A DARKER SHADE OF GRAY: AN EMPIRICAL EXAMINATION OF GRAY SWANS IN THE SUPPLY CHAIN

A Dissertation

by

TONY N.K. LYNCH

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COMMITTEE MEMBERS

Dr. Joon Jung
Committee Chair

Dr. Jorge Gonzalez
Committee Member

Dr. E. Thomas Coyle
Committee Member

Dr. Francis Kofi Andoh-Baidoo
Committee Member

December 2020

ABSTRACT

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The complexity and interconnectedness of markets creates risks in the global supply chain and may lead to various types of disruptions. Prior research in the supply chain management literature has focused on some aspect of disruption and firm performance. However, the effect of Gray Swans on various aspects of firms' operational or financial performance is an under-research area. Understanding why managers often underestimate and overlook Gray Swans contributes to ongoing conversation of risk in the global supply chain. Gray Swans are defined as low probability risk events that if/when they occur can have a severe or catastrophic impact on a firm's operations.

Gray Swans have been examined in the finance and economic literatures. However, these types of risk events have eluded significant discussion in the broad organization management literature. I present a new scale for measuring Gray Swans. Additionally, I have adapted and revised existing measures for the other constructs in the model.

My research seeks to (i) understand Gray Swan construct in supply chain management context, (ii) understand the relationship between Gray Swans and Firm Resilience, and (ii) investigate how the buyer-supplier relations and the firm's risk management system affect Firm Resilience in the context of a Gray Swan.

In this dissertation, I utilize an integrated theoretical approach applying Contingency Theory and Punctuated Equilibrium Theory to understand the 'punctuated contingent' effects of a Gray Swan on firm resilience. Prior research has utilized transaction cost economics, agency theory or institutional theory primarily to explain disruptions in the supply chain. While either of these theories may explain the relation between variables in the model, I believe Contingency Theory which focuses on "fit" and Punctuated Equilibrium which focuses on "convergence" better explain my model an overarching theoretical framework.

Two pilot studies were conducted to validate the constructs in the proposed research model. An exploratory factor analysis (EFA) demonstrated reliability and internal consistency of the model. I also conducted a confirmatory factor analysis to fit the data to the model. The findings from this research indicate a negative and significant relationship between Gray Swans and the transactional buyer-supplier relationship. I also found a positive and statistically significant relationship between buyer-supplier relationship – whether relational or transactional – and firm resilience. Finally, I found that Gray Swans negatively affects Firm Resilience.

DEDICATION

For my daughters, Tonyé and Elizabeth for believing in me throughout this whole process. To my parents who shared my dream to earn my PhD, and to my brothers and sisters for being a constant source of support and love. To Aimée, my inspirational cheerleader and Jenn my dear friend for being sources of strength. Thank you all for your love and support. Finally, for my grandmother, Eleanor and my uncle Henderson, I know you are both watching over me and this moment is a testament to your faith in me and my faith in GOD.

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CHAPTER I

INTRODUCTION

"Some events can be rare and consequential, but somewhat predictable, particularly to those who are prepared for them and have the tools to understand them. These near-Black Swans, or extreme modelable events, are Gray Swans." – Nasim Taleb (2007, p. 32)

1.0. Introduction to the Study

The ability to anticipate, respond to and recover from a disruptive event is characteristic of a firm's resilience (Ali et al., 2017). For example, General Motor's lack of preparedness to respond to a disruption in its supply chain because major supplier, Clark Cutter McDermott, filed for bankruptcy led to GM suffering significant losses in production and in the market (Gleason, 2011). The global environment in which firms operate is characterized by high levels of volatility. Firms are forced to obtain resources globally because market forces have reduced firms' abilities to vertically or horizontally integrate (Tarver, 2019). As a result, global supply chain disruptions have become as ubiquitous as dew on the morning grass. Disruptions which expose companies' supply chains to various kinds of endogenous and exogenous shocks have been the subject of extensive research. The extant operations management (OM) literature is replete with discussion of the various kinds of risk such as demand risk, process risk and inventory risk of various and natural or man-made disasters such as floods and political instability, that can severely disrupt supply chains (Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005). However, little attention has been devoted to understanding the risks posed by Gray Swans. These are low probability risk events that when they occur can have a significant negative impact on a firm's operations (Taleb, 2007). These events can be extremely costly to firms. For example, the West Coast ports strike in

2015 is estimated to have reduced U.S. economic output by approximately one percent; i.e. approximately $1.5 trillion off the nation's GDP (Oyedele, 2015). The ports' strikes of 2002 and 2012 also resulted in billions of dollars in losses across the economy (Gerrity, 2015). These Gray Swans could have been averted or mitigated to reduce economic losses if companies had a better understanding of the phenomena.

Companies' supply chains are exposed to various kinds of disruption risks. Samvedi et al (2013) discussed several types of supply chain risks: (1) demand risk; (2) process risk; (3) environmental risk; and (4) supply risk. These risks are further disaggregated into other types of risk. For example, supplier insolvency is reported in the literature under supply risk; labor strikes are treated as process risk; and political instability is reported under environmental risk. Controlling and assessing risks and supply chain disruptions should be a part of a firm's overall supply chain management strategy (Neureuther, 2009). In this dissertation, these three types of risks are regarded as Gray Swans. Other researchers have investigated supply chain disruption and disruption risks without a specific focus on low probability risks and disruptions. In their study of firms suffering from supply chain glitches, Hendricks & Singhal (2003; 2005) defined supply chain disruptions as unpredictable or unplanned events. While disruptions may be unplanned, not all are unpredictable. Gray Swans, i.e. political instability (POLINS), supplier insolvency (SPINSLV), and labor disputes (LABDIS) while, low in probability, are within the realm of predictability. These types of disruptions (i.e. Gray Swans) pose several challenges for those engaged in assessing, mitigating and managing risk and developing risk strategies in

complex and interconnected markets. For example, developing an effective response, and estimating costs.

This dissertation applies an integrated theoretical approach to examine and understand some of these challenges. Disruptions may result in the misalignment of firms and their external contingencies (Donaldson, 2001). When there is a disruption in the market, firms seek to regain "fit" (Donaldson, 2001) or in another context regain equilibrium through reorientation (Tushman & Romanelli, 1985; Gersick, 1991; Romanelli &Tushman,1994). One major challenge managers face is determining the amount of resources to allocate to extremely low probability risk events.

Gray Swans have received considerable examination in the finance and economic literatures (Minsky, 1992; Vercelli, 2009; Stachkov, 2010; among others). In their study, Mazarr (2016) listed six reasons why firms overlook Gray Swans: (1) time and money; (2) warning overload; (3) decision fatigue; (4) institutional culture; (5) wishful thinking; and (6) motivated reasoning. Time and money are always a consideration in every decision. However, the cognitive biases, e.g. anchoring and adjustment, bandwagon effect and belief (see Carter et al., 2007 for a comprehensive list) of decision makers prevent them from fully appreciating the dangers of Gray Swans. Cognitive dissonance may explain why companies tend to be more reactive than proactive in the face of a Gray Swan (Mazarr, 2016). In the risk management literature, there is still no consensus on various aspects of risk and the risk management process. Although there is a large body of risk management literature (see Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005; Manuj & Mentzer, 2008; Wagner & Bode, 2009; among others), Gray Swans have not been addressed in the same manner as other types of risk, e.g. demand risk or inventory risk.

Only Akkermans & van Wassenhove (2013) have devoted any attention to Gray Swans. This dissertation extends these authors' earlier discussion and develops a scale to empirically measure the Gray Swan construct. Further, this research departs from Akkermans &Van Wassenhove (2108) most recent discussion of business tsunamis and offers a more extensive theoretical and methodological examination of Gray Swans.

In this study, I do not address "human-induced crises" (see Pearson & Mitroff,1993) or man-made disasters (see Turner & Pidgeon, 1997). I also do not address acts of terrorism in this study. Other scholars have addressed acts of terrorism and the human element in disruptions noting that some disruptions in the supply chain can be the result of intentional or unintentional acts by a person or group (Stecke & Kumar, 2009). This research focuses exclusively on explicating several dimensions of Gray Swans and seeks to provide a theoretical and empirical understanding of this phenomena. I focus on the risk of a disruption and its effects on firm resilience.

Grays Swans are conceivable risks that fail to produce adequate or effective responses (Mazarr, 2016). Gray Swans may be regarded as low probability risk, high negative impact (LP-HNI) events that when they occur can have severe or catastrophic impacts on a firm's operations. These types of risk may fail to provoke adequate or effective responses because there are no empirically acceptable measures – especially in operations management. Other disciplines have sought to measure and predict Gray Swans. In the Finance and Economic literatures, researchers have utilized various pricing models to predict the appearance of Gray Swans in the market (Filatov & Vanyarko, 2014). The Value at Risk (VaR) is one of the more common measures in

Finance used to predict financial Gray Swans (Satchkov, 2010). However, firms tend to miss predicting Gray Swans because the model used assumes stability over an extended period of time (Satchkov, 2010). The model used in this dissertation assumes that the effects of a Gray Swan (a) may be predicted by accounting for near misses and prior disruptions, and (b) may be affected by the type of buyer-supplier relationship – whether relational or contractual and the firm's risk management system (Marley, Ward & Hill, 2014).

This study makes four significant contributions to the risk management literature. First, it presents a scale for measuring Gray Swans. No such scale currently exists in the OM literature. Second, it provides a new empirical and methodological approach to understanding Gray Swans. Third, it increases our understanding of risks posed by Gray Swans and the need for companies to become more adept at engaging in boundary scanning and risk management activities to mitigate and manage these types of disruptions. Finally, this dissertation also provides practical insight for practitioners seeking ways to mitigate and manage Gray Swans in their supply chains to remain resilient.

1.1. Motivation

The motivation for this research comes from the supply chain disruption literature (see Hendricks & Singhal, 2005; Bradley, 2014) and risk management literature (see Chopra & Sodhi, 2004; Shefi & Rice, 2005) and the supply chain management literature (see Hendricks & Singhal, 2003; Rungtusanatham, Miller & Boyer, 2014) – where scholars have examined the probability of particular types of disruptions, and the likelihood of predicting and mitigating these types of disruptions. Gray Swans have an impact on companies' operations through their

relationships with their suppliers, their production processes, their employees, the top management team (TMT) and the environment in which they are operating (Christopher & Peck, 2004; Sheffi & Rice, 2005; Tang & Tomlin, 2008;Brusset & Teller, 2012; Lumineau & Henderson, 2012). Firms operate in the global interconnected economy where they obtain raw materials and sometimes engage in operations in emerging and developing economies. Managers must be especially vigilant to anticipate disruptions in the supply chain. An instance where managers were vigilant occurred when a fire at one of its manufacturing plants forced Philips, N.V to halt production of its microchips which affected the operations of two buying firms – Nokia and Ericsson. Nokia anticipated the Gray Swan and was able to obtain its components from other manufacturing plants whereas Ericsson was caught unawares. The result was that Ericsson lost significant market share whereas Nokia gained significant market share (Latour, 2001). In another instance, the ports strike on the U.S. West Coast in 2015 left container ships with valuable goods sitting off the shores of the ports of Los Angeles and Long Beach for more than a month (Gerrity, 2015). It is estimated that the strike reduced total economic output in the U.S. by one percent (Oyedele, 2015). While that may seem small in the grand scheme of things, it highlights the effects of a Gray Swan for which firms were neither prepared nor able to effectively respond to and recover from. These types of risks pose several challenges for those involved in assessing, mitigating and managing risk. This dissertation seeks to address these challenges by finding answers to the following questions:

RQ1. *What is a Gray Swan in the supply chain management context?*

RQ2. *How can we empirically quantify and measure a Gray Swan?*

RQ3. *How does the buyer-supplier relationship affect the relationship between Gray Swans and Firm Resilience or operational performance?*

RQ4. *How does the firm's risk management system affect the relationship between Gray Swans and operational performance?*

Supply chain disruptions can occur at any node of the supply chain network and failure to adequately assess and respond to the risk can result in significant economic shocks (Qi, Shen, & Snyder, 2010). While there is considerable research on disasters, particularly natural disasters, and their impact on a firm's supply chain, (Chopra & Sodhi, 2004; Altay & Green, 2006; Schmidt, 2015); there is scant research on man-made disruptions, specifically Gray Swans and their impact on companies' supply chains. Researchers in other fields (e.g. disaster management, crisis management) have addressed the issue of man-made disasters (see Turner, 1978; Pearson & Mitroff, 1989; Turner & Pidgeon, 1997). However, man-made disruptions, specifically Gray Swans, have remained an under-researched phenomenon. Given the complexity and the cost of Gray Swans, it is important, both for academics and practitioners, to gain a better understanding of this phenomenon. Some disruptive events have significant long-term effects. For example, the Tohoku earthquake and tsunami caused significant damage and disruption in Japan in 2011. Other events cast a long pall over the effective operation of supply chains. For example, the Soviet invasion of Crimea in 2014 resulted in severe supply chain disruptions (Krauskopf, 2014). These events demonstrate that supply chains are exposed to various natural and man-made risks and often succumb to volatility unless managers can adequately, anticipate, respond and recover from the volatile event (Ali et al. 2017). Discussions of risk in the OM and Supply Chain

literature focus on various kinds of risk, e.g. (exchange rate risk, political risk, supply risk, demand risk, among other types of risk). This dissertation adds Gray Swans to the list of risks that demand researchers' attention. Norman & Jansson (2004) noted that supply chain risk management is focused on increasing our understanding of the devastating ripple effects that disasters or other disruptions can have in a supply chain. Despite these concerns about risk, not much research has been devoted to understanding the financial or other impact of a financial crisis on a company's operations (Pearson & Mitroff, 1993). This dissertation addresses that gap in the literature.

There are significant differences between human-induced and natural disasters. The most obvious difference between the two types of disasters is that man-made disasters may be viewed as being somehow within a company's locus of control. A notable exception is the World Trade Center bombing which I regard as a Black Swan. Man-made disasters have the following characteristics: (1) Liability – the leadership of the organization suffering from the disruption is held responsible for the disaster; (2) Legal – there are legal ramifications for the disruption, e.g. lawsuits; (3) Legislative – there are regulatory ramifications, e.g. new industry regulations; (4) Liquidity – there are market ramifications, e.g. loss of market value because of the disruption; and (5) level of coordination required (Shrivastava et al., 1988; Pearson & Clair, 1998; Pidgeon & O'Leary, 2000). Natural disasters are or can be viewed as being outside the company's locus of control (Pearson & Mitroff, 1993). Natural disasters require significant coordination with government agencies and other affected businesses as well as significant communication and consensus. For example, Hurricane Katrina in the U.S. in 2005, and the Tohoku earthquake in

Japan in 2011 required significant government intervention. It has been advanced in the literature that the public generally reacts more negatively to the effects of human-induced crises than to natural disasters (Pearson & Mitroff, 1993). This is evidenced, for example, from the public's response to the Mattel supply chain crisis. The Consumer Product Safety Commission issued a recall of several of the company's toys that were produced in China. The company was accused of producing toys that were coated with lead paint (Story, 2007).

This study seeks to determine whether an integrated theoretical framework offers a more comprehensive explanation of Gray Swans. This research builds on and extends the supply chain disruption and risk management literatures (see Christopher & Peck, 2004; Hendricks & Singhal, 2005; Sheffi & Rice, 2005; Akkermans & van Wassenhove, 2013; Bradley, 2014) and investigates how companies assess the risks of Gray Swans and how they respond to and recover from these disruptions. Prior research in the supply chain management literature has not focused on these variables and their effects on firm resilience. The relationship between man-made supply chain disruptions and supplier quality, process management, top management teams, employee relations and firm operational performance is an under-research area. This research addresses a significant limitation that exists in knowledge of the Gray Swan phenomena. I conducted an extensive review of the literature to investigate the effects of risks in the supply chain. While, there is considerable research on the effects of various kinds of risk on firm or supply chain performance in the literature (Juttner, 2005; Narashimham & Talluri, 2009; Wagner & Bode, 2009; Brusset & Teller, 2017) among others, there is scant empirical research in the operations management literature on the effects of Gray Swans on firm resilience.

1.2. Statement of Research Problem and Theoretical Foundation

This dissertation investigates the effects of a Gray Swans on firm resilience. Firms suffer from the effects of a Gray Swan despite the fact that these risk events have occurred before. This research is interested in understanding "Why do managers underestimate and often unprepared for Gray Swans?" More importantly, what is a Gray Swan and how can we develop and norm a scale to measure this construct? Finally, the study is interested in understanding whether risk management strategies and the buyer-supplier relationship mediate the effects of a Gray Swan on firm resilience.

Several theoretical approaches, e.g. Transaction Cost Economics/Analysis (TCE/A), Agency Theory, Resource Dependence Theory (RDT) and Institutional Theory, have been utilized in the literature to explain various risk phenomena. An integrated theoretical perspective is applied to understand the Gray Swan phenomena. Contingency theory has been useful for explaining how firms seek to regain fit with their external environment (Donaldson, 2001). Punctuated Equilibrium Theory is concerned with how firms regain convergence after a "punctuation." i.e. a severe disruption in the ordinary processes of an organization (Tushman & Romanelli, 1985, Romanelli & Tushman, 1994). Integrating these two theoretical perspectives provides an overarching framework to answer the questions in my model. Whereas Agency Theory may address the buyer-supplier relationship and Institutional Theory may explain a firm's risk management strategy, Contingency Theory and Punctuated Equilibrium Theory provides a more comprehensive theoretical model to answer the foregoing research questions.

1.3. Significance of Research

This study is the first undertaking in the literature of measuring the Gray Swan construct and providing empirical evidence of its impact of the supply chain and firm resilience. This study builds and extends on the supply chain disruption literature (see Christopher & Peck, 2004; Tang, 2006; Stecke & Kumar, 2009; Bode et al., 2010; Golgeci & Panomarov, 2011) and investigates, specifically, how companies respond to Gray Swans and their effects on firm resilience. I depart from the general focus on man-made and natural disasters and instead focus on the relationship among Gray Swans, buyer-supplier relationship, firm risk management system, and firm resilience. Prior research in the supply chain management literature has focused on some aspect of these variables and firm performance. However, the relationship between Gray Swans and firm resilience has not been explored in any significant manner in the OM or risk management literatures. This dissertation contributes to the conversation by investigating the specific phenomenon.

1.3.1. Contribution to Research

This study contributes to the literature by providing a new theoretical lens through which to view the phenomena. I integrate two theoretical frameworks: Contingency Theory (Donaldson, 2001) and Punctuated Equilibrium (Tushman & Romanelli, 1985; Gersick, 1992; Romanelli & Tushman, 1994) to develop the research hypotheses. Hillman, Withers & Collins (2009) argued that combining theoretical frameworks can offer new insights into the relationship between an organization and its environment. This theoretical framework offers a new perspective on the Gray Swans risk in the supply chain. To the best of my knowledge, the Gray Swan construct has

not been operationalized in the operations management literature. Therefore, to address that gap, I developed and normed a scale for measuring Gray Swans. This investigation "pushes the envelope" to either build or confirm theory in operations management (Harking, Gattiker & Parente, 2006).

1.3.2. Contribution to Practice

This study also has practitioner implications regarding plant operations, plant location and outsourcing. Practitioners can use this research to develop better strategies to mitigate risk. Sourcing decisions require considerable investment. Purchases often compromise the largest expenditure for companies (Hallikas et al., 2011, p. 145). Disruptions in companies' operations can have a significant impact on a nation's economy. For example, the output of the German economy was affected by the negative consequences of German companies, e.g. Henkel, operating in Russia and in the Ukraine. "We expect the escalation of the Russian-Ukrainian conflict as well as the persisting political turmoil in the Middle East to have a negative impact on the market environment", stated Henkel CEO, Kasper Korsted (Webb, 2014). Companies that are more aware of the existence of Gray Swans can take steps to eliminate or mitigate the effects of these events on their operations. Practitioners may also use my model to determine which type of the Buyer-Supplier Relationship (BSR) and the kind of Risk Management System (RMSYS) ensures continuity of operations in the event of a Gray Swan.

1.4. Structure of Dissertation

The rest of this dissertation is outlined as follows: Chapter II contains the literature review; Chapter III contains the theory and hypothesis development; Chapter IV contains the research design and methodology; Chapter V contains the analysis and results; and Chapter VI contains the discussion and conclusion.

CHAPTER II

LITERATURE REVIEW

2.0.Introduction

This chapter provides an expansive review of the constructs in the research model. I begin with an overview of supply chain disruptions providing a discussion on the various types of disruptions, e.g. natural and man-made disasters and their effects on the supply chain. I draw a distinction in this dissertation between man-made disasters and man-made disruptions because their events do not have the same loci, nor do they have the same effects on the supply chain. Although the focus of this dissertation is on the effects of Gray Swans on firm resilience, I included a brief discussion of the Black Swan construct because these risk events share similar characteristics. Finally, I provide a detailed discussion of the constructs in my model – Gray Swans, Buyer-Supplier Relationship, Risk Management System, and Firm Resilience. This is not an exhaustive list of Gray Swans. Future research may identify other Gray Swans. The Gray Swans identified in this dissertation appear to be the most frequently occurring types of low probability risk which have extreme impact. These risks have occurred before. Therefore, it seems puzzling that managers would be unprepared to track and mitigate them. This chapter concludes with a summary of the interplay among these constructs and the impact on firm resilience.

2.1 Gray Swans

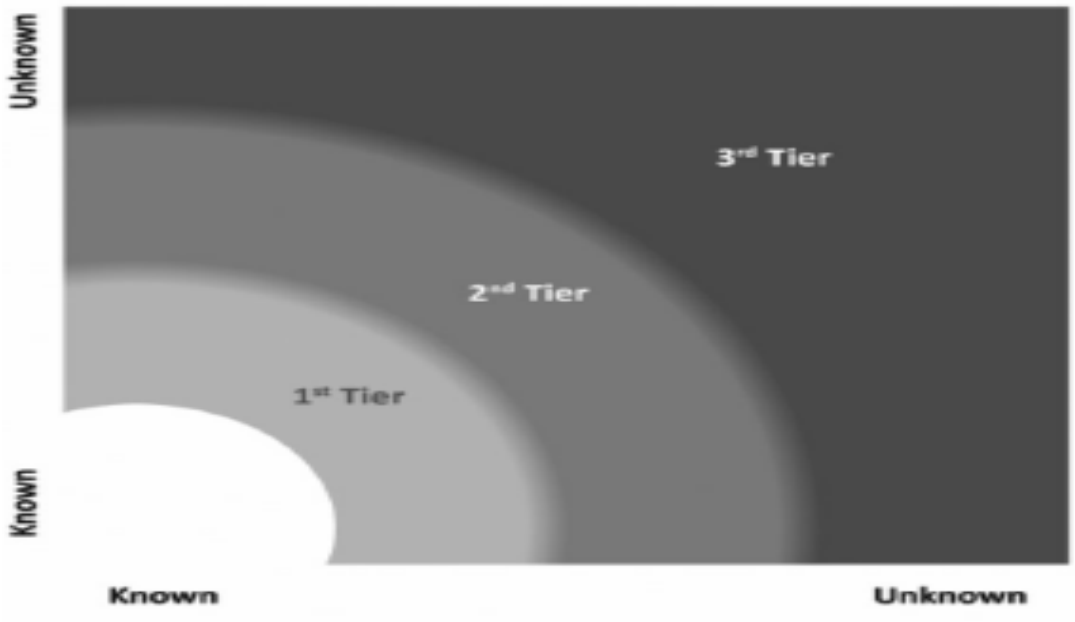
Gray Swans may be regarded as "known unknowns" i.e. we know that these types of risk exist, but we do not know the level of impact when they occur (Taleb, 2007). Figure 1 below presents

a description of Gray Swans. These risk events can escalate from the "known" i.e. White Swans to the "unknown" Black Swans in the third tier. The focus of this dissertation is on those in the first and second tiers – the gray Swans (Adams et al., 2017). These are low probability events whose impact can be devastatingly high, but which can be predicted based on history and other conditional factors. Mazarr (2016, p. 90) define a Gray Swan as "an unlikely but fully conceivable risk that lies well within the bounds of experience and has been openly discussed but becomes discounted and fails to generate mitigating actions." Gray Swans have the following characteristics: (1) These risk events are human induced, i.e. they have a human locus. There is some action either endogenous or exogenous to the supply chain that results in a chain of events leading to a disruption. (2) These events have a history, i.e. they have occurred before. Unlike black swans which happen without warning and have not occurred before, Gray Swans have occurred before. However, the relative low frequency of occurrence lulls managers into aspects of Managerial Myopia. (3) Low probability of occurrence. I assume that the probability of a Gray Swan falls between 0 – 0.05 – all else being equal. I use the statistical significance level of 0.05 based on industry guidance from the Food and Drug Administration's (FDA's) for conducting clinical trials.[1] However, whereas the FDA is concerned with the safety and effectiveness of a drug, I am concerned with the safety of the supply chain i.e. the potential for disruption and the effectiveness of a response i.e. minimizing the economic and social costs of a disruption. (4) I believe that Gray Swans can be endogenous or exogenous to the supply chain.

[1] Guidance for Industry – Providing Clinical Evidence of Effectiveness for Human Drug and Biologic Products. The FDA assumes that the likelihood of a false positive for a clinical trial is .025 and argues for independent verification of single studies' test results.

(5) Finally, Gray Swans, or the effects of a Gray Swan are extremely costly. For example, GM suffered tremendous losses in production when one of its principal suppliers, Cutter Clark McDermott filed bankruptcy in 2016. Additionally, the ports strike on the U.S. West Coast in 2015 reduced economic output by approximately one percent. That is approximately $1.5 trillion.

Figure 1 – Shades of Gray Swans



Adapted from Adams, Smart & Huff (2017)

A Gray Swan may also be regarded as a "Minsky moment[2]." A "Minsky moment" is a situation characterized by severe financial instability that occurs in a complex financial system

[2] Hyman P. Minsky (1992) developed the Financial Instability Hypothesis (FIH) which served as a model for understanding how exogenous shocks can disrupt complex and sophisticated financial systems. These shocks often lead to financial crises.

(Minsky, 1992). The instability created by Gray Swans may be similar to the instability created by a financial crisis (Vercelli, 2009). Supply chains are integrated networks that may suffer from contagion when one party either in a dyadic or multi-echelon relationship is affected by a labor dispute, supplier insolvency or affected by political instability. Scholars have applied various theoretical approaches to understanding risk phenomena. Hillman et al. (2009) argue that combining Resource Dependence Theory (RDT) with other theoretical frameworks such as Stakeholder Theory, Population Ecology and Institutional Theory among others can offer new insights into the relationship between an organization and its environment. In this study, I utilize an integrated theoretical framework: Contingency Theory (Donaldson, 2001) and Punctuated Equilibrium Theory (Tushman & Romanelli, 1985; Gersick, 1992; Romanelli & Tushman, 1994) to develop my hypotheses. I believe this integrated approach offers a more coherent examination of the firm's strategic decision-making processes and how managers respond to environmental contingencies. Population Ecology assumes that firms can easily adapt to changes in their environment and the organizational structure is affected by changes in the environment. However, inertial pressures prevent the organization from effectively responding to changes in the environment. This argument is advanced by Meyer & Rowan (1977) in their seminal study on organizations. Institutional theory asserts that firms strive to maintain legitimacy through their formal structures which are shaped by isomorphic forces (Meyer & Rowan, 1977). Stakeholder Theory is more concerned with the relationship between the firm and its key groups such as customers, suppliers, employees etc. (Freeman & Philips, 2002). The focus of this dissertation is how organizations regain fit with their task environment after a disruption. In the literature,

Institutional Theory is often used to explain organizational internal fit under "normal" operating conditions whereas contingency theory and punctuated equilibrium focus on organizations responding to changes in their operating environments. While Social Exchange Theory (SET) may explain the relationship between the organizations and its suppliers and Institutional Theory or Population Ecology may explain the inertial or isomorphic pressures that affect the organization, Contingency Theory coupled with Punctuated Equilibrium better explain the internal and external responses to a Gray Swan.

Prior Supply Chain Management (SCM) studies have focused on some aspect of disruption and firm performance – whether firm stock price, firm financial performance or operational effectiveness and efficiency (Hendricks & Singhal, 2003; Hendricks & Singhal, 20035a, 2005b). However, the effect of Gray Swans on various aspects of firm performance whether operational or financial is an under-research area. I bridge that gap in this dissertation by closely examining the Gray Swan phenomenon and providing a methodological and empirical approach to better aid in our understanding of Gray Swans. In my research, I found that there are certain strategies in which a firm can engage to mitigate and manage a Gray Swan. Latour (2002) noted that firms can engage in activities such as developing an in-house team to oversee the supply chain or hiring a Chief Supply Chain Officer to oversee operations. Firms may also hire a Chief Supply Chain Officer (CSCO) to oversee all supply chain operations. Further, firms can develop a risk management system and a more effective relational buyer-supplier relationship to mitigate the effects of a Gray Swan (Carr & Pearson, 1999). But why does it appear that Gray Swans tend to be such a surprisingly disruptive events for firms? I believe the following

conditions may act as antecedents and are likely to reduce the effectiveness of a firm's response to a Gray Swan: (1) Hubris; (2) Institutional Inertia; (3) Managerial Myopia; and (4) Organizational Culture. The thinking that "If it ain't (sic) broke, don't break it" seems to consume managers generally (Hannan & Freeman, 1977). The assumption that "it can't happen here" (sic) produces a level of hubris that generally leads to nemesis.[3] The structure of an organization determines its ability to function effectively in its operating environment (Chandler, 1962; Thompson, 1967; Hannan & Freeman, 1984; Stinchcome, 1965; Woodward, 1965). Managers often fail to recognize the dynamic nature of the operating environment and often fail to make the necessary changes in policies and procedures. When there is a disruption in the environment, firms with a mechanistic structure tend to fail to make the necessary adjustments and can die (Hannan & Freeman, 1977). Managerial Myopia complements institutional inertia such that managers have tunnel vision. Myopic managers tend to avoid engaging in any boundary spanning. They focus on the internal environment often ignoring the complexities of the external environment. These conditions either singly or collectively can spell disaster for a firm in the event of a Gray Swan. Finally, organizational culture may be viewed as an antecedent and determinant of the decision-making process vis-à-vis risk in the supply chain. Organizational culture may also shape managers' perception of risk. The norms and beliefs of an organization dictate the behaviors of its members (Mitroff et al., 1989).

[3] In Greek mythology Hubris and Nemesis represent two ends of a spectrum of behavior. People who engage in hubristic behaviors tends to be overconfident bordering on arrogance. Nemesis was the goddess who exacted retribution on those individuals who succumbed to hubris (Retrieved from https://en.wikipedia.org/wiki/Nemesis).

Burns & Stalker (1961) wondered why companies that saw a looming disruption often failed to move to a more organic structure from current mechanistic structure. The authors determined that the organizational culture was in a factor in the shaping how quickly that change occurred. Further, Burns & Stalker (1961) noted that, there may be latent factors, such as individuals' status within the organization, and the political system, i.e. management structure of the organization, which my inhibit change. In short, there may be some entity within the organization that may want to maintain the status quo. Burns & Stalker's (1961, p.143) discussion of the "latent and manifest organization (i.e. senior management) concern" may be a precursor to the discussion of concerned entities within the organization determining its fate. Cyert & March (1963) and note that the "Dominant Coalition" i.e. "TMT" in an organization may view its potential problems through their social, economic and educations perspectives (Hambrick & Mason, 1987; Thompson, 1967). So, while organizations may be able to predict disruptive events, institutional factors such as their structure, policies and procedures may limit their ability to respond effectively to these potential disruptions. This has the effect of turning a 'molehill into a mountain'; i.e. seemingly small problems can become more intractable because of institutional inertia (Keown-McMullan, 1997).

2.2. Overview of Black Swans

The idea of a Black swan as an improbable event has its origin in myth and history. Nassim Taleb in his 2007 book, "*The Black Swan: The Impact of the HIGHLY IMPROBABLE*," used the bird to define highly improbable but devastatingly disruptive events. A Black swan has three attributes: (1) It is an outlier, i.e. rarity; (2) it has an extreme impact; and (3) human nature

makes us concoct explanations for its occurrence after the fact, making it explainable and predictable, i.e. retrospective (though not prospective) predictability Taleb (2007, p. xxii). The 2008-2009 financial crisis and the terrorist attack on the World Trade Center in 2001 are examples of Black swans that academicians, politicians and others sought to explain after the fact and argue these events were predictable (Hajikazemi et al., 2016). Firms tend to ignore the somewhat improbable but predictable events in the pursuit of black swans. Wucker (2018) noted that in attempting to identify, assess and mitigate risk, organizations tend to ignore the "gray rhino" and scramble to understand "black swans." I argue that Wucker's (2018), designation of a "gray rhino" type risk is similar to Gray Swan type risk. Application of the "gray" to rhino highlights the rarity of the risk firms are likely to encounter.

2.3. Supply Chain Disruptions

Supply chain disruptions have been characterized by different terms in the literature: such as "incident", "accident", "glitch", "failure", "hazard", "crisis" or "disturbance" (Wagner & Bode, 2009). Whatever the label, a supply chain disruption represents a change in the status quo. These unplanned and unanticipated events interrupt the normal flow of goods and materials (Craighead et al., 2007). A supply chain may be regarded as a loosely coupled system in which independent firms act interdependently by sharing resources and information to ensure the efficient operation of the supply chain (Liu et al., 2012). How well a firm responds to a disruption of its operations is a function of its supply chain resiliency (Chopra & Sodhi, 2004). The authors note that supply chain risks can become full-fledge problems which may result in delays or disruptions. In the literature, supply chain resiliency has been defined as "the ability to maintain control over

performance varaibility while being adaptive and capable of sustained response to sudden and significant shifts in the environment" (Hohenstein et al., 2014, p. 96). Resilient firms are better able to mitigate their vulnerability to supply chain disruptions and respond more effectively and efficiently to supply chain disruptions when they occur (Ambulkar et al., 2015). The resilient firm continues its operations despite the disruption (Ambulkar et al., 2015). A taxonomy (see Pearson & Mitroff, 1993, Pearson & Clair, 1998, Shaluf 2003; 2007) of the various kinds of disasters, disruptions and crises is presented in Table 1 below.

Table 1 –
Taxonomy of Supply Chain Disruptions

Types of Disasters or Disruptions	Examples of Disasters or Disruptions
Natural Shaluf (2007)	Volcanoes Hurricanes (Katrina, 2005) Floods (Thailand, 2011) Tsunamis Earthquakes (Fukashima, 2012) Typhoons Snowstorms Blizzards
Human-Induced Pearson & Mitroff (1993) Pearson & Clair (1998) Shaluf (2003)	Response to Hurricane Katrina (2005) Refugee Crisis
Intentional (Stecke & Kumar (2009)	Sabotage (Tylenol, 1984) Terrorist Attacks
Non-terrorist Intentional Stecke & Kumar (2009)	1.Political Instability, e.g. Coups; Insurrections; etc. 2. Labor Disputes e.g. Strikes; Job Actions, etc. 3. Supplier Insolvency, e.g. Supplier bankruptcy. 4. Supply Chain Visibility; supplier non-compliance with fair employment practices; no child labor or slavery
Unintentional (Accidents) Stecke & Kumar (2009)	Three-Mile Island; Chernobyl; Union Carbide, Bhopal, Exxon Valdez
Fires Latour (2001)	Philips, N.V. (2001)

Despite their effect on supply chains, man-made supply chain disruptions have not received greater empirically examination in the operations management literature. A review of the literature found only one article, Munim et al (2014) with the phrase "man-made" in the title. Much of the discussion in the OM literature focuses on man-made disasters, which is not the subject of this dissertation (Pearson & Mitroff, 1993; Turner & Pidgeon, 1997; Pearson & Clair, 1998). I make a distinction between these types of events in the next section. In this dissertation, labor disputes, political instability and supplier insolvency are viewed as types of man-made supply chain disruptions. Man-made supply chain disruptions are defined as "any human-induced, derived or inspired event within a company's locus of control or within the supply chain that negatively impacts the structural integrity of the supply network and significantly reduces a firm's ability to operate efficiently" (Lynch & Kaynak, 2017). Disruptions with these attributes are characterized as Gray Swans. Table 2 below list various kinds of disruptions.

Table 2 –
Major Types of Disruptions

Author/s	Year	Type of Disruption	Article Objective
Chaing et al.	2013		The objective of this study is to investigate two potentially key drivers of a firm's supply chain agility, namely strategic sourcing and firm's strategic flexibility.
Loh and Thai	2014	Managing Port-Related Supply Chain Disruptions: A Conceptual Paper	The main objective of this research is therefore to identify the actions which the port should initiate to minimize port-related supply chain disruptions.
Weber et al.	2015	Organizational Disruptions and Triggers for Divergent Sensemaking	This article examines an incident that occurred at the Midwest District (MWD) headquarters of the United States Coast Guard (USCG).

Ivanov et al.	2015	Supply Chain Design with Disruption Considerations: Review of Research Streams on the Ripple Effect in the Supply Chain	This study aims at analyzing recent research on supply chain design with disruption considerations in terms of the ripple effect in the supply chain.
Skipper and Hanna	2009	Minimizing supply chain disruption risk through enhanced flexibility	The purpose of this paper is to examine the use of a strategic approach (contingency planning) to minimize risk exposure to a supply chain disruption. Specifically, the relationship between several attributes of a contingency planning process and flexibility are examined.
Blome et al.	2013	The Impact of Knowledge Transfer and Complexity on Supply Chain Flexibility: A Knowledge-Based View	The objective of this paper to investigate supply chain flexibility as a means to respond to the increasing global complexity in today's environment.
Braunscheidel and Suresh	2009	The organizational antecedents of a firm's supply chain agility for risk mitigation and response	This research investigates the impact of two cultural antecedents, market orientation and learning orientation, and three organizational practices, all aimed at augmenting the supply chain agility of a firm.
Swafford, et al.	2006	The antecedents of supply chain agility of a firm: Scale development and model testing	This study first presents a framework of an organization's supply chain process flexibilities as an important antecedent of its supply chain agility, and then establishes the key factors that determine the flexibility attributes of the three critical processes of the supply chain—procurement/sourcing, manufacturing, and distribution/logistics.

