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The Impact of Inventory Leanness and Slack Resources on Supply Chain Resilience: An Empirical Study

David J. Lyons
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The Impact of Inventory Leanness and Slack Resources on Supply Chain Resilience: An Empirical Study

BY

David Jerome Lyons

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ACCEPTANCE

This dissertation was prepared under the direction of the David J. Lyons Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctoral of Philosophy in Business Administration in the J. Mack Robinson College of Business of Georgia State University.

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ABBREVIATIONS

List of Abbreviations [in Alphabetical Order]

DOI .....Days of Inventory

DV.....Dependent Variable

F&B.....Food and Beverage

OLS .....Ordinary Least Squares

Q .....Quarter (a fiscal period of 3 months)

ROA .....Return on Assets

SC.....Supply Chain

VIF .....Variance Inflation Factor

WCR .....Working Capital Ratio

ABSTRACT

The Impact of Inventory Leanness and Slack Resources on Supply Chain Resilience: An Empirical Study

BY

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When a major disruption occurs, an organization's performance is usually negatively affected. The great recession of 2008 – 2009 was such a disruption which had global implications that had not been seen since the great depression that started in the 1930s. This thesis is intended to contribute to the understanding of how leanness and slack resources affect firm performance in the presence of disruptions that test supply chain resilience, or the ability to restore the firm's performance to its original condition after encountering stress or a large disturbance. These disruptions may not only affect the firm's financial performance during the disruption but also well after the disruption has occurred. Two industries with differing supply chains, food and beverage, and electronics and computer, were investigated. The study is based on archival data (N=10,020 and 668 firms) with observations from just before and just after the great recession, a disruption that affected the entire global economy.

Our results suggest (1) the effect of inventory leanness and slack resources on firm performance is industry specific; and (2) variation in firm performance is less in the post-disruptive period than in the pre-disrupted period. Overall, our findings call for a contingency

perspective to specify the level of inventory leanness and slack resources when determining their impact on firm performance to support supply chain resilience.

1.0 INTRODUCTION

1.1 Research Domain

Toward the end of 2007, the global financial crisis rapidly moved from a housing bubble in the United States to the worst recession the world has witnessed for over six decades. This great recession created financial turbulence that was collectively not seen globally since The Great Depression of the 1930's. The crisis came as a surprise to many academics, managers, policymakers, and investors (Verick & Islam, 2010). Galbraith (2009) provided an argument that "the implicit and explicit intellectual collusion made it difficult for members of the profession (primarily associated with American universities) to predict an alternative view, and the severity of the global financial crisis was underestimated" (p. 87). This worldwide economic crisis in 2008-2009 reduced the amount of money that was available to many firms. Leveraged mistakes in working capital in supply chains became obvious and toxic; in fact, some supply chain networks would have been on the verge of collapse if liquidity deficiencies among suppliers had not been balanced by financially strong firms within the supply chain. This crisis created a freezing of capital and an inability of organizations to expand and grow (Lux & Westerhoff, 2009). Disruptions, especially supply chain disruptions, often are unpredictable, occur quickly and have lasting effects. In the last few years, over 85 percent of firms worldwide have experienced at least one major disruption ("Supply Chain Resilience," November, 2012). These disruptions can come in many different forms; for example, an oil spill in the Gulf of Mexico, political and social unrest in Africa and Middle East, and/or an earthquake and subsequent tsunami in Japan. The great recession, which is an example of one such disruption, triggered a global financial panic that was followed by reduced asset values and freezing of credit flows.

The great recession began with a collapse in housing prices in the United States, which triggered a financial panic because of the opaque nature of securitized mortgage instruments, which quickly became "toxic assets." The financial panic was followed by the collapse of real activity as the result of reduced asset values and the freezing up of credit flows. As the crisis deepened in the advanced economies, projections for the world economy became more uncertain (Verick, 2010). The increase in worldwide economic and political uncertainty acted like a "tsunami effect" that sharply reduced productive asset values throughout the world. Stock markets around the globe responded accordingly with significant corrections.

A lesson from the great recession is that firms need to prepare for not only unanticipated financial disruptions, but also for any significant disruption. As a firm moves from a period of normal activity through a disruption and then back to a more normal state, financial performance is often negatively affected during and for a long period after the disruption. Resiliency within a firm supports the recovery from a disruption (Lengnick-Hall, Beck, & Lengnick-Hall, 2011). Building resiliency is an investment in a firm's future (Reinmoeller & Van Baardwijk, 2005). Like any other type of investment, investment in resiliency is often difficult and costly. A key lesson from the recent past, however, is that while investments in resiliency can be too extreme and costly, they should not be undervalued (Grusky, Western, & Wimer, 2011; Montiel, 2011).

The need for resiliency in a firm's supply chain (SC) has been studied extensively by researchers (Beamon, 1999; Chen & Miller-Hooks, 2012; Christopher & Holweg, 2011; Horne, 1997; Kleindorfer & Saad, 2005; Pettit, Fiksel, & Croxton, 2010). However, the research performed on this topic is by no means complete, and process models studying the effect of lean and slack resources on a firm's resiliency prior to and after a significant disruption is of great interest for researchers and practitioners. Many researchers have formulated assessment tools to

identify and implement SC resiliency, identify the components of SC resiliency, define SC resiliency, and articulate how to design and simulate SC's for resiliency (Blackhurst, Dunn, & Craighead, 2011; Christopher & Peck, 2004; Ellis, Shockley, & Henry, 2011; Hendricks & Singhal, 2005b; Pettit et al., 2010). Yet despite this significant amount of research on SC resiliency, there is a paucity of research on the pre- versus post-disruption interaction of resilience in the face of a significant disruption, especially with respect to global implications. Also, the effect of leanness and slack has not been included in this interaction by prior researchers.

Leanness, and specifically inventory leanness, is included in this study to aid in understanding the role that a widely adopted inventory management practice plays in reducing costs. When firms are faced with an economic environment that disrupts their ability to meet expected profit levels and the expectations of their stakeholders, they often resort to emphasizing lean practices to aid in the recovery efforts (Lewis, 2000; Pettersen, 2009). Lean practices in a firm are expected to result in improved operational outcomes, such as a reduction in required levels of inventory, which therefore should enhance firm performance (Eroglu & Hofer, 2011). Lean practices, or more specifically lean production, is often described as a philosophy or a strategy with a set of practices (e.g. total quality management, value stream mapping, etc.) which seeks to minimize or eliminate waste (e.g. excess inventory, rework, delays, etc.) to improve firm performance (Eroglu & Hofer, 2011). Leanness in a supply chain supports maximizing profit through cost reduction (Agarwal, Shankar, & Tiwari, 2006). There is thus a linkage between the larger concept of lean production principles and inventory leanness (Eroglu & Hofer, 2011).

Conversely, slack resources provide a cushion or pool of resources that are available to an organization to adapt to internal or external pressures, as well as initiate adjustments with

respect to the external environment (Bourgeois, 1981). These excess resources can be viewed as a buffer that is waste or the results of improper management of inventory. In a neoclassical view, slack would only be present when a firm is not in an equilibrium state and should be minimized for the sake of efficiency (Sharfman, Wolf, Chase, & Tansik, 1988). Thompson, Scott, and Zald (2009) argue that slack should be used to provide protection to the firm from its external environment. Slack is included in this study due to the constant tension that SC managers face to have proper balance between operational efficiency and lean practices, while simultaneously meeting the demand to have surplus resources available to prepare for unexpected threats or disruptions.

Firm size may affect a firm's capability to achieve increased competitiveness and financial performance. Garmestani, Allen, Mittelstaedt, Stow, and Ward (2006) found that periods of uncertainty have significantly greater effect on survivability of small firms than large firms. Larger business units tend to have a larger market size and greater control over the competitive environment, combined with access to resources that are not as available to a smaller firm[1] (Beck et al., 2005). Firms with fewer resources, such as small firms, may be unable to afford strategies that include slack resources (Raisch & Birkinshaw, 2008). Additionally, small firms may not have the power and influence to change the behavior of other supply chain partners to help recover from the disruption as do large firms (Kuper, 2002). Therefore, I focus exclusively on the category of large firms and control for firm size in this study.

Industries often have differing inventory patterns and product life cycles. These patterns and life cycles are often due to fast changing consumer preferences, as well as the rate of

[1] Large firms are often determined as those that employ more than 500 employees. Annual revenue is also a measure to differentiate between smaller and larger firms (Beck, Demirgüç-Kunt, & Maksimovic, 2005). The threshold is established at annual revenue for larger firms greater than one hundred million dollars. Revenue is a compatible measure for categorizing firm size when studying quantitative measures, i.e., inventory, cash, and other financial resources (Lev, 1969).

innovation. Different inventory levels are often due to seasonality, production capability, raw material availability, storage capability, or product shelf life. The consumer electronics and computer industries (i.e., technology industries) are prime examples of a short life cycle industry with high inventory turns. In contrast, the food and beverage industries life cycles and inventory turns are considered longer due to less innovation, capital intensity for manufacturing and distribution, and slower fad effects (Kurawarwala & Matsuo, 1996), as is the case with soft drinks or packaged foods. The food and beverage industries also have inventory dynamics that often increase inventories due to raw materials that have a short shelf life and can be limited to seasonal harvests. Including both the food and beverage and the electronics and computer industries in this study provides a dichotomy of inventory management patterns that encompass the wide diversity of inventory volumes and velocities due to demand characteristics, complexity, volume of stock keeping units, and channels of distribution. This diversity between the two industries will support generalizing the findings across the consumer goods segment of which these industries are included.

An organization's pre disruption and post disruption performance is often determined in part by the organization's resources and capabilities at the start of the disruption. Firm size, profitability, and diversification can have an effect on short- and long- term performance. “Short-termism” specifically emerges when managers are driven to invest current resources during disrupted economic periods, thereby putting pressure on cost reduction initiatives. In short, these responses to recessionary pressure indicate management's short-term objective to get "lean and mean" (Latham & Braun, 2011). The short term economic period is often within a fiscal year, and any business period beyond that time is considered long-term (Fama & French, 1989). Going beyond the short-term period, this study will include data that spans for more than

one fiscal year. In other words, this study will include time periods in the pre and post disruption periods so as to provide a longer-term view. The pre-recessionary time period in this study will include the first quarter of 2007 to the fourth quarter of 2008, as well as the post-recessionary time periods of the first quarter of 2010 to the fourth quarter of 2011. Theses pre and post disruption time periods will support the long-term view beyond short-term effects (Rothaermel & Hill, 2005).

1.2 Background

1.2.1 Motivation for the study. As stated earlier, most firms have experienced a major disruption in the recent past. It was a disruption that, in some way, significantly affected almost every firm, whether they were global or not, or large or small (Grusky et al., 2011). Firms are affected by a disruption in different ways, determined in part by the type of disruption (Rao & Goldsby, 2009). Economic recessions are often the most transformative event that an organization will face. Additionally, not all firms within an industry will have the capabilities to survive or adapt to the new economic reality post hoc a recession. While the disruptive nature of an economic recession is widely acknowledged by practitioners and academics alike, scant research has addressed how supply chain managers can successfully maneuver through these turbulent events (Latham & Braun, 2011).

1.2.2 Significance of the study. A majority of the supply chain management efforts in the recent past have focused on increasing the efficiency (lowering costs, lean practices) of the supply chain operations, and less on managing the risks of potential disruptions. The carrying cost of inventory in the consumer goods industries often ranges between 8 percent to 15 percent of sales (Dullaghan, Harcourt, McCarthy, & Raftery, 2001). This high level of cost becomes a prime target by managers seeking savings. Much of the recent academic literature on supply

chain models also seems to be focused on managing costs. This focus could be partly because improving efficiency is an ongoing activity at most firms. Managers have developed the necessary skills to focus on cost reduction, and they know how to justify and manage resources that improve efficiency (Cecere & Chase Jr., 2013). Rationale for retaining slack resources is limited, especially when carrying costs for such resources are high. Major supply chain disruptions are infrequent and they are hard to predict and manage. Thus, it is difficult to justify consistently and proactively devoting resources to managing such risks (Hendricks & Singhal, 2005b).

Lean production philosophy sees inventory as a form of waste to be minimized (Jones, Roos, & Womack, 1990). Leanness in inventory is often viewed by supply chain management as a means to improve financial performance, especially when the stress of a disruption is placed on an organization (Levy, 1997). While lower inventories may improve a firm's cash position or working capital (thereby creating financial slack resources), emphasis upon lowering inventory stock may jeopardize the ability to support a supply-side disruption (Zsidisin & Wagner, 2010). Nonetheless, lean practices are widely implemented, and under normal circumstances their implementation results in improved financial performance (Fullerton & McWatters, 2001). However, it is not clear whether such a focus enhances a firm's resiliency.

