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# The Contagion of Lean Inventory Management in the Supply Chain

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**The Contagion of Lean Inventory Management in the Supply Chain**

**by**

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**An Honors Thesis in partial fulfillment of the requirements for the degree Bachelor of  
Science in Business Administration in Finance**

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## Table of Contents

<b>1. Introduction</b> .....	3
<b>2. Literature review</b> .....	4
<b>2.1. Research on determinants of inventory leanness</b> .....	4
2.1.1. Research on determinants of inventories .....	4
2.1.2. Research on lean production and its effect on inventories .....	4
<b>2.2. Research on buyer-supplier relationships</b> .....	5
2.2.1. Research on supplier development .....	5
2.2.2. Research on buyer-supplier collaboration.....	5
<b>2.3. Research at the intersection of inventory determinants and buyer-supplier relationships</b> .....	5
<b>3. Theoretical framework and hypothesis development</b> .....	6
3.1. Theoretical framework.....	6
3.2. Hypothesis development.....	7
<b>4. Methodology</b> .....	12
4.1. Data.....	12
4.2. Measurement.....	13
4.2.1. Dependent variable.....	13
4.2.2. Independent variables.....	13
4.2.3. Control variables .....	13
4.3. Sample and descriptive statistics.....	13
<b>5. Empirical results</b> .....	15
<b>6. Discussion and conclusion</b> .....	17
6.1. Summary of statistical results.....	17
6.2. Implications for theory development .....	17
6.3. Implications for managerial practice .....	17
6.4. Limitations and future research .....	18
<b>References</b> .....	19

## 1. Introduction

After searching for ways to operate more efficiently, many firms began to implement lean production into their operational practices towards the end of the 20<sup>th</sup> century. Lean production is a strategy that relies on a set of practices to minimize waste. Previous studies that have focused on this have found that lean production practices lead to reductions in cost, decreased lead times and increased on-time deliveries (Cheung et al., 2011). However, one of the most common and important outcomes of lean production is inventory leanness, the minimization of waste in inventory. The effects of lean production on firm performance have been studied since the 1980s when U.S manufacturers first started adopting lean practices. Inventory leanness should enhance firm performance (Eroglu and Hofer, 2011). Enhancing firm performance can result in the firm becoming more efficient and effective. Examples of effectiveness include new product development, product quality enhancement, and other factors that enhance product quality and competitiveness (Cheung et al., 2011).

Now, firms are putting more focus into making their suppliers leaner. Examples of this new implementation of lean production in suppliers' operations can be seen throughout the manufacturing industry. Major auto manufacturing firms, such as Honda and Toyota, have been successful in implementing lean production into their suppliers' operational practices. This implementation stemmed from political pressure to source parts locally (MacDuffie and Helper, 1997).

The inventory leanness of a firm can have an impact on the inventory leanness of the supplier. Many buyers are likely to experience higher productivity when they work with lean suppliers (MacDuffie and Helper, 1997). When suppliers are able to meet the lean production requirements of buyers, the buyer-supplier partnership yields major benefits, such as reductions in inventory and delivery service improvement (Corbett et al., 1999). A representation of this can be seen in the case of Honda and its suppliers. In the 1990s, Honda decided to become more involved with the operations of its suppliers. Honda sent its own employees to work with suppliers to modify their current operations to match its lean production. After the implementation of these modifications, the suppliers saw great improvements in efficiency. For example, when Honda encouraged Tower, one of its suppliers, to invest in robotic technology, productivity rose (MacDuffie and Helper, 1997).

Previous studies have shown that there are several different factors that can lead to inventory leanness and that lean production can also influence a firm's inventories. Research on buyer-supplier relationships and collaboration within these relationships has also been pivotal in contributing to the impact of lean production.

The goal of this research is to examine how a buyer firm's inventory leanness impacts inventory leanness of its suppliers and how relationship characteristics, such as relationship age and firm similarity, affect this relationship. This research on relationship characteristics could not only have an impact in academic research, but also in research on operations of buyer-supplier

relationships. This research will also focus on how organizational learning ties into age and similarity in buyer-supplier relationships. In this study, organizational learning theory plays an important role in explaining how learning from the buyer's operational practices of lean management can lead to inventory leanness for the supplier.

## **2. Literature review**

### ***2.1. Research on determinants of inventory leanness***

#### *2.1.1. Research on determinants of inventories*

The present research builds on prior studies on the determinants of inventories. For example, Eroglu and Hofer (2011) found that demand was a key predictor of inventories. In a similar vein, Rumyantsev and Netessine (2007) analyzed absolute and relative inventories using quarterly data of 722 U.S. public companies from 1992 to 2002 to determine if classical inventory models could be used for insight into inventory dynamics of entire companies. They found that “many of the predictions from classical inventory models extend beyond individual products to the aggregate firm level” (Rumyantsev and Netessine, 2007, p.134). Both studies focus on inventory from the firm's perspective only and do not consider how customers' inventory leanness may impact supplier inventories. Lieberman et al. (1999) used survey data on North American automotive suppliers to discover the determinants of inventory levels. It was found that technological and managerial factors could determine inventory levels, consistent with classical inventory theory. While this research incorporates inventory management from a supplier perspective, it does not account for the buyer firm.

