods can be done more efficiently in an agile supply chain or with responsive suppliers. Preventing future occurrences for each newly discovered vulnerability, however, will require a unique and individually tailored approach. Recovering from a disruption of this type is challenging as well. In more extreme cases, there might be no recovery available beside moving on to a new product, as the specific product could be no longer legal to produce or no longer viable such as might be the outcome of a legal battle such as those experienced by Samsung and Apple or Bratz and Mattel discussed earlier. In other cases, it might be possible to introduce a new or modified version of the product. The public perception of such events also can lead significant pressures to restructure a supply chain to avoid a reoccurrence. Regardless of the specific circumstances for a Targeted Strike disruption, it is fairly difficult to have an active and prepared plan in place for a disruption of this type, and firms will be reliant on having a supply chain structure that can be quickly restructured in case such a disruption occurs.

Inside Job disruptions are the most difficult type of disruption to recover from, not only because the impact is often very great. Inside Job disruptions involve firms taking advantage of their partners in a deceitful way that makes it difficult or impossible to continue to reestablish trust in the relationship. The damage may also be quite extensive throughout a supply chain in the case of inter-organizational fraud as well. Recently, Aston Martin expanded a recall to include over 17,000 cars (approximately 75% of the cars produced from 2007–2012) due to a supplier using a counterfeit plastic material in the accelerator arms (Klayman 2014). Recovering from this event is more than simply reordering additional parts from the same supplier, but requires more extensive changes to the supply chain. Ping (1993) suggests that two options to relationship problems might be exit or voice, which rely on changing suppliers or voicing concern to create sufficient change. Regardless of the option selected, it will be a difficult process to recover fully. Having potential alternative suppliers or excellent relationship management techniques will greatly alleviate the cost of a disruption recovery for an Inside Job as the supply chain is repaired. However, there are limited means of dealing with the initial damage from the disruptive event that has been explored by the literature.

Both Force Majeure and Performance Failure disruption approaches reflect those discussed in the literature under the concept of resilience, being able to withstand and return to the previous state without sustaining significant costs (Christopher and Peck 2004). Inadvertent disruptions act as injuries to the supply chain, which need to be repaired to restore complete functionality within the system. The goal is to return to the previous working state of a system. Intentional disruptions, on the other hand, might be more appropriately viewed as evidence of something that is fundamentally wrong with the current system and needs to be changed for the system to become operational again. In these circumstances, it might be necessary to restructure by changing product lines, changing suppliers, or redesigning the supply chain in some way to account for the change. Therefore, we propose:

Proposition 5a *Recovery efforts for inadvertent disruptions such as Performance Failure and Force Majeure disruptions are primarily based on the resilience of a supply chain.*

Proposition 5b *Recovery efforts for intentional disruptions such as an Inside Job or Targeted Strike are primarily based on the ability to restructure a supply chain.*

4 Implications for practice

One of the key challenges of managing disruptions is managing a variety of different types of risk. Appropriately recognizing and balancing the strategies to manage the different types of disruption risk is an important factor for success in risk management (Chopra and Sodhi 2004). The research model presented in this paper provides a useful tool for appropriately identifying strategies for managing risks that are due to intentional and inadvertent disruptions. These approaches are presented in Fig. 2 and connected to the different phases of risk management.