2.3.1 Distinguishing Between Man-Made Disasters and Man-Made Disruptions

The phrase "man-made disaster" has been used in numerous studies in the supply chain management literature (See Hendricks & Singhal, 2003; 2005a; 2005b; Craighead et al., 2007; Wagner & Bode, 2009). A man-made disaster has been defined as an unusual event, including an event caused by failure of technological systems, which temporarily overwhelms the response capacity of human communities, groups of individuals or natural environments and which causes massive damage, economic loss, disruption, injury, and/or loss of life (Shaluf, 2007, c.f. Parker, 1992). This definition encompasses medical accidents and disasters such as those which affect

people such as whooping cough vaccine, Opren and HIV/AIDS haemophiliac cases (Shaluf, 2007). A table presenting the various definitions of disaster, disruption and crisis is presented in Table 3 below:

Table 3 –
Defining Disaster, Disruption and Crisis

Disaster (Natural)	A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.[4]	United Nations International Strategy for Disaster Reduction (UNISDR); Sendai Framework, (2015).
Disaster (Man-Made)	A man-made disaster is a significant disruption of collapse of the existing cultural beliefs and norms about hazards and for dealing with them and their impacts.	Turner (1978); Pidgeon and O'Leary (2000); Turner and Pidgeon (1997)
Disruption (Man-made)	Any human-induced, derived or inspired event within a company's locus of control or along the supply chain that negatively impacts the structural integrity of the supply network and significantly reduces a firm's ability to operate efficiently and effectively.	Lynch and Kaynak (2017)
Organizational Crisis	An organizational crisis is a low-probability, high-impact event that threatens the viability of the organization and is characterized by ambiguity of cause, effect, and means of resolution, as well as by a belief that decisions must be made swiftly	Pearson and Clair (1998)

[4] Retrieved from https://www.unisdr.org/we/inform/terminology

One critical distinction between man-made disasters and disruptions is that disasters can result in the loss of human life (Shaluf et al., 2003). Man-made disasters are chance events. They are the interaction of complex human organizational structures and socio-technical systems used to manage risk (Pidgeon & O'Leary, 2000). In their study, Shaluf (2007) distinguished among three types of disasters: (1) natural; (2) man-made; and (3) hybrid. While disruptions at their most extreme may result in the loss of a human life or lives, all disruptions have some negative effect on firm operations. Another distinction between a man-made disaster and a disruption is that someone of/in authority must declare an event a disaster if it meets criteria outlined by the United Nations or some governmental authority. The United Nations[5] defines a *disaster* as - - "*a situation or event, which overwhelms local capacity, necessitating a request to the national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering."* The following events qualify as a natural disaster: (1) floods; (2) natural disasters of geological origin, (volcanic eruptions, earthquakes and landslides); (3) natural disasters of climatic or meteorological origin, (droughts, cold waves, heat waves, avalanches, wave surges including tsunamis and tidal waves, and windstorms including cyclones, hurricanes, storms, tornadoes, tropical storms, typhoons and winter storms); (4) wildfires, both forest and scrub; (5) insect infestations; and (6) epidemics of cholera, diarrhea, meningitis, dengue fever and malaria. While this definition is comprehensive in scope, I believe the following definition by Pidgeon & O'Leary addresses the human element in these

[5] Retrieved from http://unstats.un.org/unsD/ENVIRONMENT/envpdf/UNSD_UNEP_ECA%20Workshop/Session%2004-7%20Natural%20disasters%20(UNSD).pdf

types of disasters. They define a disaster as "a significant disruption or collapse of the existing cultural beliefs and norms about hazards, and for dealing with them and their impact" (Pidgeon & O'Leary, 2000, p. 16). Our view of the world shapes how we respond to disasters. For example, because many hurricanes weakened before reaching New Orleans, it can be argued that the general perception of those in authority and the average residents of New Orleans seemed to believe that nothing like Katrina was going to happen there (Thomas, 2005). When it did, they were completely ill-prepared for the disaster which metastasized into a crisis (Thomas, 2005).

A man-made disaster occurs because of the interaction or combination of several critical factors: human, organizational, and technical (i.e. HOT) factors; and regulatory, infrastructure and preparedness (i.e. RIP) factors (Shaluf, 2003). Man-made disasters may be viewed as human-induced catastrophic events (Shaluf, 2007). The following disasters are discussed in the literature as man-made disasters: e.g. Bhopal, Exxon Valdez, Chernobyl. While a man-made disaster may create a disruption in the supply chain, man-made disruptions generally do not rise to the level of disaster or crisis – unless completely unmanaged by the firms experiencing the events. It is argued in this dissertation that man-made disruptions, i.e. Gray Swans is the combination of HOT factors. Further, it is argued here that RIP factors are environmental contingencies that influence the magnitude of the impact of a man-made disruption.

In this dissertation, I also draw a distinction drawn between disasters and crises. A disaster which involves the collapse of the existing cultural beliefs and norms about hazards (see Pidgeon & O'Leary, 2000) is not a "crisis" in the traditional meaning of the word (Shaluf et al. 2003). However, like a disaster, a disruption requires management procedures to ensure the

effective resolution of the disruptive event (Shaluf et al., 2003). Crises may derive from disasters. Shaluf (2007) noted that a crisis is a man-made event. However, crises may also result from political and economic issues. Crises are viewed as having a human locus while disasters can be natural or man-made. Other scholars have viewed crisis differently. Koewn-McMullan (1997) regarded a crisis as highly probable but unstable condition which has the potential for a significantly negative outcome or a highly desirable positive outcome. Shaluf (2007) viewed a crisis as an abnormal situation which poses extra-ordinary high risk to a business. Pearson & Clair (1998, p. 60) defined an organizational crisis as "a low probability, high-impact event that threatens the viability of an organization." In this dissertation, I adapted a similar position for a Gray Swan. Gray Swans have crisis-like implications but are as disruptive or more disruptive than disasters.

In their study, Mitroff and colleagues noted that failure to acknowledge or effectively manage several factors related to organizational behavior, organizational structure and corporate culture may make some organizations more crisis prone and others more prepared for a catastrophic event (Mitroff et al., 1989). In this dissertation, I assert that these factors may also prevent an organization from spotting a Gray Swan. Gray Swans, as defined and discussed in this dissertation have a history. A company that has experienced a disruption in the past is well aware of the likelihood of another disruption somewhere in the supply chain. This assumes some level of organizational learning. It is assumed in the literature that organizations learn from past events. Fiol & Lyles (1985) note that there is the implication that firms have the potential to learn, unlearn or relearn based on past behaviors. For example, GM is experiencing its first strike

in more than a decade (Foldy, 2019) which begs the question, "What has GM learned over the years?" Mitroff et al. (1989) noted that organizations commit several fallacies about their capacity and the operating environment. For example, organizations sometimes commit the *fallacy of unpredict*ability – wrongly assuming that because events are unpredictable, it is not possible to prepare for them (Mitroff et al., 1989). They also commit the fallacy of size – wrongly assuming that their size can shield them from disruptions in the supply chain Mitroff et al., 1989). Ericsson wrongly assumed that a small fire at one of its suppliers' plants would not have an effect on its operations because it was a market leader. The company lost a significant portion of its market to its competitor Nokia which was prepared for such an event. Another fallacy committed by organizations is the *fallacy of location or geography*. Organizations sometimes fall into the myth of believing that bad things only happen somewhere else and does not affect the organization in its home country (Mitroff et al. 1989). Nike was affected when it was discovered that its merchandise was being produced in "sweatshops". Apple lost market share and was deluge by consumer complaints when it was discovered that employees at one its suppliers – Foxconn – were committing suicides at an alarmingly high rate because if working conditions (Merchant, 2017).

2.4. Supply Chain Risk Management (SCRM)

The extant literature is replete with studies on various aspects of risk in the supply chain. Chopra & Sodhi, (2004) – present a high level categorization of supply chain risks and their drivers with recommendations to improve risk preparedness. Kleindorfer & Saad, (2005) – developed a conceptual framework for managing supply chain disruption risk that includes the tasks of

specification, assessment, and mitigation (See Manuj & Mentzer, 2008; Pujawan & Geraldin, 2009; Simchi-Levi, Schmidt, & Wei, 2014 Tummala & Schoenherr, 2011; Wagner & Bode, 2009; Wagner & Neshat, 2010; among others for a further discussion on risk). Some scholars view risk as a multidimensional construct. For example, Jüttner et al. (2003) noted that risk may "refer to uncertain internal or external environment that reduces outcome predictability" or it may "refer to the consequences of risk" (Jüttner et al., 2003, pp.199-200). Given the multidimensionality of the construct, decision-making under uncertainty or risk-taking link the firm's corporate strategy to its operational performance (Jüttner et al., 2003). Confusion about risk may inhibit firms' ability to respond to Gray Swans. The risk of disruption is such a prominent fixture in supply chain management as well as management in general that some firms have created the position of Chief Risk Officer (Lee & Shimpi, 2005). Some firms are even creating the position of Chief Supply Chain Officer (CSCO) (Roh et al. 2016).

All firms are exposed to risk. Conversely, all firms can their vulnerability to risk by engaging in some form of boundary spanning and being observant to information flows in their supply chains. Supply chain vulnerability may be defined as the exposure to a serious disturbance that has the propensity to outweigh risk mitigating strategies (Wagner & Neshat, 2010). Risk may also be viewed in the context of performance. For example, Singh et al. (2009) note that "risk based on firm performance is the distribution of possible outcomes in a firm's performance over a given time horizon due to changes in key underlying variables. The greater the dispersion of possible outcomes, the higher the firm's level of exposure to uncertain returns." The returns can have either positive or negative consequences. The organization's sensitivity to

risk is a funtion of : (1) the significance of its exposures to changes and events, e.g. abrupt loss of a major supplier; (2) the likelihood of those different changes and events occurring; and (3) its ability to manage the business implications of those different possible future changes and events, if they occur" (Singh et al., 2009).

2.5. Buyer-Supplier Relationship (BSR)

Supply chain relationships are generally characterized by dependency, with a focus on structural interdependence and asymmetric information (Zhang & Huo, 2013). In a dyadic relationship, buyers may be dependent on suppliers and vice versa if there are several suppliers in the market. It may be assumed given the relational ties that the threat of a Gray Swan would be less disruptive when there are strong ties between buyer and seller. Most studies generally classify the buyer-supplier relationships are either contractual or relational (Bastl et al., 2012; Grotsch et al., 2012). Relational types of governance are based on ideas of partnership and collaboration. Transactional types of governance are based on formal legal contracts (Grotsch et al., 2012). Buyers and suppliers in relationships with high levels of relational exchange are characterized by joint problem solving, interdependence, and high levels of commitment (Bastl et al. 2012). These authors examine the buyer-supplier relationship along five dimensions: (1) information exchange, i.e. sharing information that might be useful to both parties; (2) operational linkages, i.e. the degree to which systems and procedures are routinized between parties' operations; (3) legal bonds, i.e. legally binding contracts; (4) cooperative norms; and (5) buyer-supplier adaptations, i.e. assuming specific process, product or procedures of an exchange partner. It is assumed that buyers and suppliers in a cooperative relationship communicate more

frequently and act to reduce information asymmetries (Bastl et al., 2012). However, the literature is inconclusive on whether buyer and suppliers in a cooperative relationship actually communicate more.

Buyer and suppliers experiment with various kinds of contracts. Bai et al. (2016) discuss two types of contracts: Output-based and behavior-based contracts. There are control and coordination dimensions as well as prevention and promotion dimensions of contracts (Bai et al., 2016, p.13). Output-based contracts specify the performance standards suppliers must meet (Bai et al. 2016). These types of contracts focus on the following characteristics: (1) performance outcomes – by prescribing specific goals for the suppliers; (2) align the preferences and goals of the buyer and seller; and (3) reduces ambiguities and misunderstandings of each party's role in the relationship (Bai et al., 2016). A lack of trust results in higher transaction costs as well as higher agency costs (Kwon & Suh, 2004, p. 5). Information sharing is one of the most critical aspects of trust in a buyer-supplier relationship (Kwon & Suh, 2004). People in high trust relationships are not afraid to share important information and are more inclined to take risks (Kwon & Suh, 2004, p. 5). The relational view suggests that firms make specific investments to improve exchange relationships (Zhou et al., 2014). This view asserts the strength of weak ties. Granovetter (1973, p. 1361) noted that the strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie. In the supply chain context, the types investments made by a buyer in its supplier whether through knowledge transfers, or other types of investments are critical to maintain the flow of goods and services.

2.6. Organizational/Firm Resilience (RES)

Organizational resilience refers to an entity's ability to respond to and recover from unexpected disruptions in the external environment so that it emerges more strengthened and resourceful (Bui et al., 2019; Brueller et al., 2019; Schriber et al., 2019). "Resilience is something you realize you have *after* the fact" (Coutu, 2002). Resilient people, they posit, possess three characteristics: (1) a staunch acceptance of reality; (2) a deep belief, often buttressed by strongly held values, that life is meaningful; and (3) an uncanny ability to improvise. An individual can bounce back from hardship with just one or two of these qualities but will only be truly resilient he/she possess all three characteristics. I assert that these three characteristics also apply to resilient organizations as well (Coutu, 2002). Companies respond effectively and efficiently to different types of uncertainties and demands differently based on their organizational capabilities (Fayezi, Zutshi & O'Loughlin, 2017). While all companies face risks -whether, operational, demand, or process risk- some companies respond better and prove to be more resilient than their competitors at recovering from a risk event. This situation prompts the question raised by van de Vegt and colleagues in an editorial "Why do some organizations and societies successfully adjust and thrive amid adversity while others fail to do so?" (van der Vegt et al., 2015, p. 971). I follow van der Vegt's logic, I focus on organizations and not societies, in this dissertation. However, I am cognizant that organizations function within a societal structure. Therefore, consistent with contingency theory, there is likely to be some environmental effect on the organization. Further, I assume there may be some societal characteristics that lend themselves to the sustainability of organizations. Some organizations may survive and thrive amid adversity because of their

adaptive capacity. Van der Vegt et al (2015) suggested that adaptive capacity might be construed as the time it takes for a system to recover adverse events. A firm's adaptive capacity ensures its resiliency. The robustness of a firm's supply chain can reduce its exposure to disruptions and increase its time to recovery (van der Vegt et al. 2015). I theorize that the following factors determine firm's adaptive capacity: (1) The absorptive capacity of a society. There is evidence that the absorptive capacity of the United States would permit companies to recover from adverse risk events sooner than some other emerging, undeveloped or underdeveloped economies. (2) The organizational structure – the adaptive capacity of an organization is imbued with the skills and ability of it managers (McGuire & Silvia, 2010); (3) The operational strategy; and (4) The structure of the top management team (TMT) – the education, gender and tenure of the TMT determines its adaptive capacity (Van der Vegt et al. 2015). A firm's absorptive capacity may help it to regain fit with its task environment sooner than a firm with less absorptive capacity.

Firms seek to return to normal, i.e. some optimal level of operating following a disruption (Zsidisin & Wagner, 2010, c.f. Sheffi & Rice 2005). The ability to return to normalcy is a measure of the firm's resilience and can be achieved through flexibility or redundancy (Zsidisin & Wagner, 2010; Christopher & Peck, 2004; Sheffi and Rice, 2005). Supply chain flexibility has been defined as "*an operational ability that assists organizations to change efficiently internally and /or across their key partners in response to internal and external uncertainties via effective integration of supply chain relationships"* (Fayezi et al. 2017, p. 398). The same authors also define agility which can be viewed in the context of resiliency as *"a strategic ability that assists*

organizations to rapidly sense and respond to internal and external uncertainties via effective integration of supply chain relationships" (Fayezi et al., 2017, p. 396). The authors do not indicate "how" organizations acquire this ability or why agility should be considered an ability. Carmeli et al. (2016) suggested that firms may acquire agility through inter-organizational learning which is determined by the kind of relationship – transactional or commitment – that exists between buyer and seller in a supply chain. It is expected and understandable if organizations face external uncertainties.

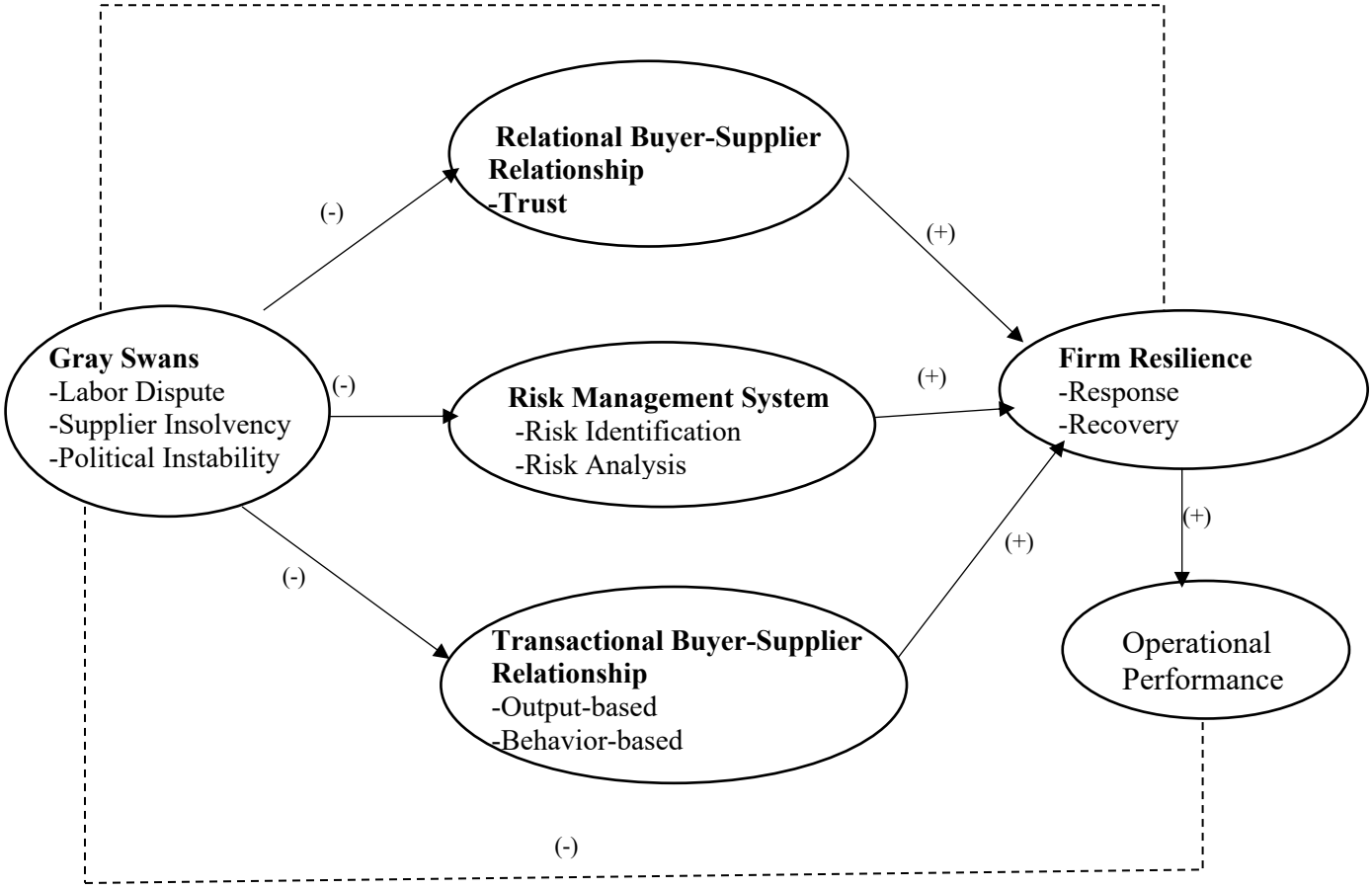
2.7. The Research Model

The research model presented below (see Figure 2) highlights the relationship among several variables: (1) Gray Swans; (2) relational buyer-supplier relationship; (3) transactional buyer-supplier relationship; (4) risk management system; and (5) firm resilience. I identify three categories of risk, which are characterized as Gray Swans: supplier insolvency; labor disputes and political instability that are examined in the context of a disruption risk (Hill et al., 2009). I hypothesize that the occurrence of a Gray Swan has a negative effect on the buyer-supplier relationship and on the firm's risk management system. I further hypothesize that the buyer supplier relationship and a firm's risk management system mediate the effect of a Gray Swan on firm resilience. Finally, I assert that the occurrence of a Gray Swan negatively impacts or tests a firm's resilience.

Managers' behaviors may be shaped by their perceptions of risk. It seems plausible that managers' perception of a Gray Swan may be an antecedent to the relationship between Gray Swans and Firm Resilience. The ability to spot a Gray Swan or any other risk may be shaped by

managers' risk perception. I do not test for this relationship, i.e. managers' risk perception, in the current model. However, it seems likely that managers' perception (MGRPCP) of a Gray Swan may influence how they prepare for risk events and shape their Risk Management Systems. A manager's risk profile could be used as a proxy to obtain a measure of managers' risk perception. Managers' risk perception will have some effect on the relation between Gray Swans and Firm Resilience. Managers' Risk Perception will also have an influence on the firms' Risk Management system. Therefore, I believe there is a relationship between managers' risk perception and a firm's Risk Management System (RMSYS). This relationship could be the subject of future research.

Figure 2 –
Proposed Research Model



CHAPTER III

THEORY AND HYPOTHESIS DEVELOPMENT

3.0. Theory

Scholars have applied various theoretical approaches, e.g. Transaction Cost Economics (TCE), Institutional Theory or Agency Theory to understand the risk phenomena in Supply Chain Management (SCM). I integrate two theoretical frameworks: contingency theory (Burns & Stalker, 1961, Thompson, 1967, Donaldson, 2001) and punctuated equilibrium (Tushman & Romanelli, 1985, Gersick, 1992, Romanelli & Tushman, 1994) to develop my research hypotheses. I examine the "*punctuated contingent*" effects of Grays Swans on firm resilience. Disruptions "punctuate" a firm's equilibrium, i.e. disrupts a firm's normal steady state operations (Tushman & Romanelli, 1985). Once that disruptive event occurs, the firm seeks to achieve 'convergence'. The firm seeks to regain 'fit' internally and with its external environment. Donaldson (2001) argued that there were three significant contingency factors: (1) task uncertainty, (2) task interdependence, and (3) size. In this dissertation, I focus on the task interdependence contingent factor as a determinant of the relationship between Gray Swans and firm resilience. Gray Swans are viewed as an environmental uncertainty contingent factor. Shaw et al (2016, p.1) posited three broad reasons why researchers may seek to integrate theories: (1) to solve a puzzle in management literature where no adequate explanation exists; (2) to explain a recurring pattern of findings or "stylized facts" that have appeared in the management literature or elsewhere; or (3) to offer a new way of seeing an existing issue or phenomenon. I hue more to

the third factor in this dissertation – a new way of seeing an existing issue or phenomenon. Further, Mayer & Sparrowe (2013, p. 917) noted that integrating theories may address related phenomena from a related or common set of explanatory factors.

Combining theoretical frameworks can offer new insights into the relationship between an organization and its environment (Hillman, Withers, & Collins, 2009). However, integrating theories within and across disciplines can be pose particular challenges for the researcher, i.e. lack of compatibility. To mitigate this challenge, I sought two theories that can reasonably predict the same phenomenon (Mayer & Sparrowe, 2013; Shaw et al. 2018). Both of these theories focus on the same level of analysis – disruptions in the organization's task environment. Contingency Theory focuses on 'fit' while Punctuated Equilibrium focuses on convergence and reorientation. Applying this integrated approach allows me to see an existing phenomenon from a new perspective (Shaw et al. 2018). There is a level of compatibility between these two theories in their assumptions regarding epistemology, human nature, and level of analysis (Shaw et al. 2018). Punctuated Equilibrium focuses on the internal workings of an organization – particularly issues of inertia (institutional and individual) whereas Contingency Theory focuses on the organization's fit with its external environment. As Tushman & Romanelli (1985, p. 174) noted, "organizations require external as well as internal legitimation." Integrating these two theories helps us to understand the tension and dynamics that manifest when a disruption occurs. In the first instance, there is the struggle to regain fit with the external environment. In the second instance, there is the challenge to maintain the institutional framework that has kept the organization going prior to the disruption.

Organizations go through evolutionary periods – that is through transformation and change (Sammut-Bonnici & Wensley, 2002). Organizational change can be gradual, or it can be disruptive. In this study, change is examined from two perspectives: (1) internal organizational structure and strategy, and (2) the organization's relationship with its external environment. It is argued here that integrating two theoretical perspectives – Contingency Theory (CT) and Punctuated Equilibrium Theory (PET) - allows for a better understanding of how organizations adjust to changes in their internal and external environments. Applying evolutionary theory to management concepts is not novel in the general management literature. However, it is somewhat novel in the Operations Management context. Singhal & Singhal (2012) had called for more interdisciplinary studies and a greater integration of theories from such disparate field as Physics to be used in the broader Operations and Supply Chain Management field. The authors noted that interdisciplinary research "can uncover new phenomena, revise the boundaries of existing disciplines, and give birth to new ones" (Singhal & Singhal, 2012, p. 240). Applying Singhal & Singhal's (2012) logic is one pf the goals of this study in integrating CT and PET – helping us uncover and understand Gray Swans. One can think of the supply chain network as a biological ecosystem wherein various species, think firms and industries exist. Hannan & Freeman (1977) in their work on Population Ecology examined this notion from an organizational perspective. The authors discussed two types of environmental variation: (1) fine-grained, which focuses on the short duration between environmental fitness and misfit; and (2) coarse-grained variation where there is considerable uncertainty in the environment (Hannan & Freeman, 1977). Organizations may be slow to adapt to changes in their operating environments

because of inertial pressures (Hannan & Freeman, 1984). Three factors affect how quickly an organization can respond to a change in its environment: (1) Time – the temporal patterns in key environments. (2) Speed – the ability to learn and respond to information quickly; and (3) Resiliency or Agility – how quickly can the organization change (Hannan & Freeman, 1984). It is argued in this study that the buyer-supplier relationship and the firm's risk management system can have an effect on resilience. Romanelli & Tushman (1994) advanced a similar argument suggesting that organizations create institutional frameworks and enter relationships with buyers, suppliers and others in their financial network to maintain a level of inertia.

Population Ecology assumes that organizations can easily adapt to change in their environments and contingencies. It is argued here that assumption does not hold when assessing the supply chain ecosystem. Hence, a punctuated contingent perspective better explains the Gray Swan phenomena. Punctuated Equilibrium supports Hannan & Freeman (1977) notion of fine-grained variation since 'sudden and discontinuous change' is necessary to dislodge institutional inertia (Romanelli & Tushman, 1994). Given the foregoing, I argue that both theories reasonably explain the effect of a Gray Swan on firm resilience as well as the mediating or moderating effects of the buyer-supplier relationship and risk management system on firm resilience. Combining Contingency Theory with Punctuated Equilibrium Theory offers new insight into the problem of Gray Swans in the supply chain.

Uncertainty is an important element of Contingency Theory (Flynn et al. 2016). Gray Swan contingencies can be viewed as environmental fluctuations that can disrupt the core activities of an organization (Flynn et al., 2016). Given the low probability of occurrence, there

is some debate whether these uncertainties can or should be anticipated by firms in the supply chain. I assert that since Gray Swans have a history, i.e. they have occurred before, they can or should anticipated and mitigated against by firms making the necessary adjustments. These adjustments enable the firm to maintain homeostasis (Flynn et al. 2016 c.f. Thompson, 1967). The preceding argument is presented from a different perspective applying punctuated equilibrium. During reorientation, organizations experience changes and realignment in strategies, structure, power and systems, e.g. a major supplier filing for bankruptcy or going out of business results in major changes in the buying organization (Tushman & Romanelli, 1985). This allows the organization to return to stasis. The desire to return to stasis assumes there is some amount of organizational learning. There is discussion in the literature (see Fiol & Lyles, 1985) why change or learning is so difficult in human systems because of issues related to three factors: (1) cognition; (2) motivation; and (3) obligation (Gersick, 1991).

Contingency Theory posits that there is no "one best" organizational structure that is inherently more efficient than all others (Walker & Jones, 2012). Since organizations differ in the tasks they perform and environments they face, the appropriate organizational structure in each case is a function of such factors as technology, market, and the predictability of tasks (Thompson, 1967; Walker & Jones, 2012). A contingency may be defined as "any variable that moderates the effect of an organizational characteristic on organizational performance" Donaldson (2001, p. 7). Contingency factors such *task uncertainty* and *task interdependence* lie within the organization (Donaldson, 2001). However, task interdependence also lies outside the organization when one includes the firm's supply chain – which affected by another contingency

factor – environmental contingency. Fit is disrupted in the organization and its supply chain when environmental contingencies affect internal contingencies such as task interdependence (Donaldson, 2001). In this dissertation, I posit that contingencies may also mediate the effect of an organizational characteristic on organizational performance. I further posit that some contingencies may be characteristics of some overarching construct. In their study, Grötsch, Blome & Schleper (2013) view past supplier insolvencies as a major contingency indicating the level of vulnerability of an organization. A supplier insolvency also has the potential to severely disrupt an organization's operations. Grötsch et al. (2013) noted that supplier insolvency is one of the most disruptive supply chain risks the focal firm can experience. My examination of supplier insolvency as a Gray Swan echoes this perspective. I believe that to build and maintain a resilient supply chain, companies need to predict, mitigate and manage these types of disruptions (Grötsch et al., 2013). In their model, Grötsch et al. (2013) view Relational Buyer-Supplier Relationship (RBSR) as an antecedent to SCRM proactiveness. I view the RBSR as a mediator (see Liu et al, 2009; Lumineau & Henderson, 2012) determining the level of effect between Gray Swans (GRSWN) and firm resilience (FMRES).

Contingency Theory is most often used in the literature to explain moderation. It may be positive or negative; strong or weak (Donaldson, 2001). For example, the size of an organization may determine the effect of a disruption on that organization. A larger organization may be better able to absorb the effects of a loss of resources than a smaller organization. In the research model, I assert that the theory may also explain mediation. In their study, Narayanan and colleagues used trust as a mediating variable to understand the impact of collaboration on agility

in the buyer-supplier relationship (Narayanan et al., 2015). Trust is often used as a mediating factor in the understanding the relational buyer-supplier relationship (Kwon & Suh, 2004, 2005; Nyaga et al. 2010, Hammert et al., 2016). I examine the effects of the mediating buyer-supplier relationship in the firm's supply chain relationship.

The variables in the model, buyer-supplier relationship and firm risk management system have an effect of the occurrence of a Gray Swan on organization resilience. In the research model, I examine two types of Buyer-Supplier Relationships - Relational Buyer-Supplier Relationship (RBSR) and Transactional Relational Buyer-Supplier Relationship (TBSR). I also view organizational structure as a contingency that will moderate the strength of the relationship between Gray Swans and the type of Buyer-Supplier Relationship and other variables in the model. Applying a contingency perspective, I posit that the firm's risk management system will mediate the level of effect between Gray Swans and the firm resilience.

Gray Swans are viewed in the context of an environmental contingency. Contingency Theory asserts that organizational effectiveness results from a fit between the internal organizational structure and the external contingencies. Organizational effectiveness may be defined as "the ability of the organization to function well as a system to achieve organizational goals (Donaldson, 2000, p. 6). I argue that organizational effectiveness is related to organizational resilience. Donaldson (2001) also argued that organizational effectiveness and performance are similar concepts. Donaldson (2001) argued that performance is a function of fit between the organizational structure and three contingencies: (1) the *environment* (cf. Blau, 1970; Burns & Stalker, 1961; Child, 1972; Emery &Trist, 1965; Lawrence & Lorsch, 1967;

Thompson, 1967); (2) *size* (cf. Child, 1972); and (3) *strategy* (cf. Chandler, 1962). The relationship between the level of organizational structure and firm performance was examined by Lawrence & Lorsch (1967). Firms operating in dynamic environments tended to have less formalized (i.e. more organic) structures. The size contingency affects the bureaucratic structure of an organization (Blau,1970). In their study, Drazin & Van de Ven (1985) noted that the key concept in a contingent proposition is fit. The authors posited three forms of fit: the selection approach; the interaction approach; and the systems approach. The selection approach advances the logic of Hannan & Freeman (1977) that organizations survive by adapting to their environments. Another aspect of the selection approach extends the logic of DiMaggio & Powell (1983) that isomorphic pressures shape the firm's institutional structure and its management. The interaction approach examines the relation among the variables on firm performance. In this dissertation, I examine the selection, interaction and systems form of fit in the context of a Gray Swan contingency and its effect on firm resilience.

There is another contingency with which the organization must contend: task. The task contingency is composed of task uncertainty and task interdependence. Donaldson (2001) argued that task uncertainty and task interdependence are contingency factors that lie within the organization. I argue that in the context of a supply chain, these contingency factors are enhanced by environmental uncertainty which lies outside the organization. The kinds of risk a firm is likely to encounter should determine its structure. Gray Swans present unique challenges to firms given their low probability of occurrence. These challenges are exacerbated or mitigated

by the organization's internal structure. While a firm's internal structure should be stable, the firm's external environment can expose it to vulnerabilities that can create misfit.

Structural Contingency Theory helps to explain the effects of managers on their environments and vice versa. Firms operating in a stable environment tended to have more formalized (i.e. mechanistic) structures. In his study, Donaldson (1987) highlighted many of the disadvantages of the mechanistic and organic frameworks and proposed an alternative - The Structural Adjustment to Regain Fit – the (SARFIT) model. The author notes that there are three core aspects of the contingency paradigm: (1) there is an association between contingency and the organizational structure; (2) contingency determines the organizational structure. As the contingency change, the structure also changes; and (3) there is a fit of some level of the organizational structure variable to each level of the contingency (Donaldson, 1987). One wonders if either company engaged in any attempts to regain fit with their changing environment, which as Emery & Trist (1965) noted was changing as the technology was changing. In reviewing prior studies, Donaldson (2001) noted that "fit" is the common denominator across the different contingency theories. Since the focus is on manipulating the contingencies to achieve fit, which ultimately leads to higher performance, Donaldson (2001) argued that researchers should focus on how contingency change leads to structural change. Gray Swans create misfit between the firm and its task environment. This misfit can lead to lower firm performance, i.e. reduced resilience.

In their examination of the use of Contingency Theory in OM studies, Sousa & Voss (2008) focused on three variables: (1) "contingency variables – which are exogenous to the focal

organization; (2) response variables – which are managerial or organizational actions taken in response to current or anticipated factors; and (3) performance variables – which are dependent measures and represent specific aspects of effectiveness that are appropriate to evaluate fit between contextual variables and response variables" (Sousa & Voss, 2008, p. 703). In this study the contingency variable is the Gray Swan; the response variables are the buyer-supplier relationship and the risk management system; and the performance variable is firm resilience. Applying this framework allows me to gain some perspective on how organizations address disruptions. Organizations seek to cope with uncertainty by creating certain structures (Hickson et al. 1971, c.f. Cyert & March,1963). These institutional structures – which enable the organization to maintain stasis - may "blind" the organization's decision-makers to changing external environmental conditions.

Punctuated Equilibrium Theory asserts that equilibrium is maintained by inertia during the equilibrium period. Managers may not engage in boundary spanning and miss identifying risk percolating right below the surface of their organizations. This misidentification occurs because of resistance to change either as a result or bounded rationality, lack of motivation or some legal obligation. Therefore, when the organization enters a revolutionary period it is ill-equipped to adjust to the change. Gersick (1991) likened the situation to one in which rather than moving the basketball hoop higher during a game, the hoops are removed while the game is in progress.

Punctuated Equilibrium also offers a theoretical explanation of how organizations address endogenous and exogenous environmental shocks (Romanelli & Tushman, 1994, p. 1142).