#### *2.1.2. Research on lean production and its effect on inventories*

The current study is also related to prior work examining the effects of lean production on inventories. Both Balakrishnan (1996) and Huson and Nanda (1995) examined how the implementation of just-in-time (JIT) techniques impacted operational performance measures such as inventory turnover. They found evidence that JIT implementation resulted in a higher inventory turnover. Cua et al. (2001) also examined the effects of lean production manufacturing programs on performance. They explored Total Quality Management (TQM), Just-in-Time (JIT), and Total Productive Maintenance (TPM). They found “evidence supporting the compatibility of the practices in these programs and that manufacturing performance is associated with the level of implementation of both socially- and technically-oriented practices of the three programs” (Cua et al., 2001, p.675). In sum, there is ample evidence that lean production techniques implemented within a firm lead to lower firm-level inventory holdings. None of these studies, however, examined the role of external factors—such as customer inventory leanness—in shaping a focal firm's inventories.

## ***2.2. Research on buyer-supplier relationships***

### ***2.2.1. Research on supplier development***

This research bears similarity to the supplier development literature since the latter examines how buying firms may influence and help improve supplier performance outcomes. Several studies have investigated how supplier performance was impacted by buying firms that implemented supplier development activities. Krause (1999) found that supplier commitment to the buying firm was based largely on the firm's perspective toward that supplier. Modi and Mabert (2007) used data for over 200 supplier development experiences from the U.S. manufacturing industry and concluded that "collaborative inter-organizational communication is identified as an important supporting factor in transforming an organization's efforts to develop suppliers into supplier performance improvements" (Modi and Mabert, 2007, p.42). MacDuffie and Helper (1997) examined how Honda taught lean production to their suppliers through BP (Best Process, Best Performance, Best Practice). Honda used organizational learning, technology transfer and the transplantation of Japanese management practices to the United States. With these studies, the relationship between the buyer and supplier is examined, but only from a firm-specific perspective. Industry, or external factors, and how they impact the buyer-supplier relationship were not examined. These studies also did not focus specifically on inventory leanness of both the firm and the supplier.

### ***2.2.2. Research on buyer-supplier collaboration***

A central tenet of this research is that buyer-supplier relationships provide opportunities for knowledge transfer and collaborative learning. As such, this research also relates to the supply chain collaboration literature. After surveying purchasing executives of firms involved in collaborative planning, Petersen et al. (2005) found several factors that impact the buying firm's performance. Two crucial factors were trust and the quality of information being shared between firms. Aviv (2007) examined collaborative partnerships between retailers and manufacturers and found that certain supply chain characteristics, such as relative explanatory power of supply chain partners and supply side agility, can determine the benefits of collaborative planning. These studies examine supply chain relationships further, however, they do not specifically focus on collaboration in the context of inventory management.

## ***2.3. Research at the intersection of inventory determinants and buyer-supplier relationships***

The work of Emory and Marques (2011) is particularly relevant to the present study since it is at the intersection of research on inventory determinants and buyer-supplier relationships. Focusing on raw materials inventories, Emery and Marques (2011) found that relative power and dependence levels in buyer-supplier relationships were significant predictors of inventory holdings. This study does not, however, account for other inventory types and does not specifically explore how customers' inventory leanness may affect supplier leanness.

### **3. Theoretical framework and hypothesis development**

#### ***3.1. Theoretical framework***

Organizational learning is a theoretical lens that explains how or why a supplier can benefit from a buyer's inventory leanness. In organizational learning, "an entity learns if, through its processing of information, the range of its potential behavior is changed" (Huber, 1991, p.89). Organizational learning is broken down into four constructs: knowledge acquisition, information distribution, information interpretation and organizational memory. Each of these constructs have sub-constructs.

Knowledge acquisition is simply the process of acquiring knowledge. Organizations can acquire knowledge through "customer surveys, research and development activities, performance reviews, and analyses of the competitor's products" (Huber, 1991, p.91). Knowledge acquisition has five sub-constructs that allow for organizations to acquire knowledge: congenital learning, experimental learning, vicarious learning, grafting, and searching. Congenital learning can be described as the impartment of knowledge of the environment and helpful processes by the new organization's creator(s). Acquiring knowledge through experience is experimental learning. Vicarious learning, or learning through second-hand experience, occurs when "organizations commonly attempt to learn about the strategies, administrative practices, and especially technologies of other organizations" (Hubert, 1991, p.96). Grafting, another form of learning through second-hand experience, occurs when the organization is able to acquire new knowledge through members who are new to the organization. The last sub-construct, searching, occurs when organizations acquire knowledge through scanning, focused search or performance monitoring. Examining the environment that the organization operates in for ways to strengthen management strategies can be described as scanning. Focused search is the process of an organization seeking a replacement to their current operating strategies. Performance monitoring is simply the evaluation of performance by the organization itself.