One definition of resiliency is the ability to cope with externalities and restore normal operations to its original state, or move to a new and more desirable state after being disrupted (Chen & Miller-Hooks, 2012; Christopher & Peck, 2004; Sheffi, 2005). Based on the foundations of life and social sciences, this perspective of resilience has been adapted to supply chain management (Martin-Breen & Anderies, 2011). It is important that supply chain managers understand the role of inventory leanness and slack resources in enhancing or reducing a firm's

resiliency when faced with a significant disruption. From a theoretical perspective, supply chain and lean philosophy researchers would benefit from having a greater understanding of the determinants of resilience and the approach of firms managing inventory leanness and slack resources during episodes of turbulence.

1.2.3 Theoretical and conceptual framework. This thesis empirically examines the effects of inventory leanness and slack resources on firm performance prior to and after a major global disruption that tests the presence of supply chain resiliency in a firm.

Supply chain resilience has varying viewpoints, and it draws from multiple disciplines, including psychology and ecology (Martin-Breen & Anderies, 2011). Although there have been many definitions proposed for supply chain resilience, there is an underlying assumption that resilient organizations prosper in dynamic environments (Cho, Mathiassen, & Robey, 2006). Among scholars, there are two approaches when evaluating or describing organizational resilience. Some see resilience as the ability of an organization to rebound from unanticipated adverse disruptions to their pre-disrupted performance level, while others see organizational resilience as having the dynamic capability to rapidly recover, adapt, and emerge from the disrupted conditions with new capabilities strengthened and more resourceful (Ponis, 2012). Resilience is applied in this thesis as a theoretical construct that subscribes to the former description, whereby if a firm returns to its prior level of financial performance after the disruption, then the firm would be determined to have resiliency.

Much of the ongoing supply chain management efforts at most firms over the last several decades have been focused on lowering costs. This is where managers have honed their skills to deliver performance, and upper level leaders have focused on allocating resources, including training and incentives, to drive performance through cost containment (Cecere & Chase Jr.,

2013). Placing greater emphasis on lean activities, Womack and Jones (2010) argue that an organization should never relax until it reaches perfection, which is defined as the delivery of pure value instantaneously with zero waste. In other words, the implementation of lean practices should be relentlessly pursued because these practices will lead to improved operational performance outcomes which will, in turn, continue to enhance firm performance. Lean practices are an important multi-dimensional construct that have a positive influence as an antecedent in firm performance (Fullerton & McWatters, 2001; Inman & Mehra, 1993).

Under normal conditions, the relentless pursuit of efficiency does in fact lead to improved financial performance (Jones et al., 1990). However, as disruptions or threats to the supply side occur, being lean in inventory can negatively affect a firm's performance if the firm is unable to competitively fulfill demand. There is some evidence that in the longer term, slack resources are necessary for survival and effectiveness (profit optimization) of the firm (Sharfman et al., 1988). Thus, the foundational basis for this study is that slack resources support firm performance as a firm navigates the effects of a disruption, and firms will place an emphasis on inventory leanness over slack resources due to the view that slack represents waste that should be eliminated while lean practices are relentlessly pursued.

1.3 Research Questions

Because of the many disruptions, whether they are economic, environmental, or geopolitical that have affected organizations, especially in the last two decades, there is abundant research defining, assessing, modeling, and examining disruptions on supply chain resiliency and firm performance (Kleindorfer & Saad, 2005). However, there is a paucity of research on understanding the relationship between supply chain resiliency and firm performance through a virtually ubiquitous disruption like the great recession. Once a firm experiences a disruption,

managers will often reflect to understand what changes in practice should occur to prepare for a future perturbation (Ketchen, Rebarick, Hult, & Meyer, 2008). With the popularity and widespread adoption of lean practices, the reduction of inventories is primary within those practices (Eroglu & Hofer, 2011; Huson & Nanda, 1995).

Lean principles have been adopted at some level by most manufacturing firms (Womack & Jones, 2010), while a lack of attention has been applied by most firms toward slack resources (Daniel, Lohrke, Fornaciari, & Turner Jr, 2004). Often these principles of leanness and slack are primarily applied to reduce cost and improve firm performance and often not in balance. A nuanced understanding of these principles is likely to benefit SC managers and executives to prepare for the next inevitable disruption. As a result, this study is intended to explore the following questions:

1. Does a firm's focus on inventory leanness and slack resources in the firm have an effect on firm performance under conditions of an economic disruption?
2. Is a firm's supply chain resiliency affected by its inventory leanness and slack resources under conditions of an economic disruption?

2.0 LITERATURE REVIEW

2.1 Supply Chain Resilience

Resilience is the theoretical perspective used in the design and implementation of this research study. Historically, resilience has been a key concept in the fields of ecology and psychology, and lately it has a strong presence in planning and organizational management (Martin-Breen & Anderies, 2011). In the realm of enterprises, the concept of organizational resilience emerges as a relatively new area in organizational theory that includes insights from both coping and contingency theories (Gittell, 2008). Resilience in an organization can be a single level or multiple level construct. When considering the ecological concept it favors the science of engineering. Within the engineering material science, resilience is often viewed as restoring to its original condition or returning to normal after encountering stress, a large shock, strain or disturbance (Christopher & Peck, 2004; Horne, 1997; Mandal, 2012; Martin-Breen & Anderies, 2011). The other stream of organizational resilience visualizes it beyond restoration to include the development of new capabilities, creating new opportunities and emerging from the disruption strengthened and more resourceful (Jüttner, 2005; Pettit et al., 2010; Ponomarov & Holcomb, 2009). Although a robust, agile, and capable supply chain may be desirable, it is important to note that a robust, agile, and capable does not always equate to a resilient supply chain (Christopher & Holweg, 2011). These adaptive capabilities may not support the means to respond and recover at the same or better state of performance (Jüttner & Maklan, 2009).

A focus on supply chain is highly regarded as one of the most effective ways for firms to enhance their competitive advantage and firm performance. There is a highly positive relationship between supply chain performance and firm performance (Ou, Liu, Hung, & Yen, 2010). As firms experience a disruption, their performance often declines. Resilient firms are

able to quickly emerge from a disruption to their performance level just prior to the disruption or to a greater level of performance (Christopher & Peck, 2004; Mandal, 2012).

2.1.1 Disruptions. Disruptions manifest themselves in many different forms, and as supply chains increase the distance of their network, become more global, and shorten the time required between transactions or cycle time through strategies such as lowering their inventory levels, disruptions seem to be more severe (Blackhurst , Craighead, Elkins, & Handfield, 2005; Zsidisin & Wagner, 2010). Additionally, SC disruptions can negatively impact productivity and utilizations of assets. For example, firms may end up with excess inventory for some products and out of stock for others, a fact that can negatively affect customer service if customers cannot receive the products they want when they want them. These symptoms of a disruption can also negatively affect a firm's reputation and credibility in the mind of investors, customers, and suppliers (Hendricks & Singhal, 2003).

Christopher & Peck (2004) state "in today's uncertain and turbulent markets, supply chain vulnerability has become an issue of significance for many companies", and that "as supply chains become more complex as a result of global sourcing and the continued trend to 'leaning down', supply chain risks increase" (p. 4067). Moreover, as companies increasingly compete with other supply chains "the challenge to business is to manage and mitigate that risk through creating more resilient supply chains" (Christopher & Peck, 2004, p. 4067).

2.2 Supply Chain Performance

Hendricks and Shinghal (2005b) show that firm operating performance is eroded and that capital markets penalize organizations that experience supply chain disruptions. Wagner and Bode (2008) suggest that supply-side risks have a negative impact on supply chain performance. To minimize loss of firm performance from disruptions, attention must be given to the supply

chain and the overall efficiency of the supply chain under normal operations. Over the last two decades, the importance of leanness has been emphasized in internal operations, as well as in the extended enterprise (Hofer, Eroglu, & Rossiter Hofer, 2012). Much less attention has been given to the tradeoff between leanness and supply chain robustness. Supply chain robustness in this sense is defined as the time it takes to go from disruption to a return to 100% capacity (Womack & Jones, 2010). Resilient supply chains are not detrimental or inimical to efficiency and lean operations, but the dimensions of the supply chain must be explicitly considered in the design process of the supply chain (Kleindorfer & Saad, 2005). Whereas resilient capabilities are not excess or waste but complimentary and should be a part of the overall lean supply chain design. Lean management practices are a key construct in supply chain management theory building (Chen & Paulraj, 2004).

2.2.1 Leanness. Lean philosophy has become popular and has been evolving since the 1980's (Jones et al., 1990). Toyota Motor Company was the company that many firms emulated in the operational waste reduction efforts that defined leanness. Specifically, "waste is any human activity which absorbs resources but creates no value" (Womack & Jones, 2010, p. 15). Lean inventory has become synonymous with good inventory control (Cooper & Maskell, 2008). Inventory leanness is an outcome of lean practices and has been shown to result in improved operational performance, which in turn should enhance firm performance (Eroglu & Hofer, 2011; Fullerton, McWatters, & Fawson, 2003). However, there are other studies that have found no significant effects of lean production practices on firm performance (Huson & Nanda, 1995; Jayaram, Vickery, & Droge, 2008). One reason for this finding is that greater product variety that can increase the burden rate on product cost that is greater than the savings from lean efforts. In addition, the need for a systemic focus on lean strategy, design, and manufacturing stands in

contrast to the potential benefit of focusing on a few segments or subsystems, and integration of business processes, not just functions. Inventory is generally created based upon anticipated future demand and production capabilities (Jones et al., 1990). It is possible that certain industries may be more responsive to lean inventory systems than others due to characteristics of markets, technologies or other environmental factors (Eroglu & Hofer, 2011). Additionally, it is possible that when inventory levels are high, focus on inventory leanness effectively enhances firm performance, but at some point additional focus on leanness may have negative effects on performance. The current research project will explore that potential relationship.

The application of inventory leanness in firms can provide valuable insight on how organizations influence performance and withstand significant disruptions to their supply chain and their overall business. Research has hinted that once a disruption (especially in the case of a recession) concludes, some firms may continue with their lean strategies that may ultimately compromise the organization (Hendricks & Singhal, 2005b). In other words, a firm's continued myopic focus on lean strategies and "belt tightening' efforts after the disruption may stifle exploratory efforts of innovation, market growth, and investment.

2.2.2 Slack resources. Slack resources are defined as "the difference between total resources and total necessary payments" (Cyert & March, 1963a, p. 42). Often slack resources are used for the purpose of smoothing or cushioning fluctuations. These resources are physical properties such as inventory, cash, people, and so forth (Thompson et al., 2009). These types of slack resources are often categorized into two groups. One group includes unabsorbed or high discretion slack such as cash, cash equivalents, credit lines, raw materials, low skilled labor, and highly flexible machine capacity. The other group includes absorbed or low discretion slack such as processed inventory (i.e., work in process to finished goods), skilled labor and low

flexibility machine capacity (Daniel et al., 2004; Hambrick & D'Aveni, 1988; Singh, 1986). Working Capital Ratio (WCR; the ratio of total current assets to total current liabilities) was chosen in this study as the proxy for measuring slack resources because it is a strong measure for determining the slack-performance relationship. WCR measures unabsorbed slack. Unabsorbed slack can immediately be employed to address opportunities, whereas absorbed slack has a longer time frame. Additionally, the strong slack-performance relationship and the temporal aspect of unabsorbed slack minimizes the need to control for industry effects due to differential slack-performance relationships in absorbed slack (Daniel et al., 2004). My study does not distinguish between types of slack and uses WCR as the proxy for measuring slack resource.

Strategically positioning slack resources to adapt to internal or external pressures should be performed throughout the life of an organization. Reacting to placement of slack once a disruption has occurred becomes much less effective and is often viewed by management as wasted resources (Marino & Lange, 1983). Some research suggests that slack resources often only appear when a firm is not in a normal or equilibrium state, and that slack should be eliminated for the sake of efficiency (Jensen, 1986; Sharfman et al., 1988). Other researchers find that slack improves firm performance but is detrimental beyond a given range (Bourgeois, 1981; Tan & Peng, 2003). Bourgeois (1981) added that slack is a resource excess that can be used in a discretionary manner, both to exploit opportunities and counter threats or disruptions. Ideally, firms should have surplus resources sufficient to address unforeseen disruptions but limited enough to curtail excess waste and irresponsible behavior by managers (Cheng & Kesner, 1997). Slack remains a somewhat nebulous construct, and the effect depends on how the researcher hypothesizes how supply chain managers will apply these resources (Daniel et al., 2004). There is often an inherent tension in organizations that lies between a desire for

efficiency (lean), as well as resources (slack) to provide a margin of safety to respond to unforeseen disruptions (Daniel et al., 2004). Within this dialectic, there is a contradiction with colliding forces that often compete with each other for control (Cho et al., 2006). As organizations strive to gain and maintain resilience, understanding these contradictions between inventory leanness and slack resources will help SC managers ready an organization for the next inevitable disruption.