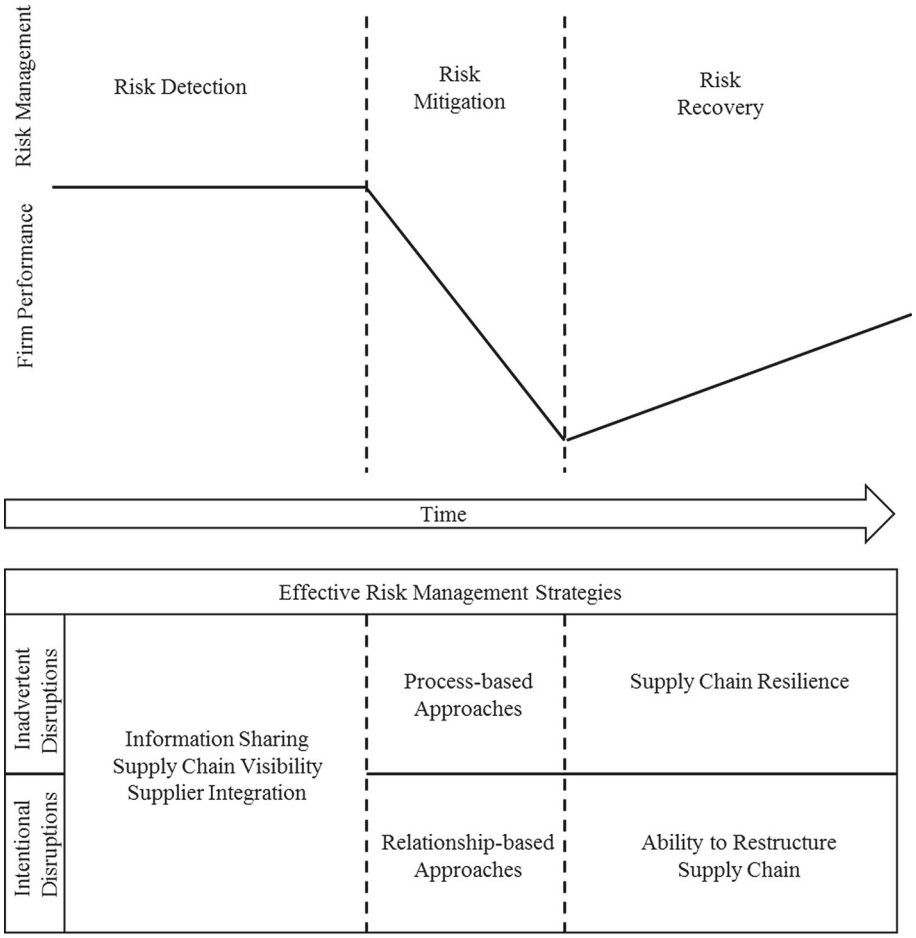

Fig. 2 Effective risk management strategies

One of the interesting findings from the review of risk management in previous literature is that information sharing, supply chain visibility, and supplier integration are effective deterrents of both intentional and inadvertent disruptions, suggesting that risk detection might be the best method to balance risk management approaches which consider behavioral intent appropriately. However, once a disruption has occurred, it is critical to understand that the efficacy of mitigation and recovery efforts differ substantially between intentional and inadvertent disruptions. Using process based approaches alone or focusing on supply chain resilience can limit the efficacy of a supply chain if it is exposed to the risk of intentional disruptions, as effective risk mitigation and risk recovery for intentional disruptions require relationship-based approaches and the ability to restructure a supply chain for effective.

5 Future research and limitations of the study

This paper makes three key contributions to the literature on disruption management and risk. First, we provide a theoretical underpinning for supply chain disruptions in OIPT. Previous research on risk lacks a cohesive theoretical framework that explains firm behavior with regards to risk detection, risk mitigation, and risk recovery. The adaptation of the OIPT framework to the disruption literature allows each of the relevant streams of disruption literature to be combined into a single research perspective, which yields additional insight and understanding into the role of the nature of disruptions when it comes to managing risk.

Second, we present a framework for understanding the varied nature of disruptions when taking into account the intent and the source of the disruption. This framework provides appropriate classifications for the various specific disruptions that are discussed in the literature. Recognizing that disruptions extend beyond the stoppage of the physical flow of goods leads to additional insight to understanding the aspect of relational risk of intentional disruptions.

Third, using the new framework, this research highlights the difference in impacts between endogenous and exogenous disruptions, and between intentional and inadvertent disruptions. Furthermore, additional insights regarding how to manage risk in terms of risk detection, risk mitigation, and risk recovery have been developed. These are discussed in terms of the new insight available from viewing the behavioral intent behind supply chain disruptions, showing how effective supply chain risk management strategies differ according to the nature of the disruption. These insights explain how risk detection strategies are similar between the different classifications, but risk mitigation and risk recovery differ in substantive ways. Risk mitigation strategies for intentional disruptions are driven by relational-based strategies, while process-based approaches drive strategies for risk mitigation for inadvertent disruptions relationships. Risk recovery efforts are distinguished based on intention by the firm's ability to recover from a disruption. The ability to recover from an intentional disruption is based on a firm's ability to restructure their supply chain, while the ability to recover from an inadvertent disruption is based on a firm's ability to return to the previous state of a supply chain, often termed resilience within the supply chain literature. This finding is synthesized in Fig. 2. This provides a valuable perspective for better understanding disruption risk theoretically, as well as practically for developing risk management approaches within a firm.