Companies experience periods of stability during which they establish and maintain structures, conduct and policies (Chandler, 1962) to reinforce institutional norms (Hannan & Freeman, 1984; Romanelli & Tushman, 1994). Organizations go through convergent periods, i.e. long periods of incremental changes and adaptations which are punctuated by reorientations that demark and set the next convergent period for the organization (Tushman & Romanelli, 1985, p. 173). The ability of an organization to respond to and recover from a punctuation of its equilibrium is a measure of its resilience. Convergence is regarded as that period of stability in which organizations interact effectively and efficiently with their external and internal environments (Tushman & Romanelli, 1985). "Reorientations are relatively short periods of discontinuous change where strategies, power and systems are fundamentally transformed towards a basic new alignment" (Tushman & Romanelli, 1985, p. 173). The need to regain stasis can be expressed as a function of "fit". I argue that Managerial Myopia may inhibit a firm's ability to spot a Gray Swan. For example, Managerial Myopia heightens managers' resistance to change in ongoing dyadic relationships (Romanelli & Tushman, 1994). Further, dyadic relationships and other coercive isomorphic pressures (Di Maggio & Powell, 1983) create a form of institutional inertia that constrains firms (Romanelli & Tushman, 1994). These inertial pressures exacerbate the risk of a Gray Swan. Hickson et al. (1971) note that Managerial Myopia may derive from sub-unit or department power. However, the top management team (TMT) of the organization should be the countervailing force that negotiates between periods of convergence and reorientation. In the research model, the following variables: RBSR and RMSYS fall within the purview of the firm's executive leadership and determine the time

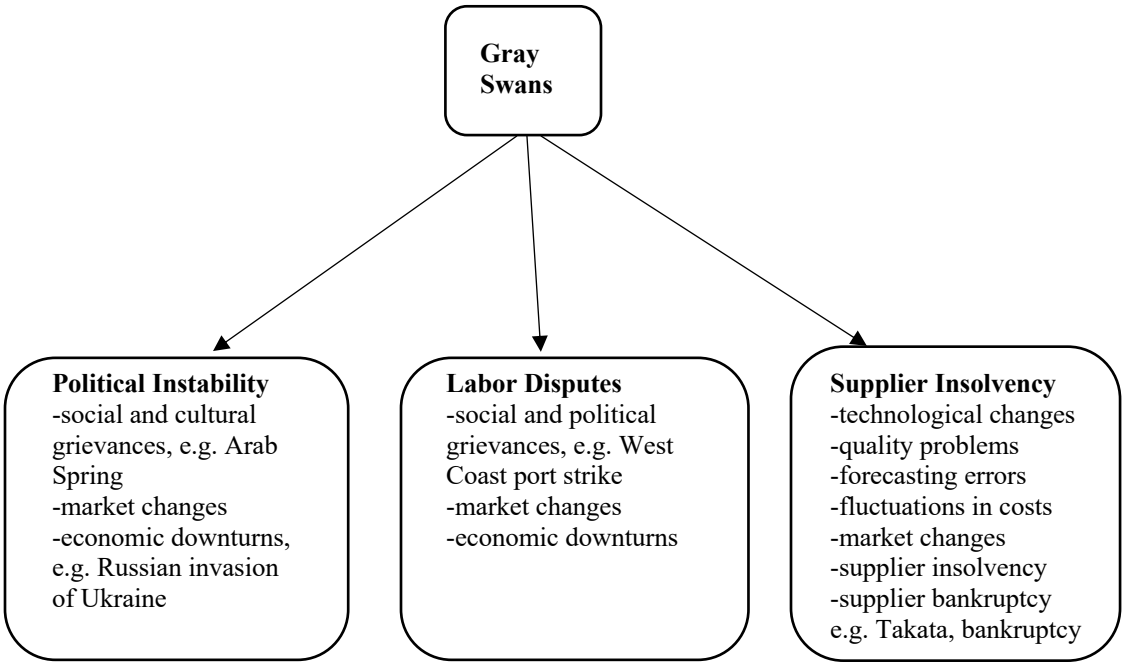
between convergence and reorientation (Tushman & Romanelli, 1985). However, trying to maintain equilibrium through erecting these institutional structures may 'blind' decision-makers to changing environmental conditions. For example, a firm that has a close relationship with a supplier may overlook signs that the supplier is becoming or has become financially distressed until it is too late – the supplier files for bankruptcy of ceases operations. Such was the case with GM and one of its main suppliers, Clark-Cutter McDermott (Gleason, 2016).

3.1. Gray Swans

In this dissertation I have characterized three contingency factors: political instability, labor disputes and supplier insolvency- as Gray Swans, which are regarded as high impact events with low predictability. I distinguish Gray Swans from black swans (which were discussed in the previous section) in the following manner: (1) Gray swans have occurred before (Akkermans &Van Wassenhove, 2018). These events have a history, i.e. there are small, sometimes unnoticed events leading up to the ultimate disruption. These events are more predictable than black swans which are rare, sudden, and consequential. The danger for companies is that these events often go unnoticed or "under-noticed." For example, the student protests (the "Arab Spring") in Egypt and other countries in the Middle East foreshadowed the government crackdown and the resulting political instability. The fallout from the political instability affected pending business deals between Egyptian and foreign multinational companies (MNCs) which affected foreign direct investment (FDI) into the Egyptian economy (Reuters, 2011). (2) Gray Swans are subject

to other "enabling conditional factors."[6] For example, the demand for wages and better working conditions by members of the International Longshore Warehouse Union did not cause the supply chain disruption. However, it was a necessary and sufficient condition that contributed to the labor dispute which ultimately led to the shutdown of the port. The port shutdown had a significant impact on the global supply chain and on the US economy (Oyedele, 2015). Figure 3. below presents my exposition of Gray Swans.

Figure 3
Classification of Gray Swans

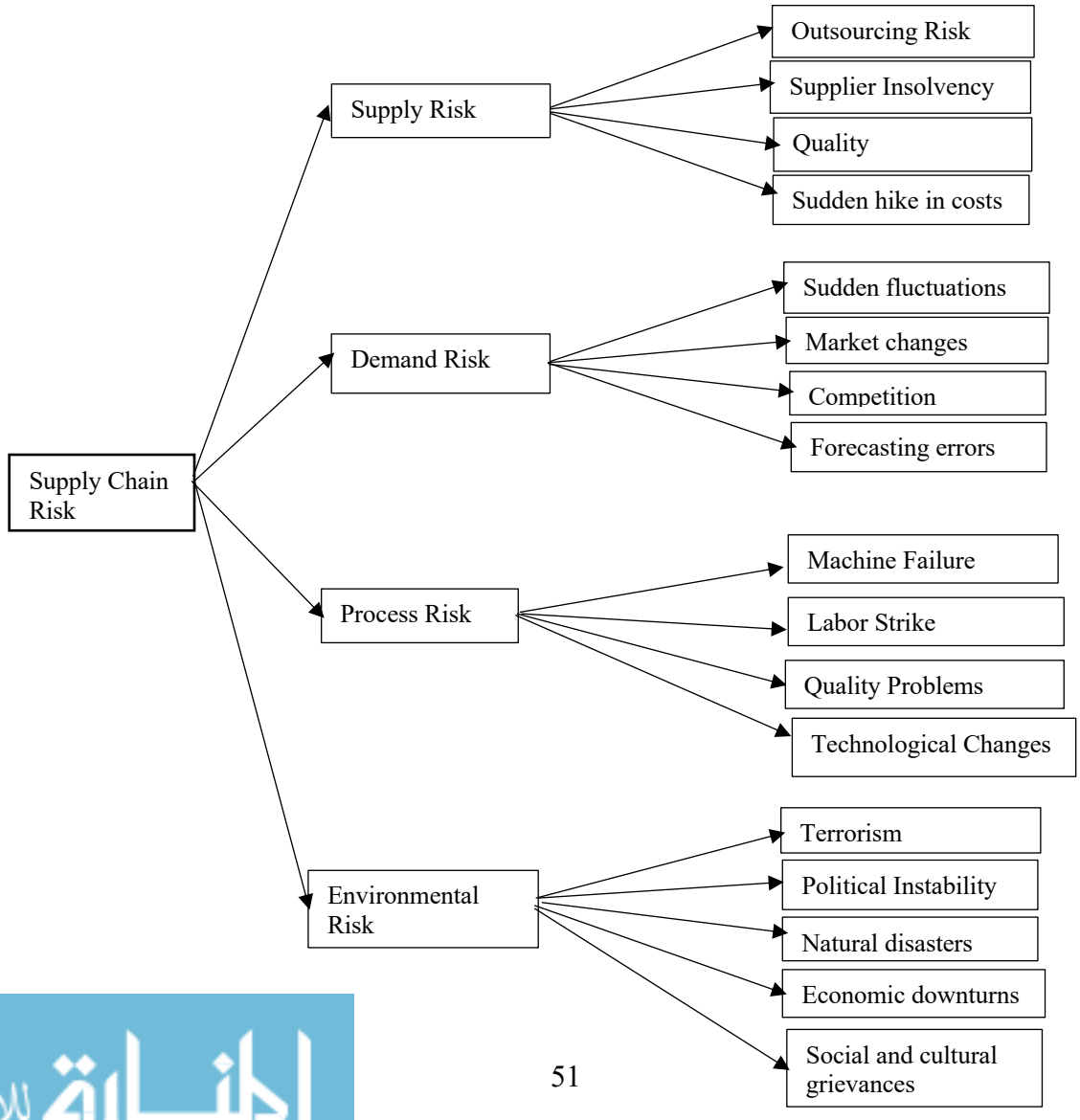


I adapted Samvedi's et al. (2013) delineation (see Figure 4) below to provide the classification of Gray Swans see Figure 3 above. Samvedi and colleagues listed Gray Swans

[6] The Center for Chemical Process Safety defines an "enabling condition" as a condition that does not directly cause the scenario but must be present or active for the scenario to proceed to a loss event."

within the broader category of Supply, Process and Environmental Risk (Samvedi et al., 2013). Given their unique characteristics, this category of risk deserves more critical examination. As indicated in Figure 4, some of the risks described by Samvedi and his colleagues, e.g. political instability, may capture other types risk such as terrorism, economic downturns or social and cultural grievances (Samvedi et al., 2013)

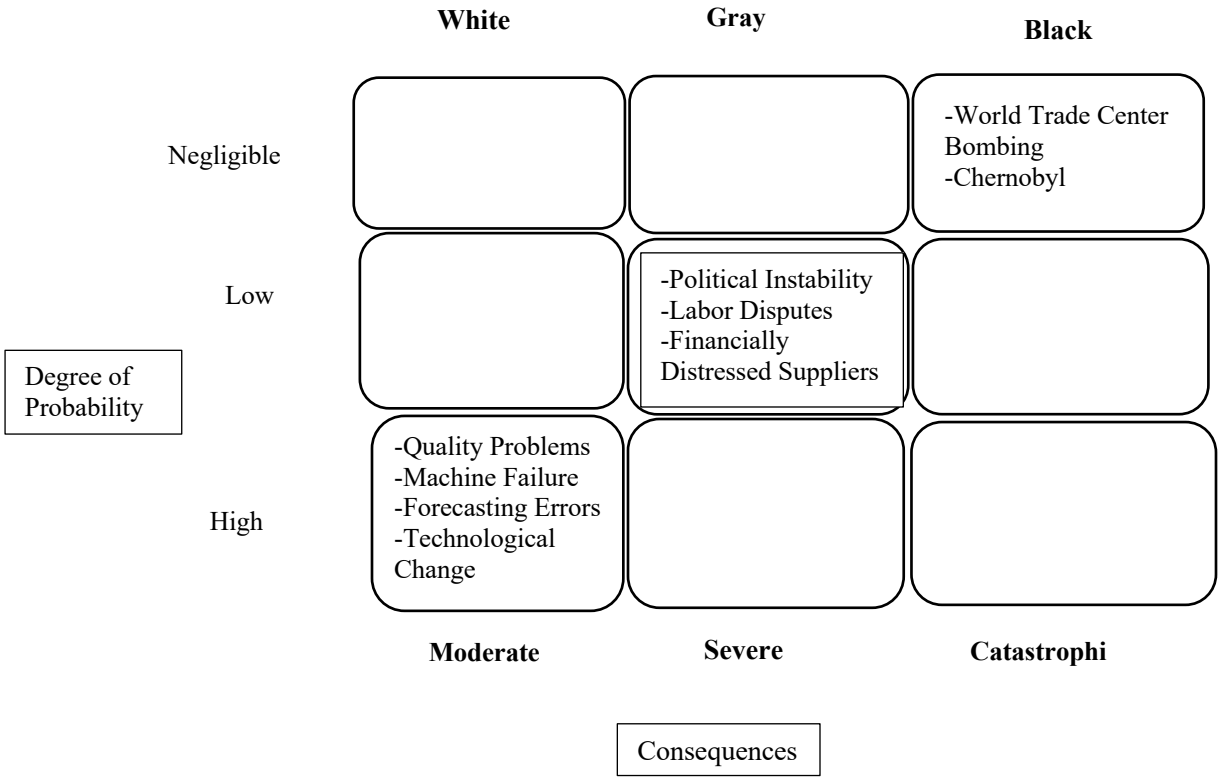
Figure 4 –
Classification of Supply Chain Risk



Adapted from Samvedi et al. (2013)

In the review of the literature, I found very few articles addressing Gray Swans. In the social science literature, some scholars have discussed Gray Swans in a financial context and argue that "financial crises are gray (rather than black) swans because they are cyclically recurring" (Vercelli, 2009, p. 6). In the disaster management literature, Masys (2012) and Ning & Emanuel (2015) discuss Gray Swans in a meteorological context and define gray swan tropical cyclones as "high-impact storms that would not be predicted based on history but may be foreseeable using physical knowledge together with historical data." Other scholars have noted that Gray Swans are unexpected events that are recognizable to happen in theory but ignored until they appear in practice (Filatov & Vanyarkho, 2014). In reviewing the OM and risk management literatures, only Akkerman &Van Wassenhove (2013) discuss Gray Swans in an operations management context. However, they use disaster management related terminology to discuss Gray Swans. These authors describe four types of Gray Swan events which they label business tsunamis: (1) relationship spiral tsunami; (2) Demand shock tsunami; (3) Scheduled pressure tsunami; and (4) Quality cascade tsunami. This dissertation categorizes Gray Swans risk as depicted in Figure 3. I present the Gray Swan risk matrix in Figure 5 below.

Figure 5–
Risk Matrix of the Various Types of Swans and Risk Levels



Taleb (2007) noted that Gray Swans seem to follow the law of iterated expectations, i.e. if a manager expects that there will be a disruption in the supply chain, that event is not entirely unpredictable because the manager has an expectation of the occurrence of the event. I provide a detailed discussion of the three dimensions of Gray Swans in this dissertation. Despite the *law of iterated expectation*, there still seems to be a disconnect between cognition and concrete action by managers. Inertial pressures may still keep managers from being able to spot a Gray Swan, i.e. a financially distressed firm.

3.1.1. Supplier Insolvency

The risk of supplier insolvency seems to have increased as supply chains have become more complex. Insolvencies have become a major source of supply chain disruptions (Grotsch, Blome, & Schleper, 2013). Following Samvedi et al. (2013) I view a supply chain partner insolvency as a catastrophic event that results in a supplier or buyer closing the business completely or suffering a significant operating disruption that interrupts the flow of raw materials of components to the firm's supply chain partners. A review of the literature on insolvencies (Babich et al., 2007; Frisby, 2011; Grotsch et al., 2013) highlighted the fact that although managers have some understanding of disruption risk, they invest little time in engaging in any risk analysis, or risk assessment strategies. Managers employ one of two common strategies in addressing supply chain risk: (1) they are proactive and utilize risk assessment, mitigation and management strategies; or, (2) they react to the disruption (Grotsch et al., 2013). Although insolvency is a catastrophic event, bankruptcy can be and often is a strategic move by a company. In their study, Yang, Birge, & Parker, (2015) noted that United Airlines was able to reduce its aircraft lease payments by 50%. Other companies were also able to restructure payments thereby reducing operating costs. Whether for strategic or practical reasons, these insolvencies have negative effects upstream and downstream in the supply chain.

3.1.2. Labor Disputes

The general discussion about labor disputes in the supply chain literature centers on the dyadic relationship among labor and management, or industry or national effects (Wright & Kaine, 2015) usually without addressing the spillover effects in the global supply chain. For example,

until recently, the growing concern of "forced labor' and "human trafficking" did not seem to factor into the labor-management issues in one industry or one country. Apple found itself facing considerable criticism after it was discovered that one of its subcontractors in China, Foxconn, were abusing employees (Merchant, 2017). In their discussion of supply chain breakdowns, Chopra & Sodhi (2004) discussed labor disputes and bankruptcies as risk drivers that managers should assess and mitigate. However, the authors do not address either problem in great detail. I give these supply chain risk drivers greater examination in this dissertation. In some instances, different types of Gray Swans may converge. Yang et al. (2015) discuss how bankruptcy filings can be used as a strategy to wring concessions from labor unions engaged in a dispute with a company. The authors note that American Airlines was able to reduce its labor costs by $1 billion.

Labor disputes can have a significant impact on the supply chain. The recent dispute between the Pacific Maritime Association (PMA) and the International Longshore and Warehouse Union (ILWU) resulted in the shutdown of 29 ports on the U.S. West Coast. This brought all shipping to a virtual standstill (Stevens & Ziobro, 2015). The economic impact of this labor dispute was felt across the supply chain since West Coast ports account for approximately 12.5% of U.S. gross domestic product (GDP) (Gerrity, 2015). A similar labor-management dispute in 2002 had cost the U.S. economy approximately $1 billion per day and lasted 10 days (Gerrity, 2015).

3.1.3. Political Instability

Political instability is discussed most frequently in the political science and economic literatures in the context of abrupt changes in the political system or heads of government (Aisen & Veiga, 2013; Roe & Siegel, 2011), and the humanitarian disaster literature (Van Wassenhove (2006). In the operations management literature, Kleindorfer & Saad (2005) addressed political instability as disruption risk while Trkman & McCormack (2009) discuss endogenous and exogenous sources of uncertainty. In this study, I view political instability from a macroeconomic perspective with destabilizing effects on an economy through disruption of the nation's supply chain infrastructure. This type of Gray Swan affects all firms operating in that environment. For example, the Arab Spring uprising scuttled a deal between Sweden's Electrolux and Egypt's Olympic (Reuters, 2011). The two companies were close to completing a deal before the political upheaval. The unfolding events in the Ukraine also affected the joint venture between Ford and Russian carmaker Smollers. The company was forced to reduce its staff by 700 employees (Krauskopf, 2014). As the two examples demonstrate, political instability can have deleterious effects on any economy. Political instability is regarded as a serious malaise that is harmful to economic performance (Aisen &Veiga, 2013). Other scholars note that political instability impedes financial development (Roe and Siegel (2011). I extend Alesina et al.'s (1996) definition and treat political instability as a change in executive power be constitutional or unconstitutional means by treating political instability as a severe disruption in the normal operation of a government of a country that negatively impacts the economic development of that country. In light of the foregoing discussion, I offer the following hypothesis:

H1: The impact of a Gray Swan in the supply chain is negatively related to firm resilience. i.e. Gray Swan tests a firm's resilience.

3.2. Buyer-Supplier Relationship

Supply chain relationships are generally characterized by dependency with a focus on structural interdependence and asymmetric information (Zhang & Huo, 2013). Most SCM studies generally classify the buyer-supplier relationships as either contractual or relational (Bastl et al., 2012; Grotsch et al., 2012). Relational types of governance are based on ideas of partnership and collaboration. Transactional types of governance are based on formal legal contracts (Grotsch et al., 2012). Buyers and suppliers in relationships with high levels of relational exchange are characterized by joint problem solving, interdependence, and high levels of commitment (Bastl et al., 2012). These authors examine the buyer-supplier relationship along five dimensions: (1) information exchange, i.e. sharing information that might be useful to both parties, (2) operational linkages, i.e. the degree to which systems and procedures are routinized between parties' operations (3) legal bonds, i.e. legally binding contracts, (4) cooperative norms, and (5) buyer-supplier adaptations, i.e. assuming specific process, product or procedures of an exchange partner. It is argued that buyers and suppliers in a cooperative relationship communicate more frequently and act to reduce information asymmetries (Bastl et al., 2012). However, the literature is inconclusive on whether buyers and suppliers engaged in a cooperative relationship actually communicate more than those engaged in a contractual relationship (see Lumineau & Henderson, 2012; Tangpong et al., 2012; Katak & Pavlov, 2013; Bhattacharya et al., 2015; Bai et al., 2016). Further, Bastl et al. (2012) found a disconnect between theoretical expected and

empirically observed post-servitization relationships. This dissertation disaggregates the buyer-supplier relationship and discusses each aspect separately.

3.2.1. Transactional - Contracts

Firms tend to engage in financial myopia, focusing on their own profits rather than aligning their interests with supply chain partners by sharing information (Sluis & De Giovanni, 2016). This focus is achieved through various forms of contracts. Bai et al. (2016) discuss two types of contracts: Output-based and behavior-based contracts. There are control and coordination dimensions as well as prevention and promotion dimensions of contracts (Bai et al., 2016, p. 13). Output-based contracts specify the performance standards suppliers must meet (Bai et al. 2016). These types of contracts focus on the following characteristics: (1) performance outcomes – by prescribing specific goals for the suppliers; (2) align the preferences and goals of the buyer and seller; and (3) reduces ambiguities and misunderstandings of each party's role in the relationship (Bai et al., 2016). A lack of trust results in higher transaction costs as well as higher agency costs (Kwon & Suh, 2004, p. 5). Information sharing is one of the most critical aspects of trust in a buyer-supplier relationship (Kwon & Suh, 2004). People in high trust relationships are not usually afraid to share important information and are more inclined to take risks (Kwon & Suh, 2004, p. 5).

3.2.2 Relational - Trust

The relational view suggests that firms make specific investments to improve exchange relationships (Zhou et al., 2014). This view asserts the strength of ties. Granovetter (1973, p. 1361) noted that the strength of a tie is a (probably linear) combination of the amount of time,

the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie. In the supply chain context, the investments made by a buyer in its supplier whether through knowledge transfers, or other types of investments are critical to maintain the flow of goods and services. It may be assumed given the relational ties that the threat of a Gray Swan would be less disruptive when there are strong ties between buyer and seller. Zhou et al (2014) asserted that weak ties are good for acquiring novel information while strong ties encourage the exchange of specific and complex knowledge flows.

Trust is viewed by researchers as an essential ingredient in the buyer-supplier relationship (Capaldo & Giannaccaro, 2015). Trust indicates some belief about a supply chain partner's ability, benevolence and integrity (Wang et al., 2014). Ability is defined as skills, capabilities and characteristics that give a supply chain partner influence; benevolence refers to the extent to which a supply chain partner exhibits some measure of emotive behavior beyond the profit motive and integrity is a supply chain partner's perception that the other partner will behave ethically (Wang et al., 2014). Numerous studies have been conducted focusing on trust as an antecedent, causal, mediating or moderating variable (see Kwon & Suh, 2005; Hill et al. 2009; Liu et al., 2009; Nyaga et al., 2010; Capaldo & Giannaccaro, 2015 among others). Other researchers view trust is as a multidimension construct consisting of such subconstructs as (1) fairness; (2) loyalty; (3) vulnerability; (4) dependability; (5) non-opportunism; (6) benevolence; and (7) collaboration (Capaldo & Giannaccaro, 2015).

Given its multidimensionality, trust is defined in various ways in the literature. Narayanan et al (2015) viewed trust as synergistic with collaboration. Kwon & Suh, (2004:5)

defined trust as "the willingness to take risks." Capaldo & Giannaccaro (2015) assert that trust shapes the altruistic behavior of firms participating in the supply chain. It is not entirely clear that altruism drives the behavior of players in the supply chain. Trust may be regarded as an informal governance mechanism (Zhou et al., 2004, Capaldo & Gianncaro, 2015). Some researchers have focused on aspects of justice as a critical factor in determining a relational governance mechanism (See Liu et al. 2012, Wang et al. 2014, among others). While procedural justice may be a significant factor in influencing trust (Wang et al., 2014), this dissertation asserts that the nature of the buyer-supplier relationship whether, transactional (driven by procedural of distributive justice) or relational (driven by interpersonal or interactional/informational justice) mediates the effect of a Gray Swan on firm resilience.

3.2.3 Combining Relational and Transactional Governance Mechanisms

Much of the buyer-relationship literature address the relational or transactional governance mechanism singularly, i.e. as compliments or substitutes (Liu et al., 2010; Lumineau & Henderson, 2012; Cao & Lumineau, 2015). Trusts and contracts are mutually reinforcing mechanisms. It has been shown that trust in a relationship can be a precondition for more complex contractual relationships (Sluis & De Giovanni, 2016). However, Liu et al (2009) wondered whether combining transactional and relational governance mechanisms would reduce the tendencies for opportunistic behaviors by either the buyer or supplier in a transaction. They found that tangible and intangible investments reduce relational opportunism (Liu et al. 2009) In their study, Zhou et al. (2014) also found that contract specificity strengthened the effects of relational ties. Cao & Lumineau (2015) also examined the relationship between contractual and

relational governance mechanisms focusing on factors that moderate the relationship. They found that contracts based on trust and relational norms improved the buyer-supplier relationship and relationship performance. In the buyer-supplier relationship, transactional mechanisms generally provide some legal or institutional framework to monitor relations whereas relational mechanisms entail inherent and moral control to govern exchanges in a cooperative environment (Liu et al, 2009). Their findings demonstrate that the interaction between contract and relational mechanisms is significant. This suggests that firms would be better off supplementing a relational governance mechanism with a contract. While this may work under "normal" operating conditions, i.e. during evolutionary periods, I am not certain of the influence of an interaction effect in the presence of a Gray Swan. A Gray Swan may significantly and negatively affect either governance mechanism.

It has been advanced in the literature that both types of buyer-supplier relationships acting in tandem reduce agency and transaction costs (Liu et al., 2009). However, the results of those studies are inconclusive regarding how much of either type of governance mechanism is necessary to reduce agency and transaction costs (Kwon & Suh, 2004; Kwon & Suh, 2005; Sommer & Loch, 2009; Bai et al., 2016,). The results of my analysis indicate that there may be other effects, such as culture, that have not been examined thoroughly by these studies. This may be an avenue of future research examining the impact of culture on the type of buyer supplier relationship. Note that Cannon et al. (2010) have examined culture as a moderating variable in examining long-term buyer-supplier relationships. Their findings indicate that in collectivist cultures such as Francophone Canada and Mexico, trust had a greater effect than in individualist

cultures such as the United States and Anglophone Canada. The effect of culture is significant given that more companies have moved from local to global sourcing (Cannon et al. 2010). The effect is more acute in cultures with high power distance and Guanxi (*relationship*) networks, such as China (Zhang & Huo, 2013). Understanding culture is extremely important given the risk of a Gray Swan. Although the probability is low, culture may affect the buyer-supplier relations in the event of a Gray Swan disruption (Cannon et al., 2010). However, the effect may be different as the study by Cannon and his colleagues demonstrate (Cannon et al., 2010). Further, in their study of Korean firms, Hemmert et al. (2016) found that institutional factors accounted for the differences in trust building between geographically and culturally similar countries. Despite these findings by Hemmert et al. (2016) and others, I assert in this dissertation that the buyer supplier relationship mediates the negative effect of a Gray Swan on firm resilience.

3.2.4 Theories Used to Explain the Buyer-Supplier Relationship

Researchers have used various theories to explain the buyer-supplier relationship. For example, social exchange theory has been used in a number of studies to explain the social interactions and socially embedded relationships in economic activities (Liu et at., 2012). The majority of studies examining the buyer-supplier relationship have utilized a few theories: Social Exchange Theory (Emerson, 1976), Relational Exchange Theory, Transaction Cost Economics/Analysis (TCE/A) (Williams, 1985), Agency Theory (Coase, 1937; Jensen and Meckling, 1976; Eisenhardt, 1989). Grotsch et al (2012) noted that social exchange theory (SET) explains the relational buyer-supplier type of governance. Resource Dependence Theory (RDT) (Pfeffer and Salancik, 1978) may also characterize the power dependence that exists buyer and seller in a relational type of

governance. Social Exchange Theory is often used in conjunction with another theory, e.g. TCE (see Kwon & Suh, 2004, 2005; Bastl et al., 2012) or RDT (see Bastl et al., 2012) to explain the buyer-supplier relationship. Loose Coupling Theory which posits that a supply chain is a loosely coupled system with independent elements that are somehow responsive to each other has also been used to explain the buyer-supplier relationship (Liu et al., 2012). Loose Coupling Theory may be linked to Contingency Theory in the sense that both theoretical approaches focus on independent actors engaged in exchange.

While TCE and other theories have been used extensively in the OM literature to explain characteristics of the buyer-supplier relationship (Liu et al., 2009; Kwon & Suh, 2004, 2005; Bastl et al., 2012), I employ a "punctuated contingent" perspective to examine the buyer-supplier relationship in the context of a Gray Swan. Bhattacharya et al (2015) noted that TCE is a context-specific theory and may not be useful in all circumstances. Other studies have focused on reducing agency and transaction costs (see Liu et al., 2009 among others). While TCE or Social Exchange Theory (SET) may explain the direct effects of the type of buyer-supplier relationship, e.g. transactional or relational, it is argued here that Contingency Theory, with its focus on 'fit' combined with Punctuated Equilibrium, with its focus on 'convergence' provides a more comprehensive theoretical framework to understand the research model.

In their review of the literature, Terpend et al. (2008) argued that more longitudinal studies were necessary to gain a better perspective of the buyer-supplier relationship. The vast majority of studies viewed the buyer-supplier relationship in a single period. This is not sufficient for researchers to fully understand the buyer-supplier dynamics (Terpend et al., 2008).

The authors also noted that there were significant limitations in using a single theory to explain the buyer-supplier relationship. It is posited that the buyer-supplier relationship whether transactional or relational influences the effect of a Gray Swan on firm resilience. Given the preceding discussion, I offer the following hypotheses:

H2: The impact of a Gray Swan in the supply chain is negatively related to the relational buyer-supplier governance mechanism.
H3: The impact of a Gray Swan in the supply chain is negatively related to the transactional buyer-supplier governance mechanism.
H4: The transactional buyer-supplier governance mechanism is positively related to firm resilience.
H5: The relational buyer-supplier governance mechanism is positively related to firm resilience.
H6: The transactional buyer-supplier governance mechanism mediates the effects of a Gray Swam on firm resilience
H7: The relational buyer-supplier governance mechanism mediates the effects of a Gray Swam on firm resilience

3.3. Risk Management

All firms are exposed to risk. Conversely, all firms can mitigate their vulnerability to risk. However, organizations do as little as possible to reduce exposure to risk (Cyert & March 1963, 2013). Organizations avoid the requirement that they can correctly (or statistically) anticipate "distant" future events by using decision rules. They tend to emphasize short-term planning (Cyert & March 1963, 2013). Organizations seek to reduce environmental uncertainty by creating or arranging 'negotiated environments' (Cyert & March 1963, p. 119). For example, an organization may insist on a transactional arrangement – either output-based or outcome-based to reduce environmental uncertainty. Organizations may also engage in isomorphic behaviors such as utilizing industry-wide practices to reduce environmental uncertainty (Cyert & March 1963).

Applying "best-practices" may work during evolutionary periods, but expose organizations to significant vulnerability during revolutionary periods (Gersick, 1992). Supply chain vulnerability may be defined as the exposure to a serious disturbance that has the propensity to outweigh risk mitigating strategies (Wagner & Neshat, 2010). These authors developed the Supply Chain Vulnerability Index to measure industry vulnerability to a supply chain event. Risk may also be viewed in the context of performance. For example, Singh, Jain, & Mishra, (2009) note that "risk based on firm performance is the distribution of possible outcomes in a firm's performance over a given time horizon due to changes in key underlying variables. The greater the dispersion of possible outcomes, the higher the firm's level of exposure to uncertain returns." The returns can have either positive or negative consequences. The organization's sensitivity to risk is a funtion of several factors: (1) the significance of its exposures to changes and events; (2) the likelihood of those different changes and events occurring; and (3) its ability to manage the business implications of those different possible future changes and events, if they occur" (Singh et al., 2009).

The most recent amendment to ISO 31000 defines risk as the "effect of uncertainty on objectives." An effect is a positive or negative deviation from what is expected. When considering risk and engaging in risk analysis we are forced to ponder a number of questions. In the literature, it is asserted that risk analysis consists of an answer to the following three questions: (1) What will happen? (2) How likely is it that (the expected thing) will happen? (3) If it does happen, what are the consequences? (Singh et al., 2009). In their treatment of risk in the supply chain, Wagner & Bode (2009) and Marley, Ward, & Hill, (2014) identify five distinct

classes of risk: (1) demand-side risk; (2) supply-side risk; (3) regulatory, legal and bureaucratic risk; (4) infrastructure risk; and (5) catastrophic risk. Each type of risk requires a different response. To survive in a risky business environment, companies must practice proper risk management (Pujawan & Geraldin, 2009). To mitigate and manage risk, companies should become familiar with the Supply Chain Risk Management Process (SCRMP) which identifies the various phases of risk (Tummala & Schoenherr, 2011).

In their study, Tummala & Schoenherr (2011) outline the steps in the risk management process: (1) risk identification – which involves a structured and comprehensive assessment of potential supply chain risk; (2) risk measurement – which involves determining the consequences of all potential supply chain risk and their magnitudes of impact; (3) risk Assessment – which is concerned with determining the likelihood of each risk factor; (4) risk evaluation – which involves the sub-steps of risk ranking and risk acceptance; (5) risk mitigation and contingency plans – which involves developing response actions plans; and (6) risk control and monitoring – which involves overseeing the entire risk management process to ensure that everyone involved is following the approved risk strategy (Tummala & Schoenherr, 2011). In the proposed research model, I focus on two aspects of the risk managment process: (1) Risk Identification; and (2) Risk Assessment, i.e. Analysis.

In addition to applying the SCRMP, firms must consider another critical factor – recovery from a disruption. Companies should utilize Simchi-Levi et al.'s (2014) "Time to Recovery" (TTR) and "Risk Exposure Index" to assess how long it would take for a particular node in the supply chain to be restored to full functionality after a disruption. TTR is often an overlooked

factor in disruption risk and risk management studies. In this dissertaion, risk is examined in the context of a man-made disruption. These are Gray Swans. The following tables (4 – 8) present the various types of risks discussed in the literature.

3.3.1 Categories of Risk

Tummala & Schoenherr (2011) discuss various kinds of risks (see Table 4 below). What are labeled Gray Swans in this dissertation, Tummala & Schoenherr (2011) treat as separate kinds of risks. e.g. Labor disputes are considered disruption risks (NB. port strikes are viewed as a form of labor dispute and not listed as a transportation risk.). Political instability is treated as a sovereign risk and the focus is on regional stability. While I view political instability in the context of an unplanned change in government, Tummala & Schoenherr (2011) discuss sovereign risk in the context of regional stability. Finally, the authors treat supply chain partner insolvency in the context of supply (procurement) risk. In this dissertation, supply chain partner insolvency is treated as a Gray Swan.

Table 4 –
Categories of Risk

Disruption Risk	Natural Disasters Terrorism and wars Labor Disputes
Sovereign Risks	Regional instability Communication difficulties Government regulations
Transportation Risks	Port Strikes (NB. Port strikes are derived from labor disputes)
Supply (Procurement) Risks	Supplier bankruptcy
Delay Risks	Port capacity and congestion Custom clearances at ports
Demand Risks	Order fulfillment errors Inaccurate forecasts due to longer lead times
Inventory Risks	Cost of holding inventories

	Demand and supply uncertainty
Manufacturing (Process) Breakdown Risks	Poor quality
System Risks	Information infrastructure breakdowns Lack of compatibility in IT platforms among SC partners

Adapted from Tummala & Schoenherr (2011)

Christopher & Peck (2004) cover several categories of risk (see Table 5 below). The authors view labor strikes and socio-political and economic events as environmental risk. While socio-political and economic events occur in the firm's operating environment, labor strikes are well within the firm's sphere of influence. Since these events have a history, i.e. they have occurred before, it is posited that firms should develop strategies to mitigate the effects of these disruptions.

Table 5 –
Categories of Risk - Expanded

Supply Risk	Process Risk	Demand Risk	Control Risk	Environmental Risk
Potential or actual disturbances to the flow of product or information Interdependencies between upstream suppliers and the focal firms	Risk that affect the sequence of value-adding and managerial activities	Potential or actual disturbances to the flow of product or information Interdependencies between upstream and downstream firms	Risk arising from the misapplication of rules, systems and procedures of the firm	Direct action, i.e. labor strikes Extreme weather or natural disasters Socio-political, economic or technological events

Adapted from Christopher & Peck (2004)

Kleindorfer & Saad (2005) focused on two types of risk: (1) operational risk; and (2) environmental risk. The authors treat labor disputes as an operational risk and political instability as an environmental risk. Treating political instability as an environmental risk is consistent with

Christopher & Peck's (2004) and Samvedi et al.'s (2013) treatment. However, labor disputes or strikes are treated as Gray Swans.

Table 6 –
Disruption Risk Management

Operational Risks	Environmental Risks
Equipment malfunctions Unforeseen discontinuities in supply Human centered issues from strikes to fraud	Natural hazards Terrorism Political Instability

Adapted from Kleindorfer & Saad (2005)

Manuj & Mentzer (2008) discuss several kinds of risk that are prevalent in the global supply chain (see Table 7 below). With the exception of survival risks which is related to bankruptcy, the authors do not address Gray Swan specific risks.

Table 7 –
Global Supply Chain Risks

Currency Risk
Transit time variability
Forecasts
Quality
Safety
Business disruption
Survival (bankruptcy)
Inventory (and tools) ownership
Culture
Dependency and opportunism
Oil price fluctuation
Risk events affecting suppliers and customers

Adapted from Manuj & Menzter (2008)

Marley, Ward & Hill (2014) adapted Wagner & Bode (2008) risk categories (see Table 8 below) to discuss the various kinds of risks that affect supply chain performance. The authors do not list any Gray Swan risks.

Table 8 –
Categories of Risk that Impact Supply Chain Performance

Demand-side risk
Supply-side risk
Regulatory, Legal and Bureaucratic risk
Infrastructure risk*
Catastrophic risk

Adapted from (Marley et al., 2014)

In their case study of risk in the Brazilian automotive and electronic industries, Blos, Quaddus, Wee, & Watanabe (2009) classified risks in two areas: (1) supply and demand; and (2) environmental, political, process, and security risks. The authors note that it is difficult to quantify political and environmental risks. They also note that security risks are highly unpredictable and are of grave concern for a firm. I extend and amplify the authors' classification (See Table 5). In their discussion of risk, Samvedi et al. (2013) use an integrated approach to quantify and classify supply chain risks in four categories: (1) Supply risk – which are downstream operating risks; (2) Demand risk – demand and supply fluctuations which can affect the firm; (3) Process risk – which are associated with the firm's internal processes; and (4) Environmental risk – which are risks external to the firm's operations, but can affect the supply chain. The authors classify Supplier insolvency as a Supply Risk; Labor strike as a "Process Risk" and Political Instability as an "Environmental Risk." The authors integrate their fuzzy Analytical Hierarchical Process and Technique for Order Preference by Similarity Ideal to the

Solution (TOPSIS) to quantify risks. I classify supplier insolvency, labor dispute and political instability, collectively, as Gray Swans and assert that these types of risks are not predictable and quantifiable. I believe this classification of risks makes it easier for practitioners to understand those particular kinds of risks that, in a global context, pose a significant threat to the firm's ongoing operations. I believe these risks deserve closer treatment because they are often overlooked in the supply chain and often have deleterious consequences for the firm. For example, if contractors with the Rana Plaza firm had been aware their firm had not passed or initiated several fire inspections, it is possible the fire would be as deadly as it was (Jacobs & Singhal, 2017).