3.0 CONCEPTUAL MODEL AND HYPOTHESES

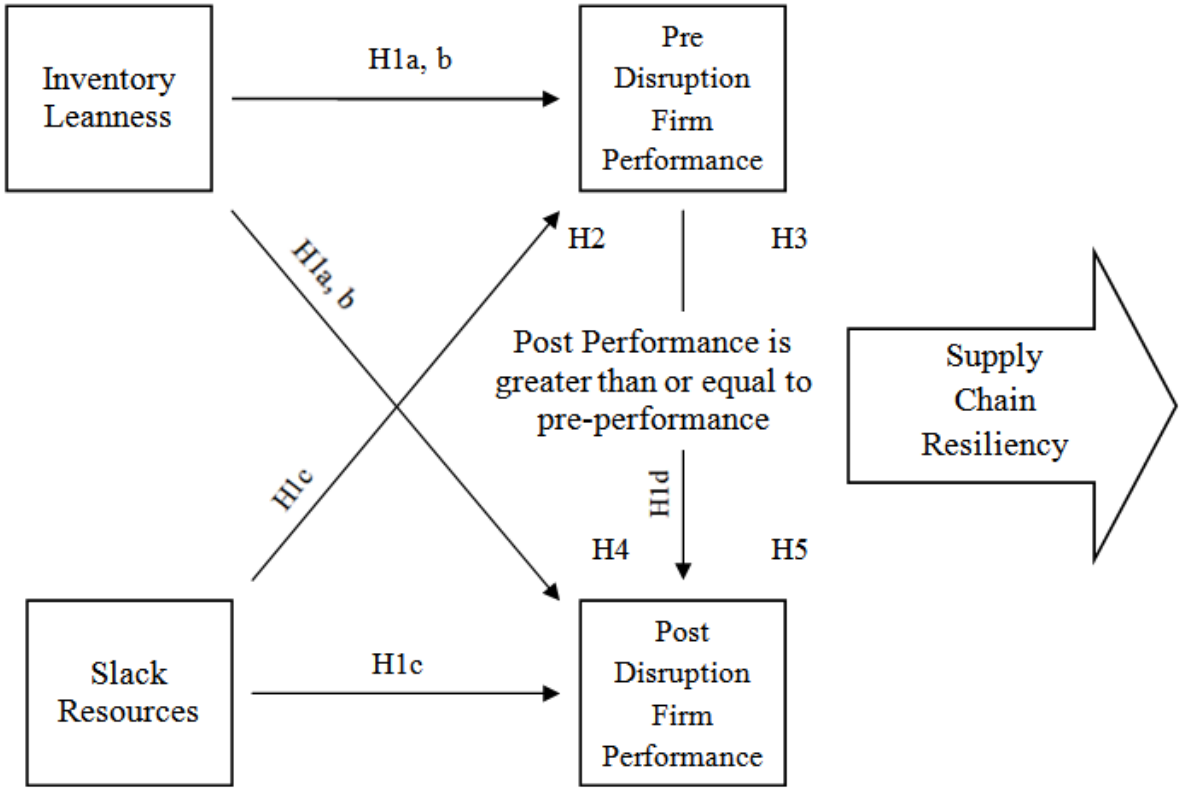
This chapter presents the conceptual model and hypotheses. The conceptual model incorporates all of the constructs, and the formal hypotheses specify the expected relationships.

3.1 Conceptual Model

In this section, the theoretical model and associated hypotheses are introduced. The research model for this study is a broader conceptualization of the relationships between inventory leanness and slack resources and their effect on firm performance as firms withstand a global disruption. Resilience of the firm's supply chain provides the theoretical foundation. This study will be focused on investigating the tension and complimentary influence on firm performance between leanness and slack resources as firms navigate a significant disruption over the long run (see figure 1). As firms emerge from a disruption often their performance suffers, but firms that have resilience will emerge over the long run from this punctuated period at or greater in firm performance as compared to when the disruption began (Blackhurst et al., 2011; Latham & Braun, 2011; Mandal, 2012).

There has been significant research in defining, identification, implementation, and assessment of resiliency within a firm's supply chain. This study is not about those areas of research, but is instead focused on understanding the effect of a primary lean production practice (e.g. inventory leanness) and slack resources on firm performance. Additionally, I argue that slack resources and inventory leanness will positively influence firm performance as the firm maneuvers through an economic disruption, thus supporting the notion of firm supply chain resilience.

Figure 1: Conceptual Model



The framing of the research questions is whether inventory leanness and slack resources have an effect on firm performance under conditions of an economic disruption, and do these SC processes affect supply chain resiliency? The leanness, slack, and resilience literatures provide perspectives on these areas. Figure 1 illustrates the framework of this study that is explicated by these literatures but extended by the interaction of an economic disruption.

The construct of inventory leanness is determined by the variables: days of inventory and inventory turns and their direct effect on firm performance, which is extensively researched in the literature (Demeter & Matyusz, 2011; Eroglu & Hofer, 2011; Jones et al., 1990; Wagner, Grosse-Ruyken, & Erhun, 2012). As is often stated, firms that adopt lean practices may have a tendency to apply those practices excessively when results yield positive performance with

respect to not only financial performance but other SC performance measures as well (e.g., service levels, postponement strategies, and operating costs) (Eroglu & Hofer, 2011; Wagner et al., 2012), especially in disrupted times. Secondly, the construct of slack resources is included in this study and empirically operationalized by measuring working capital. The literature is mixed on the effect that slack resources have on firm performance (Daniel et al., 2004). Slack and inventory leanness capabilities are often applied by supply chain managers to address a firm's performance (Gill, Biger, & Mathur, 2010). As identified with inventory leanness, slack must also be pursued from an optimal perspective. Too much slack can put pressure on the ability of a firm to meet its current liabilities and leads to underutilized assets or bad investments (Hambrick & D'Aveni, 1988). Without clearly defined strategic goals, these SC practices often result in trade-off debates and can be paradoxical in practice, especially when paired with performance incentives (Beamon, 1999). Conceptually, I posit that inventory leanness and slack resources both contribute to SC resiliency, especially in the face of a disruption.

The time frames during the pre-recession period (quarter 1, 2007 to quarter 3, 2008) and the post-recession period (quarter 1, 2010 to quarter 4, 2011) are considered to be long-term, i.e., greater than one year. This longer time frame minimizes the effect of short-term gains on firm performance that accrues by focusing on lowering inventories, often at a higher cost to suppliers. Such strategies do not normally lead to long term success (Ketchen et al., 2008; Wagner & Neshat, 2010). Business financial cycles are often described as short-term when they are no greater than one year, and long-term when they are greater than one year (Fama & French, 1989; Gertler & Gilchrist, 1994)

3.2 Hypotheses Development

This section formally develops the hypotheses associated with the conceptual model. I

formulated five primary hypotheses, all of which were inspired by resilience theory and the supporting literature.

A pre and post disruption design was selected in order to provide answers to the previously mentioned research questions that require a temporal aspect to explore the hypotheses of this thesis. Further, the notion of introducing the element of leanness into the predictive model was decided due to the nearly ubiquitous adoption of lean practices, especially within manufacturing firms, as supply chain managers often apply lean practices to overcome the cost pressures of a financial disruption while neglecting the importance or slack resources (Christopher & Holweg, 2011; Sharfman et al., 1988). Critical to this research is the proposition that firm resilience can be affected by inventory leanness and slack resources while supporting firm performance as a firm enters into and exits an economic disruption.

In terms of contributions, examining the tension that exists between leanness and slack, as well as their effect on firm performance across two industries that are diametrical in managing their inventories and supply chains due to differences in inventory cycles across a significant global recession, should provide SC managers with insight that goes beyond prior research. Research on the impact of external disruptions on individual firm's performance has been primarily limited to contingency planning, mitigation strategies, and supply disruptions (Altay & Ramirez, 2010).

3.2.1 Variables. The dependent variable (DV) selected for this study, firm performance, was derived from the literature on firm financial performance. Firm performance is a multidimensional construct (Rothaermel & Alexandre, 2008), but in this research it was applied along only one dimension: financial performance. Firm financial performance was proxied by a firm's return on assets (ROA). ROA is a commonly used variable by management to proxy firm

financial performance because it assesses how efficiently a firm uses its resources, and it is very useful for comparing competing companies in the same industry (Daniel et al., 2004; Wu & Ho, 1997). Moreover, using ROA as the DV has the added benefit of negating the need to explicitly control for firm size, because ROA is a size adjusted ratio (Rothaermel & Alexandre, 2008) . Critical to this study is how firms perform prior to an exogenous economic disruption and how they perform after the disruption. Therefore, if supply chain managers are evaluating, in the aggregate what the determinants of firm performance pre and post disruption were will aid firms to position themselves to be resilient in case such a disruption occurs. If their firm has resilience, then SC managers can look further to identify their capabilities and vulnerabilities then determine how to pursue maintaining and increasing supply chain resilience. If resilience is not present then, a deeper strategic investigation should be conducted to assess the firm's ability to survive (Pettit et al., 2010).

Table 1 is a description of the variables used in the current investigation.

Table 1: Description of Variables

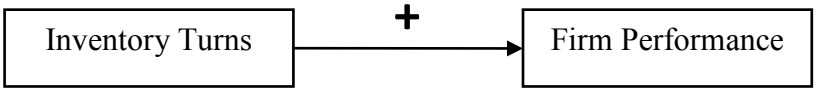
Variable	Description
Return on assets – dependent variable, firm performance	Net Income / Total Assets
Inventory Turns – independent variable, inventory leanness	Cost of Goods Sold (COGS)/ Average Cost of Inventory
Days of Inventory – independent variable, inventory leanness	Average Inventory / COGS / Days
Working Capital Ratio – independent variable, slack	Current Assets / Current Liabilities
Annual Revenue – control variable, firm size	Total Annual Net Sales

The independent variables of days of inventory, inventory turns, and working capital ratio were selected from the literature on lean production philosophy, supply chain management

practices, and organizational slack. The two inventory variables are commonly used by both researchers and practitioners (Demeter & Matyusz, 2011). Days of inventory provide a forward look into how many days of forecasted demand can be supported, and inventory turns provides a backward view on historically how often a firm has sold their entire inventory within a year. These variables represent a firm's inventory leanness. The proposition that these inventory practices will result in improved firm performance (as measured by ROA) are presented in the following hypotheses:

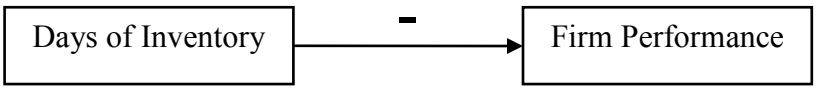
H1a. *Inventory leanness (as measured by greater inventory turns) increases resilience and therefore improves firm performance.*

Visually I see hypothesis 1a as follows:



H1b. *Inventory leanness (as measured by lower days of inventory) increases resilience and therefore improves firm performance.*

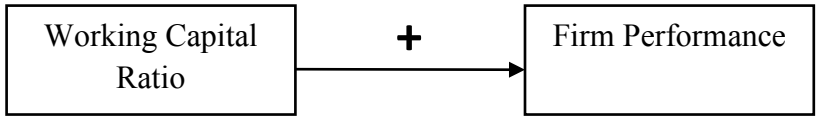
Visually I see hypothesis 1b as follows:



Although slack is often viewed by SC managers as an excess or waste, there is empirical evidence that, especially in a disrupted period, slack will have a positive effect on firm performance (Bourgeois, 1981). Based on the premise that slack will have a positive effect on firm performance, the following hypothesis is presented:

H1c. *An increase in working capital ratio increases resilience and therefore would lead to improved firm performance.*

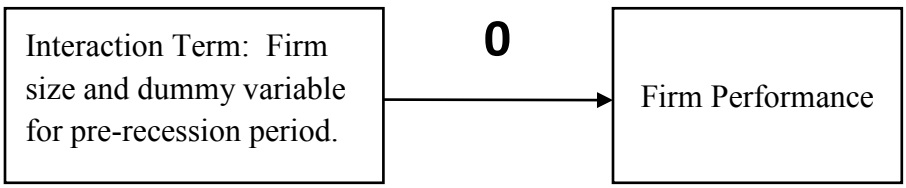
Visually I see hypothesis 1c as follows:



Since all firms included in this research meet the operational definition of being a large firm (i.e., greater than $US 100 million in annual revenue), and because large firms generally have greater control over their competitive environment and less impact on their survivability from disruptions (Kuper, 2002), it is anticipated that firm size will pre- versus post- recession will have no differential effect on firm performance (Raisch & Birkinshaw, 2008). Hypothesis 1d states that firm size (as measured by annual revenue) does not differentially affect firm performance between the pre-recession and the post-recession period. In order to estimate this relationship, firm size (as measured by annual revenue) is entered directly into the equation and interacted with the dummy variable that marks the pre versus post-recession time period.