While the intent of this study is to begin a conversation on the implications, dynamics, and intricacies of intentional disruption behavior and the management thereof, there are some limitations to note. First, the present study is a conceptual piece. Understanding supply chain disruptions is a critical endeavor that can lead to far greater operational performance, and

thus future research should test this framework empirically. Also, using simulation based approaches to test the recommendations presented with respect to disruption detection, mitigation and recovery can aid in managerial practice by providing a framework for supply chain planning. In addition, incorporating behavioral research into the perspective as a tool for understanding *how* and *why* actors will create intentional disruptions, can act as a useful tool; particularly if its paired with experimental studies that replicate the dynamics suggested herein.

Understanding how the nature of a disruption impacts risk management strategies opens up new avenues of research and improves the ability to manage disruption risk. Although this paper explores the different types of supply chain strategies that should be adopted to best manage risk due to different relational strategies, the emphasis on how to implement the different strategies merits additional emphasis. For example, while information sharing, visibility, integration are critical constructs for risk detection, understanding how to implement these aspects in a global supply chain is a key component of future research. It is critical to understand not only when different strategies for detection, mitigation, and recovery can be effective in terms of intentional and inadvertent behavioral causes, but also how to successfully implement these strategies.

References

2014 Annual Report (2014). Analog Devices. Accessed Feb 9, 2016.

Azad, N., Saharidis, G. K., Davoudpour, H., Malekly, H., & Yektamaram, S. A. (2013). Strategies for protecting supply chain networks against facility and transportation disruptions: an improved Benders decomposition approach. *Annals of Operations Research*, *210*(1), 125–163.

Babich, V., & Tang, C. S. (2012). Managing opportunistic supplier product adulteration: Deferred payments, inspection, and combined mechanisms. *Manufacturing and Service Operations Management*, *14*(2), 301–314.

Bartz, D. (2013). U.S. agency: Apple infringes Samsung patent on older iPhones, iPads.*Reuters*.

Bates, H., Holweg, M., Lewis, M., & Oliver, N. (2007). Motor vehicle recalls: Trends, patterns and emerging issues. *Omega*, *35*(2), 202–210.

Blackhurst, J., Craighead, C. W., Elkins, D., & Handfield, R. B. (2005). An empirically derived agenda of critical research issues for managing supply-chain disruptions. *International journal of production research*, *43*(19), 4067–4081.

Bode, C., Wagner, S. M., Petersen, K. J., & Ellram, L. M. (2011). Understanding responses to supplychain disruptions: Insights from information processing and resource dependence perspectives. *Academy of Management Journal*, *54*(4), 833–856.

Braunscheidel, M. J., & Suresh, N. C. (2009). The organizational antecedents of a firm's supply chain agility for risk mitigation and response. *Journal of operations Management*, *27*(2), 119–140.

Business Continuity Institute (2012). *Supply Chain Resilience 2012*. Accessed Jan 6, 2016. http://www.thebci.org/index.php/supply-chain-resilience-survey-2012.

Carnovale, S., & Yeniyurt, S. (2015). The role of ego network structure in facilitating ego network innovations. *Journal of Supply Chain Management*, *51*(2), 22–46.

Cegielski, C. G., Jones-Farmer, L. A., Wu, Y., & Hazen, B. T. (2012). Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach. *International Journal of Logistics Management*, *23*(2), 184–211.

Chang, A. (2011). Mattel must pay MGA $310 million in Bratz case. *Los Angeles Times*.

Choi, T. Y., Budny, J., & Wank, N. (2004). Intellectual property management: A knowledge supply chain perspective. *Business Horizons*, *47*(1), 37–44.

Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. *MIT Sloan Management Review*, *46*(1), 53.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *The international journal of logistics management*, *15*(2), 1–14.

Collier, J., & Esteban, R. (2007). Corporate social responsibility and employee commitment. *Business ethics: A European review*, *16*, 19–33.

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007). The severity of supply chain disruptions: Design characteristics and mitigation capabilities. *Decision Sciences*, *38*(1), 131–156. doi:10.1111/j.1540-5915.2007.00151.x.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount and equivocality of information processing in organizational work units. *Administrative Science Quarterly*, *26*, 207–224.

de Matta, R. (2016). Contingency planning during the formation of a supply chain. *Annals of Operations Research*, *1–31*. doi:10.1007/s10479-015-2085-0.

