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The Sustainability of Lean Manufacturing as a Competitive Advantage

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ABSTRACT

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Since the early 1990's lean manufacturing has been employed by companies looking to reduce costs, increase efficiencies and improve quality. Academic studies of the financial benefits of lean manufacturing are mixed in their results, where some show benefit and others do not. The objective of the current work was to confirm a financial benefit of lean manufacturing, while also establishing whether such a financial advantage was sustainable.

Financial data was collected for a large number of companies in the manufacturing sector, over the period from 1990 to 2010. The data were used to show correlation between inventory turns and return on assets (ROA), where turns were a measure of the leanness of a firm or an industry. A positive correlation between turns and ROA showed evidence of financial benefit from lean implementation, confirming previous results from a smaller-scale study. It was then shown that about 45% of firms studied had a competitive advantage that could be attributed to their level of leanness. Firms with a competitive advantage were compared to peer companies and it was found that about 60% are able to sustain their competitive advantage for more than 10 years.

Keywords: Louis G. Jones, lean manufacturing, efficiencies, financial advantage, sustainability, competitive advantage, waste, inventory turns, six sigma, information velocity, IV, kanban

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1 INTRODUCTION

James Womack introduced the term lean production in "The Machine that Changed the World" in the early 1990's (Womack et al., 1990). Since that time it has been a heavily researched topic attracting a lot of attention from firms looking to reduce cost while improving profitability and quality. Lean production is defined as an integrated socio-technical system, whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability (Shah and Ward 2007).

There has been a great deal of debate on the question "Does lean manufacturing provide a financial benefit?" Lean production has been said to reduce lead-times, lower inventory levels, and have a continuous eye on process improvements (George 2002). The intentions of lean are obvious and most companies would like to see the results within their organization. However proponents of lean have said that lean manufacturing is just another fad that provides no real process improvements for firms (Näslund 2008).

1.1 Problem Statement

Ryan Williams conducted prior research on this subject and came to the conclusion that lean production does provides a financial advantage to firms that are found to be more lean than their competitors (Williams 2010). The question then arises, if lean principles provide a financial advantage to companies that correctly implement them, is that advantage sustainable?

This research will primarily be concerned with answering the question, “Does lean manufacturing provide a sustainable competitive advantage?” Some believe that lean principles are imitable and therefore provide at best a temporary advantage (Porter 1996). On the other hand, some may feel lean principles give a real advantage. Toyota is seen at the forefront of lean, Steven Spear said: “What’s curious is that few manufacturers have managed to imitate Toyota successfully even though the company has been extraordinarily open about its practices” (Spear 1999). So does lean provide a sustained financial benefit? To help answer this question, financial reports from publicly traded companies were used to see if lean provides a financial advantage that is sustainable.

This research will be helpful in discovering if lean manufacturing principles can provide an advantage to firms that correctly implement them. Every year companies all over the world invest time, money, and resources working to become a lean enterprise. It would be beneficial to know if lean principles can be imitated and therefore provide a temporary benefit at best. Conversely it would also be worthwhile to find out if they do provide some financial advantage to companies that implement them correctly and if that financial advantage can last. This would help companies who are deciding whether or not to implement lean production and its principles.

1.2 Hypotheses

The goal or objective of this research is to find out whether lean manufacturing provides a sustainable advantage over other firms. There are numerous arguments on both sides, but the research I have done will provide hard data that I believe should help clarify this argument and show that lean principles can lead to a sustained financial advantage.

To test this hypothesis I have gathered financial data from 10-K reports. These reports contain public financial information. Included in the data is the inventory turnover or inventory turns for these companies. This metric was used to compare the leanness of two or more firms. Inventory turnover is a very good indicator of the manufacturing lead-time, which is a great lean indicator. The data can be analyzed over a period of time to see if the financial benefits are sustainable. The data was collected from the WRDS database, cleaned and analyzed. With clean data, regressions and analysis can be done on the data.