H1d. *Firm size in the pre- versus the post-recession has no effect on firm performance between the pre-recession and the post-recession period.*

Visually I see Hypothesis 1d as follows:



3.2.2 Control variables. As described earlier, two industry sectors were chosen. The possibility that firm performance will vary as a function of whether or not a company is part of

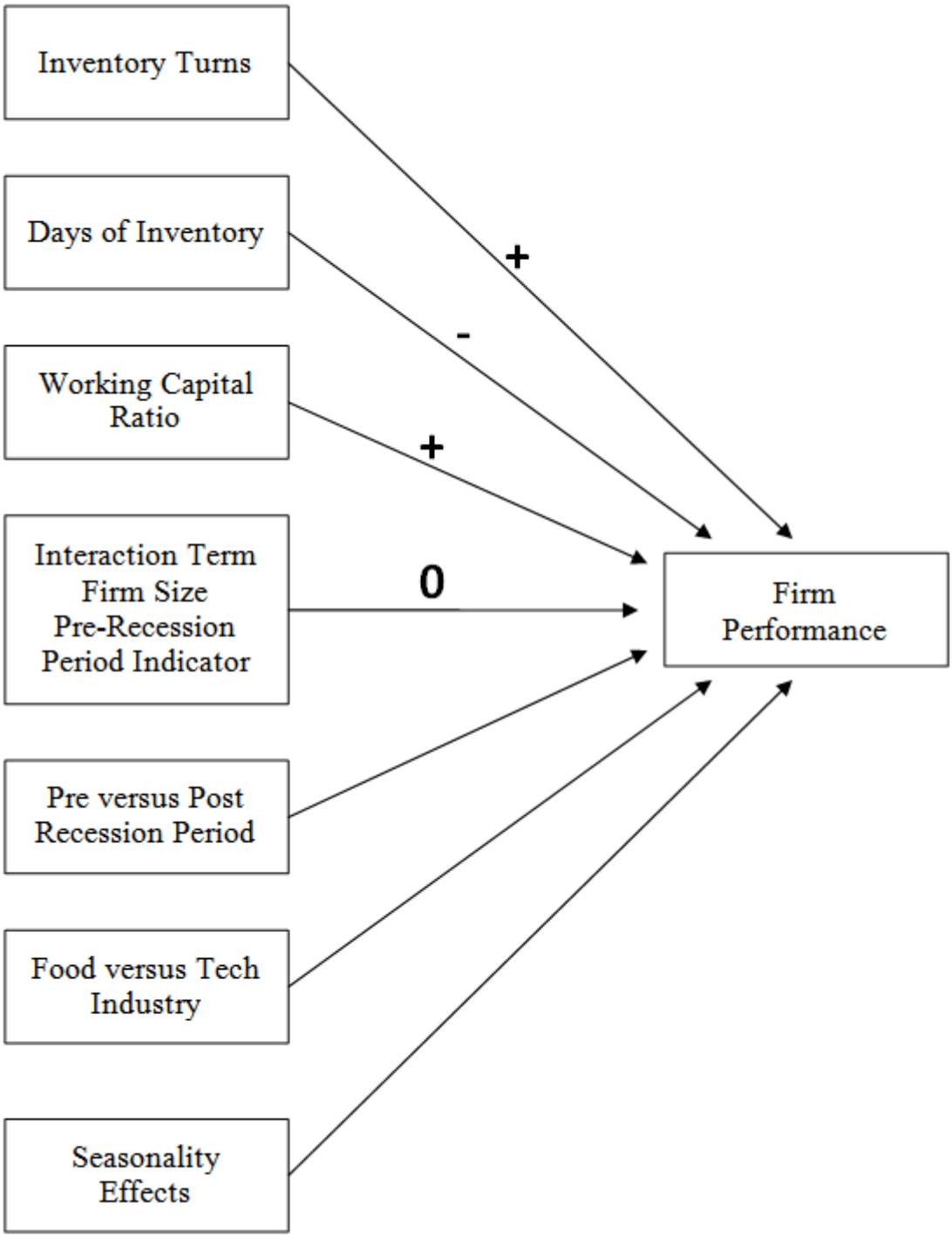
the food and beverage sector versus the technology sector was accounted for in the predictive model used to empirically investigate Hypotheses 1a, 1b, 1c and 1d.

The issue of seasonality was also raised as a potential confound in the model used to estimate Hypothesis set 1. Many economic phenomena have seasonal cycles due to factors such as agricultural production or consumer demand. Often it is necessary to adjust for this component in order to understand underlying effects or trends in the marketplace. Seasonal components usually happen in a similar pattern during the same time each year. By controlling for seasonality, it is easier to focus on the contribution effect of other variables (Småros, Lehtonen, Appelqvist, & Holmström, 2003). In order to account for seasonality within the statistical model that was used to investigate Hypothesis set 1, three variables were constructed. The first variable, entitled Q1, was coded as a dummy to indicate if the data came from the first, fifth, thirteenth or seventeenth quarter under investigation. The second variable, entitled Q2, was coded as a dummy to indicate if the data came from the second, sixth, fourteenth, or eighteenth quarter under investigation. The third and final variable, entitled Q3, was coded as a dummy to indicate if the data came from the third, seventh, fifteenth or nineteenth quarter under investigation. A measure that tracks the pre-recessionary period versus the post recessionary period was also added as a control for the possibility that firm performance might be greater in the post-recessionary time period than in the pre-recessionary period.

When each of the four subcomponents of hypotheses H1a - d are combined into a single graphic, I see the following, as shown in Figure 2, below.

Prior literature estimated the effects of inventory leanness on firm performance using linear models. These findings implied that greater inventory leanness often leads to better firm performance. However, there is recent literature which suggests there is an optimal level of

Figure 2: Combined Variables



inventory leanness (Eroglu & Hofer, 2011; Hofmann & Kotzab, 2010). Just-in-time theory, when combined with a linear perspective of inventory leanness, frequently leads SC managers to exploit these practices as managers lead their organization through a disruption to maintain firm performance expectations (Goldsby, Griffis, & Roath, 2006; Huson & Nanda, 1995). Similarly, earlier financial research presented evidence that suggests the greater the working capital, the better the firm's performance (Bierman, 1960), yet further research suggests that an optimal range exists for working capital ratio (Emery & Cogger, 1982). Working capital requires balance between a firm meeting current liabilities and greater asset utilization. In order to better understand this differentiation, several new hypotheses stated below will attempt to tease out a greater understanding of the relationship of leanness and slack resources while anticipating that management will realize their favorable results during normal conditions and apply them to a greater extent to drive performance due to the negative force from the economic disruption. As stated earlier, this disruption created an inability for firms to expand and grow, corrections in stock markets and the freezing of credit flows were some of the factors working against firms to perform as they had during the prior economic growth period. The effects of this type of disruption often forces firms to apply pressure across its supply chain to reduce costs and exploit processes that can support "bottom line" financial improvement (Hendricks & Singhal, 2003). Based on that premise, and with respect to the discussion above, the following hypotheses are presented:

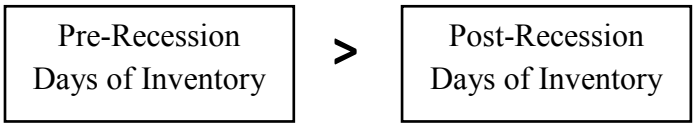
H2a. *Days of inventory in the post-recession period should be lower than days of inventory in the pre-recession period.*

H2b. *Inventory turns in the post-recession period should be higher than inventory turns in the pre-recession period.*

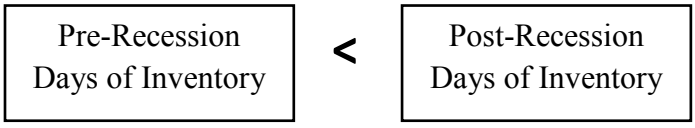
H3a. *The variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period.*

H3b. *The variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period.*

Hypothesis 2a states that days of inventory in the post-recession period should be lower relative to the pre-recession period. Hypothesis 3a proposes that the variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period. The two hypotheses are similar insofar as both hypothesize greater average days of inventory and greater days of inventory variance in the pre-recessionary period relative to the post-recessionary period. Visually I see Hypothesis 2a and 3a as follows:



Hypothesis 2b states that inventory turns in the post-recession period should be higher relative to the pre-recession period. Hypothesis 3b proposes that the variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period. The two hypotheses are similar insofar as both hypothesize greater average inventory turns and greater inventory turns variance in the pre-recessionary period relative to the post-recessionary period. Visually I see Hypothesis 2b and 3b as follows:



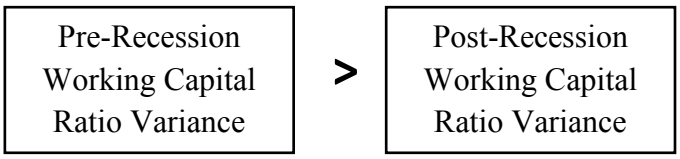
Thompson et al. (2009), Purdy (1967), and Galbraith (1973) see slack as a means to provide inventories at the input (to absorb supplier delivery schedules) and output end (to absorb

fluctuations in demand). They posit that slack allows the supply to be less prone to interruption and providing economic benefits to the firm in the long run. Yet, much of management and administrative theory is preoccupied with eliminating slack through efficiency improvement and optimization principles (Cyert & March, 1963b). Staw, Sandelands, and Dutton (1981) agree with Cyert and March (1963) by demonstrating in their research that depleting slack can cause rigidity and tightening of control tends to also diminish a firms financial performance and move it closer to failure.

I argue that in a more prosperous economic period, e.g. a pre-recession period, slack resources will be considered and implemented when firms have greater financial resources to support slack in their strategic efforts. Conversely, in a declining economic period, e.g. a post-recession period, firms will be eliminating slack resources to reduce costs or convert them into performance enhancing activities due to pressure from the economic disruption (Daniel et al., 2004). Therefore, the following hypothesis is proposed:

H4: *The variance in working capital ratio in the pre-recession period will be greater than the variance in working capital ratio in the post-recession period.*

Visually I see hypothesis H4 as follows:

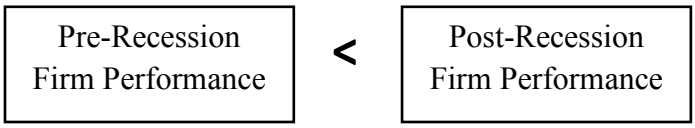


As mentioned earlier, prior research (Kuper, 2002) has proposed that larger firms generally have access to resources (i.e., financing, inventory) which are not as available to smaller firms and greater control over their competitive environment. Additionally, larger firms may be able to afford slack resources, especially during normal periods (Garmestani et al., 2006).

Based on the definition of resilience as posited in this study, if smaller firms have less access to resources and their survival becomes vulnerable, it is likely that their resilience will be affected due to their size. This bias of smaller firms was eliminated by focusing only on firms with annual revenue greater than $100 million. I follow Lev (1969) by identifying small firms as having annual revenue less than $100 million. As firms become larger with greater control over their competitive environment, their access to resources becomes greater (Garmestani et al., 2006). Based on this premise, the largest firms within the large firm group should have greater capability of managing their resources to withstand a disruption. Therefore, the following hypothesis is proposed:

H5. *The variance in firm performance in the pre-recessionary period will be less than the variance in firm performance in the post-recessionary period.*

I visually see hypothesis 5 as follows:



Regardless of firm size, the industry, degree of inventory leanness in a firm, or slack resources I expect there to be significant variation among firm performance between the pre-recession period and the post-recession period. Different firms have different resources and capabilities, and this should lead to a high degree of heterogeneity in the ability of firms to adapt and survive in response to a significant economic disruption (Rothaermel & Hill, 2005). I also anticipate a wide degree of resilience among the firms. The range should be from non-existent to a high degree of resilience within firms. If all firms were resilient, then they would not experience a decline in firm performance in the post-recession period as compared to the pre-recession period. This condition is highly unlikely since research demonstrates that, globally,

supply chain resilience is lacking across many industries and organizations (Hendricks & Singhal, 2005b); therefore, I anticipate less variance in firm performance in the pre-recession period than in the post-recession period.

3.3 Summary

This chapter has established the research context for the study with a discussion of the relationships between inventory leanness, slack resources, firm size, and firm performance against a significant global economic disruption. A conceptual model was presented for the study, and hypotheses have been developed and are summarized in Table 2.

Table 2: Summary of Hypotheses

Hypotheses Number	Hypotheses
H1a	Inventory leanness (as measured by greater inventory turns) increases resilience and therefore improves firm performance.
H1b	Inventory leanness (as measured by lower days of inventory) increases resilience and therefore improves firm performance.
H1c	An increase in working capital ratio increases resilience and therefore would lead to improved firm performance.
H1d	Firm size in the pre-versus the post-recession has no effect on firm performance between the pre-recession and the post-recession period.
H2a	Days of inventory in the post-recession period should be lower than days of inventory in pre-recession period.
H2b	Inventory turns in the post-recession period should be higher than inventory turns in the pre-recession period.
H3a	The variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period.
H3b	The variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period.
H4	The variance in working capital ratio in the pre-recession period will be greater than the variance in working capital ratio in the post-recession period.
H5	The variance in firm performance in the pre-recessionary period will be less than the variance in firm performance in the post-recessionary period.

4.0 RESEARCH METHODOLOGY AND DATA COLLECTION

This chapter describes the methods used for data collection and discussion of the research design.

4.1 Research Design

Secondary data was collected from a data collection organization that included many firms across two industries located across the globe to address the stated research questions. A summary of the research design is provided in Table 3.