Doherty, B., Paterson, M., Plows, A., & Wall, D. (2003). Explaining the fuel protests. *The British Journal of Politics and International Relations*, *5*(1), 1–23.

Durach, C. F., Weiland, A., & Machuca, J. A. D. (2015). Antecedents and dimensions of supply chain robustness: A systematic literature review. *International Journal of Physical Distribution and Logistics Management*, *45*(1/2), 118–137.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic management journal*, *21*(3), 345–367.

Ellis, S. C., Shockley, J., & Henry, R. M. (2011). Making sense of supply disruption risk research: A conceptual framework grounded in enactment theory. *Journal of Supply Chain Management*, *47*(2), 65–96. doi:10.1111/j.1745-493X.2011.03217.x.

Finch, P. (2004). Supply chain risk management. *Supply Chain Management: An International Journal*, *9*(2), 183–196.

Galbraith, J. R. (1974). Organization design: An information processing view. *Interfaces*, *4*(3), 28–36.

Garvey, M. D., Carnovale, S., & Yeniyurt, S. (2015). An analytical framework for supply network risk propagation: A bayesian network approach. *European Journal of Operational Research*, *242*(2), 618–627.

Giunipero, L. C., & Aly Eltantawy, R. (2004). Securing the upstream supply chain: A risk management approach. *International Journal of Physical Distribution and Logistics Management*, *34*(9), 698–713.

Gosling, J., Purvis, L., & Naim, M. M. (2010). Supply chain flexibility as a determinant of supplier selection. *International Journal of Production Economics*, *128*(1), 11–21.

Hazen, B. T., & Sankar, C. (2015). Cross-border process innovations: Improving the fit between information processing needs and capabilities. *International Journal of Innovation and Technology Management*, *12*(03), 1550013.

Hendricks, K. B., & Singhal, V. R. (2003). The effect of supply chain glitches on shareholder wealth. *Journal of operations Management*, *21*(5), 501–522.

Hendricks, K. B., & Singhal, V. R. (2005). An empirical analysis of the effect of supply chain disruptions on long-run stock price performance and equity risk of the firm. *Production and Operations Management*, *14*(1), 35–52.

Hult, G. T. M., Ketchen, D. J., & Slater, S. F. (2004). Information processing, knowledge development, and strategic supply chain performance. *Academy of Management Journal*, *47*(2), 241–253. doi:10.2307/20159575.

Ito, J. K., & Peterson, R. B. (1986). Effects of task difficulty and interunit interdependence on information processing systems. *Academy of Management Journal*, *29*(1), 139–149.

Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: Outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, *6*(4), 197–210.

Klayman, B. (2014). *Aston Martin recalls 17,590 cars due to counterfeit material*. Reuters: Reuters Business News.

Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruption risks in supply chains. *Production and Operations Management*, *14*(1), 53–68.

Kouvelis, P., & Li, J. (2008). Flexible backup supply and the management of lead-time uncertainty. *Production and Operations Management*, *17*(2), 184–199.

Kunreuther, H., & Heal, G. (2003). Interdependent security. *Journal of Risk and Uncertainty*, *26*(2–3), 231–249.

Lee, H. L., & Whang, S. (2005). Higher supply chain security with lower cost: Lessons from total quality management. *International Journal of Production Economics*, *96*(3), 289–300.

Lu, M., Ran, L., & Shen, Z.-J. M. (2015). Reliable facility location design under uncertain correlated disruptions. *Manufacturing and Service Operations Management*, *17*(4), 445–455.

MacKenzie, C. A., Santos, J. R., & Barker, K. (2012). Measuring changes in international production from a disruption: Case study of the Japanese earthquake and tsunami. *International Journal of Production Economics*, *138*(2), 293–302.

Manuj, I., & Mentzer, J. T. (2008). Global supply chain risk management strategies. *International Journal of Physical Distribution and Logistics Management*, *38*(3), 192–223.

Maureen, M. (2014).Taco bell ridicules McDonald's egg McMuffin in new spot. *Advertising Age*.