Samvedi and colleagues label "terrorism" as an "environmental risk". I classify terrorism as a Black Swan – an unpredictable but catastrophic event. There is some discussion across the disciplines on how to classify terrorism. The authors also classify "natural disasters" as an environmental risk. I classify this type of risk as a Black Swan for the same reason – they are unpredictable and catastrophic. Some of the risks listed in the categories by Samvedi and colleagues are especially broad (Samvedi et al., 2013). For example, *outsourcing risks* encompasses supplier insolvency, labor strike, and political instability. Quality problems may also be a risk in outsourcing. A number of the other risks in Samvedi et al.'s (2013) classification may be regarded as "White Swans" which I view as normal business operating risks, e.g. machine failure; technology changes, quality; quality problems; and sudden hike in costs (See Figure 4). In their highly influential work on supply chain resilience, Sheffi & Rice (2005) classified "loss of key supplier" and "labor unrest" as high probability events with severe

consequences. The authors regard port closures as a high probability event with low consequences. However, the port strike on the U.S. West Coast in 2015 which was the result of a largescale strike had a significant impact on the U.S. economy (see Oke, 2016). Both Blos et al. (2009) and Sheffi & Rice (2005) created Vulnerability Frameworks. However, whereas Sheffi & Rice (2005) focused on the probability of consequences of certain types of risk, Blos et al. (2009) focused on four areas of vulnerability: (1.) financial vulnerability; (2) strategic vulnerability; (3) hazard vulnerability; and (4) operations vulnerability and incorporates several of the risk factors addressed in Sheffi & Rice's (2005) discussion. I select political instability, labor disputes and supplier insolvency for detailed examination given their low probability and severe consequences when they do occur. In light of the foregoing discussion, I posit the following hypotheses which I do not test in this dissertation:

H1: The impact of a Gray Swan is negatively related to a firm's risk management system.
H2: The firm's risk management system is positively related to operational performance.
H3: The relational buyer-supplier relationship is positively related the firm's risk management system.
H4: The transactional buyer-supplier relationship is positively related the firm's risk management system.
H5: The firm's risk management system is positively related to operational performance.
H6: The impact of a Gray Swan on operational performance is mediated by the firm's risk management system.
H7: The impact of the relational buyer-supplier governance mechanism on operational performance is mediated by the firm's risk management system.
H8: The impact of the transactional buyer-supplier governance mechanism on operational performance is mediated by the firm's risk management system.

3.4. Resilience

Organizational resilience refers to an entity's ability to respond to and recover from unexpected disruptions in the external environment so that it emerges "more strengthened and resourceful"

(Bui et al., 2019; Brueller et al. 2019; Schriber et al., 2019). Organizational resilience is derived from "the aggregated human capital, knowledge stock, and work processes that enable the organization to cope with and adapt to environmental jolts" (Brueller et al., 219, p. 724). In this dissertation, I utilize "firm" to refer to a "complex organization encompassing multiple individuals" rather than merely an economic organization pursuing specific objectives (Grant, 1996). Following Grant (1996, p. 109), I view an organization as "a body of knowledge about the entity's circumstances, resources, causal mechanisms, objectives, attitudes, policies, and so forth." The author views a firm's primary role as 'the application of knowledge to the production of goods and services" (Grant, 1996, p. 112). Resilience is defined as "the process by which individuals are able to positively adapt to substantial difficulties or hardships (Fisher et. al., 2019, p. 542). The authors note there are three aspects of resilience discussed in the literature: (1) There must be some adversity facing the individual; (2) There must be some evidence of positive adaptation; and (3) There must be some process through which individuals respond to and recover from adversity (Fisher et al. 2019). In a similar manner, I argue that firms face these three determinants of resilience. In light of the foregoing, and in context of a Gray Swan, I define firm resilience as the process by which organizations successfully respond to and recover from disruptions in their task environment (Fisher et al., 2019; Lawrence & Lorsch, 1967).

Companies respond effectively and efficiently to different types of uncertainties and demands differently based on their organizational capabilities (Fayezi, Zutshi & O'Loughlin, 2017). While all companies face risks of some sort, some companies respond better and prove to be more resilient than their competitors at recovering from a risk. This situation prompts the

question raised by van de Vegt and colleagues in an editorial "Why do some organizations and societies successfully adjust and thrive amid adversity while others fail to do so?" (van der Vegt et al., 2015, p. 971). Firm success and survival depend on the entity's ability to successfully respond to and recover from unforeseen risk events and unexpected disruptions (Schriber et al. 2019). In their study, Fisher et al. (2019) discuss four categories of variables relating to resilience: (1) adversity triggers; (2) resilience outcome; (3) resilience mechanisms; and (4) resilience promoting factors. The risk of a Gray swan may be viewed as an adversity trigger given its potential to cause disruption and disequilibrium in the firm's supply chain. Firm performance may be regarded as a resilience outcome. A firm's risk management system may be regarded as a resilience mechanism. Finally, organizational learning may be regarded as a resilience promoting factor.

I discuss resilience in an OM context in this dissertation. However, discussion on resilience has occurred most often in the psychology and sociology literature with a focus on individuals (Brueller et al. 2019; Fisher et al. 2019). Despite extensive discussion, there is still some disagreement in the literature on the meaning of resilience in an organizational context. Most recently, some scholars have begun investigating organizational resilience (see Brueller et al. 2019; Fisher et al., 2019; Schriber et al. 2019 for further discussion). As Coutu (2002) notes resilient people possess three characteristics: a staunch acceptance of reality; a deep belief, often buttressed by strongly held values, that life is meaningful; and an uncanny ability to improvise. You can bounce back from hardship with just one or two of these qualities, but you will only be truly resilient with all three. These three characteristics hold true for resilient organizations as

well. Given the foregoing, I regard a resilient organization as one that has the ability to withstand an adverse event and respond in such a way that it successfully maintains its ongoing operations (Fisher et al. 2019).

Some organizations may survive and thrive amid adversity because of their adaptive capacity. Van der Vegt et al (2015) suggest that adaptive capacity might be construed as the time it takes for a system to recover adverse events. A firm's adaptive capacity ensures its resiliency. The robustness of a firm's supply chain can reduce its exposure to disruptions and increase its time to recovery (van der Vegt et al., 2015). This can be accomplished by focusing on four factors: (1) the absorptive capacity of a society; For example, there is evidence that the absorptive capacity of the United States and many other developed economies would permit companies to recover from adverse risk events sooner than some other emerging, undeveloped or underdeveloped economies; (2) the organizational structure; (3) operational strategy; and (4) structure of the top management team (TMT).

Secondary data sources can provide information on how organizations respond to adverse risk events. These data sources may provide a baseline of companies 'normal' operating procedures and highlight how the risk event forces the company to divert from its normal operating procedures. Secondary sources can provide researchers with the "before", "during" and "after" aspects of companies' behavior. Van der Vegt (2015) suggest two approaches for studying companies' resilience (vulnerability, robustness and recovery): (1) researchers can conduct an experiment where disasters or other adverse events are simulated; or (2) researchers can conduct an "interrupted time-series" investigation where they would collect longitudinal data

about an entity's performance. Firms may achieve and maintain resilience through agility and flexibility. Agility may be defined as "a strategic ability that assists organizations to rapidly sense and respond to internal and external uncertainties via effective integration of supply chain relationships" (Fayezi et al., 2017). Flexibility may be defined as "an operational ability that assists organizations to change efficiently internally and /or across their key partners in response to internal and external uncertainties via effective integration of supply chain relationships" (Fayezi et al., 2017). The authors do not indicate "how" organizations acquire this ability or why agility should be considered an ability. It has been advanced in the literature that firms acquire agility through inter-organizational learning which is determined by the kind of relationship – transactional or commitment – that exists between buyer and seller in a supply chain (Carmeli et al., 2016). Moreover, why are organizations facing internal uncertainties? It is expected and understandable if organizations face external uncertainties. However, that should not be the case internally. This suggests that the organization has structural issues that may hamper its long-term viability. Institutional inertia may also be a factor determining organizational resilience (Hannan & Freeman, 1977, 1984). During evolutionary periods, firms rely on institutional structures to maintain equilibrium (Gersick, 1992)

Agility and flexibility are not extremes on a continuum, nor are they interchangeable terms. Fayezi et al (2017, p. 380) supply chain agility and flexibility while related to organizational agility and flexibility are fundamentally different in terms of key drivers and operational focus. Moreover, agility is derived from flexibility (Fayezi et al., 2017). I argue that agility and flexibility are co-mingled strategic operational processes that enable an organization

to effectively respond to environmental contingencies while preserving organizational capabilities. Carmeli et al (2016) note that the buyer-supplier relationship is disaggregated into strategic and operational perspectives. “In the end, supply chain risk is not just about hurricanes and wildfires. It can also stem from human factors, like ineffective quality assurance processes, faulty building inspections or labor disputes. A market crash could knock the ground out from under a resilience plan any day” (Lopez, 2017).

H8: The impact of a Gray Swan in the supply chain is negatively related to operational performance., i.e. A Gray Swan has a negative effect of operational performance.
H9: The relational buyer-supplier governance mechanism is positively related to operational performance.
H10: The transactional buyer-supplier governance mechanism is positively related to operational performance.
H11: Firm resilience is positively related to operational performance.
H12: The impact of the relational buyer-supplier governance mechanism on operational performance is mediated by firm resilience.
H13: The impact of the transactional buyer-supplier governance mechanism on operational performance is mediated by firm resilience.

3.5. Operational Performance

Research on firms’ operational performance (OP) relative to SCM practices and other variables has produced mixed results (Duong et al., 2017). The authors define OP as “the ability of a company to reduce management costs; order-time lead-time; raw materials inventory, and distribution capacity (Duong et al., 2017, p. 181). OP is defined differently across the literature. However, cost reduction and reduction of lead time and order time appear to be consistent in many of the definitions (See Wong et al., 2011; Danese & Bortolotti, 2014; Shou et al., 2018). Hong et al (2019) examine SCQM practices and capabilities affect a firm’s innovation and operational performance. The authors define SCQM capabilities as a multidimensional construct

that encompasses three dimensions: quality information exchange capability, quality cooperation and integration capability, and supply chain responsiveness capability (Hong et al. 2019, p. 228). I view a firm's supply chain responsiveness capability as an indicator of its ability to respond to a Gray Swan.

Performance, as an abstract construct, has been and remains a recurrent theme in the broader Management literature (Venkatraman & Ramanujam, 1986). However, what measures actually determine business performance is still an unresolved empirical issue. In a recent Guidepost article, Barney (2020) called for strategic management scholars to develop empirically testable measures of the firm performance the encumbered a broader conceptual understanding of the firm (Barney, 2020). In their discussion, Venkatraman & Ramanujam (1986) provided a classificatory scheme for measuring firm performance. These authors conceptualized three domains of performance: (1) a financial performance domain; (2) a financial and operational performance domain; and (3) an organizational effectiveness domain (Venkatraman & Ramanujam, 1986, p. 803). This study is concerned with the second domain, with a particular emphasis on operational performance which the authors suggest consists of nonfinancial indicators such as product quality, new product introduction, and manufacturing value-added, among other indicators (Venkatraman & Ramanujam, 1986).

Operational Performance is viewed either as a unidimensional construct (see Yu et al., 2014; Shobayo, 2017) or as a multidimensional construct (see Miguel & Brito 2011, among others). There is very little consistency in the literature. In the operations management (OM) literature discussion of operational performance focuses on the several dimensions. Some studies view

operational performance as a second order construct consisting of four dimensions: cost, delivery, quality, flexibility (see, Miguel & Brito 2011; Prajogo et al., 2012; Yu et al., 2014a; Yu et al., 2019); delivery, production costs, product quality, and production flexibility (see Wong et al., 2011; Shou et al., 2018); or five dimensions: customer service, cost management, quality, productivity, and asset management (see Inman et al., 2011); or quality improvement, cost reduction, on-time delivery, lead time reduction, and the ability to quickly respond to customer requests (see Shi & Liao, 2015, p. 945); or quality, delivery, flexibility, cost, and customer service performance (see Kauppi et al., 2016). In other studies, flexibility is treated as a separate construct not related to operational performance (see Shobayo, 2017). Following Yu et al (2014) I regard Operational Performance as an aggregated construct to avoid inconsistencies of interactions among the various dimensions and our antecedent variables. I operationalized the construct based on the items on the questionnaire which are presented below. These items utilize a 7-point Likert scale.

1. improved flexibility of processes
2. improved existing product quality
3. improved overall efficiency of operations
4. reduced total cost of acquisition/ownership
5. reduced lead time for delivery

Operational performance is also related to operational efficiency which focuses on quality, cost, delivery and flexibility (Prajogo et al. 2012, Hong et al. 2019). This research asserts that operational performance will be negatively affected by a Gray Swan.

3.6. Summary of Chapter

In this chapter, I outlined the theoretical basis of this dissertation examining the relationships among the various constructs. In the next chapter, I present the survey instrument based on a review of the literature and conducted several pilot studies to validate the constructs in this study. I have conducted a larger study to test the scale. Although some of the variables in the dissertation have been addressed in the literature, they have not been investigated in this manner – i.e. in the context of a Gray Swan. This dissertation sheds some light on this low probability, but highly disruptive event.

CHAPTER IV

RESEARCH DESIGN AND METHODOLOGY

4.0. Introduction

The methodological approach used to collect data for this study was a through a web-based approach sampling a cross-section of supply chain managers and executives (Hoffman et al., 2013). I utilize both exploratory and confirmatory analysis thus assuring fidelity of the data (Tukey, 1980). I am interested in understanding how companies affected by these types of disruptions, mitigate or manage them to maintain resilience. I investigated several research methodologies, e.g. survey research, case study and following other researchers, (Babbie, 1995; Krippendorf, 2004a; Tangpon (2011) determined that a survey would be more practical and pragmatic for the study. Conducting a survey can sometimes costly and time consuming. I also utilized content analysis to obtain content validity of the constructs. Seuring & Gold (2012, p. 546) define content analysis as "a research technique for the objective, systematic, and quantitative description of the manifest content of communication." Content analysis allows researchers to convert large amounts of publicly available data into suitable information needed for a study (Montabon, Sroufe & Narashimham, 2007). This approach also allows researchers to focus on any particular unit of analysis, e.g. individual or institutional, and allows them to draw inferences that can be corroborated with other data collection methods (Montabon et al., 2007). I employ and integrate two related theoretical frameworks to guide the development and operationalization of the constructs.

In the literature, there are two established approaches for performing content analysis: latent and manifest (Dooley, 2016; Seuring & Gold, 2012). I utilize Latent Semantic Analysis (LSA) in this study. LSA has utilized most often in operations management studies (see Duriau, Reger, & Pfarrer, 2007; Kulkarni, Apte, & Evangelopoulos, 2014). The methodology has been described as an approach where the research reads the relevant texts and responds to the research question with a textual response (Dooley, 2016). Other researchers note that latent content analysis is used to excavate the underlying meaning of terms and arguments in the document under review (Seuring & Gold, 2012). The other approach, Manifest Content Analysis (MCA) relies on statistical methods (Seuring & Gold, 2012) and the use of computer software (Dooley, 2016). Content analysis is usually conducted using various software programs, e.g. NVivo and Atlas ti. Because I had a small sample of articles, I conducted a manual analysis of the documents. Manual content analysis of documents has been utilized extensively in operations research (see Lee & Lee, 2006; Redman & Matthews, 1997; Sodhi & Son, 2010).

4.1. Conceptual Domain

Numerous conceptual models have been utilized in the supply chain risk management literature to explain the effects of certain risks on supply chain resilience (Kleindorfer & Saad, 2005; Jiang, Baker & Frazier, 2009; Knemeyer, Zinn & Eroglu, 2009; Ellis, Shockley & Henry, 2011; Behdani et al., 2012; Chowdhury & Quaddus, 2017). However, despite an ever-growing body of literature, discussion of Gray Swans, except for limited investigation by Akkermans & Van Wassenhove (2013), has remained largely silent. To engage in empirical research requires the use of clearly defined constructs and scales to measure them (Froehle & Roth, 2004). Poor

construct definition makes it difficult to correctly specify how the construct should relate to its measures (MacKenzie, 2003). Further, model misspecification can negatively impact construct and statistical conclusion validity and may also undermine the credibility of the study's hypotheses (MacKenzie, 2003). In defining the constructs, I followed Suddaby's guidance for establishing construct clarity (Suddaby, 2010). A good definition should accomplish three goals: (1) It should effectively capture the essential properties and characteristics of the concept or the phenomenon; (2) It should avoid tautology or circularity, i.e. it should avoid using the construct in the definition; and (3) It should be parsimonious (Suddaby, 2010:347).

This dissertation focuses on interconnected firms in uncertain environments, and how they respond to and recover from Gray Swans. I utilize prior literature to theoretically define the constructs, define the operational measures and guide the scale development process (Froehle & Roth, 2004). I define and describe each of the constructs in the model in the next section.

4.2. Development of Constructs

Scale development is an iterative process of constant refinement of multi-scale items to devise constructs useful for measuring variables of interest in research (Froehle & Roth, 2004). I followed the standard scale development process established in the literature (see Churchill, 1979; Spector, 1992; Hinkin, 1995; Bagozzi et al., 2017) for further discussion. I reviewed the scale development literature in Marketing literature (see Churchill, 1979; Sweeney & Soutar 2001; Rossiter, 2002) and Operations Management (Ambulkar et al. 2015; Hensley, 1999 among others) to develop items to measure the constructs. I adapted Froehle & Roth's (2004) methodological steps as well as others in the literature (see Churchill, 1979; Ambulkar et al.,

2015) for scale development (see Figure 5) because I found it to be more comprehensive than some others used in the OM literature. I also utilized aspects of procedures developed by Forza (2002) and Spector (1992). Other scale development approaches such as those used by MacKenzie (2003) and Turker (2008) were also helpful.

Scale development is vital to empirical research in operations management (Froehle & Roth, 2004). Valid and reliable scales enable researchers to more accurately measure the construct under investigation. I reviewed scales used in the following literatures and adapted with revision or created new items for the scale items used in this study: (1) Risk (Jüttner et al., 2003; Peck, 2005; Manuj & Mentzer, 2008; Narasimhan & Talluri, 2009; Neiger et al., 2009; Blome & Schoenherr, 2011; Tummala & Schoenherr, 2011); (2) Disruptions (Hendricks & Singhal, 2003; Hendricks & Singhal, 2005; Kleindorfer & Saad, 2005; Craighead et al., 2007); Resilience (see Sheffi & Rice, 2005; Ambulkar et al., 2015; Van der Vegt et al, 2015; Chowdhury & Quaddus, 2017); and the (3) Buyer-Supplier Relationship (see Petersen et al., 2008; Grotsch et al., 2013; Chaurasia, 2014; Bai et al. 2016; Cameli et al., 2016; Hajmohammad & Vachon, 2016). I utilized exploratory and confirmatory factor analysis to validate the new constructs. The final reduced scale achieves the attribute of parsimony and is valid and reliable for further empirical research in Supply Chain Risk Management (Forza, 2002; Froehle & Roth, 2004). Some of the items in the new scale used in this study have been validated in previous research. (See Table 9 below). For example, Grötsch et al. (2013) in their study validated the Relational Buyer-Supplier Relationship construct - $\propto$ = .763, composite reliability = .831 and AVE = .553. However, the items used to validate the construct differ completely from the items

used to validate the construct for this dissertation. Items used by Grötsch et al (2013) included: *"joint problem- solving philosophy"* and "*dependency on supplier."* Ambulkar et al. (2015) in their study also validated the Firm Resilience - $\propto$ =.85 and Risk Management - $\propto$ = .91- constructs. Items for the Risk Management construct included "*We have a department to manage supply chain risk and disruptions."* Items for the Firm Resilience construct included: "*we are able to cope with changes brought about by the supply chain disruption."* In the literature, there is discussion of output-based and outcome-based contracts in the buyer-supplier relationship (see Eisenhardt, 1989). Rather than attempting to validate output-based and outcome-based contracts, I viewed then as second order constructs of the Transactional Buyer-Supplier Relationship construct.

Table 9-
Development of Scale Items

Construct	Measures	Literature
Gray Swans	1. Labor Disputes 2. Political Instability 3. Supply Insolvency	Grotsch et al (2013) Kolay et al. (2016) Finley (2009) Babich et al. (2007) Weber et al (2002)
Buyer-Supplier Relationship	1. Relational Buyer-Supplier Relationship 2. Transactional Buyer-Supplier Relationship	Chaurasia (2014) Petersen et al (2008) Grötsch et al (2013) Carmeli et al (2016)
Supply Chain Resilience	1. Response 2. Recovery 3. Readiness	Sheffi & Rice (2005) Christopher & Peck (2004) Chowdhury & Quaddus (2017)

		Van de Vegt et al. (2015)
Risk Management Framework	1. Risk Assessment 2. Risk Identification 3. Risk Analysis 4. Risk Evaluation 5. Risk Treatment 6. Risk Avoidance	Neiger et al (2009) Peck (2005) Tummula & Schoenherr (2011) Manuj & Mentzer (2008)

Some items in the scale may be viewed as worded negatively and may need to be recoded. I did not reverse score any items in the scale nor did I use any attention checks. Kung et al. (2017) in their discussion about the use of attention checks in survey research suggested that the use of such devices had the [un]intended effect of causing respondents to engage in more social desirability. Assuming that respondents determined that they were being "fooled" they would then "game" their responses thereby affecting overall results. This would affect validity. I took a cautionary approach and decided not to use any attention checks. I also decided, following the logic of Tukey (1977) not to remove any outliers from the data set. I believe this approach allowed me to capture any unaccounted-for variance in the constructs. I discuss each construct more formally in this section. I was able to establish content validity for the constructs through content analysis and by enlisting a small group of industry experts to review the instrument.

4.3. Gray Swans

Gray Swans have the potential to significantly disrupt a firm's operations and may even affects a firm's viability (Akkermans & van Wassenhove, 2013; Ricci & Sheng, 2017). These risk events should meet the following criteria: (a) history – the event must have occurred before (longer than the recent past); (b) low probability – I assume the probability of a Gray Swan to be between 01 and .05; (c) extremely costly – can threaten the viability of an organization; (d) human-induced – are the result of a man-made disruption; and (e) internal or external to the supply chain. Further, whereas Pearson & Clair (1998) examined adverse events such as floods, hurricanes, earthquakes and other types of man-made or natural disasters (i.e. hazards[7]) as external to the system, I view Gray Swans as events within the supply network that should be expected to occur given certain historical trends.

Since the Gray Swan construct is relatively new to the field and has not been adequately operationalized in OM research, I followed suggestions in the literature to establish validity for the construct (Ambulkar et al., 2015). These procedures are discussed extensively in Lawshe, (1975) and Anderson & Gerbing (1991). I focus on three types of Gray Swans: labor dispute, supplier insolvency and political instability. I discuss each of these in greater detail below. I

[7] Applying the Sendai Framework, the UN Office for Disaster Risk Reduction (UNDRR) formerly known as the UNIDCR prefers the term "hazard" rather than disaster. The organizations assert that natural hazards can become disasters.
The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk, but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. Retrieved from: https://www.unisdr.org/l/coordinate/sendai-framework

assert that the following factors can be considered antecedents to Gray Swans: (1) hubris – assuming that since nothing has gone wrong; nothing is going to go wrong, (2) institutional (or individual) inertia – the policies and procedures and more bureaucratic than organic and managers preserving the status quo, (3) Managerial Myopia – managers do not engage in boundary spanning and focus internally, and (4) organizational culture – the pattern of basic assumptions, invented, discovered or developed by a given group as it learns to cope with its problems of external adaptation and internal integration that has worked well enough to be considered valid and therefore is to be taught to new members as the correct way to perceive, think and feel in relation to those problems (Schein, 1988, p. 7). Possible reasons for Managerial Myopia and Institutional Inertia may include: (1) lack of specific training and education or managers; structural organizational changes threatened, (2) managers' personal position, (3) managers' power, and (4) Managers' psychological security (Chandler, 1962). I assert that managers' ability to spot a Gray Swan requires them to have some knowledge and an entrepreneurial outlook (Chandler, 1962).

I developed – either directly or from revising established items – scale items for each type of Gray Swan after examining scale items in articles that were investigating the same of a similar issue. (see Wagner & Bode, 2006; Babich et al., 2007; Finley, 2009; Grotsch et al., 2013; Kolay et al., 2016). Responses were scored on a 7-point Likert scale from *Strongly Disagree* to *Strongly Agree* because a larger range of choices may reduce the risk of extreme values. The initial scale used in the study will be referred to as Scale I and is presented in the Appendix A.

4.3.1. Labor Disputes

This contingency represents one dimension of the larger Gray Swan construct. I define a labor dispute as an impediment to normal business operations where employees of the focal firm or a firm in the supply chain withdraw their labor, challenge management, or quit their jobs because of procedural, monetary, social or economic issues (Sydow & Frenkel, 2013). The definition does not assume a time factor. However, it should be noted that the longer a labor disputes lasts, the greater the likelihood of a significant economic impact. The West Coast ports strike in 2002 cost the U.S. economy approximately $14 billion. Two examples of items in the Gray Swan scale are listed below:

1. Management at my firm generally responds to labor's demands.
2. Management at my firm insists that its supply chain partners pay a fair wage.

4.3.2. Supplier Insolvency

This contingency represents another dimension of the Gray Swan construct. The definition of Supply Chain Partner Viability includes aspects of Supplier insolvency and bankruptcy. I regard Supplier Insolvency as a catastrophic event that results in the supplier closing the business completely or suffering a significant operating disruption that interrupts the flow of raw materials or components to the firm's supply chain partner/s (Samvedi et al., 2013). Two examples of items in the Gray Swan scale are listed below:

1. The firm has a strategy to continue operations if a supply chain partner becomes insolvent.
2. The firm has a strategy to continue operations if a supply chain partner files bankruptcy*

4.3.3. Political Instability

I view political instability from a macroeconomic perspective given its destabilizing effects on economy. I define political instability as a change in the executive power by constitutional or unconstitutional means which results in a severe disruption in the normal operation of a government and threatens the economic development of that country (Alesina et al., 1996). The following factors are indicative of political instability: (1) currency devaluations or erratic fluctuations, (2) trade sanctions or embargoes, (3) reduced economic activity, i.e. lower GDP; destruction or disruption of infrastructure, and reduced free market policies.). Two examples of items in the Gray Swan scale are listed below:

1. The firm has operations in countries with escalating border tensions.
2. The firm has operations in countries that are subject to economic sanctions.

4.3.4. Risk Attitude

A firm's exposure to risk is a function of the managers' attitude toward risk. Some managers are risk averse; other risk neutral, while some managers are risk takers. I defined Risk Attitude as a firm's propensity to avoid or accept risk (Heckman et al. 2015). Items were developed based on existing scales in the literature. Responses scored on a 7-point Likert scale from *Strongly Disagree* to *Strongly Agree.* Two examples of items in the Gray Swan scale are listed below:

1. The managers at my firm always assess risk before making decisions.
2. The managers at my firm use all available information before making decisions.

4.3.5. Buyer-Supplier Relationship

The Buyer-Supplier Relationship denotes the degree to which buyers and suppliers promote behaviors that maintain or improve their relationship (Tangpong, 2011, p. 632). I focus on two aspects of the buyer-supplier relationship – Relational Buyer-Supplier Relationship (RBSR) and Transactional Buyer-Supplier Relationship (TBSR). I believe that TBSRs have the following

benefits: reduction in transaction costs (safeguarding); reduction in agency costs (monitoring); and reduction in behavioral uncertainty (behavioral costs). RBSRs confer the following benefits: alignment of interests; alignment of processes; and ability to better manage more complex projects. Items for the Gray Swan scale were developed based on existing scales in the literature (Petersen et al., 2008; Grotsch et al., 2013; Chaurasia, 2014; Bai et al., 2016; Cameli et al., 2016; Hajmohammad & Vachon, 2016) and revised or reworded to fit the purposes of this research. Responses scored on a 7-point Likert scale from *Strongly Disagree* to *Strongly Agree.* Several examples of items in the Gray Swan scale are listed below:

Relational

1. The reputation with the supplier is important to achieve the organizational objectives.
2. The Top Management Team (TMT) has a close personal relationship with the TMT of the supplier/s.

Behavior-based Contract

1. The contracts contain specific technological provisions that the supplier must abide by when manufacturing the product.
2. The contracts contain specific provision that give us the right to audit the supplier's manufacturing procedure.

Output-based Contract

1. The contracts specify interim goals that I expect the supplier to achieve.
2. The contracts contain performance standards I expect the suppliers to meet in the product they supply us.

4.3.6. Firm Resilience

Organizational resilience is concerned with the entity's ability to withstand external shocks (Fisher et al., 2019). Viewed in the context of a supply chain, firm resilience is concerned with the ability of a firm and its partners in the supply chain network to respond to and recover from challenges to the viability of the formal organizational structure (Adger, 2000; van de Vegt et a., 2015). The following factors determine how quickly a firm can respond to and recover from a disruption: (1) employees who can easily adapt to the new environment; (2) executives with the right experience. e.g. does the firm have members of its TMT with supply chain management

experience? (3) organizational structure – does the firm have a mechanistic or organic structure? And, is the firm a large and complex organization or a small to medium-sized enterprise (SME)? (4) firm's capital structure – is the firm financially sound? Does the firm have access to the capital markets in the event of a disruption? Some of the factors are coping efforts while others are outcome functioning factors (Fisher et al., 2019). Items for the Gray Swan scale were developed based on existing scales in the literature and items from Chowdhury & Quaddus (2017); Sheffi & Rice, 2005; Ambulkar et al. (2015), and Van der Vegt et al., 2015) and revised to fit the purposes of this research. Responses were scored on a 7-point Likert scale from *Strongly Disagree* to *Strongly Agree.* Several examples of items in the Gray Swan scale are listed below:

Response

1. Management has a strategy for responding to disruptions.
2. The firm has a team or a manager responsible for anticipating disruptions.

Recovery

1. The firm has access to all the resources it will need to recover from a disruption.
2. The firm can recover from a disruptive event in a short period of time.

Readiness

1. The firm has the ability to detect disruptions early.
2. The firm has the resources to get ready for a disruption.

4.3.7. Supply Chain Risk Management

Supply chain risk management is concerned with the ability of an organization to detect, predict, avoid or reduce uncertainty and to develop the strategic responses to mitigate the threats that can affect its operational, market, and financial performance as Ill as environmental, safety and social outcomes. Items for the Gray Swan scale were developed based on scales in the literature and from (Jüttner et al., 2003; Peck, 2005; Manuj & Mentzer, 2008; Narasimhan & Talluri, 2009; Neiger et al., 2009; Blome & Schoenherr, 2011; Tummala & Schoenherr, 2011; Hajohammad & Vachon, 2016; ISO 31000) and revised or reworded to fit the purposes of this research.

Responses scored on a 7-point Likert scale from *Strongly Disagree* to *Strongly Agree*. * - denotes reversed scored items

Risk Assessment

1. The firm has a framework for assessing risk.
2. The firm incorporates risk assessments into its business objectives.

Risk Identification

1. The firm has a framework for identifying risk.
2. The firm is aware of the sources or consequences of risk affecting its supply chain.

Risk Analysis

1. The managers understand the nature and structure of the risks the company is facing.
2. The firm has a supply chain map of its critical suppliers.

Risk Evaluation

1. My firm has a framework for evaluating risk.
2. The managers know which risks are acceptable and which are not.

Risk Treatment

1. The firm has a framework for responding to various risk events.
2. The firm has a Business Continuity Plan to aid in recovering from a disruptive event.

Risk Avoidance

1. The managers are aware of the risk factors in the supply chain.
2. The managers are aware of the vulnerabilities that expose the firm to risks.

4.4. Scale Design and Development

Scale Development requires a significant investment of time and other resources (Spector, 1992). Good scales must satisfy several often seemingly conflicting requirements: precision, brevity and comprehensibility. Satisfying these requirements should be a necessary and sufficient condition for developing a valid scale. Precision assumes the researcher is presenting respondents with an

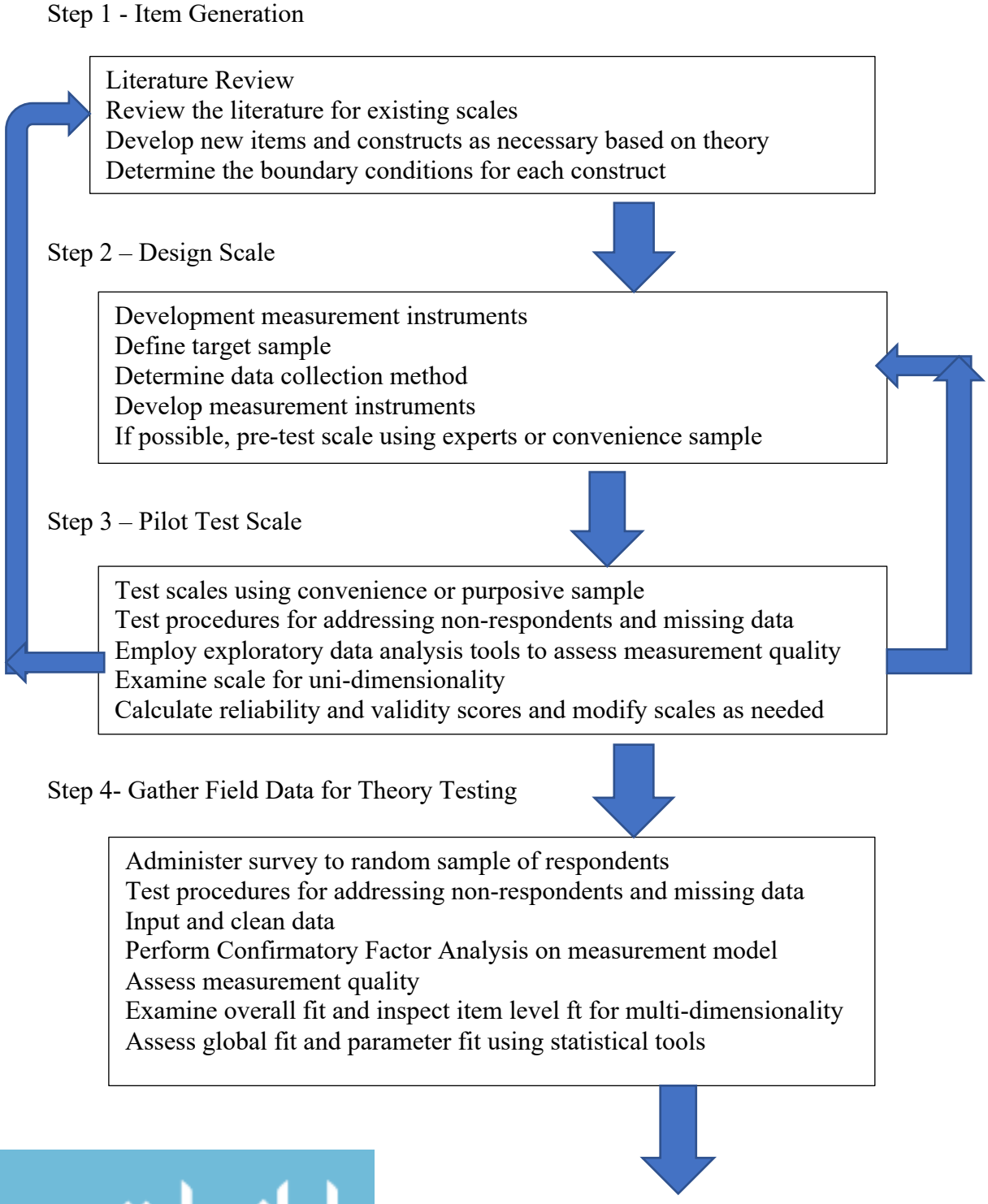
accurate statement of question of the phenomenon the researcher is attempting to measure. Precision also assumes that the researcher is presenting the respondents with closed-end questions and not asking "double-barrel questions (Churchill, 1979). NB. Double-barrel may confuse the respondent. E.g. The firm shares information about potential risks with upstream and downstream supply chain partners. Assuming a 7-point Likert scale, respondents may differ sharply in their responses depending on whether the supply chain partner is upstream of downstream. Further, precision also assumes that statement require more than as simple, "Yes" or "No" response (Churchill, 1979). E.g. The firm has a framework for identifying risk. Scale developers must be careful not to have too many binary statements in the questionnaire unless that is the expressed aim of the researcher. Brevity assumes that the statement or question is sufficiently short for the respondent to comprehend and does not "tax" the respondent's cognitive abilities. e.g. risk assessment is part of the firm's strategy, structure, policies and procedures. Finally, statements in the questionnaire must be comprehensible, i.e. intelligible and easily understood by the respondent. Note that although scale development does not require the researcher to "know the mind" of the respondent, careful design reduces incidences of social desirability (Crowne & Marlowe, 1960).

Good scales are both valid and reliable (Spector, 1992). Although a scale may be reliable, it does not mean that it is valid. For example, assume that you are test firing a 45 Automatic Colt Pistol (ACP) for approximately 75 yards. You fire three mis-aimed shots at the target completely missing the bulls-eye but hitting the target in the upper right-hand corner. Let us further assume that you reduce the distance to 50-yards and fire another three mis-aimed shots at the target

hitting it in exactly the same spot. It is reasonable to assume the weapon is reliable since the shooter hits the target consistently in the same location. However, that is not the bull-eye. So, while I can assume reliability, I cannot assume validity.