Table 3: Overview of Research Design

Area of Concern	Supply Chain
Research Method	Secondary Data Analysis
Unit of Analysis	The Firm
Data Source	Publicly reported financial and operational data
Target Firms	Food and Beverage, and Technology (consumer electronics and computers) firms across the globe.
Industries Included	Both low-and high-technology industries, such as food and beverage (SIC 2000-2099), and computer and technology (SIC 3670-3679), respectively.

4.2 Research Philosophy

The research method provides a foundation for advancing knowledge in any given domain (Stone, 1978). Therefore, careful consideration is given in this study not only to theoretical constructs, but also to the methodological approach. It should be noted that this project follows the positivist research approach as the epistemological position (Myers, 2013). To explore this particular area of research, secondary data are gathered to evaluate the aforementioned hypotheses regarding the direct relationship of inventory leanness and slack

resources on the dependent variable of firm performance. Specifically, a quantitative approach was applied to investigate the hypothesized relationships in the theoretical framework of resilience.

4.3 Research Method

Ordinary Least Squares (OLS) regression, which is also known as multiple linear regression, will be used to test hypotheses H1a through H1d. Multiple linear regression is used when the dependent variable is continuous in nature and there are multiple independent variables (Miles & Shevlin, 2001). Hypotheses 2a, 2b, 3a, 3b, 4 and 5 will be analyzed via an independent samples t-test for differences in means. The use of an independent samples t-test is appropriate when the dependent variable is continuous in nature and the independent variable is a dichotomous nominal-level discrete variable (Ritchey, 2000). In addition, Levene's test for equality of variances will be used as a supplement to the independent samples t-test results.

4.4 Data Collection

Secondary data that is publically available was obtained from OneSource, Inc. through Supply Chain Insights, LLC for the purpose of analysis of the aforementioned hypotheses. Secondary data is well suited for studies designed to understand the present, investigate change, and to examine phenomena comparatively (Jarvenpaa, 1991). The data collected for this project will support the temporal aspect and provide the robustness to examine two industries and hundreds of firms simultaneously. The research setting for this study is the manufacturing sector of the global economy, as many of the firms in the dataset are multinational in scope. The data are categorized by quarter (Q). The period of Q1, 2007 to Q3, 2008 represents the pre-recession period, and the period Q1, 2010 to Q4, 2011 represents the post-recession period. Since the great recession (which represents the disruption period in this study) was officially declared to have

begun in Q4, 2008 and then end in Q4, 2009 (Verick, 2010), these quarters have been eliminated from the current analyses.

4.5 Data Preparation

Prior to all statistical analyses it was determined that said analyses should only be conducted on companies that contained robust data. In other words, only companies that had valid data points for all pre-recession and post-recession quarters under investigation were included in the final dataset. In all there were 688 companies which had valid data for the seven quarters of the pre-recession time period (Q1 of 2007 to Q3 of 2008) and the eight quarters of the post-recession time period (Q1 of 2010 to Q4 of 2011). A total of 10,320 unique data points for 688 different companies are contained within the base dataset for these quarters.

As part of the procedure to ensure that only companies with robust data were used, a few outlier observations (and the related observations from the same firm) were removed from the data. For example, companies reporting return on assets greater than 100 percent (+/-) were deleted from the dataset. It would be very rare for a company to have ROA greater than 100 percent, and it is more likely that the reporting of a ROA outside of this parameter was reported in error. The removal of this faulty data resulted in the deletion of 19 companies (285 observations) from the base dataset. One of the companies in the dataset reported revenue of -9.821 million for Q4 of 2007. It was decided that all observations for this company should be removed from the dataset, since it is very rare for a company to have negative revenue. Thus the final sample used for purposes of all data analyses was 10,020 unique data points for 668 different companies.

5.0 QUANTITATIVE ANALYSIS AND RESULTS

The chapter presents the analysis of the quantitative data obtained from the secondary source. Section 5.1 presents the results for each of the hypotheses as they relate to each of the constructs. The control variables were also included in the analysis to evaluate seasonality and industry type. I used the SPSS Version 21 statistical application package to perform all data analysis.

5.1 Results

In this section, I test each of the hypothesis associated with the conceptual model (see Figure 1).

5.1.1 Hypotheses 1a - 1d. I argue that leanness and slack resources have an effect on firm performance between the pre-recession and post-recession period when controlling for firm size.

Hypotheses 1a through 1d are stated below:

H1a*: Inventory leanness (as measured by greater inventory turns) increases resilience and therefore improves firm performance.*

H1b: *Inventory leanness (as measured by lower days of inventory) increases resilience and therefore improves firm performance.*

H1c: *An increase in working capital ratio increases resilience and therefore would lead to improved firm performance.*

H1d*: Firm size in the pre-versus the post-recession has no effect on firm performance between the pre-recession and the post-recession period.*

Table 4 presents the means and standard deviations for all variables used in this investigation. Several variables have been proxied as a way to concretely measure the concept

Table 4: Means and Standard Deviation for All Variables Used in Analysis

	Full Dataset		Pre-Recessionary Period		Post-Recessionary Period		Food and Beverage Industries		Technology Industries	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Measure for Firm Size: Revenue by Value	585.65	2379.74	552.89	2267.57	614.33	2473.58	450.49	1441.40	1310.40	4927.32
Measure for Inventory Leanness: Days of Inventory	97.10	237.66	99.53	293.74	94.99	174.37	100.16	253.79	80.70	116.92
Measure for Inventory Leanness: Inventory Turns	8.86	14.01	8.97	14.81	8.76	13.26	8.87	13.97	8.81	14.23
Measure for Firm Performance: Return on Assets	0.05	0.10	0.04	0.10	0.05	0.10	0.05	0.10	0.30	0.11
Measure for Slack Resources: Working Capital Ratio	0.19	0.49	0.17	0.62	0.20	0.34	0.16	0.51	0.34	0.30
Variable Marking Pre or Post Recession Time Period (1=Post)	0.53	0.50	-	-	-	-	0.53	0.50	0.53	0.50
Variable Marking Food or Tech Industry (1=Food)	0.84	0.36	0.84	0.36	0.84	0.36	-	-	-	-
	N=10,020		N=4,676		N=5,344		N=8,445		N=1,575	

indicated. For example, the concept of inventory leanness has been operationalized via the measures of days of inventory and inventory turns. Table 4 shows that the average days of inventory among all 668 companies is approximately 97.10 days, whereas the average number of inventory turns among all companies is 8.86. Firm size has been operationalized via the proxy measure of annual revenue. This variable was measured in millions of US dollars; as such, the mean of 585.65 suggests that the average revenue for all 668 companies was 585.65 million dollars. The measure used to estimate firm performance was return on assets. The average return on assets for all companies under investigation was 4.75 percent. Finally, the average working capital ratio in the dataset was .19.

Two variables were constructed for use in the various hypothesis tests discussed below. It should be noted that both of the constructed variables have been dichotomized; that is to say, each constructed variable has been coded as 0 and 1, with a value of 1 if the company is in the food and beverage industry, and 0 if in the consumer electronics and computer industry (i.e., technology industry). Coding variables in this manner allows for a percent interpretation of the respective means contained in Table 4. For example, the variable that marks whether a company belongs to the food and beverage industry or technology industry has an average score of .84, which means that 84 percent of the companies in the dataset are from the food industry. Along these same lines, Table 4 reveals that 53 percent of the data lies within the post-recessionary time period.

Table 4 bifurcates the data along pre versus post recessionary time periods and presents a side-by-side comparison of the means and standard deviations for seven of the variables used in the current investigation. As can be seen in Table 4, average revenue in the post-recessionary period was 614.33 (SD = 2473.58) and in the pre-recessionary period was 552.89 (SD =

2267.57). Days of inventory in the pre-recessionary period (M = 99.53; SD = 293.74) was not significantly different than in the post-recessionary period (M = 94.99; SD = 174.37). Likewise, inventory turns in the pre-recessionary period (M = 8.97; SD = 14.81) are not significantly different than in the post-recessionary period (M = 8.76; SD = 13.26). Finally, the ratio between food and beverage industries and technology industries is the same in both time periods (M = .84; SD = .36), thus showing parity of the data.

There are only two statistically significant differences that exist within these means between the pre- and post-recession period. Return on assets was slightly lower in the pre-recessionary period (M = .04; SD = .10) than in the post-recessionary period (M = .05; SD = .10). An independent samples t-test shows that the mean score for return on assets in the pre-recessionary period is statistically lower than in the post-recessionary period ($t = 2.638$, $df = 10{,}018$, $p < .01$). Working capital ratio was also lower in the pre-recessionary period (M = .17; SD = .62) than the post-recessionary period (M = .20; SD = .34). An independent samples t-test also shows that working capital ratio is also statistically lower in the pre-recessionary period as compared to the post-recessionary period ($t = 2.837$, $df = 10{,}018$, $p < .01$).

Table 4 also bifurcates the data along food and beverage industries versus technology industries and presents a side-by-side comparison of the means and standard deviations for six of the variables used in the current investigation. Statistically significant differences exist within these means between the food and beverage industries and the technology industries for all variables except inventory turns. Results of a series of independent samples t-tests showed that return on assets ($t = 6.428$, $df = 10{,}018$, $p < .001$), revenue ($t = 13.280$, $df = 10{,}018$, $p < .001$) and working capital ratio ($t = 13.514$, $df = 10{,}018$, $p < .001$) were all statistically significant for technology industries as compared to food and beverage industries. In contrast, days of inventory

was statistically larger for the technology industries than for the food and beverage industries (t = 2.985, df = 10,018, p < .01).

In order to investigate the various aspects of Hypothesis 1 simultaneously, an Ordinary Least Squares (OLS) regression was performed as the statistical modeling technique. The use of regression is optimal when modeling two or more independent variables and one dependent variable (Miles & Shevlin, 2001). Additionally, the standard errors were clustered at the firm level. Without clustering the standard errors, correlations among variables might cause misleading small standard errors and consequently narrow confidence intervals, larger t-statistics, and low p-values (Miles & Shevlin, 2001). A regression without clustering of standard errors was also performed; the results showed results similar to those obtained via the regressions with the clustered standard errors. As such, the results with clustered standard errors are presented in this chapter. Table 5 presents the results of the OLS regression of firm performance as measured by return on assets on the six primary independent predictors of interest.

Table 5: Unstandardized OLS Regression Coefficients Predicting Firm Performance as Measured by Return on Assets

Variable	*B*	*SE(B*	*p*	*B*	*SE(B)*	*p*	*B*	*SE(B)*	*p*
Constant	2.118	0.375	***	1.965	0.401	***	2.020	0.402	***
Inventory turns	-0.002	0.007		-0.0004	0.017		-0.001	0.017	
Days of inventory	-0.002	0.001	***	-0.001	0.001		-0.001	0.001	
Working capital ratio	2.417	0.231	***	2.536	0.245	***	2.535	0.245	***
Firm size as measured by revenue by value	0.219	0.004	***	0.223	0.044	***	0.139	0.066	**
Pre versus post recession time period	0.447	0.207	*	0.430	0.207	*	0.345	0.213	
Food and beverage versus technology	2.485	0.288	***	2.491	0.288	***	2.490	0.288	***
Seasonal effects, Q1	-0.327	0.305		-0.339	0.305		-0.341	0.305	
Seasonal effects, Q2	0.373	0.305		0.371	0.305		0.367	0.305	
Seasonal effects, Q3	-0.246	0.305		-0.244	0.304		-0.244	0.304	
Inventory turns, squared				0.0001	0.0001		0.000002	0.0001	
Days of inventory, squared				-0.00000001	0.000		-0.000001	0.000	
Working capital ratio, squared				-0.065	0.028	*	-0.065	0.028	*
Interaction of pre versus post recession time period and firm size							0.147	0.087	
R^2	0.018			0.020			0.020		
F	20.680		***	16.777		***	15.707		***

Note: N=10,020, *=p<.05, **=p<.01, ***=p<.001, two-tailed tests.

It should be noted here that inventory leanness has been measured with two different variables: days of inventory and inventory turns. Both variables in the regression equation have been modeled as continuous data. A measure for slack resources (WCR) was also used in the regression equation: the full and continuous distribution of WCR has been used as part of the regression model. It should also be noted that the variable which marks pre- versus post-recession time period has been dichotomized, with the post-recession time period being marked as the category of interest. A dichotomous variable marking the food and beverage industry versus technology industry in the dataset has been included as a statistical control in the regression equation, with the food and beverage sector being coded as 1 and the technology sector being coded as 0. Finally, three dummy variables have been entered to account for seasonality effects.

The possibility that curvilinear relationships may exist within the data was raised. In order to control for this possibility, the variables that estimate working capital ratio, inventory turns and days of inventory were transformed into quadratic terms and entered into models 2 and 3 of Table 5.

Three modes were calculated as part of the OLS regression. The first model contained the main effects. The second model added the quadratic terms. The third and final model added the interaction term. Results are presented in Table 5.