Information distribution occurs when an organization is able to create new information by putting pieces of information together from other units in the organization. An example of this would be when "a shipping department learns that a shortage problem exists by comparing information from the warehouse with information from the sales department" (Huber, 1991, p.100). This form of learning can also lead to the creation of new information. The third construct of organizational learning, information interpretation, is defined as "the process through which information is given meaning" (Huber, 1991, p.102). Information interpretation can be influenced by five different factors: cognitive maps, framing, media richness, information load and unlearning.

Organizational memory is the organization's potential to collect, create and store information or knowledge over time. There are two sub-constructs that describe how an organization uses organizational memory. The first sub-construct is storing and retrieving information. According to Huber (1991), most of "organizational knowledge about how to do things is stored in the form of standard operating procedures, routines and scripts" (p.105). The

second sub-construct of organizational memory is computer-based organizational memory. The use of computers has allowed operations in organizations to run smoother. These expert computer systems, usually created by expert members within an organization, “have some properties, such as accessibility, reliability, and own ability, that are superior to those of human experts and that, in some situations, are useful components of organizational memories” (Huber, 1991, p.106).

Organizational learning occurs in buyer-supplier relationships when buyers exchange information with their suppliers, thus enabling one organization to learn from another. Buyers help their suppliers “through information sharing in return for benefits of improved performance and joint value creation” (Krause et al., 2007, p.530). The main goal of the buyer is to align production operations of the supplier with their own production operations. This can lead to improved results on both ends of the buyer-supplier relationship.

### ***3.2. Hypothesis development***

Inventory leanness is a positive outcome of lean production. When firms incorporate lean production into their operations, enhanced firm performance usually follows. However, in order for the buyer to see improvement in performance, the supplier(s) would also need to implement lean production into their operation activities to become leaner. Suppliers must meet certain requirements of the buyer to become leaner. For example, one requirement a supplier may have to meet for a buyer is “accommodating customer requests for engineering changes in their product or manufacturing process” (MacDuffie and Helper, 1997, p.120). If the supplier fails to meet this requirement, it could struggle with becoming leaner. This, in turn, could not only hurt the performance of the buyer, but also the relationship between the buyer and supplier. Other examples of requirements that a supplier may have to meet for a buyer include “assuming substantial responsibility during product development,” being “highly reliable with respect to quality and delivery,” and “the ability to respond quickly in case of problems” (MacDuffie and Helper, 1997, p.120).

Organizational learning can give insight on how buyers track their performance and how suppliers meet buyer requirements. When buyers track their performance, they “formally and routinely assess how well they are meeting both their own standards, such as inventory levels, and the expectations of external constituencies and stakeholders” (Hubert, 1991, p.99). When a supplier makes changes to their operational activities, sometimes they have to unlearn current knowledge. Unlearning, which falls under the information interpretation learning construct, can be described as “the discarding of obsolete and misleading knowledge” (Hubert, 1991, p.104). This means that the supplier may have to disregard its current knowledge to allow for new knowledge to be acquired. This new knowledge will allow suppliers to meet buyer requirements and eventually become leaner.

Buyers often transfer knowledge to their suppliers. This transfer of knowledge can help suppliers become leaner. Incorporating lean production into operational practices can lead to



improved performance for suppliers. Generally, there should be a sense of trust between the buyer and supplier in order for the transfer of knowledge to take place. According to MacDuffie and Helper (1997), since “the knowledge transfer process opens up so many unforeseen avenues for improvement (and potential investment, it is crucial that the supplier believe that its customer is trustworthy in a goodwill sense” (p.145). This was also found to be true of the relationship between Honda and its suppliers in the 1990s. It was concluded that “a supplier-customer relationship which generates high motivation for learning and high trust between provider and recipient is a crucial condition for any transfer of a complicated, largely tacit body of knowledge like lean production” (MacDuffie and Helper, 1997, p.148). Trust is often an underlying driver of buyer-supplier relationships.

When suppliers become leaner to meet their buyer’s lean production requirements, the buyer-supplier relationship produces positive outcomes such as “increased market share, improved quality and shorter product development cycles” (Corbet et al., 1999, p.71). These outcomes can be seen in buyer-supplier relationships in many different industries, such as healthcare and auto manufacturing. Two examples of successful buyer-supplier relationships would be “between Baxter Healthcare Corporation and American Hospital Supply Corporation and Toyota and its first-tier suppliers” (Corbett et al., 1999, p.71).