I utilized the five-step process outlined in Figure 6 below to develop the scale. The model was adapted from Churchill (1979), Chen & Paulraj, (2004); Forza (2004); Froehle & Roth, (2004); and Turker (2009). Other approaches have been suggested in the literature. For example, Hinkin (1995) proposed a three-stage approach, which mirror's Spector's (1992) model. Rossiter's (2002) six-step C-OAR-SE model is somewhat more comprehensive yet seems inadequate to the task of developing supply chain constructs. Hensley (1999) in her review of scale development in Operations Management provides excellent guidance for OM researchers seeking to develop new scales. I found Churchill's (1979) to be a suitable model and used it as the basis for the design. I believe combining these various scale development approaches offers a more comprehensive procedure. As indicated in Fig. 6, the first step in developing a multi-item scale is to generate sets of items that accurately and reliably measure the latent construct under consideration (Churchill 1979; Hinkin 1995; Froehle & Roth, 2004).

Figure 6 –
Steps in Developing a Research Scale



Step 5- Analyze Data and Generate Report

Conduct preliminary data analysis Test hypotheses Draw theoretical implications

I reviewed the literature and determined that some of the constructs, e.g. buyer-supplier relationship and resilience, have been operationalized in other studies. However, they have not been operationalized in the manner in which I utilize them in this study. For example, the Buyer-Supply Relationship construct has been operationalized in numerous studies (See Liu et al., 2009; Nyaga et al. 2010; Liu et al., 2012; Narayanan et al. 2015; Bai et al., 2016) for further discussion. However, in this study, I viewed that relationship from two perspectives – a relational buyer-supplier relationship which is based on trust and a transactional buyer-supplier relationship which encompasses outcomes and outputs. I utilized this perspective because of how the items loaded in the exploratory factor analysis (EFA). It appeared that the output-based contract items and the outcome-based contract items were measuring the same construct.

Scale development is vital to empirical research in Operations Management (Froehle & Roth, 2004). Developing valid and reliable scales enables researchers to more accurately measure the constructs under investigation (Froehle & Roth, 2004). Before beginning the scale development process, I obtained IRB approval from the university. The initial version of the scale consisted of 81 items. I sought to establish face validity by consulting a small group of industry experts to review the items in the scale. I also sought to establish content validity of the constructs by utilizing content analysis. Hinkin (1995) noted that there is no generally accepted

quantitative method of determining content validity. I followed standard procedures that are used in the literature to establish both content and face validity. Following Hinkin (1995), I utilized a deductive approach to generate items for the scale. Deductive scale development requires the researcher to possess a thorough understanding of the phenomenon through a comprehensive review of the literature (Hinkin, 1995).

4.5. Pilot Study I

I conducted a Lexis-Nexis search using terms such as "political instability and supply chain"; "bankruptcy and supply chain management"; "default and supply chain management"; "bankruptcy and supply chain risk"; "labor disputes and supply chains"; "port strikes"; "supply chain visibility" as well as other search terms to identify companies that fit my criteria. The search yielded 43 companies that have experienced events that qualify as Gray Swans. Many of these events have occurred within the last three years from the end period of the data search.

4.6. Survey

I devised the survey instrument (see Appendix A) which consisted of 81 items and posted it on Qualtrics. After the initial review, I reduced that number to 66 items because it was deemed that the initial pool of items was too large and may lead to response fatigue or nonresponse. There were five main constructs: (1) Perceptions of Gray Swans; (2) Risk Attitude; (3) Buyer-Supplier Relationship; (4) Supply Chain Resilience; and (5) Supply Chain Risk Management. Each main construct had several dimensions. For example, Perceptions of Gray Swans had three dimensions: (1) Labor Disputes; (2) Supply Chain Partner Viability; and (3) Political Instability. Buyer-Supplier Relationship had three dimensions: (1) Relational; (2) Behavior-based Contracts;

and (3) Output-based Contracts. Supply Resilience had three dimensions: (1) Response; (2) Recovery; and (3) Readiness. Finally, Supply Chain Risk Management had six dimensions: (1) Risk Assessment; (2) Risk Identification; (3) Risk Analysis; (4) Risk Evaluation; (5) Risk Treatment; and (6) Risk Control. I surveyed prospective respondents with supply chain experience including some working students in an MBA program to complete the survey. Respondents were asked to rate the items on a seven-point Likert scale ranging from "1- Strongly Disagree to 7 -Strongly Agree" and "1 - Not at all to 7- To a Very Large Extent." The respondents in the survey occupied various position within their companies. In the final data collection, I will recruit only managers, senior managers and executives to complete the survey. I loaded the data set into SPSS from Excel. The variables all loaded as Nominal. Some variables loaded as "String" variables. I changed the construct variables to scale variables. There is some discussion in the literature on whether survey items should be coded as ordinal or interval/ratio/scale variables. Initially, I decided to code the variables as ordinal since the values in the scale were "ordered" from one through seven (1-7).

Following Tabachnick & Fidell (2007) and Hair et al. (2006) I examined the data to determine if there were any variables with missing values. I performed a visual inspection of the data and noted that several cases had missing values. I performed descriptive statistics to analyze the variables with missing data. I found that of the 33 variables only 16 were valid listwise. I also found that since many of the variables were missing more than five percent of their values, I could not use the mean substitution method to replace missing values (Tabachnick & Fidell, 2007). The percentage of missing values ranged from 2.9% to 14.7%. While mean substitution

would work for those variables missing 2.9% of their values, it would not work for the others missing more than 5%. I decided to use the Multiple Imputation method in SPSS. Imputation is the process or practice of replacing missing data with plausible values (Schafer, 1999; Newgard & Haukoos, 2007). Multiple Imputation is similar to the EM approach used often in management research (Schafer, 1999). The Multiple Imputation approach makes the same assumptions about the distribution of the data as other methods. Therefore, I am confident that Multiple Imputation will generate unbiased estimates of the data. However, Multiple Imputation failed because I had coded the data as ordinal data. I coded the data as scale and then conducted the Multiple Imputation. I experienced similar problems with the Multiple Imputation. I decided to try another approach – SPSS's Missing Values Analysis.

I reviewed the dataset and removed six cases that had a significant amount of missing values – more than 10%. I then replaced the missing values using SPSS functions. After completing this process, I then had 29 valid variables suitable for data analysis. I performed a bivariate correlation of the transformed dataset and examined the relationship among the variables. I noted that some of the relationships were significant. E.g. RA1 was correlated to RA3 - .398, sig. .032 at the .05 level of significance; RAI was correlated to RA4 - .486, sig. .007 at the .01 level of significance; RA4 was correlated to RA3 - .476, sig. 009 at the .01 level of significance.

To determine if the variables were suitable for factor analysis, I examined the determinant value. In the literature, the determinant value must be greater than .0001 to establish positive definiteness. An output of less than .0001 suggests that the items are unrelated and

possibly not suitable for analysis. The output from the analysis was .000. Although, this output violates the assumption of positive definiteness, I decided to conduct some additional review of the data to determine if removing some of the items would make the data more suitable for analysis. After an extensive attempt to "fix" the data, I determined that the items were not suitable for analysis. This prompted me to revise the instrument and conduct a second pilot study (See Pilot Study II instrument in Appendix B).

Despite this revelation – nonsuitability of the data for conducting analysis - I proceeded to conduct a factor analysis to determine how the variables would load and on how many factors. I had 14 components with Eigenvalues greater than 1.0. In reviewing the factor loadings, I noted that some items loaded together which reinforced the thinking that the instrument was faulty and did not fully capture the construct I was attempting to measure. E.g. Items for risk assessment, supply chain partner viability, risk identification and risk analysis all loaded on the same factor (See Table 10 below). It makes sense that risk assessment, risk identification and risk analysis would all load on the same factor because they are all measuring risk. However, although supply chain partner viability is a measure of risk, i.e. risk of bankruptcy or default, I am not sure how these two things can be confounded in one construct. This demonstrates the lack of construct clarity and the need to revise the instrument. NB. The item for SCPV is negative.

Table 10 –
Factor Loadings

Risk Assessment2					0.883
Supply Chain Partner Viability4					-0.578
Risk Identification4					0.531
Risk Analysis3					0.5

The same issue occurred with another loading. As indicated in Table 10 below, the item for risk attitude, (RA6) loaded on the same factor as the items for supply chain partner viability (i.e. supplier insolvency).

Table 11 –
Factor Loadings

Supply Chain Partner Viability3				0.823
Risk Avoidance6				0.757
Supply Chain Partner Viability1				0.714
Supply Chain Partner Viability2				0.633

With these looming data problems, I determined to revise the instrument and conduct another pilot study.

4.7. Pilot Study II

I conducted a second pilot study to validate the constructs in the study. I had a sample of 33 respondents with supply chain experience in Pilot Study I. I had nearly double the number of respondents in Pilot Study I.

4.8. Data and Methods

To conduct the analysis, I downloaded the data from Qualtrics. Forty-six persons with supply chain experience responded to the questionnaire. I also had 16 questionnaires that were completed by individuals using a paper survey rather than the online survey. I added those respondents to the online respondents. This gave me a total of 62 respondents. I then conducted a visual inspection of the data. I noted that seven cases lacked complete data – more than 10% of the data was missing. I decided to remove these cases. One case provided demographic data only. I decided to remove this case. This left me with 53 usable responses from the survey to conduct analysis. More women completed the survey than men. The age range of the majority of participants was between 18 and 24. The majority of respondents worked for large firms - with more than 1000 employees. Except for a few responses which coded as categorical, e.g. age, gender job responsibility, the majority of variables were coded as ordinal. There is some discussion in the literature on how to code survey data. Some researchers tend to code survey data as scale data while other prefer to code survey data as ordinal data. I decided to code the data as ordinal data. I followed Tabachnick & Fidell (2007) procedures for cleaning the data. Using SPSS, I conducted a Missing Variable Analysis. I found that of the 30 cases in the survey, only two were missing three values; sixteen cases were missing only one value; seven cases were

missing two values and six cases were not missing any values. I determined since so few values were missing that it would not be necessary to perform a transformation of the data. Tabachnick & Fidell (2007:63) "note that there are no firm guidelines for how much missing data can be tolerated for a sample of a given size." The data seemed to be missing completely are random (MCAR) or missing at random (MAR). Therefore, I decided to conduct the initial analysis and examine the results for any discrepancies.

4.9. Reliability

There are several measures advanced in the literature for assessing reliability, e.g. test-retest, and split-half method (Carmines & Zeller, 1979). The most commonly used measure of construct reliability of Cronbach's alpha (Cronbach, 1955). Reliability is defined as the agreement between two efforts to measure the same trait using similar methods (Campbell & Fiske, 1959, p. 83). To establish reliability, I calculated the Cronbach's alpha (Cronbach, 1977) for each construct. The EFA produced five component factors of the coefficient matrix (See Table 12 below). I conducted reliability tests and found the following: the alpha for the Gray Swan construct was .833; the alpha for the Relational Buyer-Supplier Relationship was .858; the alpha for the Transactional Buyer-Supplier Relationship was .854; the alpha for Firm Resilience was .886; and the alpha for Risk Management System was .911.

Table 12 –
Cronbach's Alpha for Constructs

Risk Management System	Transactional Buyer-Supplier Relationship	Relational Buyer-Supplier Relationship	Gray Swans	Firm Resilience
0.798	0.854	0.858	0.833	0.911

4.10. Establishing Validity

To establish content validity, I employed a Delphi method approach by surveying several supply chain industry experts as well as academics in the field to review the items in the scale. These experts confirmed that the items sufficiently captured the various constructs in the survey. Using SPSS, I performed an exploratory factor analysis to determine the number of factors that should be extracted for analysis. I utilized the Principle Components extraction method. The rotation method was Varimax. Initially I set the threshold at .30. The values loaded on a single factor. Five factors had Eigenvalues greater than 1.0. The total amount of variance explained by these factors was 74%. The KMO was .753. The Bartlett's Test of Sphericity was significant ($p < 0.05$). In the literature, a reported KMO of .50 or greater is considered useful for analysis (see Table 12 below). To establish convergent validity, I examined the communalities and calculated the AVEs. Convergent validity is indicated when all the items of a specific construct share a high proportion of variance in common (Hair et al., 2006). All the loadings were .50 or greater indicating convergent validity. The AVEs for each construct is presented in the Table 13 below.

Table 13–
KMO and Bartlett's Test of Sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.753
Bartlett's Test of Sphericity	Approx. Chi-Square	701.542
	df	190
	Sig.	0.000

The average variance extracted (AVE) for the Gray Swan construct is 0.602 and the composite reliability (CR) is 0.809. This indicated convergent validity for that construct. The AVE for the Relational Buyer-Supplier Relationship construct is 0.515. and the CR is 0.878. The AVE for the Transactional Buyer-Supplier Relationship is 0.543 and the AVE is 0.855. The AVE for the construct Firm Resilience is 0.627 and the CR is 0.833. The AVE for the Risk Management System construct is 0.685 and the CR is 0.897. The AVEs are all greater than .5 indicating convergent validity and the CR is greater than 0.70. The factor loadings, composite reliabilities, and Cronbach's alpha are presented in the table 16 below.

Table 14–
Average Variance Extracted and Composite Reliabilities

	Risk Management System	Transactional Buyer-Supplier Relationship	Relational Buyer-Supplier Relationship	Gray Swans	Firm Resilience
AVE	0.685	0.543	0.515	0.602	0.627
CR	0.897	0.855	0.878	0.809	0.833

4.10.1. Statistical Conclusion Validity

The statistical analysis established statistical conclusion validity – which examines the correlation between independent and dependent variables. I note that in the literature, SCV is concerned with two issues which can lead to either committing Type I or Type II errors: (1) Whether the variables in question do in fact covary; and (2) the strength of the covariation (Shadish et al., 2002). While there are threats to validity in any investigation, I am confident that the analysis is minimally affected by such threats. I then changed the threshold to .40. There was cross-loading on one variable. The factor loadings are presented in Table 14 below.

4.10.2. Criterion-related validity (Predictive or External Validity)

Criterion-related validity is a measure of the relationship between the scale and surrogate measures of the construct (Hensley, 1999). It measures how well the scales in our constructs represents measures of firm resilience. Criterion-related validity was established by correlating the validity of various constructs with organizational resilience (Chen & Paulraj, 2004:134). I will utilize Pearson's correlation coefficient to assess criterion-related validity.

Table 15 –
Factor Loadings of the Component Constructs

Items	Description	Loadings	Beta Coefficient	Error variance
	Graw Swans			
GRSWN1	Sudden demise of supplier	.739	.67	.45
GRSWN2	Political instability, civil unrest or other socio-political crises	.775	.71	.50
GRSWN3	Labor disputes, ports' strikes or other labor-management issues	.814	.70	.50
GRSWN4	Changes in trade policies, tariffs, sanctions, or other macroeconomic issues	.775	.73	.55
	Relational Buyer-Supplier Relationship			
RBSR1	A close personal interaction between parties	.843	.80	.66

RBSR2	Open communications between parties	.770	.81	.64
RBSR4	Personal friendship between parties	.801	.72	.51
RBSR5	Reciprocity between parties	.793	.78	.60
	Transactional Buyer-Supplier Relationship			
TBSR1	The contract contains specific provisions that the supplier must abide by when producing the product	.78	.73	.53
TBSR2	The contract contains specific provisions that give us the right to inspect the supplier's operating procedures	.694	.69	.48
TBSR3	The contract contains specific provisions that give us the right to inspect the supplier's facilities	.673	.62	.30
TBSR4	The contracts specify interim goals that we expect the supplier to achieve	.766	.88	.78
TBSR6	The contracts specify deadlines for the supplier to deliver products.	.764	.78	.61
	Risk Management System			
RMSYS1	Engages in risk identification	.743	.71	.50
RMSYS2	Engages in risk analysis	.814	.81	.65
RMSYS4	Engages in risk avoidance	.873	.999	. 999
RMSYS5	Engages in risk control and monitoring	.874	.87	.76
	Firm Resilience			
FMRES1	Is prepared for a supply chain disruption	.686	.67	.45
FMRES2	Can recover quickly from a supply chain disruption	.849	.90	.81
FMRES3	Has the ability to respond to a supply chain disruption	.83	.93	.86

4.11. Confirmatory Factor Analysis

To determine if the model was supported by theory and good for conducting a large-scale research, I engage in the process of conducting a CFA using SPSS-AMOS Structural Equation Modeling (SEM). SEM is a statistical technique that allows researchers to examine the relationship between one or more predictor and one or more criterion variables (Tabachnick & Fidell, 2007). Initially I was concerned about conducting a CFA because SEM is a large sample technique and the sample size was quite small at 53. However, I took confidence from Bentler & Yuan (1999) who noted that SEM can be used for model estimation for sample sizes smaller than

60. After conducting an EFA, I conducted several statistical tests to ensure that I was not violating any of the assumptions for conducting a SEM. There are four basic assumptions: (1) Multivariate normality, (2) Linearity, (3) Multicollinearity, and (4) Positive definiteness (Tabachnick & Fidell, 2007). I tested the multivariate normality assumption by examining the data for outliers. I conducted a Mahalanobis D and obtained the output below (See Table 16). I then compared the Mahalanobis critical value with a probability measure to determine if any of the values were outliers. There were no outliers in the data given that none of the probabilities were less than .001.

Table 16 –
Mahalanobis Distance Test for Outliers

ID	Mah_D	Probability_MD
112	40.556	0.013
152	40.015	0.015
137	38.532	0.022
110	35.490	0.046
115	35.375	0.048
127	32.429	0.092
160	31.637	0.108
158	30.513	0.135
131	30.393	0.138
141	29.527	0.163
156	29.114	0.177
143	28.156	0.210
153	27.646	0.229
149	27.245	0.246
121	26.467	0.279
103	26.207	0.291
159	26.005	0.301

145	25.813	0.310
150	24.856	0.358
102	24.194	0.393
155	23.822	0.414
114	23.689	0.421
109	23.641	0.424
107	23.378	0.439
120	22.441	0.494
100	22.145	0.512
101	21.874	0.528
123	21.792	0.533
144	21.169	0.571
119	21.122	0.574
122	21.091	0.576
126	20.698	0.600
117	20.093	0.636
154	20.055	0.639
134	19.993	0.642
105	19.718	0.659
147	18.899	0.707
125	17.717	0.773
148	17.263	0.796
124	16.797	0.819
118	16.645	0.826
111	16.604	0.828
136	16.482	0.834
128	15.102	0.891
108	14.768	0.903
138	13.709	0.935
140	13.032	0.951
151	12.997	0.952
132	12.152	0.968
116	12.101	0.969
104	11.459	0.978

130	8.916	0.996
157	4.467	1.000

I decided against testing for linearity since I am using scale data and these types of data are usually not normally distributed. There is considerable discussion in the literature on this point (see Norman, 2010). I tested for multicollinearity and after reviewing the Tolerance and VIF found that five variables were highly correlated with a VIF greater than 10.0 (The largest was 17.609) and one was close to the maximum VIF (10.0) - VIF = 10.328. I removed three of these variables. I removed the three with the largest VIF's: 13.772, 15.095 and 17.609. I decided to keep the other three variables with smaller outsized VIF's to test if I could achieve model fit with some outliers. Tukey (1977) argued that having some outliers in the data might actually improve the analysis. Finally, I determined positive definiteness by examining the determinant of the correlation matrix in the EFA. It was significantly greater than zero.

4.12. Development of the Measurement Model

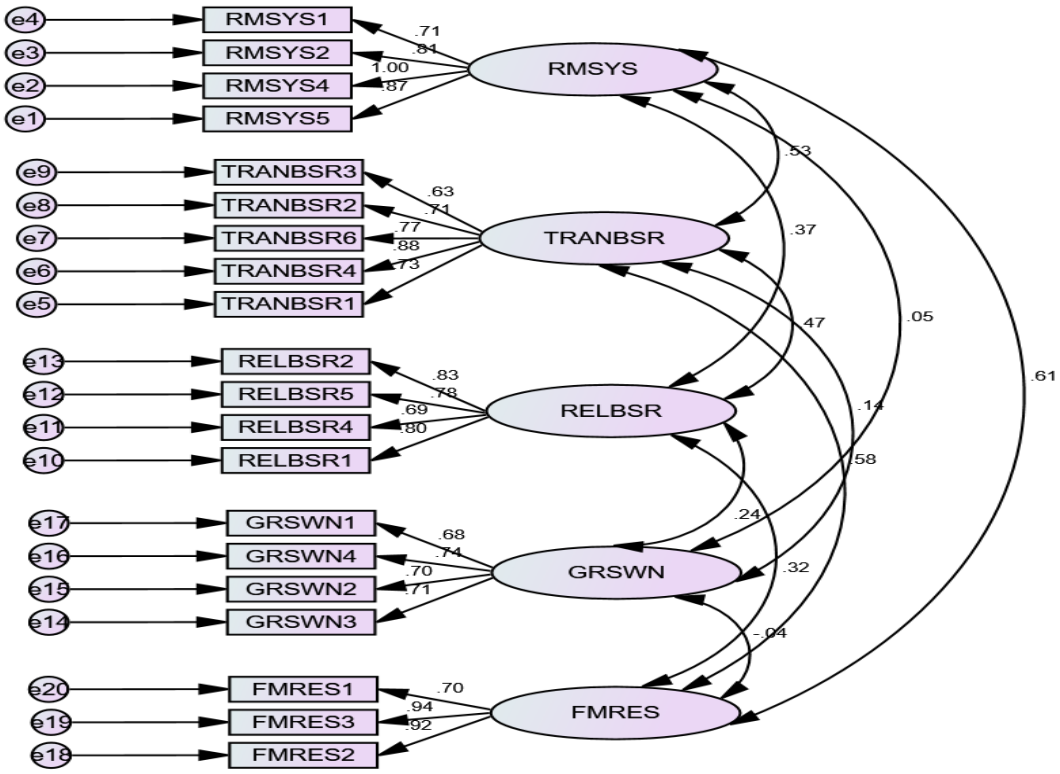
Multi-item scales were used to operationalized the constructs in the theoretical model (Liu et al. 2009). The items were obtained primarily from existing studies and modified to meet the criteria for this dissertation (Nyaga et al., 2010). For example, the items for relational buyer-supplier relationship were developed from Grotsch et al., 2013; Chaurasia, 2014; Bai et al., 2016, Cameli et al., 2016; and the items for risk management system were developed from Juttner et al., 2003; Peck 2005; Manuj & Mentzer, 2008; Blome & Schoenherr, 2011,Tummala & Schoenherr, 2011. A seven-point Likert scale was developed with boundary points, "strongly

agree = 7 and "strongly disagree" = 1, to measure the constructs in the model. Figure 7 presents the measurement model.

Table 17 –
CFA Results for the Measurement Scale

Construct Indicators	Standardized Loadings	t-value	Composite Reliability	AVE	Cronbach's Alpha
Gray Swans			.809	.602	.833
GRSWN1	.739	3.892			
GRSWN2	.775	2.795			
GRSWN3	.814	3.435			
GRSWN4	.775	2.987			
Relational Buyer-Supplier Relationship			.878	.515	.858
RBSR1	.843	5.543			
RBSR2	.770	5.992			
RBSR4	.801	4.568			
RBSR5	.793	6.055			
Transactional Buyer-Supplier Relationship			.855	.543	.854
TBSR1	.78	8.343			
TBSR2	.694	19.868			
TBSR3	.673	8.872			
TBSR4	.766	18.012			
TBSR6	.764	8.626			
Risk Management System			.897	.685	.798
RMSYS1	.743	12.840			
RMSYS2	.814	18.740			
RMSYS4	.873	61.105			
RMSYS5	.874	17.947			
Firm Resilience			.833	.627	.911
FMRES1	.686	12.377			
FMRES2	.849	33.146			
FMRES3	.83	31.588			

Figure 7 –
The Measurement Model



4.13. Development of the Structural Model

4.13.1. Fit Indices

To determine the theoretical fit of the model, I examined the following fit indices within the various fit measures. The null hypothesis assumes that the model is correct. Figure 8 presents the structural model. I examined several measures to determine fit. Under Absolute Fit Measures, I examined the CMIN or minimum value of C which is defined as C = (n-1) and the GFI, i.e.

Goodness of Fit Index. The CMIN is viewed as a Chi-Square value. The CMIN/DF should be greater than 1.0 for the model to be considered a good fit (Blunch, 2013). The CMIN/DF measure was 1.465 and the GFI was 0.72. In the literature, it is reported that the GFI is analogous to the R-squared (Blunch, 2013). Under the Relative Fit Measures, I examined the NFI – Normed Fit Index (Bentler and Bonnett, 1980) and CFI - Comparative Fit Index (Bentler, 1990). The NFI and CFI were 0.712 and 0.881 respectively. In the literature, indices greater than 0.9. are regarded as determining a good fit. However, since the values for NFI and CFI lie between 0 and 1, the closer to 1 the number is, the better indication of fit. I think the indices are sufficient to establish a good fit. Finally, I reviewed the Root-Mean Square Error of Approximation (RMSEA). In the literature it is reported that the RMSEA should be lower than .08 (Bentler & Weeks, 1980; Hu & Bentler, 1999). The value in my model was 0.093. This is higher than the cutoff criteria reported in the literature. However, it falls between the lower (.065) and upper (0.118) of the NCP – non-centrality parameter (Blunch, 2013). A reported value greater than .10 is considered a poor fit and values between .08 and .10 are considered a mediocre fit (Hu & Bentler, 1999). There is some discussion in the literature that "the designated cutoff value may not work equally well with various types of fit indexes, sample sizes, estimators, or distributions" (Hu & Bentler, 1999, p. 16). In a later study, Bentler (2010) suggested that for a sample size of 50, the RMSEA should less than .05, the CFI should be greater than .86, and the standardized root-mean squared residual (SRMR) should be less than .08. However, Hu and Bentler (1999) had suggested that the standardized root mean squared residual (SRMR) should

be replaced by the Tucker-Lewis Index (TLI). The TLI was .86 in my results. I compare the indices for the two models as presented in the Table 18 below.

Figure 8 –
The Structural Model

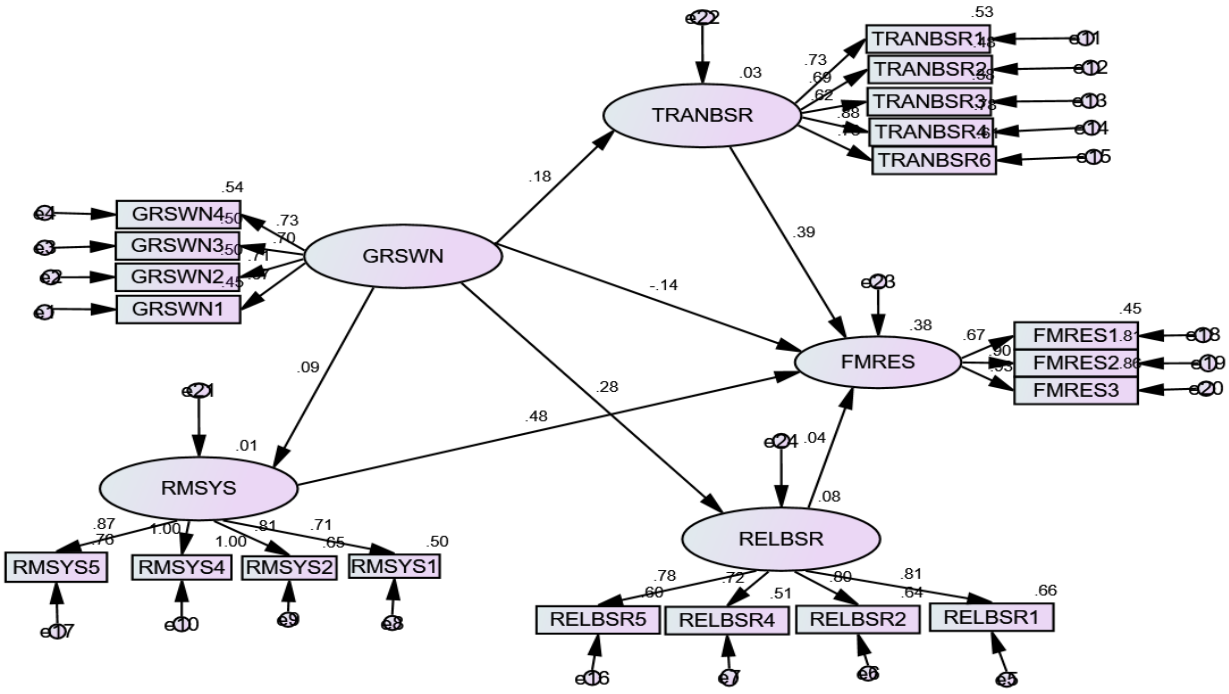


Table 18 –
Goodness of Fit Indices Statistics of the Hypothesized Research Model

Fit Index	Established Threshold	Measurement Model	Structural Model
Chi-Square (X^2)	p-value > 0.05	232.154, p = .000	256.786, p =.000
Degree of Freedom (d.f.)		160	163
X^2 /d.f.	< 3.00 (See Hair et al, 2010)	1.451	1.575
CFI	CFI ≥ .90	.885	.851
RMSEA	RMSEA < 0.08	.093	.105
PNFI	PNFI > .50	.604	.589
TLI	TLI ≥ 0.95	.864	.826

Adapted from Cho & Linderman (2019)

The results in Table 18 suggest a reasonably good model fit.

What indices should be reported is a matter of some discussion in the literature (see Brown & Cudek,1989; Blunch 2013,) for further discussion. Blunch (2013) suggested that researchers report the following information: Chi-Square with degrees of freedom and p-value; RMSEA with confidence interval and PCLOSE. For fit indices, he suggested reporting the MECVI – assuming one is using the Maximum Likelihood estimation technique, and the CFI. Following Blunch (2013) I have reported (See Table 19 below) the Chi-square = 235.909 and the Degrees of freedom = 161 and the probability level = .000. The reported MECVI is 5.53. The MEVCI is a theoretic measure used when the researcher is choosing between several but different models. The PCLOSE for the RMSEA is 0.006. It is still significant. Given the foregoing, I am confident the I have good model fit and I have validated and normed the Gray Swan scale. I propose the next step in this dissertation is to collect a large sample to test the model.

Table 19 –
Commonly Reported Fit Indices

Measure	Name	Description	Cut-off for good fit	Dissertation Results
Chi-Square (X^2)	Model Chi-Square	Assess overall fit and the discrepancy between the sample and fitted covariance matrices. Sensitive to sample size. H0: The model fits perfectly.	p-value> 0.05	X^2 = 235.909 df= 161 p = .000.
(A)GFI	(Adjusted) Goodness of Fit	GFI is the proportion of variance accounted for by the estimated population covariance. Analogous to R^2. AGFI favors parsimony.	GFI ≥ 0.95 AGFI ≥0.90	GFI = .72 AGFI = .635
(N)NFI TLI	(Non) Normed-Fit Index Tucker Lewis index	An NFI of .95, indicates the model of interest improves the fit by 95% relative to the null model. NNFI is preferable for smaller samples. Sometimes the NNFI is called the Tucker Lewis index (TLI)	NFI ≥ 0.95 NNFI ≥ 0.95	NFI = .712 TLI = .86
CFI	Comparative Fit Index	A revised form of NFI. Not very sensitive to sample size. Compares the fit of a target model to the fit of an independent, or null, model.	CFI ≥.90	CFI = .88
RMSEA	Root Mean Square Error of Approximation	A parsimony-adjusted index. Values closer to 0 represent a good fit.	RMSEA < 0.08	RMSEA = .095
(S)RMR	(Standardized) Root Mean Square Residual	The square-root of the difference between the residuals of the sample covariance matrix and the hypothesized model. If items vary in range (i.e. some items are 1-5, others 1-7) then RMR is hard to interpret, better to use SRMR.	SRMR <0.08	RMR = .274

4.14. Chapter Summary

In this chapter I provided an expansive discussion of the scale development and validation process. I established convergent and discriminant validity for the constructs in my model. I also conducted EFA and CFA to achieve model fit. While not all indices were at the desired thresholds, I am confident that a larger sample and a refined instrument will achieve the desired end. More importantly, the fit indices suggest a reasonably good model fit. I think the results indicate a valid and useful scale for examining Gray Swans. In the following section, I provide

some preliminary analysis of the data. I caution the reader that these results are indicative of a convenient sample and size of the sample I used to conduct this analysis.

CHAPTER V

DATA ANALYSIS AND RESULTS

5.0. Introduction

In this chapter, I discuss data collection and sampling procedures and the process for obtaining the final sample to conduct the analysis. In the results section of this chapter, I present my findings.

5.1. Data Collection

I obtained a list of 1622 informants from the Council of Supply Chain Management Professionals (CSCMP). Of that list, 250 email addresses were deemed "bad" and removed from the list. This resulted in a total of 1,372 informants. I supplemented that CSCMP list by emailing approximately thirteen other professionals or other managers in various industries. In total, we emailed approximately 1,385 informants. I received a total of 109 responses. The response rate was approximately 7.8 % (.0787). Fifteen respondents indicated that they would not complete the survey. Another 20 respondents did not complete the survey. Following Hair et al (2006) I conducted a missing variables analysis to determine the nature and extent of missing values. I conducted Little's MCAR test: Chi Square = 334.398; DF = 318; Sig. =.253 and determined that there's no difference in variance of the cases missing values and those not missing values. I utilized the series mean, the most common method used in the literature, to impute those observations with missing values (Tabachnick & Fidell, 2007). After cleaning the data, i.e. determining missing variables and assessing the quality of the data, I determined that only 69 were usable for data analysis. This is low. Peng & Lai (2012, p. 467) noted that one difficulty

faced by OM empirical researchers is obtaining large samples. However, the question of "how small is small?" is contingent on the number of constructs in the model. Hair et al (2006, p. 112) suggested that researchers should have at least 10 times as many observations as the number of variables. I have five variables and a total of 69 useable observations. Comrey & Lee (1992) suggested that a sample size of 50 was very poor and a sample size of 100 was poor. However, Sapnas & Zeller (2002) and Zeller (2005) suggest that under certain circumstances 100 or even 50 cases are sufficient. These scholars argue that the conventional requirements for large sample sizes can lead to sample size overkill (Sapnas & Zeller, 2002). Further, Tabachnick & Fidell (2007, p. 613) noted that 50 cases might be sufficient to conduct analysis assuming sufficiently high factor loadings. de Winter et al., (2009) argued that N=50 is a reasonable absolute minimum for conducting EFA. I believe the sample passes the Tabachnick & Fidell (2007:613) test and meets the Sapnas & Zeller (2002) and Zeller (2005) "certain conditions", i.e. factor loadings > 0.80, strong correlations and a few distinct factors.

Current OM survey research often suffers from low response rates, e.g. between 7% and 15%. Melnyk et al. (2012) addressed the problem of conducting survey research. He and his colleagues building on research by Frolich (2002) sought to determine whether response rates were really declining in OM research and what could be done about the problem (Melnyk et al. 2012). Other researchers have also addressed the problem of low response rates in survey research (Frolich, 2002). Response rates have been falling significantly since 2002 despite measures to address the problem (Melnyk et al., 2012). I sought to address the response rate problem by following the suggestion of Melnyk and his colleagues to solicit members of

professional organizations such as the Council of Supply Chain Management Professionals (CSCMP) (Melnyk et al., 2012). Despite the low response rate, we are confident that our sample will not succumb to validity and reliability issues suggested by Shaddish et al., (2002) and others (Melnyk et al., 2012). Although I agree that generalizability is the goal of research, I am acutely aware of the problem of finding respondents in the target population (Clottey & Grawe, 2014). It has been suggested that researchers should provide some explanation for a small sample (Clottey & Grawe, 2014 c.f. De Beuckelaer & Wagner, 2012). I believe that since I have more that 50 cases, we have enough data points to conduct our analysis. Further, since the communalities are (.60) or greater, and each factor is defined by several items (see Tables 23 and 24 below), we believe that our data is adequate for analysis (Williams et al 2010).

The vast majority of respondents were senior managers, executives, directors or line managers. Based on the criteria provided by CSCMP, Senior Managers accounted for 19%; Directors, 33%; Vice Presidents, 25%; Managers and Presidents each accounted for 9% of respondents. Six percent (6%) listed "other' as their industry position or title. The industry breakdown was as follows: thirty-six (36) or 52% were in the manufacturing sector; thirteen (13) or 19 % were in Wholesale/Retail Trade; ten (10) or 15% were in Transportation/Warehousing; three (3) or .04% Healthcare; six (6) or .09% listed Other and one (1) or .01% listed Services except Public Assistance as their industry category. Of the total number of respondents: sixty (60) or 87% were male; eight (9) or 13% were female. Of the larger sample 33 chose not to respond to the gender question. Twenty-nine percent (29%) or (20) of the respondents indicated they had not experienced a disruption in the past three years. The vast majority, (49) or 71% had

experienced a disruption in the past three years. Approximately seventy percent (70%) or (48) of the respondents were from companies with more than 500 employees (large companies); 19% or (13) respondents were from companies between 100 and 499 employees (medium-sized companies); and eight (8) or approximately 12% were from companies with less than 100 employees (small companies). For ease of presentation, I divided the firm by age in the following manner: Young (0-9 yrs.), Growing (10-19yrs), and mature (older than 20 yrs.). Three or (4%) of the companies were younger than ten years; five (8%) of the companies were growing; and 62 or (88%) were considered mature, i.e. older than twenty years. In determining the buyer-supplier relationship of those who responded, approximately 57% (34) indicated they were buyers; 24% (25) indicated they were suppliers; and 19% (13) indicated "Other" as their relationship with their partners in the supply chain. The demographic data are presented in the tables (20 and 21) below.