As can be seen by the omnibus f-test, the first model in Table 5[2] is statistically significant ($F = 20.680$, $df = 8, 10{,}011$, $p<.001$). Furthermore, only 1.8 percent of the variation in the dependent variable is accounted for by the various independent variables, suggesting poor model

[2] It should be noted here that the dependent variable, Return on Assets, has been multiplied by 100 so as to make for an easier interpretation of the coefficient results in Table 5. Revenue has been divided by 1000 so as to make for an easier interpretation of its coefficient results in Table 5.

fit. Five of the nine independent variables emerged as statistically significant predictors of firm performance as measured by return on assets. Decomposition of effects found in the first model in Table 5 shows that as days of inventory decreases, return on assets also increases (β = -.002, t = -4.667, p<.001), controlling for other variables in the equation. Interestingly, this result does not persist when the quadratic terms and the interaction term are entered into models 2 and 3, respectively.

Examination of the results in Table 5 also shows that as working capital ratio increases, return on assets will increase (β = 2.417, t = 10.459, p<.001), again controlling for other variables in the equation. This result is also present in model 2 (β = 2.536, t = 5.107, p<.001) and model 3 (β = 2.535, t = 2.090, p<.001).

The first model in Table 5 reveals that firm size is also related to return on assets. Specifically, as revenue increases, return on assets also increases (β = .219, t = 5.023, p<.001), net of the other predictors. This result is also present in model 2 (β = .223, t = 10.370, p<.001) and model 3 (β = .139, t = 10.367, p<.05).

Companies in the post-recession time period has a higher return on assets than in the pre-recession time period in model 1 (β = .447, t = 2.160, p<.05) and model 2 (β = .430, t = 2.078, p<.05), which justifies its inclusion in the above regression equation. Food and beverage industries in the dataset have a higher return on assets relative to the technology industries in the dataset in all three models (model 1 β = 2.485, t = 8.644, p<.001; model 2 β = 2.491, t = 8.662, p<.001; model 3 β = 2.490, t = 8.658, p<.001), again justifying its inclusion in the above regression equation. Finally Table 5 shows that inventory turns is unrelated to return on assets, as are the coefficients for seasonality effects in all three models.

When taken together, the evidence from the OLS regression results displayed in Table 5

provide partial support for Hypothesis 1. Specifically, Hypothesis 1a stated that inventory leanness (as measured by greater inventory turns) improves firm performance. There is no evidence to support this hypothesis within the regression equations presented in Table 5. Hypothesis 1b stated that inventory leanness (as measured by lower days of inventory) improves firm performance. This hypothesis is supported by the evidence presented in the first regression equation in Table 5. As days of inventory decreases, return on assets increases in the first model. Hypothesis 1c states that an increase in working capital ratio would lead to improved firm performance. This hypothesis is supported by the evidence within the regression equations presented in Table 5. As working capital ratio increases, return on assets also increases in all three models.

In order to investigate the tenets of Hypothesis 1d, an interaction term was created and entered into the third model in Table 5. The interaction term between firm size and pre versus post recessionary time periods is statistically non-significant. On the basis of this evidence it can be concluded that there is no support for Hypothesis 1d. In other words, the data does not support the contention that firm size differentially affects firm performance between the pre-recession and the post-recession period.

As previously noted, the possibility of curvilinear effects concerning working capital ratio, inventory turns and days of inventory was raised during the analysis phase of this project. In order to account for this possibility, quadratic terms for each of the aforementioned variables were entered into models 2 and 3. Results presented in Table 5 show that neither inventory turns nor days of inventory were statistically related to the dependent variable. Working capital ratio was negatively related to the dependent variable in model 2 (β = -.065, t = -2.303, p<.05) and model 3 (β = -.065, t = -2.313, p<.05) of the equation set. As such, it can be concluded that

working capital ratio has a curvilinear relationship to return on assets.

The possibility that there could be variation in the data as a function of whether a company was from the technology industries or from the food and beverage industries was raised as a possibility. In order to investigate this possibility, the dataset was divided into its two separate parts, and the regression analyses used to investigate Hypothesis 1 were re-estimated. Tables 6a and 6b present the bifurcated data used to investigate Hypothesis 1. A difference in the bifurcated data was found with respect to Hypothesis 1a. Specifically, the statistically nonsignificant results found for hypothesis 1a for the full dataset was reversed when the data were split between the technology companies and the food and beverage companies.

Table 6a: Unstandardized OLS Regression Coefficients Predicting Firm Performance as Measured by Return on Assets, Food and Beverage Industries Only

Variable	*B*	*SE(B*	*p*	*B*	*SE(B)*	*p*	*B*	*SE(B)*	*p*
Constant	4.434	0.303	***	4.507	0.338	***	4.547	0.341	***
Inventory turns	-0.020	0.008	*	-0.051	0.018	**	-0.051	0.018	**
Days of inventory	-0.002	0.001	***	-0.001	0.001		-0.001	0.001	
Working capital ratio	2.565	0.237	***	2.697	0.252	***	2.696	0.252	***
Firm size as measured by revenue by value	0.124	0.076		0.139	0.076		0.053	0.122	
Pre versus post recession time period	0.698	0.222	**	0.685	0.222	**	0.621	0.233	**
Seasonal effects, Q1	-0.086	0.327		-0.119	0.327		-0.123	0.327	
Seasonal effects, Q2	0.721	0.327	*	0.704	0.327	*	0.700	0.327	*
Seasonal effects, Q3	0.003	0.327		-0.006	0.327		-0.007	0.327	
Inventory turns, squared				0.00003	0.0001	*	0.00003	0.0001	*
Days of inventory, squared				-0.00000001	0.000		-0.000001	0.000	
Working capital ratio, squared				-0.053	0.028		-0.054	0.028	
Interaction of pre versus post recession time period and firm size							0.145	0.156	
R^2	0.017			0.020			0.020		
F	18.399		***	15.443		***	14.226		***

Note: N=10,020, *=p<.05, **=p<.01, ***=p<.001, two-tailed tests.

Among the food and beverage segment of the dataset, there was a significant and negative relationship between inventory turns and return on assets, controlling for other factors in the model. Interestingly, within the technology segment of the dataset, there was a significant and positive relationship between inventory turns and return on assets, again controlling for other

Table 6b: Unstandardized OLS Regression Coefficients Predicting Firm Performance as Measured by Return on Assets, Technologies Industries Only

Variable	*B*	*SE(B*	*p*	*B*	*SE(B)*	*p*	*B*	*SE(B)*	*p*
Constant	4.232	0.826	***	4.100	1.053	***	4.159	1.060	***
Inventory turns	0.083	0.020	***	0.148	0.054	**	0.142	0.054	**
Days of inventory	-0.006	0.002	*	-0.027	0.006	***	-0.027	0.006	***
Working capital ratio	-0.016	0.926		7.929	1.396	***	7.907	1.396	***
Firm size as measured by revenue by value	0.180	0.057	**	0.149	0.057	**	0.073	0.083	
Pre versus post recession time period	-0.752	0.553		-0.583	0.541		-0.766	0.560	
Seasonal effects, Q1	-1.459	0.814		-1.131	0.797		-1.124	0.797	
Seasonal effects, Q2	-1.130	0.814		-1.262	0.796		-1.266	0.795	
Seasonal effects, Q3	-1.410	0.813		-1.154	0.795		-1.152	0.795	
Inventory turns, squared				-0.001	0.0001	*	-0.001	0.0001	
Days of inventory, squared				0.0000007	0.00002	***	0.0000007	0.00002	***
Working capital ratio, squared				-7.155	1.084	***	-7.132	1.084	***
Interaction of pre versus post recession time period and firm size							0.0001	0.000	
R^2	0.033			0.079			0.080		
F	6.689		***	12.153		***	11.278		***

Note: N=10,020, *=p<.05, **=p<.01, ***=p<.001, two-tailed tests.

factors in the model. Therefore, estimating models of association from two different consumer goods industries may obscure relationships that differ between the industries.

Tables 6a and 6b also show that the results found for Hypothesis 1b in the full dataset are the same in the bifurcated dataset; namely, that as days of inventory decreases, return on assets increases.

Results concerning Hypothesis 1c and Hypothesis 1d were mixed in the bifurcated data. In the full dataset, it was found that higher levels of working capital ratio were associated with a concomitant increase in return on assets, net of other predictors. This relationship held within the food and beverage segment of the dataset, but not within the technology segment of the dataset. The same was found with respect to the pre versus post recessionary time period; namely, that the post-recession time period had a higher return on assets than in the pre-recession time period, but only for the food and beverage segment portion of the dataset. Interestingly, there does appear to be a seasonality effect for quarter 2 in the food and beverage segment of the

dataset across all three models, but there is no support of an effect of seasonality on any other quarter within F & B or the technology industries.

5.1.2 Hypothesis 2a and 3a. I argue that days of inventory in the post-recession period should be lower than days of inventory in the pre-recession period, and that the variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period. Hypotheses 2a and 3a are stated below:

> H2a**:** *Days of inventory in the post-recession period should be lower than days of inventory in the pre-recession period.*
>
> H3a**:** *The variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period.*

In order to investigate this set of hypotheses, an independent samples t-test was calculated for H2a, and a Levene's test for equality of variances was calculated for H3a. The use of an independent samples t-test and the Levene's test is appropriate when the dependent variable is continuous in nature and the independent variable is a dichotomous nominal-level discrete variable (Ritchey, 2000). In this instance, days of inventory is being measured as a continuous variable, and the variable which marks either the pre-recessionary or post-recessionary time period has been dichotomized. Results of the independent samples t-test are statistically nonsignificant (t= .954, df= 10,018, p>.05) and suggest that there is no relationship between time period and days of inventory. Levene's test for equality of variances is also statistically nonsignificant (F =1.521, p>.05), which suggests that there is a nonsignificant difference in the variance of days of inventory for the two time periods. Thus it can be concluded that neither average days of inventory nor the variance associated with days of inventory are significantly different between the pre-recession time period and the post-recession time period. Hypotheses 2a and 3a are not supported by the data.

5.1.3 Hypotheses 2b and 3b. I argue that inventory turns in the post-recession period should be higher than during the pre-recession period and variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period. Hypotheses 2b and 3b are stated below:

H2b. *Inventory turns in the post-recession period should be higher than during the pre-recession period.*

H3b. *The variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period.*

In order to investigate this set of hypotheses, an independent samples t-test was calculated H2b, and a Levene's test for equality of variances was calculated for H3b. The use of an independent samples t-test and the Levene's test is appropriate when the dependent variable is continuous in nature and the independent variable is a dichotomous nominal-level discrete variable (Ritchey, 2000). In this instance, inventory turns is being measured as a continuous variable, and the variable which marks either the pre-recessionary or post-recessionary time period has been dichotomized. Results of the independent samples t-test are statistically nonsignificant (t= .776, df= 10,018, p>.05) and Levene's test for equality of variances is also statistically nonsignificant (F =3.662, p>.05). Thus it can be concluded that neither average inventory turns nor the variance associated with inventory turns are significantly different between the pre-recession time period and the post-recession time period. Hypotheses 2b and 3b are not supported by the data.

The possibility that there could be variation in the data as a function of whether a company was from the technology industries or from the food and beverage industries was again raised as a possibility with respect to the tenets of Hypotheses 2a, 2b, 3a and 3b. In order to

investigate this possibility, the dataset was divided into its two separate parts, and the independent samples t-tests and Levene's test used to investigate the aforementioned hypotheses were re-estimated. With respect to Hypotheses 2a, results of the independent samples t-test for the food and beverage segment of the data (t= 1.217, df= 8,443, p>.05) and the technology segment of the data (t= 1.225, df= 1,573, p>.05) are statistically nonsignificant. With respect to Hypothesis H3a, the Levene's test for the food and beverage segment of the data (F = 2.102, p>.05) and the technology segment of the data (F = 0.780, p>.05) are also nonsignificant. Thus it can be concluded that there is no relationship between time period and days of inventory as a function of industry segment. Results of the independent samples t-test for the food and beverage segment of the data (t= .436, df= 8,443, p>.05) and the technology segment of the data (t= .936, df= 1,573, p>.05) are statistically nonsignificant for Hypotheses 2b. With respect to Hypothesis 3b, the Levene's test for the food and beverage segment of the data (F = 2.969, p>.05) and the technology segment of the data (F = .835, p>.05) are also nonsignificant. Thus it can be concluded that there is no relationship between time period and inventory turns as a function of industry segment.

5.1.4 Hypothesis 4. I argue that the variance in working capital ratio in the pre-recession period will be greater than the working capital ratio in the post-recession period. Hypotheses 4 is stated below:

H4. *The variance in working capital ratio in the pre-recession period will be greater than the variance in the working capital ratio in the post-recession period.*

In order to investigate this hypothesis, an equality of variances Levene's test was calculated. In this instance, WCR is being measured as a continuous variable, and the variable which marks either the pre-recessionary or post-recessionary time period has been dichotomized.

Levene's test for equality of variances is statistically significant (F =4.759, p<.05), which suggests that there is a statistically significant difference in the variance of WCR for the two time periods. Decomposition of the effects of the Levene's test reveals that the variance of the WCR for companies in the pre-recessionary time period (.382) is actually greater than the average variance of the WCR for companies in the post-recessionary time period (.114), a result which supports the tenets of Hypothesis 4. The evidence from the statistical analyses supports Hypothesis 4.