Suppliers can also share information with buyers. Information sharing between buyers and suppliers “positively influences both firms’ ability to provide customers with needed products, reduce cycle times (and costs) and increase on time deliveries, for example, by buyers communicating forecasted demand levels to suppliers informing buyers of capacity constraints and quality issues” (Cheung et al., 2011, p.1066). This example of information sharing falls under the information distribution learning construct of organizational learning.

When buyers invest in supplier development strategies, they assist suppliers in becoming leaner. Through these development strategies, there is an exchange of information on both ends of the buyer-supplier relationship. The buyer can help the supplier through strategies such as “technical assistance, training, and direct investment in supplier operations” (Krause et al., 2007, p.530). The investment in these strategies by buyers can lead to several benefits. These benefits include “reduced cost, greater quality and flexibility, and more delivery” (Krause et al., 2007, p.530). Similar to when buyers adopt lean production, the supplier will have to meet certain expectations of the buyer under the development strategies. For example, a supplier may have to “share information, dedicate human resources to the improvement effort, and invest in specific equipment” (Krause et al., 2007, p.530). According to the information interpretation learning construct under organization learning, the information that is exchanged under a development strategy could lead to a better understanding of the information. This better understanding could lead “to a change in the range of potential behaviors, i.e., to organizational learning” (Hubert, 1991, p.102).

There are different types of supplier development strategies. They fall into two main categories, externalized and internalized. Externalized supplier development strategies allow firms to “make use of the external market to instigate supplier performance improvements” (Krause et al., 2000, p.36). Activities under externalized supplier development strategies include competitive pressure, supplier assessment and supplier incentives.

Competitive pressure allows the buying firm to use more than one supplier. They also have the choice of switching to another supplier. The purpose of competitive pressure is to keep the supplier(s) competitive. In competitive pressure, “buying firms may purchase a particular item or production input, from several suppliers to keep suppliers competitive in terms of quality, delivery, or whatever supplier performance characteristic the buying firm deems important” (Krause et al., 2000, p.36). Incorporating lean production into operations is crucial to making suppliers lean. When the buying firm utilizes competitive pressure, they are helping the supplier(s) learn. This activity falls under the knowledge acquisition construct of organizational learning.

Supplier assessments allow the buyer to evaluate the supplier capabilities. The feedback from this assessment is what helps the supplier to improve. The feedback from the assessment can “clarify the buying firm’s expectations and provide the supplier with direction for improvement” (Krause et al., 2000, p.36). Along with competitive pressure, supplier assessments fall under the knowledge acquisition learning construct. It allows the supplier to learn new information, which could lead to becoming lean.

The third activity under externalized supplier development strategies is supplier incentives. Supplier incentives include “increased volumes of present business and priority consideration for future business” (Krause et al., 2000, p.36). This is beneficial to the supplier. Increased interactions with the buying firm can increase learning for the supplier. Supplier incentives “are awarded based on supplier performance, and designed to induce suppliers to improve their performance based on a desire for increased business with the buying firm” (Krause et al., 2000, p.36). Improved performance for the supplier can lead to improved performance for the buying firm.

Internalized supplier development strategies can be described as buyers using their resources to invest in their suppliers. Direct involvement activities, a category of activities under internalized supplier development strategies, are activities in which there is direct involvement in supplier development by buyers. These activities involve “investments by the buying firm in the supplier through activities such as training and education of a supplier’s personnel and dedicating buying firm personnel temporarily to the supplier” (Krause et al., 2000, p.37). Internalized supplier development strategies also fall under the knowledge acquisition learning construct of organizational learning. Direct involvement activities are sometimes even more effective than externalized supplier development strategies. Krause et al. (2007) states that “there is a stronger positive relationship between buyers’ direct involvement supplier development

activities with key suppliers to achieve buyers' performance improvements in quality, delivery, and flexibility than between buyers' efforts to share information and evaluate suppliers, and these performance improvements" (p.534). This means that while externalized supplier development strategies are effective, direct involvement activities, categorized under internalized supplier development strategies, tend to be even more effective.