1.3 **Delimitations/Assumptions**

This research will primarily be concerned with answering the main question of lean manufacturing providing a sustainable advantage. The research will not go into extensive depth on what lean production is or whether or not firms have properly implemented it.

1.4 **Toyota Production System (TPS)/ Lean Production**

For over 100 years, US manufacturers have relentlessly pursued efficiency strategies to reduce costs, improve output, establish competitive position, or increase market share (Emiliani 1998).

In the late 1800's specialized craftsmen would tailor products to each individual customer to provide manufactured goods. These circumstances required highly skilled workers in areas such as design, machine operation, and fitting that were required to manufacture a large variety of items. Due to inconsistencies in dimensions, functionality, and quality and the ineffective use of economies of scale, manufacturers were pressured to find a more efficient and flexible system than the low volume production that dominated manufacturing (Womack, Jones and Roos 1990).

Many of the Japanese manufacturing companies that were rebuilding after World War II had less manpower, materials, and financial resources. These problems were significantly different than anything in the Western World (Womack et al., 1990). These circumstances caused Japanese manufacturers and Japanese ideology to focus on a system that could rival the Western World. This led to the development of a new, lower cost, manufacturing philosophy (Emiliani 1998). This system became known as the "Toyota Production System" or "Lean Production".

Not only did Lean production successfully challenge mass production practices of Henry Ford and others, but it also led to a rethinking of a wide range of manufacturing and service operations beyond the high-volume repetitive manufacturing environment leading to a higher quality product (Holweg 2007).

Lean production is aimed primarily at increasing efficiency and decreasing costs incurred due to elimination of non-value adding (VA) steps. It also looks to reduce any inefficiency in a process (Motwani 2003). Some examples are reducing cycle times (Sohal and Egglestone 1994) and increasing profit for the organization (Claycomb et al., 1999). The two pillars supporting the Toyota Production System are just-in-time, and autonomation, or automation with a human touch (Ohno 1988). Lean manufacturing uses several tools to help reach these desired outcomes. Some of these tools are 5S, SPC, Kanban or pull system, consistent and error proof processes, and visual systems. Using these tools and many others, companies expect to reduce waste in their process and focus their attention on the Value added operations.

1.5 Strategy

Strategy plays an important roll for firms across the world. Many manufacturing firms are seeking to gain advantages. Some are merely trying to stay in business and others are trying to increase market share and receive increased revenues and profits. Business Strategy plays a vital role in accomplishing this. Business Strategy or Strategic Management is defined as “an ongoing process that evaluates and controls the business and the industries in which the company is involved; assesses its competitors and sets goals and strategies to meet all existing and potential competitors...” (Lamb, 1984).

Manufacturing companies are seeking to get an edge over other manufacturers and Strategic Management is one tool in accomplishing this. Firms are seeking to set their business strategy so they can receive an advantage over other firms.

As companies are able to achieve a leg up on the competition they can be rewarded with higher returns and increased profits. Lean manufacturing is possibly one strategic advantage that if implemented properly can provide a competitive advantage to those companies.

1.6 Sustainable Competitive Advantage

In Michael Porters article “What is Strategy?” he states “A company can outperform rivals only if it can establish a difference that it can preserve” (Porter, 1996).

In December 1999’s issue of Fortune Magazine, Warren Buffett stated: “The key to investing is not assessing how much an industry is going to affect society, or how much it will grow, but rather determining the competitive advantage of any given company and, above all, the durability of that advantage. The products or services that have wide sustainable moats around them are the ones that deliver rewards to investors" (Buffet 1999). Warren Buffet is known for his success in investing. It would be helpful to find out how a company can have a competitive advantage and maintain that advantage over its competitors.