The possibility that there could be variation in the data as a function of whether a company was from the technology industry versus the food and beverage industry was again raised as a possibility with respect to Hypothesis 4. In order to investigate this possibility, the data were again bifurcated, and an equality of variance test (i.e., Levene's test) was computed. Results showed that the results for Hypothesis 4 are significant for the food and beverage industries (F = 5.926, p < .05) only. No statistically significant result was found when the dataset was restricted to technology industries (F = 1.324, p>.05) via the Levene's test.

5.1.5 Hypothesis 5. I argue that as the variance in firm performance in the pre-recessionary period will be less than the variance in firm performance in the post-recessionary period. Hypothesis 1d is stated below:

H5**.** *The variance in firm performance in the pre-recessionary period will be less than the variance in firm performance in the post-recessionary period.*

In order to investigate this hypothesis, a Levene's test for equality of variance f-test was calculated. The use of Levene's test is appropriate when the dependent variable is continuous in nature and the independent variable is a dichotomous nomial-level discrete variable (Miles & Shevlin, 2001). In this instance, firm performance is being measured by return on assets, which

is a continuous variable. The variable that marks either the pre-recessionary or post-recessionary time period has been dichotomized. Levene's test for quality of variances is statistically nonsignificant (F = .743, p>.05) in this instance. Therefore, Hypothesis 5 is not supported by the data.

The possibility that there could be variation in the data as a function of whether a company was from the technology industries versus the food and beverage industries was again raised as a possibility with respect to Hypothesis 5. In order to investigate this possibility, the data were again bifurcated. As was the case with the full dataset, Levene's test for equality of variances is again statistically nonsignificant (F = .317, p>.05) for the food and beverage industries and the technology industries (F = .253, p>.05).

5.1.6 Determinants of firm performance in the post-recession period. Based on the statistical results obtained via testing each of the five hypotheses, a post hoc analysis was performed to further test supply chain resilience at the firm level, using the difference between the pre-recession period firm performance (ROA) and post-recession period firm performance (ROA) as the dependent variable. This additional analysis included collapsing independent variables for the pre- and post-periods at the firm level and standardizing or centering the variables to improve clarity of interpretation. Prior to this analysis it was suspected that DOI and inventory turns may be creating multicollinearity. Variance inflation factors (VIF) for the variable inventory turns in both pre and post periods were at 9.756 and 9.898, respectively. According to Allison (1999), a VIF greater than 5 indicates that the variance of inventory turns of the regression coefficient in increased due to collinearity. Therefore, multicollinearity exists with this variable. Inventory turns was therefore eliminated in this regression in the post period. Doing this resulted in a lowering of the VIF for all remaining variables to less than 2, which

eliminated the multicollinearity effect.

Table 7 includes the results of the additional analysis. These results show that the overall model is statistically significant ($F = 4.382$, $df = 7, 660$, p<001). However, the coefficient of determination revealed that only 4.4 percent of the variation in the dependent variable is accounted for by the 7 independent variables, suggesting poor model fit. Two of the seven variables emerged as statistically significant predictors of firm performance as measured by the difference in return on assets in the post-versus the pre-recession period. Decomposition of effects in Table 7 shows that as pre-period days of inventory increases, the difference in return on assets between the pre and the post period increases ($\beta = .004$, $t = 2.212$, p<.05), controlling for other variables in the equation. Examination of the results in Table 7 also shows that as pre-period WCR increases, ROA in the post compared to the pre-recession period will decrease ($\beta = -2.688$, $t = -4.737$, p<.001), again controlling for other variables in the equation. Also, Table 7 shows that firm size ($\beta = .055$, $t = .498$, p>.05), pre-period inventory turns ($\beta = -.013$, $t = -.736$, p>.05), and post-period WCR ($\beta = 1.404$, $t = 1.315$, p>.05) are unrelated to the difference in the pre- versus the post-period firm performance.

The evidence from the regression results in Table 7 provides a contrary perspective to the commonly held position that greater inventory leanness or lower days of inventory will improve firm performance, particularly in the post-recession period. Additionally, these regression results show that a higher WCR prior to a disruption will decrease firm performance in the post-recession time period. Higher WCR indicates that firms may not be efficiently utilizing their excess cash and/or their current assets (Lev, 1969).

Table 7: Unstandardized OLS Regression Coefficients Predicting Firm Performance as Measured by Return on Assets, Post Recession

Variable	*B*	*SE(B)*	*p*
Constant	-0.672	0.614	
Firm Size-Centered	0.055	0.110	
Pre Days of Inventory-Centered	0.004	0.002	*
Pre Inventory Turns-Centered	-0.013	0.017	
Pre Working Capital Ratio-Centered	-2.688	0.567	***
Post Days of Inventory-Centered	-0.004	0.002	
Post Working Capital Ratio-Centered	1.404	1.068	
Constructed Variable to Track Industry Type	1.445	0.668	*
R^2	0.044		
F	4.382		***

Note: N=668, *=p<.05, **=p<.01, ***=p<.001, two-tailed tests.

6.0 DISCUSSION AND IMPLICATIONS

In this section, I discuss the findings of this study and their implications. I also discuss the contribution to theory and practice. I conclude my discussion with limitations and possible future research opportunities.

6.1 Summary of Results and Discussion

In this study, I investigated the effect of inventory leanness and slack resources on firm performance in light of the conditions of a global economic disruption. I also investigated if firm resiliency is affected by inventory leanness and slack resources under conditions of this economic disruption. To test this, I investigated the influence of inventory leanness on firm performance by measuring the impact that days of inventory and inventory turns has on return on assets. I also estimated the influence that slack resources has on firm performance by measuring how working capital ratio impacts return on assets in the pre-recessionary period and the post-recessionary period. I also investigated this influence between two industries that have different supply chains. Choosing these industries provided the difference for comparison and contrasting that was anticipated to support operationalizing the findings from the study among the consumer goods categories. Finally, seasonality was investigated in the model due to the diverse demand patterns and supply dynamics between the industries, as well as firm size due to the inherent characteristic of size on a firm's ability to weather disruptions. I argued that slack resources and inventory leanness will positively influence firm performance as a firm maneuvers through an economic disruption. I further argued that this positive influence should support supply chain resiliency as a firm emerges from an economic disruption.

The literature review ties supply chain resiliency with how firms can build resiliency capability, manage risk (i.e., identifying sources of risk, how those risks lead to consequences,

understand the drivers of risk, and formulate and implement strategies to mitigate risk), and define the meaning of supply chain resilience, along with its benefits. However, I was not aware of any studies that specifically assess the influence of the two primary SC constructs of inventory leanness and slack resources. These twin SC constructs are critical to SC managers as they maneuver through a global disruption that had immense consequences and widespread economic decline not seen since the great depression and World War II era.

The study did not included data that was associated with the period defined as the great recession (quarter 4 of 2008 to quarter 4 of 2009). The reason for eliminating the disrupted time period was due to the stricter application of resilience adopted by this dissertation. The period prior to the disruption represented a more normal state, and the time period after the disruption represented a comparison to the "normal" state. If firms return to or are better than the normal state performance after the disruption, then resilience is present. If firm performance is not equal to or not better than the normal state, then resilience is not present. The normal state is associated with an environment that is not experiencing a disruption or a decline. It is possible that firms in this study could have been experiencing a disruption during the normal state or in the recovery period after the economic recession. I did not include any other types of disruption beyond the great recession period in this study.

Hypothesis 1a through 1d were structured to assess the effect of inventory leanness and slack resources on firm performance. I controlled for industry and, where appropriate, tested for differences in the effects by industry. I also controlled for seasonality. Seasonality often has an effect on inventory and slack resources due to the impact seasonal aspects, such as the fourth quarter holiday season, warm or cold weather influence on demand patterns, or raw material availability due to seasonal harvests or availability. The findings for seasonality were minimal,

with only Q2 in the food and beverage industries showing an effect. No other quarters in the food and beverage industries, or any quarter in the technology industries, supported seasonality effects.

The hypothesis that inventory leanness would have a positive effect on firm performance was partially supported. These results are mixed since hypothesis H1a, that increased inventory turns would enhance firm performance, was not supported. In contrast, H1b, that increased days of inventory would reduce firm performance, was supported. These findings are consistent with Eroglu and Hofer (2011) and Demeter and Matyusz (2011), as it was found that industry type, product type, demand or supply characteristics, and production technology will respond differently to lean practices (Eroglu & Hofer, 2011). Further, leanness on firm performance is mostly positive and generally non-linear. In most situations, inventory leanness is concave and there is an optimal level of inventory leanness where the marginal effect of leanness on financial performance becomes negative (Demeter & Matyusz, 2011). Slack resources effect on firm performance was mixed between industries. Only within the food and beverage segment did an increase in WCR show an effect on increased firm performance. The results of inventory leanness on firm performance suggest that variations will occur depending on its position of the curvilinear path. The results for an increase in WCR leading to improved performance (H1c) are inconclusive in the literature on slack resources. In their meta-analysis of the slack-performance relationship, Daniel et al. (2004) found that this relationship is more pronounced when controlling for industry compared to those that do not. The current finding provides additional empirical evidence for this industry specific relationship. In the current study, higher levels of WCR increased firm performance, but this effect was not found for the technology industry.

In Hypothesis 1d it was anticipated that firm size would decrease the variance in firm performance between the pre- and post-recession periods. The findings for these two industries did not support this hypothesis. This outcome is contrary to previous research (Garmestani et al., 2006; Hendricks & Singhal, 2003). This opposite finding to the one hypothesized may be specific to the industries selected, as industry specific results have been found with other research in the lean and slack literature (Sharfman et al., 1988; Tan & Peng, 2003; Hambrick & D´Aveni, 1988).

Inventory leanness, slack resources, time period, industry, and seasonality only accounted for 1.8% ($p<.001$) of the variation in firm performance. However, when separated by industry, these variables accounted for 1.7% ($p<.001$) in food and beverage and 3.3% ($p<.001$) in technology sector of the variation in firm performance. Further examination of the results in Table 7, found that as days of inventory and WCR increases, ROA also increases; additionally, firms in the post-recession time period has higher ROA than in the pre-recession time period. Food and beverage industry also have a higher ROA relative to the technology industry. Finally, it was found that seasonality in the pre and post time periods within the industries was not supported for the technology industry, although quarter 2 for the food and beverage supported a seasonality effect. Again, it appears that seasonality is industry specific, but it is interesting that seasonality was not a larger factor with these consumer goods industries that have demand volatility that is highly influenced by events, weather, and supply availability.

Hypotheses 2a and 3a investigated the inventory leanness variables in the two time periods. It was anticipated that in the pre-recessionary time period, which is the identified normal or growth period, firms would have higher inventory with less turns to support anticipated growth and expected demand based on historically based forecasts. These

hypotheses were supported by work done by Zsidisin and Wagner (2010) on supply chain risk and resiliency. The results of the current analysis suggested that days of inventory does not have a relationship with time period for these industries. Inventory turns in the post-recession period were not significantly lower than in the pre-recession period (H2b) and the variance of inventory turns in the pre-recession period was not greater than the variance of inventory turns in the post-recession period (H3b), providing no evidence that firms had higher inventory during a period of growth relative to a period of recovery post-recession. Thus, the results for the hypotheses set H2 and H3 showed that inventory leanness is not significantly different between the two time periods for either industry. As identified by Eroglu and Hofer (2011), the importance of inventory leanness varies greatly from one industry to another. However, in this analysis I found no support for the hypothesized relationship between inventory leanness and the economic disruption in either industry.

The same investigation was performed with slack resources via the tenets of hypothesis 4 (variance in WCR in the pre-recession period will be greater than the WCR in the post-recession period). The results were mixed for H4. Overall, the results support the hypothesis that there is a relationship between WCR and time period. Yet when the data were bifurcated between the food and beverage and technology industries, statistical significance was achieved for only the food and beverage industries. Daniel et al. (2004) and Tan and Peng (2003) find similar evidence that slack resources has a positive effect on firm performance during economic transitions. Their studies, like this one, suggest that the slack – performance relationship may be firm and/or industry specific.

In the case of variance in firm performance in the pre-recessionary period will be less than the variance in firm performance in the post-recessionary period (H5), the results lie at odds

with the original hypothesis. It was anticipated that, controlling for firm size, the variance in firm performance would be lower in the pre- than in the post-recession period. On the one hand, recessionary forces have a pervasive impact on all segments of the economy and can have a regressing to the mean effect on entire industries and economies (Blackhurst et al., 2011). However, in this case it was anticipated that these forces would increase variance in firm performance in the post time period. This assumption was based on the practical experience that industries have gained with previous significant disruptions, the media reports that portrayed the effects of this global disruption, and how a large portion of the literature on disruptions describes the effects of disruptions on firm performance (Altay & Ramirez, 2010; Hambrick & D'Aveni, 1988; Jüttner, 2005; Kleindorfer & Saad, 2005; Tan & Peng, 2003). The opposite effect occurred within the data used by this investigation. Firm performance variation was less in the post-recessionary period as compared to the pre-recessionary period, a finding that aligns with the work of Blackhurst et al. (2011). This finding may indicate that firms, especially large firms, may be able to respond quickly to a disrupted condition by releasing available resources (e.g., downsizing employees, preexisting available credit) and converting available resources into operating resources to minimize financial performance volatility (Daniel et al., 2004). Specific to both the food and beverage and technology industries, firm size was not found in the current study as a mechanism that decreased variance between the pre- and post-recession periods. Even though conceptual studies suggest that firm size would have a decreasing effect, the present results suggest that large firms may be able to rely on their size to overcome the effects on firm performance as they encounter a disruption due to firm performance variation being less in the post-recessionary period.