Due to the number of benefits both the buyer and supplier can gain from becoming lean, when a buyer is lean, suppliers tend to become lean or adopt lean production. This argument leads to the following hypothesis:

***Hypothesis 1. Greater inventory leanness of the buyer results in greater inventory leanness of the supplier.***

Considering the positive relationship between customer leanness and supplier leanness, age is also another factor that impacts supplier leanness. According to Krause et al. (2007), "there is a positive relationship between the length of buying firms' relationships with key suppliers and buyers' performance improvements" (p.535). This means that buyers will focus on maintaining longer relationships with their suppliers. Krause et al. (2007) can support this with evidence from supply chain theory. According to supply chain theory, "performance improvements sought by buying firms are often only possible when they commit to long-term relationships with key suppliers" (Krause et al., 2007, p.531). Bolton et al. (2006) explains the importance of the outcomes from buyer-supplier relationships and how they influence whether buyers will continue to work with suppliers. He states that "favorable outcomes experienced over prior time periods will positively influence firms' renewals decisions for service contracts" (Bolton et al., 2006, p.1813). The longevity of the buyer-supplier relationship will depend on previous interactions. If the previous interactions were positive, then the buyer and supplier will be willing to continue to work together in the future.

As the exchange of information improves between the buyer and supplier, some of the problems that firms face can be resolved. These problems can include "cost inefficiencies" and the "bullwhip effect, which results in excess inventories, slow response and lost profits" (Corbett et al., 1999, p.71). Getting rid of excess inventories can lead to leanness. Corbett et al. (1999) goes on to support this. They state that when there is "more open, frequent, and accurate exchange of information typical of a long-term supply-chain partnership, companies can eliminate many of these problems and ensure ongoing improvement" (Corbett et al., 1999, p.71). The exchange of information between the buyer and supplier becomes more fluid once the relationship has been established for a period of time. This type of information exchange based on age falls under the information distribution construct of organizational learning. Hubert (1991) states that "when information is widely distributed in an organization, so that more and more varied sources for it exist, retrieval efforts are more likely to succeed and individuals and units are more likely to be able to learn" (p.100). If the level of learning from buyers increases due to the length of the relationship, then suppliers are more likely to become lean.

Unlearning, under the information interpretation learning construct, also occurs when information is exchanged in a buyer-supplier relationship that has been established for a period of time. As the buyer continues to share knowledge with the supplier over time, the supplier will get rid of older, outdated knowledge and learn information that is more current.

Direct involvement activities can also have a positive impact with age. According to Krause et al. (2000), “over the long run, direct involvement investments may reduce buying firms’ transactions costs and reduce the buying firm’s uncertainty regarding important manufacturing inputs” (p.37). These improvements can lead to overall performance improvement.

Quality during the duration of the buyer-supplier relationship is another factor that plays a role in whether a buyer and supplier will be willing to work with each other in the future. For example, one source of quality is design quality. Bolton et al. (2006) states that “a firm’s norms about design quality and price influence its initial purchase of a service contract-but may also influence repeat purchase” (p.1812). When buyers purchase initial service contracts, they expect suppliers to provide quality based on their norms. If suppliers are able to provide the quality that buyers expect, buyers will be more likely to purchase another service contract in the future. Experts in the buying firm “have had organizational experiences that made them expert with respect to specific intellectual tasks such as (1) diagnosing quality problems or equipment malfunctions” (Hubert, 1991, p.106). The experts in the buying firm can determine whether the quality of the design from the supplier meets the norm of the organization. Since the design quality impacts the decision of repeating the purchase of a service contract, it falls under the organizational memory construct of organizational learning.

Another source of quality is experience quality. Bolton et al. (2006) states that “organizational norms about the quality of service also evolve through ongoing interactions and are products of the past” (p.1812). This means that the buyer may adjust its norms over the length of the relationship based on past experiences with the supplier. If past experiences with the supplier have been positive, then the supplier is more likely to become lean, which can help boost its performance, along with the performance of the buyer. When the buyer adjusts norms within its organization, it is adapting to the interactions with the supplier. This form of learning falls under experimenting organizations, a sub-construct under experimental learning, which falls under the knowledge acquisition construct of organizational learning. Huber (1991) describes adaptability as “the capacity to expand niches or to find new niches” (p.93). This is a positive outcome for the buying firm.

The third source of quality is service quality. Bolton et al. (2006) states that “increases in variability in service quality over time should decrease the value of a service contract and the likelihood of a firm renewing a contract” (p.1812). In order for the buyer to continue the relationship with the supplier, service quality should be consistent. When the service quality is consistent over the duration of the relationship, the buyer is more likely to renew the service

contract with the supplier. The longer the buyer and supplier work together, the more likely the supplier is to become lean. The quality of service over time falls under the organizational memory learning construct under organizational learning.