Nam, S., Nam, C., & Kim, S. (2015). The impact of patent litigation on shareholder value in the smartphone industry. *Technological Forecasting and Social Change*, *95*, 182–190.
Narasimhan, R., & Talluri, S. (2009). Perspectives on risk management in supply chains. *Journal of operations Management*, *27*(2), 114–118.
Norrman, A., & Jansson, U. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management*, *34*, 434–456.
Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring supply chain resilience: Development of conceptual framework. *Journal of Business Logistics*, *31*(1), 1–21.
Ping, R. A. (1993). The effects of satisfaction and structural constraints on retailer exiting, voice, loyalty, opportunism, and neglect. *Journal of Retailing*, *69*(3), 320–352.
Poole, M. S. (1978). An information-task approach to organizational communication. *Academy of Management Review*, *3*(3), 493–504.
Prasad, S., Zakaria, R., & Altay, N. (2016). Big data in humanitarian supply chain networks: A resource dependence perspective. *Annals of Operations Research*, 1–31. doi:10.1007/s10479-016-2280-7.
Raj Sinha, P., Whitman, L. E., & Malzahn, D. (2004). Methodology to mitigate supplier risk in an aerospace supply chain. *Supply Chain Management: An International Journal*, *9*, 154–168.
Rao, S., & Goldsby, T. J. (2009). Supply chain risks: A review and typology. *The International Journal of Logistics Management*, *20*(1), 97–123.
Salop, S. C., & Scheffman, D. T. (1983). Raising rivals' costs. *The American Economic Review*, *73*(2), 267–271.
Schmidt, W., & Raman, A. (2012). *When supply-chain disruptions matter*. Boston, MA: Harvard Business School Boston.
Sheffi, Y. (2001). Supply chain management under the threat of international terrorism. *The International Journal of Logistics Management*, *12*(2), 1–11.
Sheffi, Y. (2005). *The resilient enterprise: Overcoming vulnerability for competitive advantage.* MIT Press.
Sheffi, Y., & Rice, J. B, Jr. (2005). A supply chain view of the resilient enterprise. *MIT Sloan Management Review*, *47*(1), 41.
Shtub, A., Bard, J. F., & Globerson, S. (1994). *Project management: Engineering, technology, and implementation*. Prentice-Hall, Inc.
Smith, K. G., Grimm, C. S., Gannon, M. J., & Chen, M. (1991). Organizational information processing, competitive responses, and performance in the US domestic airline industry. *Academy of Management Journal*, *34*, 60–85.
Stevenson, W. B., & Gilly, M. C. (1991). Information processing and problem solving: The migration of problems through formal positions and networks of ties. *Academy of Management Journal*, *34*(4), 918–928.
Sullivan, A. K. (2010). Piracy in the Horn of Africa and its effects on the global supply chain. *Journal of Transportation Security*, *3*(4), 231–243.
Tang, C. S. (2006). Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics: Research and Applications*, *9*(1), 33–45.
Tomlin, B. (2006). On the value of mitigation and contingency strategies for managing supply chain disruption risks. *Management Science*, *52*(5), 639–657.
Tuggle, F. D., & Gerwin, D. (1980). An information processing model of organizational perception, strategy and choice. *Management Science*, *26*(6), 575–592.
Tushman, M. L., & Nadler, D. A. (1978). Information processing as an integrating concept in organizational design. *Academy of Management Review*, *3*(3), 613–624.
Véronneau, S., & Roy, J. (2014). Security at the source: Securing today's critical supply chain networks. *Journal of Transportation Security*, *7*(4), 359–371.
Wang, X., Wu, Y., Liang, L., & Huang, Z. (2014). Service outsourcing and disaster response methods in a relief supply chain. *Annals of Operations Research*, *240*, 1–17.
Williamson, O. E. (1985). *The economic intstitutions of capitalism*. New York City: Simon and Schuster.
Woo, C. (2008). Mattels Recalls (2007): Communication implications for quality control, outsourcing and consumer relations. *Arthur. W. Page Society. 2008 Case Study Competition Journal*.
Wu, Y., Cegielski, C. G., Hazen, B. T., & Hall, D. J. (2013). Cloud computing in support of supply chain information system infrastructure: Understanding when to go to the cloud. *Journal of Supply Chain Management*, *49*(3), 25–41.
Xu, J., Zhuang, J., & Liu, Z. (2016). Modeling and mitigating the effects of supply chain disruption in a defender-attacker game. *Annals of Operations Research*, *236*(1), 255–270.
Zolkos, R. (2003). Many companies still ignoring supply-chain risks. *Business Insurance*, *37*(43), 21.