Table 8 summarizes the results of the hypothesis testing.

Table 8: Summary of Hypotheses Results

Hypothesis Number	Hypothesis	Results		
		Overall	Food and Beverage	Technology
H1a	Inventory leanness (as measured by greater inventory turns) increases resilience and therefore improves firm performance.	Not Supported	Supported	Supported
H1b	Inventory leanness (as measured by lower days of inventory) increases resilience and therefore improves firm performance.	Supported	Supported	Not Supported
H1c	An increase in working capital ratio increases resilience and therefore would lead to improved performance.	Supported	Supported	Not Supported
H1d	Firm size in the pre- versus the post-recession has no effect on firm performance.	Not Supported	Not Supported	Not Supported
H2a	Days of inventory in the post-recession period should be lower than days of inventory in the pre-recession period.	Not Supported	Not Supported	Not Supported
H2b	Inventory turns in the post-recession period should be higher than inventory turns in the pre-recession period.	Not Supported	Not Supported	Not Supported
H3a	The variance of days of inventory in the pre-recession period will be greater than the variance of days of inventory in the post-recession period.	Not Supported	Not Supported	Not Supported
H3b	The variance of inventory turns in the pre-recession period will be greater than the variance of inventory turns in the post-recession period.	Not Supported	Not Supported	Not Supported
H4	The variance in working capital ratio in the pre-recession period will be greater than the variance in working capital ratio in the post-recession period.	Supported	Supported	Not Supported
H5	The varinace in firm performance in the pre-recessionary period will be less than the variance in firm perfornmance in the post-recessionary period.	Not Supported	Not Supported	Not Supported

6.2 Theoretical Contributions

This project investigated if a firm's focus on inventory leanness and the availability of slack resources have an effect on firm performance under conditions of an economic disruption. As firms execute strategic plans, these two primary SC constructs are often instrumental in determining how well a firm will perform throughout and after a major economic disruption. The performance of a firm during and after a disruption is highly dependent on the degree of resilience that exists within a firm prior to a disruption (Christopher & Peck, 2004). The literature is silent on the interaction of inventory leanness and slack resources and their effect of firm performance as it contributes to a firm's resiliency under conditions of a financial disruption, as was the case in the global great recession of 2008-2009. This study investigates this critical interaction through empirical testing. The findings provide several implications for theory.

Scholars have investigated many aspects of supply chain resilience and the relationships of SC practices and risk-performance. Christopher and Peck (2004) and Pettit et al. (2010) identified the components of a resilient SC and how to assess and apply those components. Hendricks and Singhal (2003) identified the effect of disruptions on firm performance and shareholder wealth, and Altay and Ramirez (2010) evaluated the impact of many different types of disasters on different industries. Blackhurst et al. (2011) and Jüttner (2005) empirically studied the effect of SC resilience against disruptions. None of this research, or for that matter any other locatable studies, have examined SC practices of inventory leanness and slack resources in the theoretical SC resiliency domain.

The inventory leanness – firm performance relationship has been studied as it relates to how lean practices impact performance (Demeter & Matyusz, 2011) and how inventory leanness

mediates firm financial performance (Eroglu & Hofer, 2011). The slack resources – firm performance relationship has been extensively researched in 66 separate studies that were identified in the meta-analysis by Daniel et al. (2004); however, none of the studies included the impact of slack resources on SC resilience measured against a significant global financial disruption.

This research makes a theoretical contribution by extending resiliency theory with respect to understanding the role of inventory leanness and slack resources and their effect on firm performance toward supporting a firm's supply chain resiliency. First, the study provides additional depth to understanding the effect that inventory leanness and slack resources have on firm performance relative to an economic disruption. This study used firms in two different industry sectors, which provide us with information about how supply chain resiliency can be affected. The current investigation took full advantage of a large secondary database with 15 quarters of data for 668 companies to analyze this relationship. By using ordinary least squares regression analysis, I explained how inventory leanness and slack resources impact firm performance in differing industries. The results indicate that inventory leanness does not support firm performance relative to the technology and food and beverage industries; however, support was demonstrated for the positive impact that slack resources will have on firm performance as firms emerge from an economic disruption.

6.3 Contributions to Practice

Scholars and practitioners have investigated the effect of SC antecedents such as inventory leanness and slack resources on firm performance (Pettit et al., 2010; Ponomarov & Holcomb, 2009; Sharfman et al., 1988; Williams, 2011). However, these scholars and practitioners have not evaluated these crucial processes under conditions of an economic

disruption, and the impact that said disruption will have on supply chain resiliency. The original research questions in the study have been addressed with mixed results. The positive influence of inventory leanness on firm performance is supported, but it is industry specific, and the pre- or post-recession period does not seem to perturb inventory leanness. Thus, even though inventory leanness may support firm performance for a particular industry, there is no support that it makes a difference between the pre and post disruptive time periods. The positive influence of slack resources is similar to inventory leanness. Slack supports firm performance, but it is industry specific, as slack resources are a factor among food and beverage industries, but not for the technology industry. In contrast to inventory leanness, slack resources make a difference in firm performance between pre and post-disruptive time periods. WCR is greater in the pre disruption period. This increase in a more stable growth period has been supported in other research (Sharfman et al., 1988; Daniel et al., 2004). This greater level of slack resources during the pre-disruptive period could also lead to less variation in firm performance during the disruption, and that a higher level of firm performance in the post time period leads to the "unlocking" or converting of slack into performance enhancing activity (Daniel et al., 2004). Industries that have more volatile demand patterns, short product life cycles, longer and more global supply chains, such as those in the technology sector, may not respond as positively to the presence of slack resources. Additionally, it was found that within these two industries, largeness of the firm may not be a universal antidote for encountering a disruption, but may support recovery with less variation in the post-recession period.

In this study it was anticipated that firm performance variation would be greater in the post-disruptive period as compared to the pre-disruptive time period simply due to the pressure associated with the disruption. The results supported a contrary view and may be due to factors

that were not accounted for in the predictive models estimated in the current study. There are many factors beyond the scope of this research that could contribute to such a finding, such as greater volatility in forecasting demand or greater innovation introduction into the marketplace during the pre-period. From a resiliency perspective, in the post-period, firms will often exploit resources and lean processes to support firm performance expectations. In other words, firms will become "lean and mean" to control costs, or convert resources, such as cash reserves, excess inventories or supplier relationships directed to supporting firm performance (Womack & Jones, 2010). With greater focus by the firms in the post-recessionary period on controlling costs and managing the business more tightly, it is the case that firm performance across industries will have less variation than what I typically see in a growth or more normal economy.

The current research provides a valuable contribution to the practice of supply chain management and resiliency by offering a better understanding of how inventory leanness and slack resources can affect firm performance in the face of a disruption within their respective industry. This research also provides a framework for firms to historically assess how their inventory leanness and slack resources within their supply chain responded to the great recession disruption and determine if their firm's resiliency was sufficient to emerge at or greater than their pre-disrupted firm performance level. The results of their assessment should lend insight toward how SC managers can evaluate their processes and make course corrections to their firm's strategic initiatives to become more prepared for the next, inevitable disruption.

6.4 Limitations of the Study

There are several limitations associated with the current study, the first of which is related to the selected definition of supply chain resilience. The literature on this topic is mixed. Some scholars see SC resilience as an ability to rebound from unexpected, adverse situations and

to return where they left off (Christopher & Peck, 2004), while others see SC resilience beyond restoring operations to include emerging from the disruption to a more competitive state with greater capabilities (Sheffi, 2005). This study adopts the former definition that narrows resilience to a firm returning to the financial performance they experienced before the disruption or to a greater level, but it is not necessary to be at a more competitive state with greater capabilities post the disruption to have resiliency. Also, this study only includes two industries and is limited to firms with greater than 100 million US dollars in annual revenue. The inclusion of additional industries and firms may provide different empirical results that may not support the findings that are specific to the large firms within the two industries selected.

Firm size based on annual revenue was found to be a nonsignificant predictor between the pre period and the post period in the overall results. Intuitively, based on an economic disruption of the magnitude encountered in the great recession, it was anticipated that a significant difference between the periods would emerge in the data. Several post hoc analyses were performed to investigate this question, including the results from Table 7, and each analysis with the current dataset provided nonsignificant results regarding differences between periods. The statistically nonsignificant results with respect to firm size could be the result of spuriousness and/or the failure to control for a robust number of additional independent predictors. The application of a longitudinal or panel data analysis where the variables are observed overtime with different time periods, and the inclusion of additional variables could enhance the explanatory power of a model (Frees, 2004). Additionally, this study used quarterly data for the pre- and post-recession periods across all firms. Therefore, I assumed that all firms are homogenous and there is no individual firm effect. A future research opportunity could apply a panel analysis to tease out the individual firm effects pre and post a disruption to

measure the effect on supply chain resilience.

Secondary data was used for this project. There is a concern that is inherent to the use of secondary data by this project that future researchers may wish to address. Many of the companies in the current dataset are international and are governed by different reporting requirements. Although I am confident that the data is consistent for each of the firms and that every effort was made by the supplier of the data (OneSource, Inc.) to insure consistency in the data, it may be the case that there were differences within the dataset that could not be detected. Additionally, the limited number of variables that examine leanness and slack beyond inventories and WCR may have lent to the poor fit (R square of less than 5 percent) in the regression models that were used to test the tenets of Hypothesis set 1. That is to say, the proxies used to operationalize the various concepts in the current investigation (i.e., firm size, WCR, etc.) may not have been robust. That said, it should be noted that when accessing global data across multiple years and industries, robust data is limited. The variables selected were well supported in the literature and the data was thoroughly examined for accuracy. In other words, the best available data was used to investigate the hypotheses associated with this project.

Additional ad hoc analysis highlighted conflicting results in the effect of DOI and WCR on firm performance in both pre and post periods. These results may be due to an undetected and latent interaction between DOI and WCR as WCR has both inventory and assets as a component of its ratio. Specifically, WCR has current assets as a component of the numerator of the ratio with current assets including accounts receivables, prepaid expenses, securities, cash, and inventory. However, WCR is often used as a proxy for measuring slack in much of the slack resource–firm performance relationship literature (Daniel et al., 2002). Nevertheless, future

researchers should consider other slack variables as a substitute for WCR, such as debt/equity ratio or administrative expense/cost of goods sold ratio.

The data available was at the firm level which was applied for inferring supply chain performance and limits the focus of this study to an indirect investigation of supply chain resilience. Specifically, ROA was the variable for determining performance. Future research could identify a more direct measure of supply chain resilience, e.g. the rate of recovery from sudden performance decline to a prior state of performance, or some sort of stability index despite an economic disruption.

6.5 Future Research

This study only investigated two primary supply chain practices, inventory leanness and slack resources associated with firm performance in an economically disrupted environment. This relationship between inventory leanness and slack resources was only studied during the great recession period of 2008-2009 across two industries. There are many other types of disruptions that can affect firm performance across other industries (Wagner & Bode, 2006). Also, there are other SC practices that managers can implement to support a firm's resiliency in preparing for and combating a disruption (Pettit et al., 2010). There are numerous opportunities, both quantitatively and qualitatively, based on the permutations that exist outside this study between type of industry, firm size, type of disruption, type of SC practice, measurement techniques, and capabilities assessment for additional studies. Future researchers may wish to consider these issues as they implement their own investigations.

Some additional research questions that could be investigated by future researchers based on the above opportunities could include:

1. Why do industries differ in their performance as they maneuver through a disruption?
2. Are SC principles or practices complimentary or do they create tension as firms build SC resilience? More specifically, how should firms value holding inventory (leanness) versus holding cash (slack resources) as a firm builds resilience?
3. How do attitude and risk perception of SC managers influence focus on leanness and slack resources under conditions of an economic disruption?

Historically, over the past century since the post Fredrick Taylor scientific management era, numerous disruptive events such as world wars, a great depression, "9/11", Hurricane Katrina, and the great recession, (to name a few) have threatened a firm's survival. A recent study by Sheffi (2005) found that most companies are not strategically considering how to systematically manage resilience. Understanding and building SC resilience characteristics into a firm will support the ability of a firm to defend the next inevitable disruption and provide the ability to adapt and thrive in the long-term. Increasing our understanding of supply chain resilience will prove to be the ultimate competitive advantage in an age of increasing complexity and turbulence.

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