With a longer buyer-supplier relationship bringing performance improvement for the buyer and supplier, due to a continuous exchange of information, the leanness of the buyer affects the leanness of the supplier. This argument leads to the following hypothesis:

***Hypothesis 2.** The positive effect of customer inventory leanness on supplier inventory leanness increases with the age of the relationship.*

Similarity is another factor that has an impact on supplier leanness. Buyers and suppliers that operate in the same industries have similar goals. For example, “buying firms in manufacturing industries, including automotive and electronics, have four primary competitive priorities in their end-markets: cost, quality, delivery time and reliability, and flexibility” (Krause et al., 2007, p.530). Suppliers of these firms would need to have similar goals to help the buying firms meet their priorities. This has a significant impact on buyer leanness. If the buyer must incorporate lean production into its operations to meet these priorities, suppliers would need to become lean also. Since most of “these industries rely heavily on component suppliers, the performance outcomes of buyers are largely dependent on the performance outcomes of their suppliers” (Krause et al., 2007, p.530). If the supplier is not lean, this could hurt the performance of the buyer. If the supplier negatively affects the performance of the buyer, this could hurt the buyer-supplier relationship. This, in turn, could lead to the buyer and supplier severing ties.

The more similar the buyer and supplier are to each other, the more likely the leanness of the buyer will influence the leanness of the supplier. This argument leads to the following hypothesis:

***Hypothesis 3.** The positive effect of customer inventory leanness on supplier inventory leanness increases with the degree of similarity between the customer and supplier.*

## **4. Methodology**

### **4.1. Data**

Data from buyer-supplier observations of several U.S industries is used to test my hypotheses. I use the Compustat Customer Segments database to collect firm-level financial data from corporate financial reports, which I later use for my statistical analyses. With this data, I examine buyer-supplier relationships from the years 2008 through 2015. I sample the buying firms from those observations that are public. For each year and supplier, only the supplier’s main customer is used. Customer data for each supplier is duplicated with a weighted average for the analyses.

The second database used in this study is the Compustat North America Fundamentals Annual database. This database also contains financial data from firms. The data from both

databases is used to create the two variables I examine, age and similarity. The third database used in this study was Thomas Reuter's Institutional Brokers Estimates System, or IBES. Sales forecast data was retrieved from this database.

## **4.2. Measurement**

### **4.2.1. Dependent variable**

In this research, the dependent variable is supplier inventory leanness. The ELI (Empirical Leanness Indicator), "which takes into account the nonlinear relationship between firm size and inventory holdings", is the measurement used for the dependent variable (Eroglu and Hofer, 2011, p.356). The ELI measures what firms hold as inventory compared to other firms within the same industry. It also controls for the nonlinearity in the relationship between sales and inventories (Ballou 1981, 2005). I use the regression of average total inventories against the sales of firms (from the same 3-digit NAICS industry) to attain measures of inventory leanness for each supplier and year. To make larger values of ( $S\_ELI$ ) more representative of higher inventory leanness, the residuals from this regression are multiplied by -1. The Compustat Fundamentals Annual database provides the inventory and sales data needed to calculate ELI measures. Eroglu and Hofer (2011) provide more information on the foundation and calculation of the ELI measure.

### **4.2.2. Independent variables**

There are two independent variables in this study. The first independent variable is age of the buyer-supplier relationship, or *RelAge*. This variable is the number of years the buyer-supplier relationship has been in existence since 2008. The second independent variable in this study is industry similarity, or *NAICSSim*. Industry similarity is measured based on buyer's and supplier's NAICS six-digit codes. If both firms operate in the same six-digit NAICS industry, the score is 6. If they operate in the same five-digit industry (but differ in the sixth digit), the score is 5, etc. The higher the score, the greater the similarity between the buyer and supplier.

### **4.2.3. Control variables**

There are three other variables in my study that can have an impact on the inventory leanness of a supplier. The first variable is  $S\_COGSGrowth$ , which represents firm growth, based on change in the cost of goods sold of the firm. The second variable is  $S\_SpecRatio$ , the specialization ratio. This ratio is the result of dividing the firm's industry sales (from its NAICS industry) by its total sales. The third variable used in my study is the  $S\_SalesSurprise$  variable. It measures the percent of actual sales to expected sales. The data from the IBES database was used for this variable. The dummy variables (Y2010-Y2015) control for the variation that affects inventory leanness over the time period studied.

## **4.3. Sample and descriptive statistics**

Since this study is mainly focused on inventory leanness, my analysis focuses on buyers and suppliers that put strong emphasis on inventory management. The manufacturing industry is the

main focus of my sample. The sample I used in the empirical analysis consists of 2,328 dyad-year observations.