Table 20
Firm and Industry Demographics

Construct	Category	Frequency	Percent
Disruption Experience	Yes	49	71
	No	20	29
Firm Relationship	Buyer	39	56.5
	Supplier	17	24.6
	Other	13	18.8
Firm Age	0-4yrs	3	4.3
	10-14yrs	1	1.4
	15-19yrs	4	5.8
	20-24yrs	6	8.7
	25-29yrs	4	4.3
	>30yrs	52	75.4

Firm Size	<100 employees	8	11.6
	>100<499 employees	13	18.8
	>500 employees	48	69.6
Industry	Manufacturing	36	52.2
	Wholesale/Retail Trade	13	18.8
	Healthcare and Social Assistance	3	4.3
	Transportation and Warehousing	10	14.5
	Services except Public Assistance	1	1.4
	Other	6	8.7

N=69

Table 21–
Profile of Respondents

Construct	Category	Frequency	Percent
Level of Responsibility	Manager	6	8.7
	Senior Manager	13	18.8
	Director	23	33.3
	Vice President	17	24.6
	President	6	8.7
	Other	4	5.8
Gender	Male	60	86.9
	Female	9	13
Level of Education	Some College	4	5.8
	College Graduate	31	44.9
	Graduate/Professional Degree	34	49.3

N = 69

I conducted EFA's for both models in the study using SPSS. The determinant was 7.70. In the literature, a determinant greater than .01 indicates that the variables are useful for analysis. In our EFA, four factors in our analysis accounted for more than 75% of the variance in the Simple (Gray Swan-Resilience - GSRES) Model and 75% in the Complex (Gray Swan-Operational Performance - GSOP) Model. The KMOs for both models are greater than .70 which

indicates the factors are useful for analysis. The Bartlett's Test for both models is significant ($p < 0.05$). The data are presented in the tables below.

Table 22-
KMO and Bartlett's Test of Sphericity – Simple (GSRES) Model

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.794
Bartlett's Test of Sphericity	Approx. Chi-Square	768.79
	df	136
	Sig.	0.000

Table 23–
KMO and Bartlett's Test of Sphericity – Complex (GSOP) Model

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.806
Bartlett's Test of Sphericity	Approx. Chi-Square	911.146
	df	190
	Sig.	0.000

Table 24–
Factor Loadings and Communalities – Revised Simple (GSRES) Model

Factor and Scale Items	TBSR	RBSR	FMRES	GRSWN	Commu-nalities
Gray Swans					
1.a sudden loss of a supplier due to financial distress				0.917	0.847
3. disruptions in your operations due to labor-management issues				0.690	0.599
5. a sudden loss of a supplier due to a bankruptcy				0.892	0.789
Relational Buyer-Supplier Relationship					
2. open communications between the parties		0.902			0.791
3. mutual trust between the parties		0.941			0.835
6. commitment to a long-lasting partnership between the parties		0.875			0.789
7. mutual respect between the parties		0.870			0.849

Firm Resilience						
1. is prepared for a disruption in the supply chain			0.860			0.798
2. can recover quickly from a disruption in the supply chain			0.853			0.84
3. has the ability to respond quickly to a disruption in the supply chain			0.886			0.811
4. can absorb a significant loss from a disruption in the supply chain			0.838			0.641
Transactional Buyer-Supplier Relationship						
1. contain specific provisions that the supplier must abide by when producing our product.	0.905					0.714
2. contain specific provisions that give us the right to audit the supplier's operating procedures.	0.823					0.742
3. contain specific provisions that give us the right to inspect the supplier's facilities	0.822					0.696
4. contain performance standards we expect the suppliers to meet in the product they supply us.	0.855					0.797
5. specify interim goals that we expect the supplier to achieve.	0.809					0.674
6.specify deadlines for the supplier to deliver products	0.702					0.558

Principle Components Analysis with Promax rotation

Table 25-
Factor Loadings and Communalities – Revised Complex (GSOP) Model

Factor and Scale Items	TBSR	RBSR	FMRES	OPERF	GRSWN	Commu. nalities
Gray Swans						
1.a sudden loss of a supplier due to financial distress					0.915	0.844
3. disruptions in your operations due to labor-management issues					0.692	0.596
5. a sudden loss of a supplier due to a bankruptcy					0.893	0.791
Relational Buyer-Supplier Relationship						
2. open communications between the parties		0.888				0.789
3. mutual trust between the parties		0.933				0.842
6. commitment to a long-lasting partnership between the parties		0.879				0.793
7. mutual respect between the parties		0.867				0.852

Firm Resilience				
1. is prepared for a disruption in the supply chain		0.801		0.803
2. can recover quickly from a disruption in the supply chain		0.863		0.84
3. has the ability to respond quickly to a disruption in the supply chain		0.941		0.834
4. can absorb a significant loss from a disruption in the supply chain		0.788		0.639
Operational Performance				
2. improved existing product quality			0.797	0.618
3. improved overall efficiency of operations			0.857	0.785
4. reduced total costs of acquisition/ownership			0.762	0.682
5. reduced lead time for delivery			0.872	0.815
Transactional Buyer-Supplier Relationship				
1. contain specific provisions that the supplier must abide by when producing our product.	0.927			0.730
2. contain specific provisions that give us the right to audit the supplier's operating procedures.	0.814			0.776
3. contain specific provisions that give us the right to inspect the supplier's facilities	0.818			0.715
4. contain performance standards we expect the suppliers to meet in the product they supply us.	0.865			0.808
5. specify interim goals that we expect the supplier to achieve.	0.786			0.691

Principle Components Analysis with Promax rotation

After conducting the initial pilot studies, I reviewed and revised the survey instrument. (See Appendix B). It is not uncommon to revise a questionnaire to improve the wording of some statements (see Wong et al., 2011). Apparently, that change may have affected the relationship among the various factors. After conducting the first exploratory factor analysis (EFA), I noticed that two of the constructs (Risk Management System (RMSYS) and Firm Resilience (FMRES) loaded on the same factor. I decided to test two models – a simple model (GSRES Model), a

more complex model (GSOP Model) - see Figures 9 and 10 presented below. I also considered an alternative model – presented in the appendix.

Figure 9-
GSRES Model

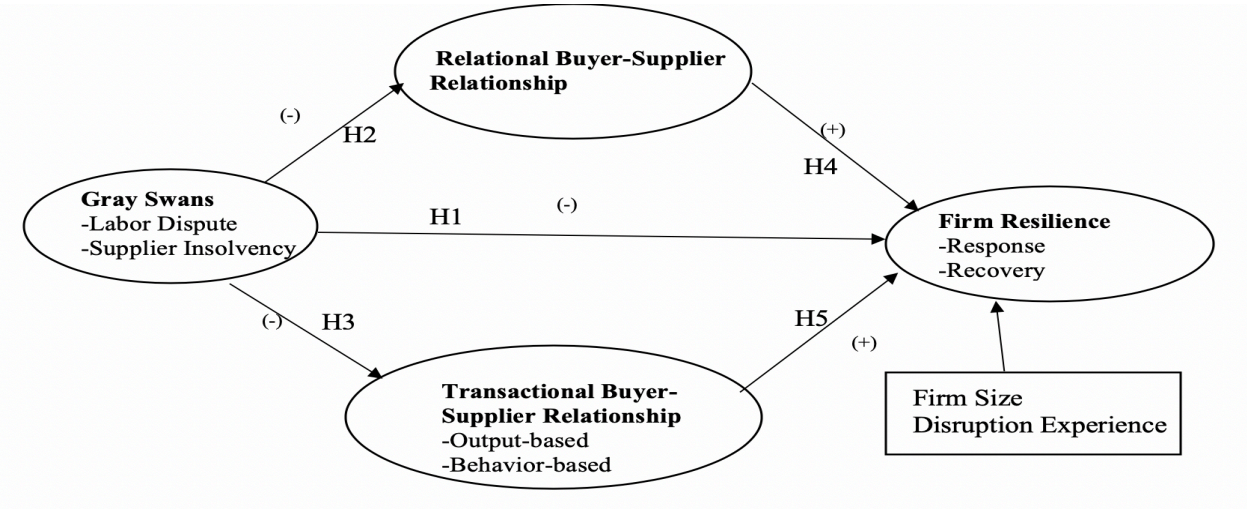
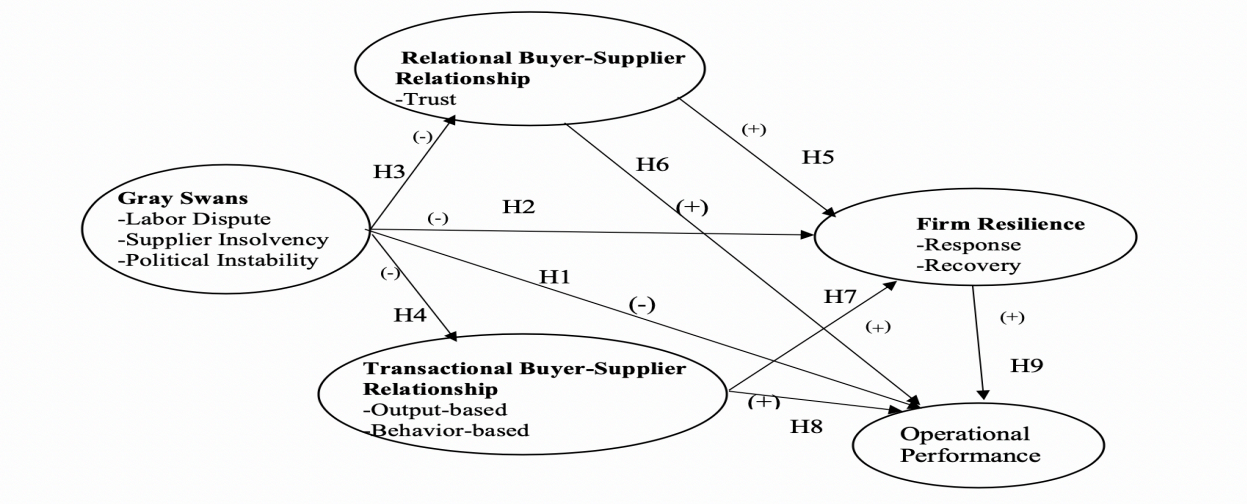


Figure 10-
GSOP Model



I found some evidence in the literature for taking the two-model approach. Cho & Linderman (2016) and Inman et al. (2011) also employed a similar mechanism to test the relationship among the variables in their models. Along with the loading of Resilience and Risk Management System, I also noted other loadings. For example, two of the items from the Gray Swan construct loaded on a separate factor. I determined that these could be labeled "Policy Risk" and treated as a separate variable that can be addressed in future research. Two items from the Relational Buyer-Supplier Relationship construct loaded on a separate construct. I determined that these items could be labeled "Trust" which is discussed extensively in the literature. These also can be pursued in future research.

There is some discussion in the literature that constructs should have at least three items to be considered for analysis (see Hair et al., 2006; Tabachnick & Fidell, 2007). I note there is published research where some constructs have only two items (see Wagner & Bode, 2008; Ambulkar et al., 2015). I determined that I would retain only those factors with more than two items regardless of the coefficients because three or more items are considered more useful for factor analysis. I believe this reduces the problem of having a single item representing a construct should one item prove not useful for further data analysis. There is discussion in the literature on the problem of single item scales and the problem of generalizability (Diamantopoulos et al. 2012, Eisinga et al. 2013; Sarstedt et al., 2016). I believe that more than two items in a scale is likely to increase predictive validity. Hinkin (1995, p. 972) noted that adequate internal consistency can be achieved with a few as three items I decided to test several research models as indicated earlier. Following Ambulkar et al. (2015) I decided to control for

the effect of Firm Size and Disruption Experience on Firm Resilience (FMRES). I wanted to determine whether prior experience with a disruption and the size of the firm increased or decreased the level of a firm's response to and recovery from a Gray Swan. I also decided to control for the effect of those variables on operational performance (OPERF).

I believe that a two-model approach allow this researcher to better test the relationship among the variables in the models.

5.2. Sample

In their discussion of survey research in OM, Forza (2002) examined the relation among, alpha (α) statistical power and effect size. The table adapted from their study (Table 26) is presented below.

Table 26-
Effect Size, Statistical Power and Sample Size

	Stat. Power = 0.6		Stat. Power = 0.8	
	$\alpha = 0.05$	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.01$
Large Effect (e.g. strong association)	12	18	17	24
Medium effect (e.g. medium association)	30	45	44	62
Small effect (e.g. small association)	179	274	271	385

The above table indicates that the relationship among these variables is governed by sample size. I believe that although it is small, the sample in this study is representative of the larger supply chain management population and allows me to test the effect of Gray Swans on firm resilience and operational performance. There is debate in the literature (Williams et. al, 2010 among others) who argue that the current guidance on sample sizes from Hair et al (2006); Comrey & Lee (1973) and Tabachnick & Fidell (2007) among others; may not serve researchers well

(Williams et al. 2010, p. 4). The authors suggest that researchers should place greater reliance on communalities greater than (.60) and correlation coefficients that are greater than (.80) as a way of determining the appropriate sample size (Williams et al., 2010). As stated earlier, the communalities are (.60) or greater and the reliability coefficients are (.80) or greater.

In their article, Inman et al (2011) collected a total of 96 responses after sending out 1,350 questionnaires for a response rate of 7.9%. The authors noted that such a low response was not "atypical for industrial research" (Inman et al., 2011, p. 347). I agree with this perspective and believe that our response rate is consistent with those found in survey research (see discussion by Melnyk et al. 2012, among others). Despite the small response rate, these are highly educated individuals charged with decision-making in their respective companies. Forty-nine percent, 49% or (34) possessed a graduate or professional degree; 45% or (31) had a college degree and 6% or (4) had some college education. I believe this sample is representative of the upper echelons of supply chain management. More than 50% or (39) of respondents were over 55 years of age; 28 or (40%) were between the ages of 35 and 54. Only 3% or (2) respondents were younger than 35. Demographic data is presented in Tables 20 and 21 above.

5.3. Non-response Bias

I followed approaches common in the literature for determining non-response bias (see Inman et al. 2011; Clottey & Grawe, 2014; Bode & Wagner, 2015 among others). Non-response bias is thought to occur when there is a significant difference in the responses of those who responded early to a survey and those who responded later (Clottey & Grawe, 2014). The most common approach to testing nonresponse bias discussed in the literature is to conduct a t-test of the means

of early and late respondents (Armstrong & Overton, 1977; Prajogo et al. 2012; Truong et al., 2017; Hong et al. 2019). In their study, Clottey & Benton (2013) proposed new statistical approaches to assessing non-response bias. The authors found that Chi Square tests were frequently used in the literature to compare respondents to non-respondents on demographic characteristics, e.g. firm size, firm age, gender etc. (Clottey & Benton, 2013). The authors suggest that OM researchers apply multiplicity adjustments (Bonferroni) to significance levels when using multiple t- or F-tests to assess non-response bias. I decided to test for bias in responses by utilizing a t-test of respondents based on some demographic such as firm size or age and comparing the results to those in the population (Bode & Wagner, 2015). In their study, Prajogo et al. (2012) compared the responses of informants based on organizational size and industry sector. Following Bode & Wagner (2015) and Prajogo et al. (2012) I conducted a statistical test to determine if there was any significant difference between respondents based on firm size, level of responsibility or level of education. The results for the Lavene's Test for Equality of Variances for firm size - $F=1.891$; $p > 0.05$ (0.175); and level of responsibility, $F= 1.968$, $p > 0.05$ (0.167) - indicate that I fail reject the null that there are no differences between the variances. The t-test for the equality of means for each variable respectively: firm size - $t=0.759$; $df = 53$; $p > 0.05$ (.451); $SE = 0.192$; $CI_L = -0.239$; $CI_U = 0.53$; and level of responsibility - $t= -1.35$; $df = 53$; $p > 0.05$ (.183); $SE = 0.334$; $CI_L = -1.12$; $CI_U = 0.219$ - indicates that I fail to reject the null hypothesis that there are no differences between the means of these groups. Hair et al (2006, p. 389) noted that if the difference between the group means is significantly larger than the standard error, one can conclude that the mean differences are

statistically significant. This finding is further supported by the fact that the Confidence Interval contains zero (0). This indicates that the means are not different. I also conducted a one-way ANOVA to compare the means of these groups based on the same descriptive variable used in the t-test above. The comparisons did not indicate any statistically significant differences between the means of the two groups: firm size - $F = .281$, $p > 0.05$ (.756) and level of responsibility – $F = 1.318$, $p > 0.05$ (.275). Therefore, I conclude that non-response bias is not a statistical problem with my sample data set.

I conducted Cohen's d to determine the effect size because I have a small sample size. Cohen's d is indicated by three effects sizes; small = .20; medium = .50; and large = .80. Cohen's d is equal to the standardized difference between means (Cohen, 1992). I utilized SPSS to calculate the effect size for our descriptive variable. I converted the variable, firm size to the standardized variable, Z-score firm size and level of responsibility and conducted our t-test of independent samples. The mean difference in our results for firm size is .21 – a small effect size and -.35 for level of responsibility – a much larger effect size. Given the small sample (N=69), I believe the effect sizes are significant and explain the relationship among the variables.

5.4. Common Method Variance

I also tested for common method bias. Common method bias occurs when data on the independent and dependent variables are collected from the same respondents and can lead to inflated estimates of the relationships between variables (Inman et al., 2011 c.f. Podsakoff & Organ, 1986). I sought to reduce the threat of CMV through the survey design and by conducting pilot test of the survey instrument (Li et al., 2015). Further, I conducted an anonymous email

survey to collect the data. The vast majority of respondents to our survey were seasoned senior managers and executives who worked for large firms (Truong et al., 2017). I believe the scope of experience about supply chain management practices and firm operations reduces the likelihood of bias (Li et al., 2015). To test for common method variance, I conducted a factor analysis loading our variables onto a single factor to determine if any single factor emerges as distinct from the others (Prajogo et al., 2012). Harman's one-factor test is the most common test used in the literature to assess common method bias (Podsakoff & Organ, 1986). I found that no single factor accounted for no more than 35% of the variance for the GSRES Model; and no more than 34% of the variance for the GSOP Model. Therefore, I concluded that common method variance does not pose a threat to the data in our sample (Prajogo et al., 2012; Li et. al., 2015).

5.5. Reliability and Validity Tests

I conducted reliability and validity test for both models in this study. I assessed for convergent and discriminant validity by utilizing approaches commonly used in the literature. I examined the factor loadings in both models, which ranged from a low (.632) to a high of (.897). These loadings far exceed the (.50) threshold (Campbell & Fiske, 1959; Hair et al., 2006). We also examined Cronbach's alpha (α), composite reliability (CR) and the average variance extracted (AVE) (Shin et al., 2015). The composite reliability for each variable is greater than (.70). Cronbach alpha is greater than the minimum threshold of (.50) (Cronbach, 1959). Finally, I assessed the AVE's for both models which are (.60) or greater and are reported in Tables 25 and 26 below. This indicates convergent validity for the constructs in the models (Hair et al. 2006; Ambulkar et al. 2015). I also assessed for discriminant validity. Discriminant validity ensures

that a latent variable uniquely represents the phenomena of interests, i.e. accounts for more variance than other measures in a model (Fornell & Larcker, 1981; Hair et al. 2010). I compared the AVE's to the corresponding factor loadings. As shown in Tables 29 and 30, the square root of the AVE's for each variable in the horizontal was greater than the squared correlations of the other latent variables (Fornell & Larcker, 1981; Shin et al., 2015). The factor loadings, t-values, AVE's, Composite Reliabilities and Cronbach Alphas are reported in the tables (Table 27 and 28) below.

Table 27-
Construct Reliability and Validity Tests – Simple (GSRES) Model

Factor and Scale Items	Factor Loadings	t-value	AVE	Composite Reliability	Cronbach's Alpha
Gray Swans			0.691	0.869	0.779
Q7-1- GRSSWN1	0.917	14.61			
Q7-3 GRSWN3	0.690	14.88			
Q7-5 GRSWN5	0.892	13.64			
Relational Buyer-Supplier Relationship			0.743	0.921	0.917
Q8-2-RBSE2	0.902	30.80			
Q8-3-RBSR3	0.941	28.49			
Q8-6-RBSSR6	0.875	36.26			
Q8-7- RBSR7	0.87	36.78			
Firm Resilience			0.699	0.903	0.889
Q9-1-FMRES1	0.86	22.59			
Q9-2-FMRES2	0.853	23.56			
Q9-3-FMRES3	0.886	23.85			
Q9-4-FMRES4	0.838	18.60			
Transactional Buyer-Supplier Relationship			0.671	0.911	0.891
Q12-1-TBRSR1	0.905	36.32			
Q12-2-TBRSR2	0.823	37.55			

Q12-3-TBRSR3	0.822	33.32
Q12-4-TBRSR4	0.855	41.78
Q12-5-TBRSR5	0.809	32.64
Q12-6-TBSR6	0.702	45.10

Principle Component Analysis with Promax Rotation

Table 28–
Construct Reliability and Validity Tests – Complex Model

Construct Indicators	Loadings	t-Value	AVE	Composite Reliability	Cronbach's Alpha
Factor 5 - Gray Swans			0.7	0.875	0.792
GRSWN1	0.915	14.608			
GRSWN3	0.692	14.881			
GRSWN5	0.893	13.638			
Factor 2- Relational Buyer-Supplier Relationship			0.8	0.939	0.917
RBSR2	0.888	30.799			
RBSR3	0.933	28.491			
RBSR6	0.879	36.256			
RBSR7	0.867	36.783			
Factor 3- Firm Resilience			0.72	0.912	0.893
FMRES1	0.801	22.591			
FMRES2	0.863	23.564			
FMRES3	0.941	23.849			
FMRES4	0.788	18.595			
Factor 4 - Operational Performance			0.68	0.893	0.858
OPERF2	0.797	28.446			
OPERF3	0.857	25.69			
OPERF4	0.762	32.527			
OPERF5	0.872	26.613			
Factor 1 - Transactional Buyer-Supplier Relationship			0.71	0.924	0.898
TBSR1	0.927	36.321			
TBSR2	0.814	37.553			
TBSR3	0.818	33.321			

TBSR4	0.865	41.783
TBSR5	0.786	32.637

Principle Component Analysis with Promax Rotation

Table 29-
Discriminant Validity – Simple (GSRES) Model

Construct	FMRES	GRSWN	RBSR	TBSR
FMRES	**0.870**			
GRSWN	-0.154	**0.715**		
RBSR	0.401	-0.219	**0.900**	
TBSR	0.342	-0.294	0.328	**0.846**

Table 30-
Discriminant Validity – Complex (GSOP) Model

Construct	FMRES	GRSWN	OPERF	RBSR	TBSR
FMRES	**0.872**				
GRSWN	-0.16	**0.712**			
OPERF	0.577	-0.300	**0.828**		
RBSR	0.396	-0.226	0.381	**0.900**	
TBSR	0.333	-0.283	0.391	0.329	**0.846**

I conducted a Pearson product moment correlation to examine the relationship among Gray Swans, Relational Buyer-Supplier Relationship, Transactional Buyer-Supplier Relationship, and Firm Resilience. The results for each theoretical model are presented below in Tables 31 and 32.

Table 31 –
Correlations, Means and Standard Deviations – GSRES Model

Construct	Mean	Std. Dev.	GRSWN	RBSR	FMRES	TBSR
Gray Swan -GRSWN	1.975	0.961	1			
Relational Buyer-Supplier Relationship -RBSR	3.931	0.898	0.017	1		
Firm Resilience - FMRES	3.237	1.057	-0.045	.379**	1	
Transactional Buyer-Supplier Relationship - TBSR	4.222	0.772	-0.165	.320**	.327**	1

** Correlation is significant at the 0.01 level (2-tailed)
N = 69

Table 32-
Correlations, Means and Standard Deviations – GSOP Model

Constructs	Mean	Std. Dev	Transactional BSR	GraySwan	Relational BSR	FirmRes	OpsPerf
Transactional BSR	4.212	0.818	1				
GraySwan	1.975	0.961	-0.162	1			
Relational BSR	3.931	0.898	.314**	0.017	1		
FirmRes	3.237	1.057	.303*	-0.045	.379**	1	
OpsPerf	3.420	0.848	.378**	-0.083	.399**	.562**	1

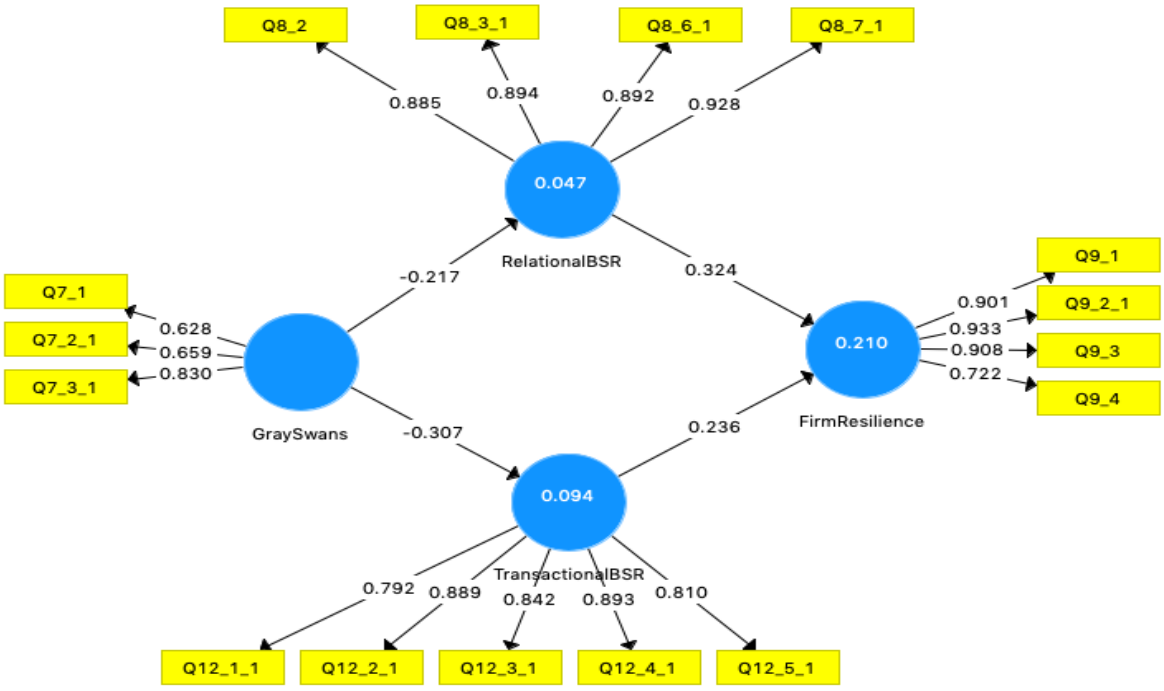
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level)2-tailed)
N=69

5.6. Results

I utilized SmartPLS3 (Ringle et al., 2015) to estimate the research model and to test the hypotheses posited in this dissertation. PLS is being utilized more in OM research (Peng & Lai, 2012). I decided to use PLS for several reasons: 1. The software can estimate models with both formative and reflective constructs. The constructs in this dissertation are all reflective. Peng & Lai (2012) advancing an argument by Jarvis et al. (2003) noted that Operational Performance

should be formative because it is determined by the following indicators: cost, quality, delivery and flexibility. I followed other researchers who have utilized reflective indicators to measure the construct. (2) The software is more useful for exploratory research rather than theory confirmation (Peng & Lai, 2012; Hair et al. 2017). The basis of this dissertation is theory development. 3. Sample size. PLS-SEM is stated to have some advantages over CB-SEM when the sample size is small which is the case in this dissertation (Hair et al. 2017; Benitez et al. 2020). The debate about the utility of PLS for smaller sample sizes rages on in the literature (Benitez et al., 2020). However, PLS is regarded as somewhat superior to other variance-based SEM techniques (Benitez et al., 2020). Further, PLS can be used in conjunction with other CB-SEM techniques for confirmatory analysis. I conducted an analysis of the Simple (Gray Swan-Resilience- GSRES) Model which is presented in Figure 9 below. The effects of the variables are as indicated in the hypotheses: GRSWN=> RBSR = -0.217; GRSWN => TBSR = -0.307; RBSR => FMRES = 0.324 and TBSR => FMRES = 0.236. NB. I did not test the direct effect of Gray Swans on Firm resilience in this model. However, the total indirect effect after bootstrapping indicated that the effect was significant: = -0.143, t = 1.825, $p < .10$ (0.051). The standardized estimates of the measurement model are presented in Figure 9 below.

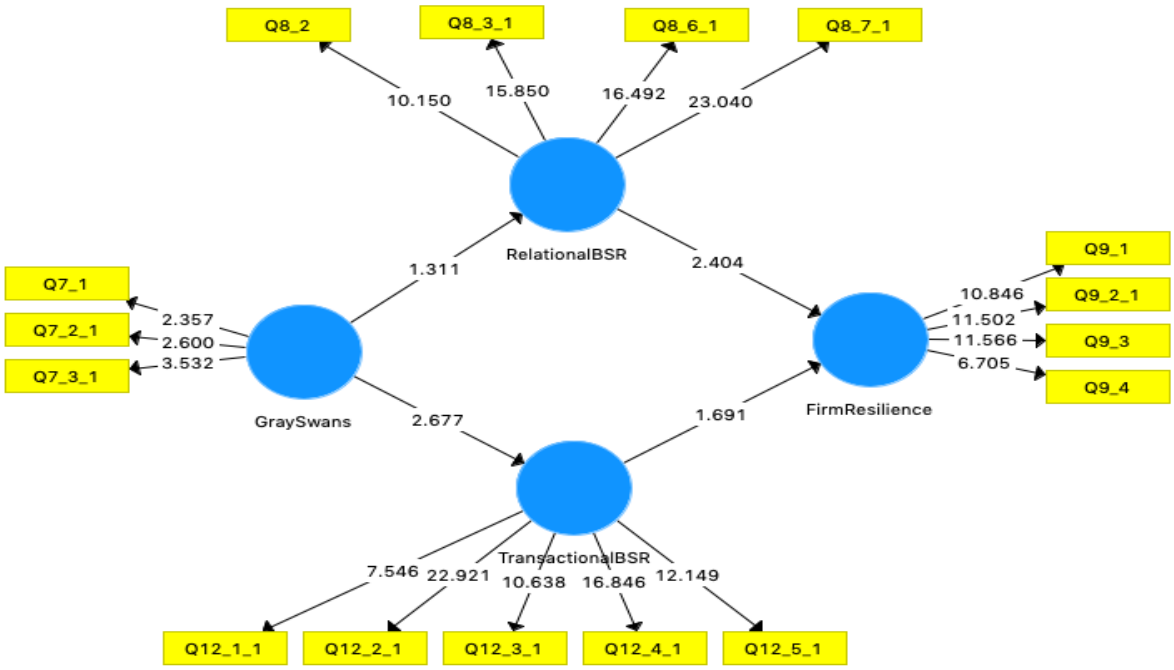
Figure 11-
Structural (Inner) Model – GSRES Model



I found that the relationship between GRSWN =>BSR is negative as stated in the second hypothesis although it is not statistically significant (-0.217, t= 1.311, p > 0.05 (0.190). I had assumed that this relationship would be significant given the discussion in much of the recent literature (Tangpon et al., 2010; Liu et al. 2012; Zhang & Huo, 2013; Narayanam et al., 2015). I found that the effect of RBSR (.324) on FMRES was larger than TBSR (0.236). This is a surprising finding. In the literature, there tends to be a greater focus on contractual relationships (see Bai et al. 2016; Shou et al. 2016; Sluis & De Giovanni 2016). What is also surprising are the relationships between GRSWN and the buyer-supplier relationship (TBSR and RBSR). Although

both relationships are negative as hypothesized, the relationship between GRSWN => TBSR is statistically significant. This suggests that contractual relationships may be more effective in the context of a Gray Swan than a trusting or collaborative relationship.

Figure 12-
Measurement (Outer) Model – GSRES Model



Findings indicate that the effects of GRSWN =>TBSR is negative and statistically significant: -0.307, t = 2.677, p < 0.05 (0.008) as indicated in the hypothesis. This indicates that the occurrence of a Gray Swan will negatively affect the firm's transactional buyer-suppler relationship. I found that the relationship between RBSR and FMRES was positive as indicated in the hypothesis and statistically significant: 0.324, t = 2.404, p < 0.05 (0.017). This indicates that a firm's buyer-supplier relationship, especially if it is relational, will have a positive effect

on resilience, i.e. a firm's ability to respond to and recover from a Gray Swan. The relationship between TBSR => FMRES was positive and significant: 0.236, t = 1.691, p < 0.10 (0.092). This supports the hypothesis of a positive effect of a transactional buyer-supplier relationship on firm resilience. While the effect of TBSR => FMRES is positive and significant, it is smaller than the effect of RBSR => FMRES. I did not expect that RBSR would have a larger effect on FMRES than TBSR since I sampled American companies. Americans tend to be very litigious and utilize contracts more than other developed and developing economies. The R^2 for each construct is as follows: FMRES = 0.210, RBSR = 0.033, and TBSR = 0.094. None of the variables had a VIF greater than 4.126. Therefore, multicollinearity was not an issue with this data.

I then examined the direct relationship of GRSWN => FMRES (see Figures 11 and 12) below. The results were as indicated the hypothesis - negative - though not statistically significant: = -0.016, t = 0.114, p > 0.05 (0.909). Adding a direct relationship between GRSWN and FMRES, did not change the relationship among the other variables. Those that were statistically significant remained so. As stated earlier, the indirect effect is negative and significant which supports the hypothesis of the mediation of the buyer-supplier relationship (RBSR and TBSR) on firm resilience (FMRES). Mediation occurs when some degree of the effect of the independent variable on the dependent variable is accounted for by a third intervening variable (Preacher et al., 2007; Aquinis et al., 2017). To test for partial mediation, there must be a significant correlation between the independent and dependent – the direct effect, and between the independent and mediator variable – the indirect effect. The mediator must also be significantly correlated with the dependent variable. All three relationships must be

significant for there to be partial mediation (James & Brett, 1984; Baron & Kenny, 1986; Preacher & Hayes, 2004). Full mediation occurs if the relationship between independent and the dependent variable is not significantly different from zero (0) when the mediator is present. When the mediator is absent, there is a direct effect between the independent variable and the dependent variable. When I introduced the mediator, the direct effect became nonsignificant and the indirect effect became significant. This indicates full mediation. Following Hair et al (2017) I assessed whether there was mediation or nonmeditation. Nonmeditation occurs when the direct and indirect effects are nonsignificant or when the direct effect is significant and the indirect effect nonsignificant or vice versa (Hair et al., 2017). The results indicate that there was mediation based on the total indirect effects: = -0.139, $t = 2.006$, $p < 0.05$ (0.045). I examined the effect size of the relationship among and between the variables by reviewing the F^2. Hair et al (2017) noted that the F^2 is useful as a measure of effect size: 0.02 is considered small; 0.15 medium; and 0.35 large. The effect of the variables on FMRES was small. GRSWN did not have an effect on FMRES (0.000); GRSWN => RBSR = 0.050; GRSWN => TBSR = 0.095; RBSR => FMRES = 0.116; and TBSR => FMRES = 0.057.