**Table 1** Descriptive statistics

Variable	Mean	Std. dev.	Min.	Max.
S_ELI	0.091	0.941	-6.391	6.724
S_COGSGrowth	0.198	3.243	-1	176.625
S_SpecRatio	0.898	0.178	0.01	1
S_SalesSurprise	-0.002	0.299	-0.951	13.496
C_ELI	-0.034	0.787	-2.657	3.635
RelAge	2.676	1.648	1	7
NAICSSim	1.186	1.914	0	6
Y2010	0.173	0.378	0	1
Y2011	0.165	0.371	0	1
Y2012	0.160	0.367	0	1
Y2013	0.163	0.369	0	1
Y2014	0.149	0.356	0	1
Y2015	0.038	0.190	0	1

**Table 2** Pairwise correlations (n=2,328)

	1	2	3	4	5	6	7	8	9	10	11	12
1 S_ELI												
2 S_COGSGrowth	<b>0.088</b>											
3 S_SpecRatio	<b>0.098</b>	0.023										
4 S_SalesSurprise	<b>0.107</b>	<b>0.092</b>	-0.009									
5 C_ELI	<b>0.048</b>	-0.017	0.022	0.015								
6 RelAge	<b>-0.034</b>	-0.004	<b>-0.059</b>	-0.009	<b>-0.061</b>							
7 NAICSSim	0.021	<b>0.049</b>	0.028	-0.026	<b>-0.115</b>	<b>-0.044</b>						
8 Y2010	-0.002	-0.009	0.007	0.024	0.013	<b>-0.276</b>	0.009					
9 Y2011	0.000	0.016	0.028	0.004	0.002	<b>-0.076</b>	-0.001	<b>-0.203</b>				
10 Y2012	0.013	<b>0.035</b>	-0.015	0.020	-0.008	<b>0.080</b>	-0.012	<b>-0.200</b>	<b>-0.194</b>			
11 Y2013	0.001	-0.014	0.002	-0.018	-0.021	<b>0.215</b>	0.003	<b>-0.202</b>	<b>-0.196</b>	<b>-0.193</b>		
12 Y2014	-0.007	-0.001	-0.005	0.000	-0.025	<b>0.359</b>	-0.011	<b>-0.191</b>	<b>-0.186</b>	<b>-0.183</b>	<b>-0.185</b>	
13 Y2015	-0.027	-0.007	0.004	-0.004	0.012	<b>0.268</b>	-0.014	<b>-0.090</b>	<b>-0.088</b>	<b>-0.086</b>	<b>-0.087</b>	<b>-0.083</b>

(correlation coefficients printed in bold are significant at  $p < .05$ )

## 5. Empirical results

The empirical results of this study were obtained through STATA, a statistical software. Table 3 presents the results below. Column A of the table only includes the control variables. In Column B, customer leanness is added. In Columns C and D, the effects of the independent variables, age and similarity, are added. Column A shows that higher rates of growth lead to leaner firms. It also shows that firms are leaner when sales exceed expectations.

Column B shows that the  $C\_ELI$  variable ( $\hat{\beta} = 0.072, p < 0.05$ ) is positive and marginally significant, which supports Hypothesis 1, which states that greater buyer inventory leanness results in greater supplier inventory leanness.

Column C presents the effects of age and similarity, represented by  $RelAge$  and  $NAICSSim$ . Column D presents an estimation of the effects of age and similarity. Column C shows that  $RelAge$  is positive and marginally significant. This supports Hypothesis 2, which states that the positive effect on customer inventory leanness of supplier inventory leanness increases with the age of the relationship. The  $NAICSSim$  variable is negative and statistically insignificant. This does not support Hypothesis 3, which states that the positive effect of customer inventory leanness on supplier inventory leanness increases with the degree of similarity between the customer and supplier. In Column D,  $RelAge*C\_ELI$  is positive, but only marginally significant ( $\hat{\beta} = 0.014, p < 0.1$ ). This provides some support for Hypothesis 2, meaning the impact of customer inventory leanness on supplier inventory leanness is somewhat affected by the age of the buyer-supplier relationship. The  $NAICSSim*C\_ELI$  variable is positive but statistically insignificant ( $\hat{\beta} = 0.003, p > 0.1$ ). This does not support Hypothesis 3, meaning the impact of customer inventory leanness on supplier inventory leanness is not affected by the degree of similarity between the customer and supplier.



**Table 3 Regression results (supplier – largest customer dyads; n=2,328).**

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Constant	-0.011 (0.09)	-0.005 (0.04)	-0.009 (0.06)	-0.022 (0.17)
S_COGSGrowth	0.005 * (2.26)	0.005 * (2.24)	0.005 * (2.24)	0.005 * (2.25)
S_SpecRatio	0.181 (1.27)	0.17 (1.19)	0.17 (1.19)	0.188 (1.32)
S_SalesSurprise	1.408 ** (14.82)	1.411 ** (14.87)	1.412 ** (14.87)	1.417 ** (14.89)
C_ELI		0.072 * (1.99)	0.073 * (2.03)	0.017 (0.33)
RelAge			0.031 (1.07)	0.031 (1.09)
NAICSSim			-0.002 (0.11)	-0.004 (0.22)
RelAge * C_ELI				0.014 # (1.73)
NAICSSim * C_ELI				0.003 (0.22)
Y2010	-0.022 (0.67)	-0.02 (0.60)	-0.049 (1.15)	-0.05 (1.17)
Y2011	-0.078 * (2.28)	-0.072 * (2.11)	-0.131 * (2.03)	-0.133 * (2.06)
Y2012	-0.038 (1.11)	-0.03 (0.87)	-0.118 (1.32)	-0.12 (1.34)
Y2013	-0.032 (0.91)	-0.02 (0.55)	-0.136 (1.19)	-0.137 (1.19)
Y2014	-0.084 * (2.32)	-0.072 (1.94)	-0.219 (1.54)	-0.22 (1.54)
Y2015	-0.027 (0.50)	-0.013 (0.24)	-0.188 (1.09)	-0.194 (1.12)
<i>F</i>	26.86 **	24.62 **	20.06 **	
<i>R</i> <sup>2</sup>	0.14	0.14	0.15	0.15

\*\* p<0.01; \* p<0.05; # p<0.1

## **6. Discussion and conclusion**

### ***6.1. Summary of statistical results***

My analysis of the data sample supports the principle in Hypothesis 1 that greater supplier inventory leanness is a result of greater buyer inventory leanness. These findings also provide support that organizational learning plays a role in inventory management of both the buyer and supplier. Suppliers can learn from their customer's inventory management practices, which can lead to inventory leanness of the supplier. I find that the results from my analysis align with Hypothesis 2. The longer a buyer and supplier are in a relationship, the more learning that can take place. This evidence suggests that age of the buyer-supplier relationship can open up an opportunity for the supplier to learn more from its customer.

Though the results of my analysis provide evidence in support of Hypothesis 2, it does not provide support for Hypothesis 3, which states that the positive effect of customer inventory leanness on supplier inventory leanness increases with the degree of similarity between the customer and supplier. This will be discussed in my *Limitations and future research* section.

### ***6.2. Implications for theory development***

The majority of inventory literature only examines inventory determinants from the level of the firm and product. My study focuses on external characteristics that play a role in inventory management of the buyer and supplier. Though previous studies have emphasized that inventory management practices of the supplier are impacted by inventory management practices of the buyer, the learning that takes place in buyer-supplier inventory management practices has not been examined thoroughly. I argue that learning in inventory management can be supported by Hypothesis 1.

The results of this study are important to literature on how organizational learning impacts buyer-supplier relationships. A supplier can learn a number of things from its customer, but this study suggests inventory management is another area that allows the supplier to learn. The results of this study provide evidence that age of the buyer-supplier relationship impacts learning of the supplier. This study can open the door for further research in external factors that play a role in inventory management, from the organizational learning perspective.

### ***6.3. Implications for managerial practice***

Hypothesis 1 of this study strongly supports the notion that suppliers can learn from their customers. When a supplier learns from the inventory management practices of their customer, it can improve its own inventory management practices. This could lead to inventory leanness for the supplier, which could lead to an increase in performance. The results from this study also align with the impact of supplier development strategies. These strategies allow the customers to teach their suppliers through sharing information. These results suggest that there is value in suppliers continuing to work with customers over time. If the supplier stays in a relationship with its customer, it can learn from the customer. This could lead to the supplier becoming leaner,

increasing performance. Suppliers may find it beneficial to establish longer relationships with their customers.

However, this is not the case for industry similarity. Since the results from this study show no relationship between the positive effect of customer inventory leanness on supplier inventory leanness and industry similarity, whether the supplier works with a customer in the same industry is irrelevant to improving inventory leanness.

#### ***6.4. Limitations and future research***

This study does have its limitations. One limitation that stands out in this study is the age measure. For this study, the measure of age is truncated from 2008 to 2015. For future research, the age range may need to be extended due to pre-existing buyer-supplier relationships. The short time period used for this study may have caused weaker statistical results. Examining a longer time period may result in higher statistical results.

The second limitation of this study is the type of similarity used. The NAICS measures only industry similarity, which had statistically insignificant results in this study. In future research, other types of buyer-supplier similarities can be tested to see if they impact the positive effect of customer inventory leanness on supplier inventory leanness.

The third limitation of this study is the factors used to test how buyer and supplier inventory leanness can be moderated. Age and similarity are just two of many external factors that can be investigated to determine how customer inventory leanness can impact supplier inventory leanness.

While this study does have limitations, it does contribute to the investigation of external supply chain influences on the operations of suppliers. The center of this study is based on inventory leanness (as an outcome) and how lean inventory management practices of a customer can affect the supplier's inventory management practices. This study allows for future research on factors that impact learning between firms and their partners in the supply chain. There is another question in the literature that should be studied in future research: What other factors can be investigated to determine the impact of customer inventory leanness on supplier inventory leanness? If future research provides the answer to this question, organizational learning theory could be expanded and lead to a better grasp of the understanding of firm performance results related to inventory management operational practices.

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