Figure 13-
Revised Structural (Inner) Model – GSRES Model

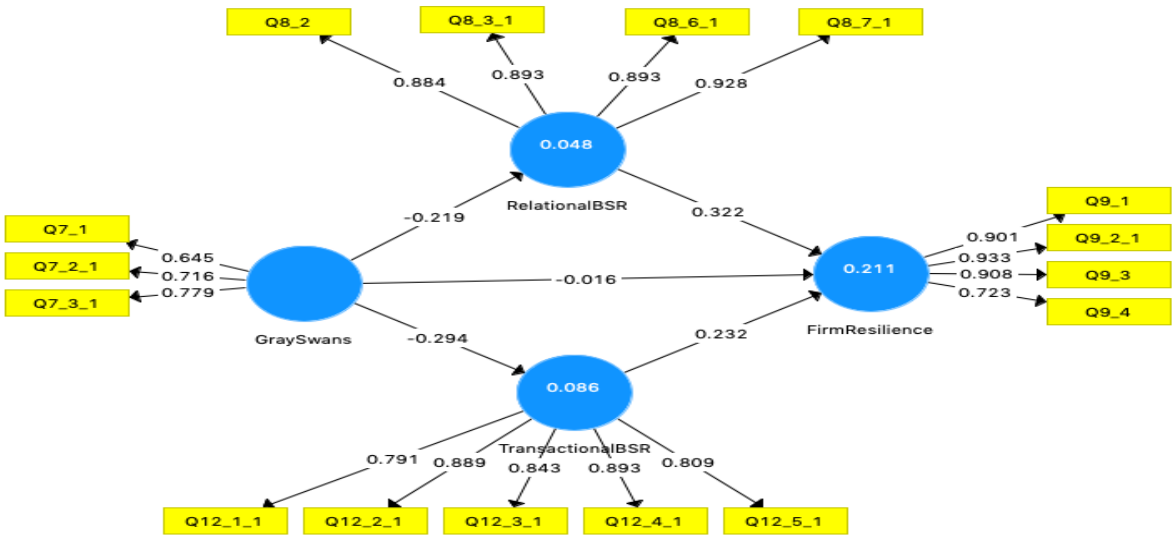
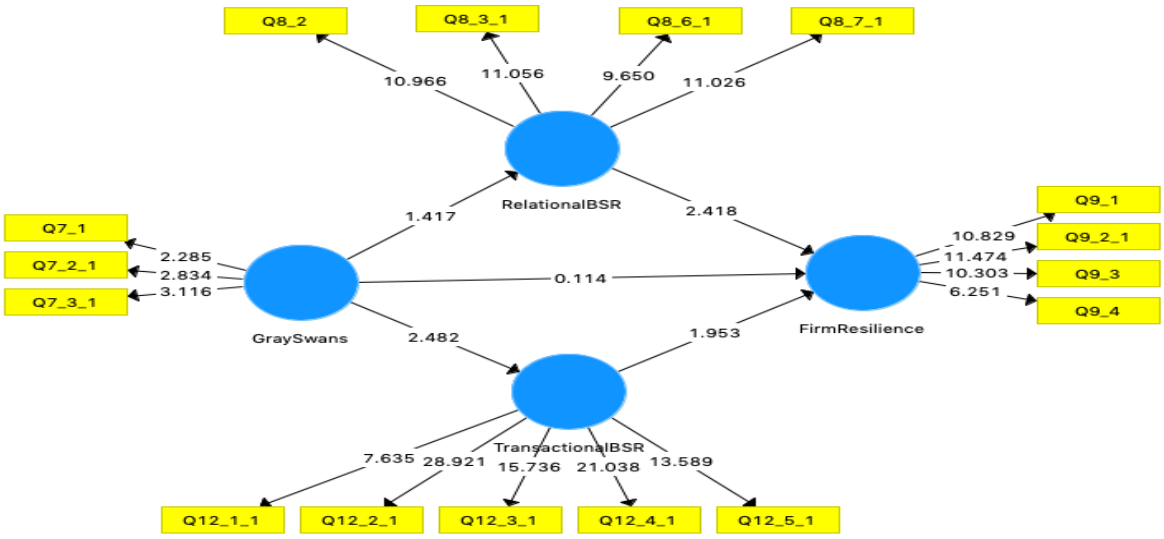


Figure 14-
Revised Measurement (Outer) Model – GSRES Model



5.6.1. Gray Swan-Operational Performance (GSOP) Model

I conducted data analysis for the Complex (GSOP) Model. The output is presented in Figures 13 and 14 below. The R^2 for variables in the model are as follows: FMRES = .203; OPERF = .377; RBSR = 0.051 and TBSR = 0.080. As with the GSRES Model, my findings indicate a statistically significant relationship among the variables. I found support for hypothesis one - GRSWN => OPERF: -0.287, t = 2.442, p < 0.05 (0.015). This indicates that the impact of a Gray Swan negatively affects firm operational performance. I also found support for hypothesis three - GRSWN => TBSR: -0.283, t = 2.288, p < 0.05 (0.022); hypothesis four – RBSR => FMRES: 0.321, t = 2.548, p < 0.05 (0.011); and hypothesis six - FMRES => OPERF: 0.543, t = 6.912, p < 0.05 (0.000). I found marginal support for hypothesis five - TBSR => FMRES: 0.226, t = 1.709, p < .10 (0.088) relationship. However, there is no statistical support for hypothesis two - the Gray Swan => relational buyer-supplier relationship: GRSWN => RBSR, -0.227, t = 1.731, p > 0.05 (0.084). I did not find support for hypothesis two - GRSWN => RBSR: -0.226, t = 1.516, p > 0.05). This finding seems inconsistent with the literature that a disruption would not negatively and significantly affect the relational buyer-supplier relationship. These findings indicate that operational performance is significantly affected by a firm's ability to respond to and recover from a Gray Swan. I examined the indirect effects and found statistical support for the mediated effects of the impact of the relational buyer-supplier relationship on operational performance - RBSR => FMRES => OPERF: 0.174, t = 2.275, p < 0.05 (0.023); and marginal support for the mediated effects of the impact of the transactional buyer-supplier relationship on operational performance - TBSR => FMRES => OPERF: 0.123, t = 1.648, p > 0.05 (0.099). These findings

indicate that a relational buyer-supplier relationship had a significant indirect effect of firm operational performance mediated by firm resilience. As with the first model, I again examined the effect size of the relationship among the variables by reviewing the F^2. Hair et al (2017) noted that the F^2 is useful as a measure of effect size: 0.02 is considered small; 0.15 medium; and 0.35 large. FMRES => OPERF had a significantly large effect size: $F^2 = 0.46$; GRSWN => RBSR = 0.054; GRSWN => TBSR = 0.087; RBSR => FMRES = 0.116; and TBSR => FMRES = 0.058. These effect sizes, though small, support the hypotheses regarding the relationship among the variables.

Figure 15-
GSOP - Structural (Inner) Model

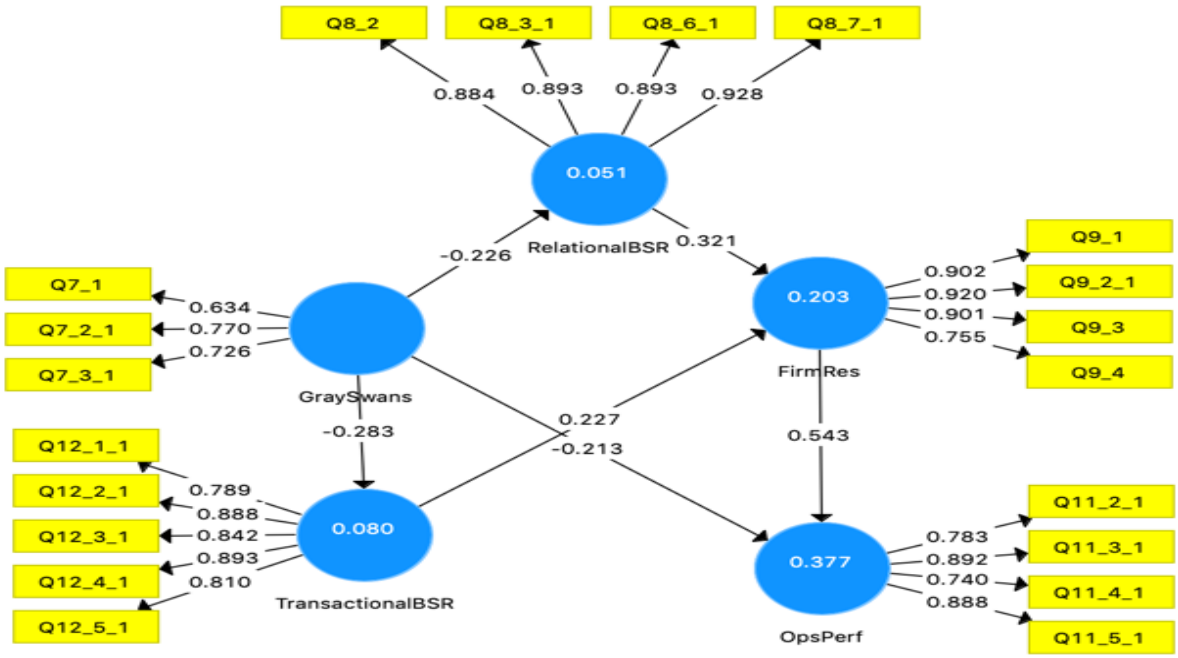
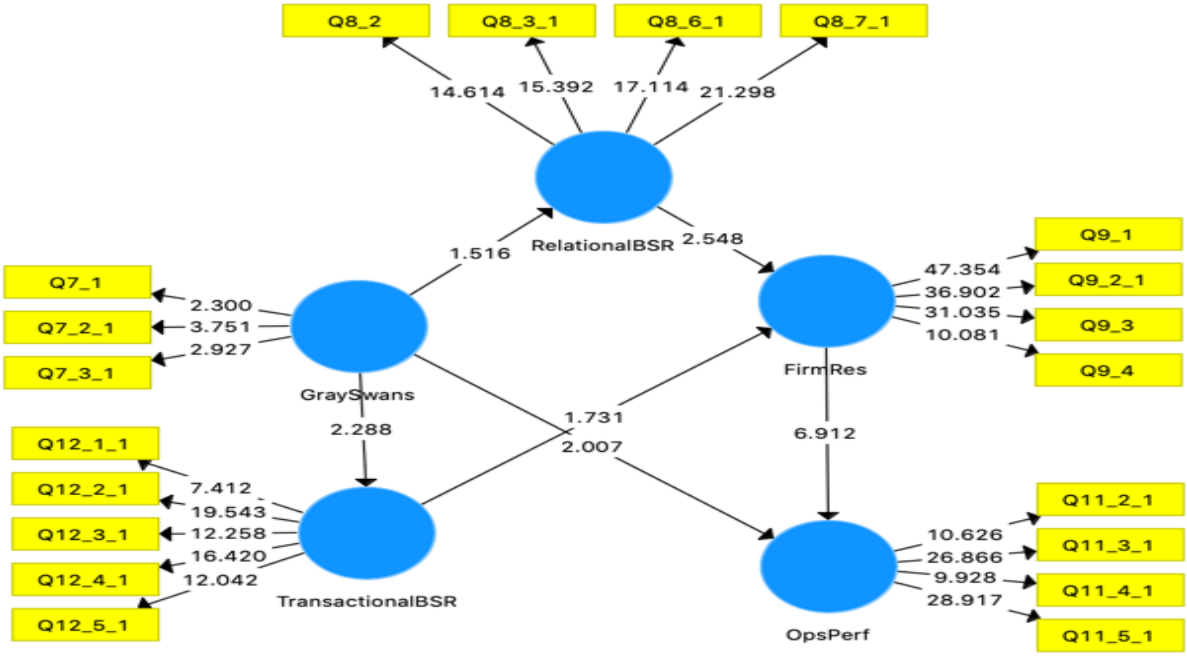


Figure 16-
Measurement (Outer) Model – GSOP Model



I then expanded the model to examine the relationship between Gray Swans (GRSWN) and Operational Performance (OPERF). The results are presented in Figures 15 and 16 below. The R^2 for variables in the model are as follows: FMRES = .221; OPERF = .536; RBSR = 0.038 and TBSR = 0.056. I found support for hypotheses one - GRSWN => OPERF: -0.350, t = 3.063, $p < 0.05$ (0.002); hypothesis five - RBSR => FMRES: 0.298, t = 2.282, $p < 0.05$ (0.023); hypothesis seven - TBSR => FMRES: 0.257, t = 2.166, $p < 0.10$ (0.030); hypothesis eight - RBSR => OPERF: 0.275, t = 3.193, $p < 0.05$ (0.001); and hypothesis nine - FMRES => OPERF: 0.457, t = 5.912, $p < 0.05$ (0.000). I found marginal support for hypothesis four - GRSWN => OPERF: -0.187, t = 1.832, $p < 0.10$ (0.073); and hypothesis six: RBSR => OPERF: 0.234, t = 1.760, $p > 0.05$ (0.078). I examined total indirect effects and found support the mediated effect of

firm resilience on operational performance - RBSR => FMRES => OPERF: 0.136, t = 2.094, p < 0.05 (0.036); TBSR => FMRES => OPERF: 0.117, t = 2.203, p < 0.05 (0.028). The significant relationship indicate mediation in the model. I did not find support for some of the other mediated relationships. The findings are reported in Tables 33 and 34.

Figure 17-
Revised Structural (Inner) Model – GSOP Model

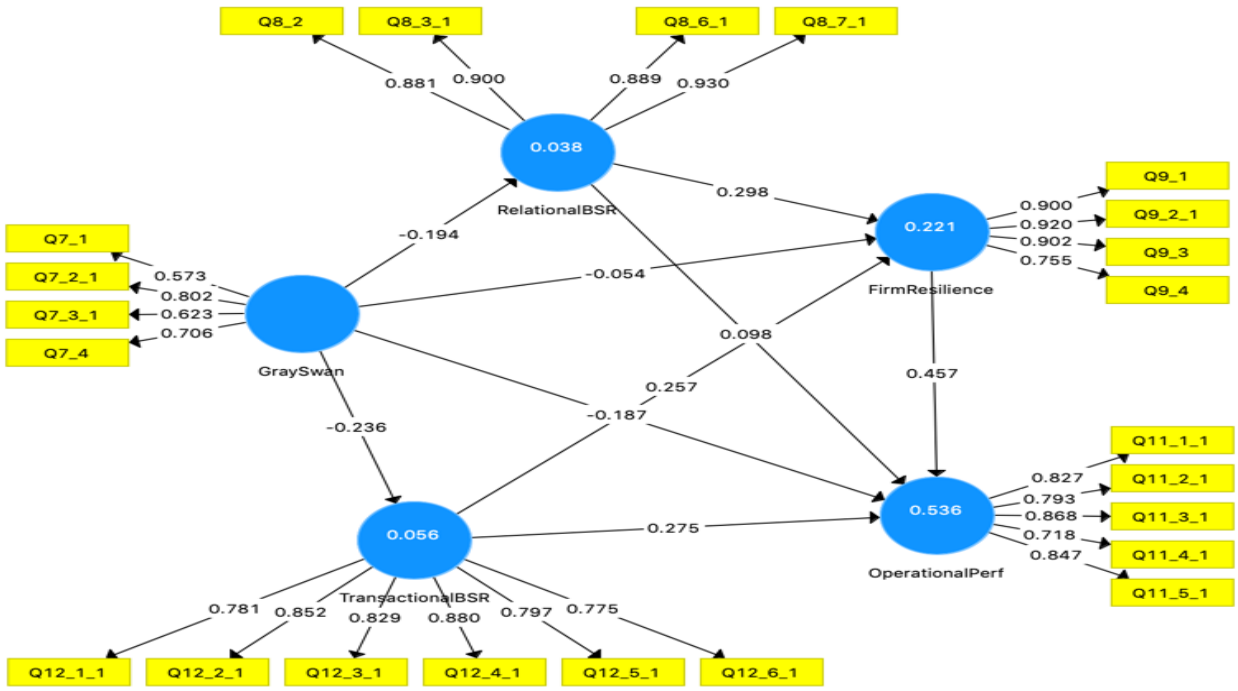


Figure 18-
Revised Measurement Model – GSOP Model

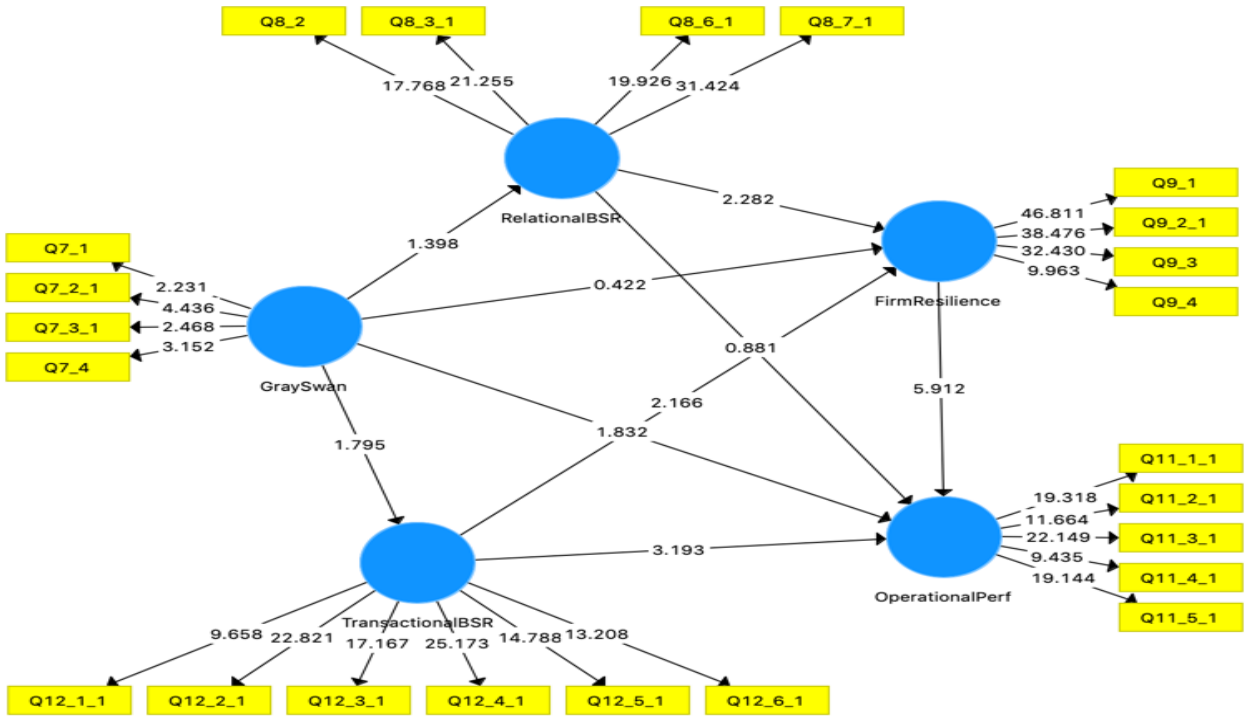


Table 33-
Summary of Hypotheses and Test Results – GSRES Model

Hypotheses	Causal Path	Coef ficients	T Statistics	P < 0.05**	LCL	UCL	Support for Hypotheses
1	GraySwans -> FirmResilience	-0.004	0.027	0.978	-0.262	0.268	No
2	GraySwans -> RelationalBSR	-0.214	1.256	0.209	-0.52	0.161	No
3	GraySwans -> TransactionalBSR	-0.299	2.329	0.020**	-0.526	-0.008	Yes
4	RelationalBSR -> FirmResilience	0.311	2.359	0.018**	0.032	0.548	Yes
5	TransactionalBSR -> FirmResilience	0.268	2.254	0.024**	0.036	0.506	Yes
	Indirect Effects						
6	GraySwans -> RelationalBSR -> FirmResilience	-0.067	0.942	0.346	-0.233	0.048	No
7	GraySwans -> TransactionalBSR -> FirmResilience	-0.08	1.609	0.108	-0.188	0.01	Marginal
	Total Indirect Effects						
	GraySwans -> FirmResilience	-0.147	1.985	0.047**	-0.301	-0.001	Yes

Table 34-
Summary of Hypotheses and Test Results – GSOP Model

Hypotheses	Causal Path	Coef-ficients	T Statistics	P < 0.05**	LCL	UCL	Support for Hypotheses
1	GraySwan -> OperationalPerf	-0.35	3.063	0.002	-0.57	-0.132	Yes
2	GraySwan -> FirmResilience	-0.172	1.356	0.175	-0.424	0.073	No
3	GraySwan -> RelationalBSR	-0.194	1.398	0.162	-0.478	0.068	No
4	GraySwan -> TransactionalBSR	-0.236	1.795	0.073	-0.488	0.035	Marginal
5	RelationalBSR -> FirmResilience	0.298	2.282	0.023	0.016	0.531	Yes
6	RelationalBSR -> OperationalPerf	0.234	1.76	0.078	-0.071	0.454	Marginal
7	TransactionalBSR -> FirmResilience	0.257	2.166	0.03	0.046	0.504	Yes
8	TransactionalBSR -> OperationalPerf	0.392	4.05	0	0.219	0.596	Yes
9	FirmResilience -> OperationalPerf	0.457	5.912	0	0.284	0.584	Yes

Indirect Effects

Hypotheses	Causal Path	Coefficients	T Statistics	P < 0.05**	LCL	UCL	Support for Hypotheses
10	GraySwan -> FirmResilience -> OperationalPerf	-0.025	0.434	0.664	-0.133	0.093	No
11	RelationalBSR -> FirmResilience -> OperationalPerf	0.136	2.094	0.036	0.007	0.259	Yes
12	TransactionalBSR -> FirmResilience -> OperationalPerf	0.117	2.203	0.028	0.02	0.227	Yes
13	GraySwan -> RelationalBSR -> OperationalPerf	-0.019	0.57	0.569	-0.099	0.034	No
14	GraySwan -> TransactionalBSR -> OperationalPerf	-0.065	1.412	0.158	-0.17	0.012	No

5.7. Model Fit

Goodness of Fit measures are not utilized in the same manner for PLS are they are for CB-SEM (see Henseler & Sarstedt, 2014; Hair et al., 2017 for further discussion). PLS focuses on the predictive ability of a model rather than assessing the fit of the data to the model. Since I am not testing theory in this dissertation but developing theory, I reported those measures commonly reported with CB-SEM application that might be useful for explaining model fit. In the GSRES Model, I reported the Standardized Root Mean Square Residual (SRMR) which was (.09) for the saturated model and (.118) for the estimated model. In the GSOP Model the SRMR was 0.09 for the saturated model and 0.121 for the estimated model. In the literature, the reported SRMR should be less than .08 and the NFI should be greater than (.90). Henseler et al. (2014) suggested that a larger threshold than the commonly reported (0.08) would be useful for PLS. Hair et al (2017) suggest reporting other measures such as the Root Mean Squared Residual (RMS Theta) covariance. They noted that a threshold of (0.12) for RMS Theta suggests a good model fit (Hair et al., 2017). The RMS Theta for the Simple Model is (0.19) and (0.17) for GSOP Model. Although these results are greater than the reported threshold, I am confident, given the reported findings, the model has predictive ability. Further, the reported R^2 of the models are sufficiently large to indicate a good model fit (Hair et al., 2017). PLS also relies on other measures such as the Stone-Geisser's Q^2 to assess model fit. If the Q^2 is greater than zero, then the model has predictive value. The Q^2 are as follows: GSRES Model: FMRES = 0.600; GRSWN = 0.025; RBSR = 0.662 and TBSR = 0.566. For the GSOP Model, the Q^2 are as follows: FMRES = 0.595; OPERF = 0.474; GRSWN = 0.017; RBSR = 0.662 and TBSR = 0.566. The Q-Squares are all

greater than zero. This indicates model had predictive relevance. The model fit indices are reported in Tables 35 and 36 below.

Table 35-
R-Square, Q-Square and AVE for the GSRES Model

Construct	R^2	Q^2 - Redundancy	AVE
FMRES	0.211	0.134	0.757
GRSWN	--	--	0.514
RBSR	0.048	0.022	0.810
TBSR	0.086	0.054	0.674

Table 36-
R-Square, Q-Square and AVE for the GSOP Model

Construct	R^2	Q^2- Redundancy	AVE
FMRES	0.221	0.138	0.761
OPERF	0.536	0.318	0.465
RBSR	0.038	0.018	0.660
TBSR	0.056	0.032	0.655
GRSWN	-	-	0.672

5.8. Regression Analysis

I conducted linear regressions of the GSRES Model and found the following: $R^2 = .19$. The variables in the model explained 19% of the variance in the dependent variable. That is, 19% of the effect on firm resilience can be explained the independent variables. The beta coefficient for RBSR was 0.36, $t = 2.598$, $p < 0.05$ (0.012). The beta coefficient for TBSR was 0.31, $t = 1.891$, $p < 0.10$ (0.063). These findings indicate that both RBSR and TBSR predict firm resilience

(FMRES) which is hypothesized in Chapter Three. TBSR is significant at the alpha level $p < 0.10$ (0.063); RBSR was significant: b= 0.36, t = 2.598, $p < 0.05$ (0.012. While the beta coefficient for Gray Swans was negative as hypothesized (-0.014), the effect on Firm Resilience was nonsignificant – t = -0.114, $p > 0.01, 0.05, 0.10$. I concluded that the occurrence of a Gray Swan does not directly affect firm resilience. I tested to see if there was interaction effect of Gray Swans and the buyer-supplier relationship. I found that although the results were negative as hypothesized – GRSWNxRBSR: = -0.19, t = -1.079, $p > 0.05$ (0.285) and GRSWNxTBSR: = -0.158, t = -0.845, $p > 0.05$ (0.401), there no interaction of Gray Swans and the Relational Buyer-Supplier Relationship or Gray Swans and the Transactional Buyer-Supplier Relationship. I then conducted a regression to determine if controlling for firm size and prior disruption experience had any effect on the variables in the model. The results indicate that prior disruption experience did not predict a firm's ability to respond to and recover from a Gray Swan. However, firm size predicted a firm's response to and recovery from a Gray Swan. When these variables are included in the model, the R^2 increases to 0.26 and the adjusted R^2 increases to 0.18. The model summary is presented below.

Table 37-
Model Summary
GSRES Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.514a	0.264	0.18	0.95695

The output for the linear regression is presented in Table 38 below.

Table 38-
Regression Coefficients – GSRES Model

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.284	0.259		12.665	0.000
Gray Swan	0.095	0.134	0.086	0.708	0.482
RelationalBSR	0.282	0.144	0.239	1.961	0.054
TransactionalBSR	0.305	0.165	0.222	1.851	0.069
GraySwan x RelationalBSR	-0.191	0.174	-0.131	-1.097	0.277
GraySwan x TransactionalBSR	-0.196	0.184	-0.123	-1.064	0.292
Disruption Experience	0.084	0.283	0.034	0.297	0.767
Firm Size	0.346	0.176	0.226	1.963	0.054

a. Dependent Variable: FirmRes. N = 69

I conducted linear regressions on the Complex Model and obtained the following results in table 39 below. The R^2 is 0.389 and the Adjusted R^2 is 0.35. See Model Summary below. This indicates that more than 30% of the variance in the dependent variable (OPERF) is explained by the variables in the model. There is some discussion in the literature on the appropriate level of R^2 to reported in management research. Peng & Lai (2012) note that R^2 levels of less than .19 are

considered weak; .33 moderate; and .67 substantial. Some scholars argue that an R^2 greater than .10 adequately explains the predictive ability of exogenous variables in the model. These findings indicate that two variables have the greatest predictive ability on Operational Performance: TBSR, b = 0.191, t = 1.725, p < .10 (0.089); FMRES, b = .351, t = 5.051, p < 0.05 (0.000).

Table 39-
Model Summary GSOP Model

Model Summary b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.623a	0.389	0.35	0.68312

a. Predictors: (Constant), FirmRes, GraySwan, TransactionalBSR, RelationalBSR
b. Dependent Variable: OpsPerf

Table 40-
Regression Coefficients – GSOP Model

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.07	0.349		0.201	0.841
GraySwan	-0.025	0.13	-0.015	-0.191	0.849
RelationalBSR	0.311	0.107	0.265	2.897	0.005
TransactionalBSR	0.254	0.071	0.29	3.565	0.001
Resilience	0.365	0.087	0.358	4.203	0.000
DisruptionExp	0.545	0.761	0.056	0.717	0.475
FirmSize	0.037	0.469	0.006	0.080	0.937
GSWNxRBSR	-0.035	0.041	-0.074	-0.845	0.400
GSWNxTBSR	0.015	0.028	0.042	0.535	0.594
RBSRxRES	-0.014	0.02	-0.064	-0.701	0.485
TBSRxRES	0.005	0.016	0.024	0.301	0.764

N = 69

5.8.1. Moderating Effects of Gray Swans

I tested the moderating effects of a Gray Swan on outcome variable. I did not test for moderation specifically. Moderation is said to occur when a variable affects the direction and/or strength of the relationship between and independent variable and a dependent variable (Baron & Kenny, 1986; Preacher et al., 2007). The moderation effects of Gray Swans in the GSRES Model are statistically nonsignificant: GRSWN x RBSR: b = -0.131, t = -1.097, p > 0.05 (0.277); GRSWN x TBSR: b = -0.123, t = -1.064, p > 0.05 (0.292). I also examined the moderating effects of the Gray Swans on the outcome variable firm resilience. I did not find any moderating effects: GRSWN x RBSR: b = -0.074, t = -0.845, p > 0.05 (0.400); GRSWN x TBSR: b = 0.042, t = 0.535, p > 0.05 (0.594). Interestingly, while the moderating effect was negative for GRSWN x RBSR in both the GSRES and GSOP models, the relationship was different in the GSOP models. The moderating effect was negative in the GSRES model GRSWN x TBSR: b = -0.123, t = -1.064, p > 0.05 (0.292). However, the relationship was positive in the GSOP model: GRSWN x TBSR: b = 0.042, t = 0.535, p > 0.05 (0.594). This finding is interesting since it suggests that the interaction of Gray Swans and the transactional buyer-supplier relationship has a positive effect on firm resilience. The direct effect is negative in both models. I surmise that contractual relationships have underlying negative consequences for the firm such that a contract may not always ensure the firm has access to the required resources in the context of a Gray Swan.

5.9. Post Hoc Analysis

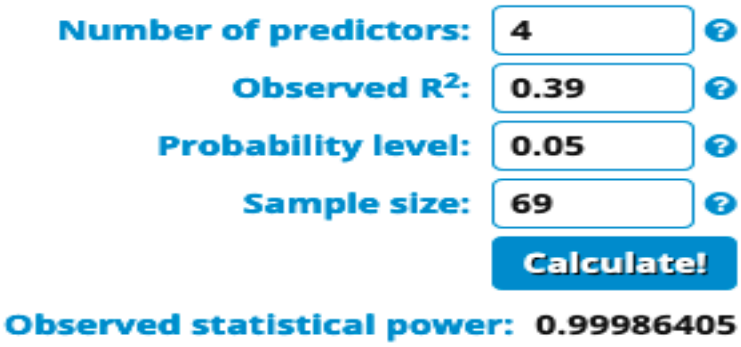
I conducted power analysis to examine the significance of the effects of the endogenous variable in the model on the outcome variable. I utilized the Soper free Statistical Calculator to conduct

the analysis. I found that I had sufficient statistical power (0.988) in the Simple Model and sufficient statistical power (0.999) in the Complex Model. This suggests that both models have predictive power. I also tested for multicollinearity by examining the VIF for the models. None had a VIF greater than 4.126. In the literature, VIF's less than 10 are considered acceptable. However, it is suggested that when there are small samples, the researcher should seek a more restrictive VIF (Hair et al. 2006). I am confident the VIF's in this dissertation meet that requirement.

Table 41-
Statistical Power Calculator for Multiple Regression – GSRES Model

Number of predictors:	3
Observed R^2:	0.26
Probability level:	0.05
Sample size:	69
	Calculate!
Observed statistical power:	0.98808108

Table 42-
Statistical Power Calculator for Multiple Regression – GSOP Model



5.10. Chapter Summary

In this chapter, I utilized several approached to conduct my data analysis. I use SPSS to perform the initial data analysis and conduct the exploratory factor analysis (EFA). I also utilized SmartPLS3 to conduct a confirmatory factor analysis (CFA) and the test the hypotheses in the model. The results were as hypothesized although there was one surprising finding which I will address in Chapter 6.

CHAPTER VI

DISCUSSION AND CONCLUSION

6.0. Summary

This research was undertaken to empirically examine the effects of a Gray Swan on firm resilience and ultimately operational performance. I found statistically significant support for three of the hypothesized relationships (H3, H4, and H5) and marginal support for (H7) the mediated relationship in the GSRES Model. I also found statistically significant support for five of the nine hypothesized relationships (H1, H5, H7, H8, H9) and marginal support for H4, and H6 in the Complex Model. While Gray Swans do not directly affect firm resilience, my findings indicate that the buyer-supplier relationship – whether relational or transactional – has a significant effect on firm resilience. NB. I did not test for moderation in either GSRES or GSOP Model. I found that Gray Swans do have a direct negative effect on operational performance. This study highlights the fact that Gray Swans presents unique challenges to managers faced with making decision making responsibilities. These results provide a deeper insight into this particular construct and illuminates an area of research for further investigation.

6.1. Discussion of Results

This dissertation sought to address several research questions. Of principal concern to the investigator was determining what is a Gray Swan – in an operations management (OM) context - and developing a scale to empirically measure a Gray Swan. Further, I wanted to determine whether relational and transactional governance mechanisms mediated the effects of a Gray

Swan on firm resilience or performance. Prior research has examined the effects of the buyer-supplier relationship on firm performance or resilience. However, in many of these studies, the buyer-supplier relationship is used as an antecedent and the researchers focus on some dimension of the construct. In this dissertation, I examine the buyer-supplier in the context of a Gray Swan. Previous studies have also examined risk. However, none, to the best of this researcher's knowledge, have examined Gray Swans. This is the first empirical examination of the Gray Swan construct. Gray Swans, except for a limited scope by Akkermans & van Wassenhove (2013), have not been investigated empirically or methodologically in operations management. OM scholars have investigated various kinds of risk (see Christopher & Peck, 2004; Kleindorfer & Saad, 2005; Manuj & Mentzer, 2008; Wagner & Bode, 2008; Tummala & Schienherr, 2011; Samvedi et al., 2013). However, the Gray Swan risk has escaped serious consideration given its low probability. Further, many of the aforementioned researchers have focused on several types of risk as posited by Christopher & Peck, 2004: (1) Supply Risk; (2) Process Risk; (3) Demand Risk; (4) Control Risk; and (5) Environmental Risk. Many of the risks addressed in the literature are essentially White Swans (e.g. machine failure) or Light Gray Swans (e.g. supply and demand failures) and easily quantifiable. However, Gray Swans, while quantifiable based on previous history, seem to escape predictability. There is the desire, and the current COVID-19 pandemic bears out this logic, to label Gray Swans as "black swans" given their catastrophic impact. The danger in this approach is that societies and businesses are less prepared for the next Gray Swan.

Graw Swans are not a new phenomenon. Previous discussion of risk in the literature have considered, but often mis-labeled Gray Swan events. Labeling is important. It determines how

managers and those responsible for decision-making, e.g. investors and policy makers frame their responses to these extremely disruptive events (Kim, 2020; Sindreu, 2020). Decision makers may often mis-identify Gray Swans because most consider these types of events as 'uncertain' and unpredictable rather than view them as "risk" events which can be measured and predicted based on past probabilities (Kim, 2020; Sindreu, 2020). While there are approaches to measuring Gray Swan risk in the financial markets, e.g. Value-at-Risk (VaR), no such measures exist in the operations management context. What scales can be developed to measure a construct is an empirical question. What is important is to clearly distinguish uncertainty, i.e., a black swan from risk, i.e. a Gray Swan. One of the goals of this study is to shift the paradigm in our thinking about risk, i.e. the risk of a supply chain disruption. Gray Swans, i.e. supplier insolvency, labor disputes, or political instability slowly buildup until there is a crescendo of disruption. This research gives managers some tools to investigate the effect of Gray Swans on the supply chain. This research also draws a distinction among several terms used in the literature to designate disruptions "disaster", "crisis", or "glitch". While much of the literature refers to "natural and man-made disasters", this research focuses exclusively on "man-made supply chain disruptions." I argue that Gray Swans have a human locus and therefore can be tamed. Some disruptions result from disasters, e.g. the Rana Plaza fire and the Tazreen Fashions fire, both in Dhaka, Bangladesh, or from labor disputes, e.g. the West Coast ports strikes in 2016, or supplier insolvency, e.g. GM's supplier, Clark Cutter McDermott filing for bankruptcy. These events all have a human locus and result in significant disruptions in the supply chain. These events have the characteristics of a Gray Swan.

In pursuing this inquiry, I examined which variables in the model mediated to effects of a Gray Swan on firm resilience. I found that the relationship between the buyer supplier relationship, whether relational or transactional, is largely consistent with the literature. The vast majority of these studies take a unidimensional approach – focusing either on relational governance mechanisms (see Kwon & Suh, 2005; Cousins et al., 2008; Tangpon et al., 2010, Corsten et al., 2011; Wong et al., 2011; Zhang & Huo, 2013, Yu et al., 2019) or transactional governance mechanisms (see Summer & Lo, 2009; Bai et al., 2016; Shou et al., 2016; Sluis & de Giovanni, 2016). While some studies have considered supply chain integration (see Wong et al. 2011; Danese & Bortolotti, 2014; Shou et al., 2018), supply chain management practices (see de Souza Miguel & Brito, 2011; Tatoglu et al., 2015; Acar et al., 2017, Croom et al. 2018) in relation to firm resilience or operational performance, none have considered these relationships in the context of a Gray Swan. This study highlights the importance of understanding Gray Swans and extends the literature and our understanding of the effects of this phenomenon on firm resilience and operational performance. The results in this dissertation provide support for the hypotheses advanced on the direct and indirect impact of Gray Swans on firm resilience and operational performance. This dissertation advances the buyer-supplier relationship literature especially those relationships based on a relational governance mechanism. The findings demonstrate that there is a statistically significant relationship between a relational governance mechanism and firm resilience or performance. There is also a statistically significant relationship between a transactional governance mechanism and firm resilience or performance. These findings advance the works of Liu et al. (2009) and Lumineau & Henderson (2012) who

call for an integrated approach to designing the appropriate governance mechanism for the buyer-supplier relationship.

Gray Swans negatively affect the buyer-supplier relationship as hypothesized. However, while the effect is significant for the GRSWN =>TBSR relationship, it is nonsignificant for the GRSWN =>RBSR relationship. This suggests that having contracts in place mitigates the negative effects of a Gray Swan on the firm's ability to respond to and recover from those disruptions. The firm is able to enforce its contractual agreements to ensure that it obtains the necessary resources to remain operational during a Gray Swan disruption. Why the relationship between the occurrence of a Gray Swan and the relational buyer-supplier relationship (RBSR) is not significant is an empirical question. It may be that unlike other types of disruptions, a Gray Swan may result in a lower level of trust among the supply chain partners. Although both types of mechanisms have a positive effect on firm resilience, the effect of the RBSR => FMRES is larger than the TBSR => FMRES. The suggests that a relational governance mechanism, i.e. one based on trust is more effective in ensuring a firm's ability to respond to and recover from a Gray Swan. This is further evidence for an integrated approach in the context of a Gray Swan.

In many of the studies cited here, the buyer-supplier relationship is often combined with some other variable to examine the effect on some outcome variable (see Kwon & Suh, 2005; Cousins et al., 2008; Summer & Lo, 2009; Tangpon et al., 2010; Corsten et al., 2011; Wong et al., 2011; Zhang & Huo, 2013; Bai et al., 2016; Shou et al., 2016; Sluis & de Giovanni, 2016; Yu et al., 2019). In this dissertation, I utilize the buyer-supplier relationship as a multi-level intervening variable affecting the relationship between a Gray Swan and firm resilience or performance.

Many of the studies presented here focus on some attribute of the buyer-supplier relationship. For example, Kwon & Suh (2005) focus on trust and commitment; Narayanam et al. (2015) focus on trust and collaboration; and Liu et al. (2012) focus on justice. While Bai et al. (2016) focus on institutional factors and Summer & Lo (2009) focus on incentive schemes. Based on the literature, I considered trust an important attribute of the relational governance mechanism and output or outcome-based contracts to be important attributes of the transactional mechanism. Cao & Lumineau (2015) argued that contracts based on trust and relational norms improved the buyer-supplier relationship. I relied on those attributes when developing items for my questionnaire.

The results of the dissertation indicate that regardless of the governance mechanism, a Gray Swan poses significant challenges for a firm. The indirect effect of a Gray Swan on firm resilience was significant: $b = -0.147$, $t = 1.985$, $p < 0.05$ (0.047). When I extended the model to examine the effects of a Gray Swan on operational performance, the direct effects were significant. However, the indirect effects were not statistically significant. The direct effect of a Gray Swan on operational performance was negative and statistically significant: $b = -0.350$, $t = 3.063$, $p < 0.05$ (0.002). This indicates that a Gray Swan will have a negative effect on firm operations. These findings are important because they demonstrate that operational performance is particularly susceptible to the disruptive nature of Gray Swans. While Gray Swans may not have a statistically significant direct effect on firm resilience, these findings demonstrate that firm resilience mediates the effect of a disruption on operational performance. The indirect effect is negative though not statistically significant: $b = -0.025$, $t = 0.434$, $p < 0.05$ (0.664). These

findings indicate that regardless of buyer-supplier governance mechanism, whether relational or transactional, Gray Swans are likely to have a negative effect on operational performance. These findings highlight the importance identifying and mitigating Gray Swans. One mitigating factor may be the type of buyer-supplier relationship the firm has in place. Another factor is the firm's risk management system. The findings in this dissertation regarding the buyer-supplier governance mechanism extend the work of Liu et al. (2009), Lumineau & Henderson (2012) and Cao & Lumineau (2015). These researchers argued for a more integrated approach to the buyer-supplier relationship. For example, Liu et al. (2009) argued that contracts should be coupled with relational investments to reduce opportunism and improve relationship performance. Whether that relationship performs sufficiently well under a Gray Swan is not borne out by this research. Cao & Lumineau (2015) argued that contracts based on trust and relational norms improve the buyer-supplier relationship. That suggestion is also not borne out in this research. How much each mechanism whether singly or together reduces or eliminates the effects of a Gray Swan is something future research can investigate. What this research shows is that an either-or approach does not necessarily produce the best outcomes. Lumineau & Henderson (2012) note that relational and contractual governance mechanisms are not polar opposites and managers should approach the buyer-supplier relationship more holistically. Striking the right balance will ensure firm resilience in the event of a Gray Swan.

6.2. Theoretical Implications

This study contributes to the resilience and operational performance researches and extends the contingency lens through which we view the Gray Swan phenomenon. Sousa & Voss

(2008:703) noted that contingency studies focus on three types of variables: (1) *contextual variables*, i.e. variables in the firm's eternal operating environment (e.g. a Gray Swan), (2) *response variable*s, i.e. organizational or managerial mechanisms utilized in response to or anticipation of the contextual variable, (e.g. they buyer-supplier governance mechanism), and (3) *performance variables,* i.e. the dependent variables that are used to evaluate the effectiveness of the fit between the contextual and response variables (e.g. firm resilience or operational performance). Previous studies have examined the buyer-supplier relationship – whether transactional or relational using well established theories. For example, Nyaga et al. (2010), Lumineau & Henderson (2012) and Zhang & Huo utilize Transaction Cost Economics (TCE); Tangpon et al. (2010) integrate TCE with Contingency Theory (CT) and Personality Trait Theory; Narayanam et al. (2015) integrate TCE and CT. Other studies relied on Agency Theory (Summer & Lo, 2009); Institutional Theory (Bai et al., 2016; Shou et al. 2016) as well as Social Exchange Theory (Kwon & Suh, 2005; Luo & Liu, 2009). However, none of these previous studies have considered the implications of a Gray Swan. This study departs form the larger body of literature and offers a new theoretical framework through which to view the Gray Swan phenomenon.

Following Shou et al. (2018) and others, I utilized a contingency framework to examine how firms seek to regain fit with their external environment. However, unlike these previous researchers I integrated a contingency theory (CT) perspective with a punctuated equilibrium perspective (PET) and devised a "*punctuated contingent perspective*" (PCP) to provide a better understanding of how firms seek to regain stasis within its internal environment and fit with its

external environment. Contingency factors such as task uncertainty and task interdependence lie within the organization (Donaldson, 2001). However, task interdependence also lies outside the organization when one considers the firm's supply chain which is affected buy another contingency factor – environmental uncertainty. Fit is disrupted in the organization and its supply chain when environmental contingencies affect internal contingencies – such as task interdependence. Similarly, organizational stability is affected by environmental conditions and the design and structure of TMT which shape organizational strategy and structure (Sammut-Bonnici & Wenskey, 2002). I believe that integrating these two theoretical perspectives is useful in this context since both share the same epistemological assumptions and level of analysis (Shaw et al., 2018). They also they exemplify what Shaw and colleagues refer to as "compatibility" and "communication clarity" (Shaw et al., 2018). Both CT and PET address uncertainty in the firms operating environments. Organizations seeks to cope with uncertainty by creating certain structures (Hickson et al. 1971, c.f. Cyert & March 1963). Uncertainty is an important element of contingency theory (Flynn et al., 2016). Gray Swan contingencies can be viewed as environmental fluctuations that can disrupt the core activities of an organization (Flynn et al. 2016). Given the level of uncertainty, firms should make adjustments enable the firm to maintain homeostasis (Flynn et al. 2016 c.f. Thompson, 1967). Punctuated equilibrium integrated with contingency theory (*punctuated contingent perspective*) offers a more fine-grained perspective of how organizations address endogenous and exogenous environmental shocks (Romanelli & Tushman, 1994). Viewed in the supply chain context, PET and CT explain how firms respond to changes in their external environments, i.e. how firms behave in the

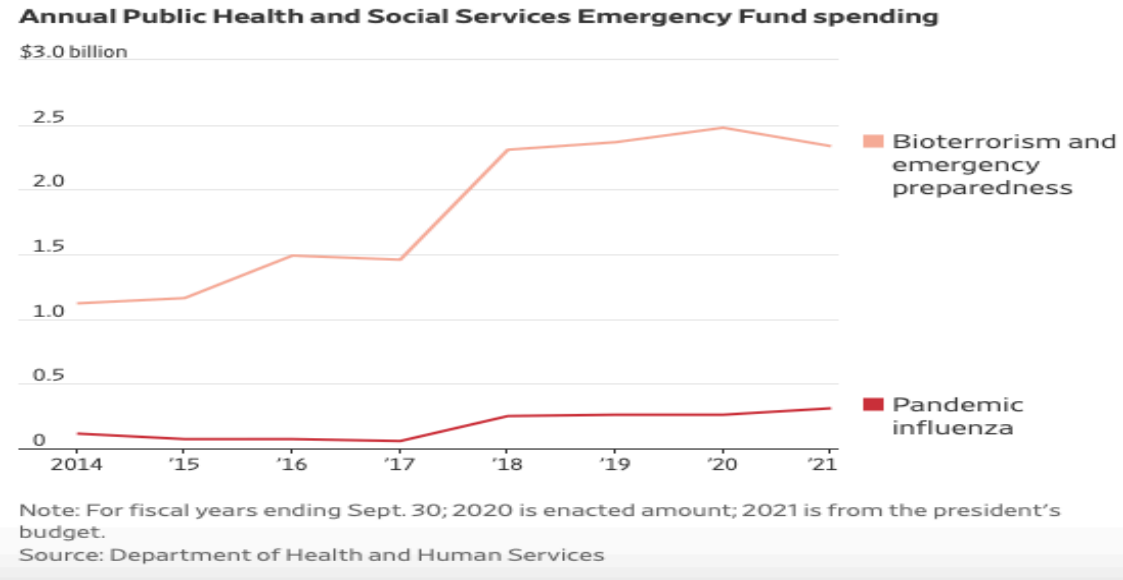
context of a Gray Swan. The results of this dissertation provide empirical for the theoretical basis of my arguments and highlight the important of 'fit' and 'stasis' for firms to remain resilient and ensure operational performance.

6.3. Managerial Implications

Managers determine the firm's ability to go through the periods of convergence and reorientation to regain fit with its operating environment. The time between convergence and reorientation is determined by the firm's executive leadership, i.e. top management team (TMT) (Tushman & Romanelli, 1985). One of the reasons why managers may not spot a Gray Swan is "managerial myopia." Managers mag not engage in boundary spanning or other activities to assess what is happening in their external environment. Another reason is institutional inertia. Organizations sometimes become hostages to the structures, processes and strategies. The organizational culture may also play a role in how managers may perceive risk. Some organizations may be risk averse while other may be risk taking. This study focuses managers' attentions on the those low-probability-high negative impact events. The current COVID-19 pandemic illustrates this point. Berzon et al. (2020) argue that the H1N1 flu epidemic in 2009 was a precursor for the current pandemic. However, managers in the healthcare relied on just-in-time and lean inventory strategies and essentially did not have sufficient safety stock (Berzon et al., 2020). The authors point out that a misalignment, i.e. misfit between supply and demand during the H1N1 epidemic created a bullwhip effect which left manufactures with costly inventory (Berzon et al., 2020). During the convergence period, managers returned to "normal" while manufactures were experiencing revolutionary periods (Tushman & Romanelli, 1985). One former government

official noted that the 'medical supply chain and health-care system pursued economic efficiency at the expense of resilience'[8] (Berzon et al., 2020). Moreover, it appears that the overall national strategic focus was on terrorism risk rather than Gray Swan risks. The graphic below highlights this point (Berzon et al., 2020).

Figure 19-
Why We Often Mis-Identify and Overlook Gray Swans?



Companies should take proactive steps to address potential Gray Swans and adopt the following approach: (1) constantly assess the operating environment; (2) acknowledge any potential threats; and (3) address the issue be engaging in the appropriate risk mitigation and risk management strategies. Managers should also consider the following five-step process proposed by Dodson and Westney (2014, p. 186) to address Gray Swans: (1) Risk framing (i.e. hunting

[8] Retrieved from: https://www.wsj.com/articles/miscalculation-at-every-level-left-u-s-unequipped-to-fight-coronavirus-11588170921. Tara O'Toole was an undersecretary in the Department of Homeland Security in the Obama Administration.

Gray Swans), frame risk scenarios and their potential impacts; (2) Risk strategies (caging Gray Swans), developing strategies that avoid, mitigate the impact if it should occur; (3) Risk assessment (understanding the Gray Swans), develop a probabilistic analysis of capital cost and schedule, reflecting both tactical and strategic risks, (4) Risk brokering (feeding the caged Gray Swans), independently allocating risk or risk cover; and (5) Risk validation (taming the Gray Swans); ensuring that the known Gray Swan risks are being managed in accordance with the plan (Dodson & Westney, 2014, c.f. Hajikazemi et al., 2016). Managers should also engage in monitoring conditions for periodic updating of Risk Scenarios and exposure (Dodson & Westney, 2014, c.f. Hajikazemi et al., 2016). Managers must recognize that today's risk needs cannot be met by using yesterday's risk management approaches (Finley, 2009). Moreover, managers must understand that best practices in supplier risk management must blend assessment of the supplier's financial viability with other related metrics to reduce exposure to risk (Finley, 2009).

Gray Swans are unique because they are recognizable in theory but ignored until they actually appear in practice (Filatov & Vanyarkho, 2014). This gives the illusion that managers need not prepare for any kind of disruption. Those responsible for overseeing supply chains must take proactive steps to reduce the risk of exposure by following strategies proposed by Mazarr (2016). The author notes that companies should: (1) Cultivate a culture of valuing warnings; i.e. acknowledge that Gray Swans are not only theoretical but predictable. (2) Include formal risk assessment and mitigation; (3) Train analytical staff to look for the signs of Gray Swans; and (4) Hire a Chief Risk Officer of some senior leader in a key position to advice senior managers and

warn of potential Gray Swans. There have been calls in the literature for the nomination of "Supply Chain Risk Manager" to manage the risk in an organization (Lavastre et al., 2012) as well as the nomination of a Chief Supply Chain Officer (Roh et al., 2016). These approaches and strategies can significantly reduce the impact of a Gray Swan.

6.4. Limitations and Suggestions for Future Research

All research has some inherent limitations which may limit the ability to make conclusive statements and shape discussion for future research. This study has two limitations.

First, this study developed and normed a scale for measuring the Gray Swan construct. This is the first known attempt to measure Gray Swans. Future research can determine whether the items used were indeed appropriate and did actually measure Gray Swans. Second, although the target sample was representative of the larger population, the number of respondents was small, N = 109 and the useable sample smaller, N =69. The sample size debate rages on in the literature (see Hair et al., 2006, Tabachnick & Fidell, 2007 among others). It agreed that larger samples, e.g. 300 of greater generally produce statistically significant results. However, low response rates and low sample sizes in OM research has been well documented (see Melnyk et al. 2008). Future research with a larger sample size can confirm – or question the results of this study. Despite these limitations, the empirical conclusions support the basis thesis of the effects of this study and provides a greater understanding of the Gray Swan on firm resilience or operational performance. This study has introduced Gray Swan risk into the lexicon and provided a conceptual framework through which to understand this phenomenon.

6.5. Conclusion

This study advances supply chain risk management and supply chain disruption research by developing a theoretical framework and providing empirical evidence to explain the relationship among Gray Swans and Firm Resilience or Operational Performance. This research also advances theory be integrating contingency theory and punctuated equilibrium to offer a novel approach [punctuated contingent perspective] to understand the relationship between Gray Swans and Firm Resilience or Operational Performance. To the best of my knowledge, these two theoretical perspectives have not been combined in the literature to examine the effects of variables on firm resilience or operational performance. This is a significant contribution to the literature and to our understanding the effects of Gray Swans on various firm outcomes. This dissertation challenges the presumption of some managers to quickly label a catastrophic phenomenon a "black swan" and offers an alternative perspective – Gray Swan. Black Swans evoke fear and dread, and seemingly utter helplessness. While black Swans may be paralyzing, this study demonstrates that Gray Swans can be captured and tamed. The desire to label some events – such as the current COVID-19 pandemic as a black swan – is one of the problems in labeling this dissertation addresses and seeks to overcome. Hopefully, the findings of this study prompt managers to engage in more boundary spanning to spot Gray Swans and implement the necessary strategies to mitigate the effects so that companies can respond and recover quickly and maintain operational performance.

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APPENDIX A

APPENDIX A

SURVEY QUESTIONNAIRE

PILOT STUDY I

Introduction
The purpose of this survey is to examine the effects of Gray Swans in the supply chain. These phenomena, which are low probability, high impact events that when they occur, have the potential to significantly disrupt a firm's operations and may even affect a firm's viability.

Please note this is an anonymous survey and the responses are confidential. It will be used only for academic purposes, and it is optional for you to complete. I greatly appreciate your genuine honest responses to the statements and your help with this project.

Demographic Information
Please select the category that best describes you.

Your Age:	18 - 24 [ ] 25 – 34 [ ] 35 – 44 [ ] 45 – 54 [ ] 55 – 64 [ ] 65 – 74 [ ] >75 [ ]
Your Gender:	Male [ ] Female [ ]
Your Education Level:	Some high school – no diploma [ ] High School/GED [ ] Some college [ ] College graduate [ ] Master's Degree [ ] Doctorate [ ]
Your Ethnic Group:	White [ ] Black or African American [ ] Hispanic [ ] Asian [ ] Native American [ ]

	Other [ ] Please describe your group: _____
Firm Age:	0 - 4 years [ ] 5 – 9 years [ ] 10 – 14 years [ ] 15 – 19 years [ ] 20 – 24 years [ ] 25 – 29 years [ ] > 30 years [ ]
Firm Size (Number of Employees):	1 – 9 [ ] 10 – 49 [ ] 50 – 99 [ ] 100 – 249 [ ] 250 – 499 [ ] 500 – 999 [ ] >1000 [ ]
Firm Type:	Sole Proprietorship [ ] Partnership [ ] Corporation [ ] Nonprofit [ ]

Among the following industry categories, select the number which best describes your firm.

Industry Classification	Agriculture, Forestry, and Fishing [ ] Mining [ ] Construction [ ] Manufacturing [ ] Transportation and Warehousing [ ] Information [ ] Electric, Gas, and Sanitary Services [ ] Wholesale Trade [ ] Retail Trade [ ] Finance and Insurance [ ] Real Estate [ ] Professional, Scientific and Technical Services [ ] Management of Companies [ ] Admin. and Support and Waste Management Services [ ] Educational Services [ ] Healthcare and Social Assistance [ ] Arts an Entertainment [ ] Accommodation and Food Services [ ] Public Administration Other Services (except Public Administration) [ ] Public Administration [ ]

If none of the above, please describe your industry: _____

Job Title/Level of Responsibility	Entry Level [ ] Analyst / Associate [ ] Manager [ ] Senior Manager [ ] Director [ ] Vice President [ ] Senior Vice President [ ] C level executive (CIO, CTO, COO, CMO, CSCO, Etc.) [ ] President or CEO [ ] Owner [ ] Other [ ] Please indicate your Job Title: _____

Carefully read each of the statements listed below. Indicate your responses, on a scale of 1 to 7 according to your agreement with the statement, with 1 being strongly disagree to 7 being strongly agree.

Perceptions of a Gray Swan

The following statements concern your perceptions about Gray Swans. Read each statement and use the scale below and indicate the extent to which you agree or disagree with the statement.

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

Labor Disputes

1. The firm has not experienced any labor disputes. [ ]
2. The firm engages in fair and open labor contract labor negotiations. [ ]
3. Management at my firm generally responds to labor's demands. [ ]
4. The firm engages in collective bargaining. [ ]
5. Management at my firm insists that its supply chain partners pay a fair wage. [ ]

Supply Chain Partner Insolvency

7. The firm has a strategy to continue operations if a supply chain partner becomes insolvent. [ ]
8. The firm has a strategy to continue operations if a supply chain partner files bankruptcy. [ ]
9. The firm has a process for identifying financially distressed suppliers. [ ]
10. The firm has explored the cost of replacing a distressed supply chain partner. [ ]
11. The firm is aware of its supply chain partners' financial viability. [ ]

Political Instability

12. The firm has operations in countries experiencing political unrest. [ ]
13. The firm has operations in countries with escalating border tensions. [ ]
14. The firm has operations in countries that are subject to economic sanctions. [ ]

15. The firm has operations in countries experiencing political uprisings. [ ]
16. The firm has operations in countries experiencing social uprisings. [ ]

Risk Attitude

Please evaluate each statement using the scale below on your understanding of your firm's tolerance for risk.

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

17. Management at my firm always assess risk before making decisions. [ ]
18. The firm has a high tolerance for risk. [ ]
19. The firm has a low tolerance for risk. [ ]
20. The firm has a comprehensive risk management strategy. [ ]
21. Management my firm uses all available information before making decisions. [ ]

Buyer-Supplier Relationship

Please evaluate each statement below on the degree to which you believe your firm and its suppliers promote behaviors to maintain or improve their relationships.

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

Relational

24. There is another supplier that can provide comparable service or raw materials. [ ]
25. The firm would have losses in time and effort in replacing a current supplier. [ ]
26. The reputation with the current supplier is important to achieve the organizational objectives. [ ]
27. It would be difficult to generate the sales and profits that a current supplier generates for us. [ ]
28. The Top Management Team (TMT) has a close personal relationship with the TMT of the supplier/s. [ ]
29. The firm has invested in the suppliers. [ ]
30. I have a longstanding and close relationship with the suppliers. [ ]

Behavior-based Contract

31. The contracts contain specific technological provisions that the supplier must abide by when manufacturing the product. [ ]
32. The contracts contain specific provisions that give us the right to audit the supplier's manufacturing procedure. [ ]
33. The contracts contain specific provisions that give us the right to inspect the supplier's facilities. [ ]

Output-based Contract

34. The contracts specify interim goals that I expect the supplier to achieve. [ ]

35. The contracts contain performance standards I expect the suppliers to meet in the product they supply us. [ ]
36. The contracts specify deadlines for the supplier to deliver products. [ ]

Supply Chain Resilience

Please evaluate each statement on the degree to which you believe your firm can respond to and recover from a supply chain disruption.

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

Response

37. Management has a strategy for responding to supply chain disruptions. [ ]
38. The firm has a team or a manager responsible for responding to disruptions. [ ]
39. The firm has access to the resources it will need to respond to a disruption. [ ]
40. Management has the technical, human and social skills to respond to a disruption. [ ]
41. The firm has the ability to detect supply chain disruptions early. [ ]
42. The firm can respond quickly to supply chain disruptions. [ ]
43. The firm has successfully responded to past disruptive events. [ ]

Recovery

44. Management has a strategy for recovering from supply chain disruptions. [ ]
45. The firm has access to all the resources it will need to recover from a disruption. [ ]
46. The firm has successfully recovered from disruptive events. [ ]
47. The firm can recover from a disruptive event in a short period of time. [ ]
48. The firm has the ability to absorb a huge loss. [ ]
49. The firm can recover from a disruption at minimal cost. [ ]
50. Management has the technical, human and social skills to recover from a disruption. [ ]

Readiness

51. The firm has the ability to detect disruptions early. [ ]
52. The firm has readiness training for overcoming disruptions. [ ]
53. The firm has the resources to get ready for a disruption. [ ]
54. The firm has forecasting to meet demand disruptions. [ ]
55. The firm has a strong security system to protect against disruptions. [ ]

Supply Chain Risk Management

Please evaluate the statements on the degree to which you believe your firm is able to detect, predict, avoid or reduce uncertainty and to develop the strategic responses to mitigate the threats that can affect its operational, market, and financial performance as Ill as environmental, safety and social outcomes.

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

Risk Assessment
56. The firm has a framework for assessing risk. [ ]
57. The firm has adopted the principles of the ISO 31000. [ ]
58. The firm incorporates risk assessments into its business objectives. [ ]
59. The firm has assessed its vulnerability to various types of risk. [ ]
60. The firm has a cross-functional team to assess risk. [ ]

Risk Identification
61. The firm has a framework for identifying risk. [ ]
62. The firm has assigned a manager with the responsibility of detecting risk. [ ]
63. The firm is aware of the sources or consequences of risk affecting its supply chain. [ ]
64. The firm has conducted a business impact analysis to assess potential threats. [ ]
65. Management has a desire to control or transfer risk. [ ]

Risk Analysis
66. The managers understand the nature and structure of the risks the company is facing. [ ]
67. The firm has a team member who has expertise in analyzing risk. [ ]
68. The firm has a framework for conducting risk analysis. [ ]
69. The firm has a supply chain map of its critical suppliers. [ ]

Risk Evaluation
70. The firm has a framework for evaluating risk. [ ]
71. Management knows which risks are acceptable and which are not. [ ]
72. Management evaluates risks based on the firm's risk tolerance levels. [ ]

Risk Treatment
73. The firm has a framework for responding to various risk events. [ ]
74. The firm has a Business Continuity Plan to aid in recovering from a disruptive event. [ ]
75. The firm shares information about potential risks with upstream and downstream partners. [ ]

Risk Avoidance
76. The firm has procedures and policies in place to avoid risk. [ ]
77. Management is aware of the risk factors in the supply chain. [ ]
78. Management is aware of the vulnerabilities that expose the firm to risks. [ ]
79. Management has received training in risk detection. [ ]
80. Risk assessment is part of the firm's strategy, structure, policies and procedures. [ ]
81. The firm has committed the resources to detecting risk. [ ]

APPENDIX B

APPENDIX B

SURVEY QUESTIONNAIRE

PILOT STUDY II

Introduction
The purpose of this survey is to examine the effects of Gray Swans in the supply chain. These phenomena, which are low probability, high impact events that when they occur, have the potential to significantly disrupt a firm's operations and may even affect a firm's viability.

Please note this is an anonymous survey and your responses are confidential. It will be used only for academic purposes, and it is optional for you to complete. I greatly appreciate your genuine honest responses to the statements and your help with this project.

Demographic Information
Please select the category that best describes you.

Your Age:	18 - 24 [ ] 25 – 34 [ ] 35 – 44 [ ] 45 – 54 [ ] 55 – 64 [ ] 65 – 74 [ ] >75 [ ]
Your Gender:	Male [ ] Female [ ]
Your Education Level:	High School/GED or less [ ] Some college or College graduate [ ]
Your Ethnic Group:	White [ ] Black or African American [ ] Hispanic [ ] Asian [ ] Native American [ ] Other [ ] Please describe your group:_____

Firm Age:	0 - 4 years [ ] 5 – 9 years [ ] 10 – 14 years [ ] 15 – 19 years [ ] 20 – 24 years [ ] 25 – 29 years [ ] > 30 years [ ]
Firm Size (Number of Employees):	1 – 9 [ ] 10 – 49 [ ] 50 – 99 [ ] 100 – 249 [ ] 250 – 499 [ ] 500 – 999 [ ] >1000 [ ]

Among the following industry categories, select the number which best describes your firm.

Industry Classification	Agriculture, Forestry, and Fishing [ ] Mining [ ] Construction [ ] Manufacturing [ ] Transportation and Warehousing [ ] Information [ ] Electric, Gas, and Sanitary Services [ ] Wholesale Trade [ ] Retail Trade [ ] Finance and Insurance [ ] Real Estate [ ] Professional, Scientific and Technical Services [ ] Management of Companies [ ] Admin. and Support and Waste Management Services [ ] Educational Services [ ] Healthcare and Social Assistance [ ] Arts an Entertainment [ ] Accommodation and Food Services [ ] Public Administration Other Services (except Public Administration) [ ] Public Administration [ ] Other [ ]

Level of Responsibility	Entry Level [ ] Mid-Level [ ]

	Senior Level [ ] Other [ ] Please indicate your Job Title: _____

Carefully read each of the statements listed below. Please indicate your responses, on a scale of 1 to 7 according to your agreement with the statement, with 1 being "Not at All" to 7 being "To a Very Large Extent).

Gray Swans

1= No at All	2= To a Very Small Extent	3= To a Small Extent	4= To neither a Small nor Large	5 = To a Medium Extent	6 = To a Large Extent	7 = To a Very Large Extent

In the past three years, to what extent has your firm experienced:
1. a sudden demise of a supplier (due to financial distress or bankruptcy) [ ]
2. political instability, civil unrest, or other socio-political crises [ ]
3. labor disputes, port strikes, or other labor-management issues [ ]
4. changes in trade policies, tariffs, sanctions, or other macroeconomic crises [ ]

Relational Buyer-Supplier Relationship

1= No at All	2= To a Very Small Extent	3= To a Small Extent	4= To neither a Small nor Large	5 = To a Medium Extent	6 = To a Large Extent	7 = To a Very Large Extent

Please indicate the extent to which the relationship between your company and your supplier is characterized by:

5. a close personal interaction between parties [ ]
6. mutual respect between the parties [ ]
7. mutual trust between the parties [ ]
8. personal friendship between the parties [ ]
9. reciprocity between parties [ ]

Transactional Buyer-Supplier Relationship

1= Strongly Disagree	2= Moderately Disagree	3= Mildly Disagree	4= Neither Agree nor Disagree	5 = Mildly Agree	6 = Moderately Agree	7 = Strongly Agree

Please evaluate each statement and indicate the degree to which you believe your company and your suppliers engage in the following activities:

10. The contracts contain specific provisions that the supplier must abide by when producing the product. [ ]
11. The contracts contain specific provisions that give us the right to audit the supplier's operating procedures. [ ]
12. The contracts contain specific provisions that give us the right to inspect the supplier's facilities. [ ]
13. The contracts specify interim goals that I expect the supplier to achieve. [ ]
14. The contracts contain performance standards I expect the suppliers to meet in the product they supply us. [ ]
15. The contracts specify deadlines for the supplier to deliver products. [ ]

Resilience

1= No at All	2= To a Very Small Extent	3= To a Small Extent	4= To neither a Small nor Large	5 = To a Medium Extent	6 = To a Large Extent	7 = To a Very Large Extent

Please indicate to what extent your company:

16. is prepared for a supply chain disruption [ ]
17. can recover quickly from a supply chain disruption [ ]
18. has the agility to respond to a supply chain disruption [ ]

Supply Chain Risk Management

1= No at All	2= To a Very Small Extent	3= To a Small Extent	4= To neither a Small nor Large	5 = To a Medium Extent	6 = To a Large Extent	7 = To a Very Large Extent

Please indicate to what extent your firm:
19. engages in risk identification [ ]
20. engages in risk analysis [ ]
21. engages in risk assessment [ ]
22. engages in risk evaluation
23. engages in risk control and monitoring [ ]

APPENDIX C

APPENDIX C

SURVEY QUESTIONNAIRE

MAIN STUDY

Introduction
The purpose of this survey is to examine the effects of Gray Swans in the supply chain. Gray Swans are low probability high impact risk events that when they occur can severely disrupt a firm's operations and may even affect a its viability.

Please note this is an anonymous survey is optional and your responses are voluntary and confidential. The collected information will be used only for academic research purposes. We greatly appreciate your time and thank you in advance for your help with this research project.

Please indicate whether your firm has experienced a supply chain disruption in the last three years
Yes [ ] No [ ]

Please indicate the nature of your firm's relationship with other firms in the supply chain.
Buyer [ ] Supplier [ ] Other [ ]

Carefully read each of the statements listed below. Please indicate your responses, on a scale of 1 to 5 according to your agreement with the statement, with 1 = "Not at All" to 5 = "To a Large Extent or 1 = "Strongly Disagree and 5 = "Strongly Agree".

1= No at All	2= Some Extent	3= Neutral	4 = Medium Extent	5= Large Extent

In the past three years, to what extent has your firm experienced:
1. a sudden loss of a supplier due to financial distress) [ ]
2. disruption in your supply chain due to political instability [ ]
3. disruptions in your operations due to labor-management issues [ ]
4. disruptions in your supply chain due changes in trade policies [ ]
5. a sudden loss of a supplier due to a bankruptcy [ ]

1= No at All	2= Some Extent	3= Neutral	4 = Medium Extent	5 = Large Extent

Please indicate the extent to which the relationship between your company and your supplier is characterized by:
1. a close personal interaction between the parties [ ]
2. open communications between the parties [ ]
3. mutual trust between the parties [ ]
4. personal friendship between the parties [ ]
5. reciprocity between the parties [ ]
6. commitment to a long-lasting partnership between the parties [ ]
7. mutual respect between the parties [ ]

1= No at All	2= Some Extent	3= Neutral	4= Medium Extent	5 = Large Extent

Please indicate to what extent your company:
1. is prepared for a disruption in the supply chain [ ]
2. can recover quickly from a disruption in the supply chain [ ]
3. has the ability to respond quickly to a disruption in the supply chain [ ]
4. can absorb a significant loss from a disruption in the supply chain [ ]
5. relies on its supply chain partners to mitigate a disruption in the supply chain [ ]

1= No at All	2= Some Extent	4= Neutral	4 = Medium Extent	5 = Large Extent

Please indicate to what extent your firm engages in the following activities:
1. risk identification [ ]
2. risk analysis [ ]
3. risk assessment [ ]
4. risk avoidance [ ]
5. risk control [ ]
6. risk monitoring [ ]

1= No at All	2= Some Extent	3= Neutral	4= Medium Extent	5 = Large Extent

Please indicate to what extent your firm is receiving the following benefits from its relationship with a supplier:
1. improved flexibility of processes [ ]
2. improved existing product quality [ ]
3. improved overall efficiency of operations [ ]
4. reduced total costs of acquisition/ownership [ ]
5. reduced lead time for delivery [ ]

1= Strongly Disagree	2= Disagree	3= Neutral	4 = Agree	5 = Strongly Agree

Please evaluate each statement and indicate the degree to which you believe the contracts between your company and its suppliers:
1. contain specific provisions that the supplier must abide by when producing our product. [ ]
2. contain specific provisions that give us the right to audit the supplier's operating procedures. [ ]
3. contain specific provisions that give us the right to inspect the supplier's facilities [ ]
4. contain performance standards we expect the suppliers to meet in the product they supply us. [ ]
5. specify interim goals that we expect the supplier to achieve. [ ]
6. specify deadlines for the supplier to deliver products. [ ]

Among the following categories of firm age and size, please select the number which best describes your firm.

Firm Age:	1. 0 - 4 years [ ] 2. 5 – 9 years [ ] 3. 10 – 14 years [ ] 4. 15 – 19 years [ ] 5. 20 – 24 years [ ] 6. 25 – 29 years [ ] 7. older than 30 years [ ]
Firm Size (Number of Employees):	1. Less than 100 [ ] 2. Greater than100 but less than 499 [ ] 3. More than 500 [ ]

Among the following industry categories, select the number which best describes your firm.

Industry Classification	1. Manufacturing [ ] 2. Retail or Wholesale Trade [ ] 3. Healthcare and Social Assistance [ ] 4. Transportation and Warehousing [ ] 5. Services Except Public Administration [ ] 6. Other [ ]

Among the following levels of responsibility, select the number which best describes your level of responsibility.

Level of Responsibility	1. Manager[ ] 2. Senior Manager [ ] 3. Director [ ] 4. Vice President [ ] 5. President [ ] 6. Other [ ]

Demographic Information

Among the following demographic categories, please select the category that best describes you.

Your Age:	1. 18 - 24 [ ] 2. 25 – 34 [ ] 3. 35 – 44 [ ] 4. 45 – 54 [ ] 5. 55 – 64 [ ] 6. 65 – 74 [ ] 7. Senior [ ]
Your Gender:	1. Male [ ] 2. Female [ ]
Your Education Level:	1. High School/GED [ ] 2. Some college [ ] 3. College graduate [ ] 4. Graduate/Professional degree [ ]

APPENDIX D

APPENDIX D

ONLINE CONSENT FORM

This survey is being conducted by T.N.K. Lynch, PhD Candidate in Operations and Supply Chain Management at The University of Texas Rio Grande Valley (email: tony.lynch01@utrgv.edu).

The purpose of this survey is to examine the effects of Gray Swans in the supply chain. Gray Swans are low probability high impact risk events that when they occur can severely disrupt a firm's operations and may even affect a its viability.

This survey should take less than 15 minutes to complete.

Participation in this research is completely voluntary. Choosing not to participate will not have any adverse effects on you. If there are any individual questions that you would prefer to skip, simply leave the response blank.

You must be at least 18 years old to participate. If you are not 18 or older, please do not complete the survey.

All survey responses that we receive will be treated confidentially and stored on a secure server. However, given that the surveys can be completed from any computer (e.g., personal, work, school), we are unable to guarantee the security of the computer on which you choose to enter your responses. As a participant in our study, we want you to be aware that certain technologies exist that can be used to monitor or record data that you enter and/or websites that you visit.

Any individually identifiable responses will be securely stored and will only be available to those directly involved in this study. De-identified data may be shared with other researchers in the future but will not contain any information about your individual identity.

This research has been reviewed and approved by the Institutional Review Board for Human Subjects Protection (IRB). If you have any questions about your rights as a participant, or if you

feel that your rights as a participant were not adequately met by the researcher, please contact the IRB at (956) 665-2889 or irb@utrgv.edu.

APPENDIX E

APPPENDIX E

RECRUITMENT EMAIL

Hope all is well with you.

My name is Tony N.K. Lynch. I am a former Marine, Council of Supply Chain Management Professionals (CSCMP) member and now a PhD Candidate in Operations and Supply Chain Management at The University of Texas Rio Grande Valley (UTRGV).

In coordination with the CSCMP, I requested a listing of members who might be interested in participating in a research study about issues related to operations and supply chain management and your name was provided to me. I am contacting you in the hope that you will agree to participate in this survey (**See link below**) which examines the effects of "Gray Swans" in the supply chain. Gray Swans are low probability high impact risk events that when they occur can severely disrupt a firm's operations and may even affect its viability.
https://utrgv.co1.qualtrics.com/jfe/form/SV_dhV14vrd2WQWL41

Participation in this research is completely voluntary. *All survey responses that we receive will be treated confidentially and stored on a secure server.* Any individually identifiable responses will be securely stored and will only be available to those directly involved in this study. De-identified data may be shared with other researchers in the future but will not contain any information about your individual identity.

I hope that you will agree to participate in this survey which takes **less than 15 minutes** to complete. I am confident the results will increase researchers' understanding of Gray Swans and will aid practitioners in developing better strategies to mitigate and manage these types of risk.

Thank you in advance for taking the time to respond to my survey.

Sincerely,

Tony

APPENDIX F

APPENDIX F

FOLLOW UP RECRUITMENT EMAIL

Hello,

This is just a short note to follow up on my earlier email regarding completing the survey. (**Please see link below**).
https://utrgv.co1.qualtrics.com/jfe/form/SV_dhV14vrd2WQWL41

If you have already completed the survey: **Thank you for your support!** If you have not completed the survey, please take this time (**less than 10 mins**.) to do so.

This research examines the effects of "Gray Swans" in the supply chain. Gray Swans are low probability high impact risk events that when they occur can severely disrupt a firm's operations and may even affect its viability.

Again, thank you if you have already completed the survey and thank you in advance for taking the time to respond to my survey if you have not already done so.

Sincerely,

Tony

BIOGRAPHICAL SKETCH

Tony N. K. Lynch is a Lecturer in Supply Chain Management at the Harbert College of Business, Auburn University in the U.S. (August 2020 ~ Present). He is a former Marine who was trained logistics and transportation. Tony received his Baccalaureate in Philosophy and International Affairs from the City University of New York; a Masters' in Public Policy and Administration from Columbia University in New York City with an emphasis in Management and Finance, an MBA with an emphasis in Finance from Rutgers University in Newark, New Jersey; and his PhD degree in Business Administration with a concentration in Supply Chain Management from the Robert C. Vackar College of Business and Entrepreneurship, The University of Texas Rio Grande Valley.

Tony's research is targets four broad areas: (1) Supply Chain Risk Management, (2) Supply Chain Disruptions, (3) Supply Chain Management, and (4) Transportation Management. Tony has presented his research at major operations and supply chain management conferences: *Production and Operations Management Society (POMS)* and *Decision Sciences Institute (DSI)*. He has published one paper in the proceedings for *Decision Sciences Institute (DSI)*.

Tony is also a recipient of the Dwight David Eisenhower Transportation Fellowship Program Grant ($3,500) from the U.S. Department of Transportation. He can be reached via email at: TNL0009@auburn.edu.