So what is a sustainable competitive advantage? It is defined as "the result of a business being either a particularly able player in its market (i.e. being better, which could mean being lower cost or more lean) and/or, being differentiated in what it offers" (Lewis 2000). Essentially it is an advantage over firms in the same industry that will last for a sustainable amount of time. How do we measure a competitive advantage? For the purpose of this study, rather than create a period of time that we would define as long term it would be more advantageous to analyze the convergence of the firms ROA against the average for that industry over a period of time. If the firm were increasing its ROA compared to the industry then we would say it is a sustainable advantage. We could also look to see if the convergence date is far enough in the future and does not appear to close in the short term.

1.7 **Information Velocity**

Information Velocity (IV) plays a pivotal role in business strategy and lean manufacturing in turn providing a competitive advantage. It is defined as information entropy divided by lead-time. IV concludes that in a competitive industry, the company that can translate information from the market into a customer-satisfying product faster than any other organization, it will achieve significant profits and growth (George 2006). Much of the world's manufacturer's work in a competitive market and the speed at which they are able to adjust to market changes is essential to running a profitable business. With product lifecycles getting shorter and shorter, market volatility is actually expected to increase (Christopher 2000).

Lean enterprises look to benefit from this Information Velocity as it is theorized that with the use of lean principles they will be able to have shorter lead times and lower counts of inventory. But too much of a focus on lean principles and tools in a stagnant market can destroy profitability. Firms should not seek to achieve maximum IV, but should learn the appropriate amount of lean implementation for the environmental volatility. IV is best described as an upward parabola with the best financial performance reached at the apex of the parabola (Williams 2010).

2 LITERATURE REVIEW

2.1 Introduction

It is necessary to perform a thorough literature review on the topics of lean manufacturing, its tools and forms of lean measurement. A literature review of manufacturing strategy and its impact on sustainable competitive advantage will also be carried out. These are two heavily studied and researched topics. In this literature review I have aimed at studying and understanding the essentials of both these topics and all articles linking the two together.

2.2 Lean Production

Lean has been regarded as a necessity to meet the demands of customers and to "remain profitable in an increasingly competitive environment" (Crute 2008). Since the early 1990's a number of scholarly articles on lean philosophies, tools, and techniques have been produced (Shah and Ward 2003). Not just for manufacturing firms, but publications have pushed lean as a universal set of management principles for production of both goods and services (Lewis 2000). Lean principles are believed to be universal principles that will have a profound effect on human society; it has even been said of lean: "it will truly change the world" (Womack, Jones and Roos 1990, 6).

One of the great testaments of lean was the International Motor Vehicle Program (IMVP), which was a five-year (1985-1990) study into the performance of the automobile industry

(Womack, Jones and Roos 1990). The study was centered on comparing Japan to the rest of the western world manufacturers. The results found Japanese's manufacturers to be more effective by a ratio of 2:1. This was believed to be the benefit of implementing lean principles that improved productivity through faster lead times, increased quality, and a more responsive supply chain. Other studies were performed, confirming the IMVP results (Boston Consulting Group 1993, IBM Consulting 1993, Andersen Consulting 1993).

Proponents of lean and the IMVP have criticized the measurement process, especially the unit of analysis (Williams et al., 1994). Some say that the United States was not performing as badly as the IMVP figures suggested. The data might suggest that IMVP highlighted the significance of the Toyota production system but that the remaining Japanese manufacturers exhibited "levels of Lean production performance comparable to the rest of the world" (Pilkington 1998).

Even with the worldwide adoption of lean, TPS, or JIT practices, skepticism exists with mixed results related to performance. Studies by some have found a lack of significant relationships between JIT practices and performance (Dean and Snell 1996), while others identified significant positive relationships between them (Shah and Ward 2003). Many companies are worried that implementing lean manufacturing is too costly and time consuming (Achanga 2006) and want to know if there will be a positive return on the investment. However critics of the methodology have acknowledged that lean production will be the standard mode of manufacturing for the 21st century (Rinehart, Huxley and Robertson 1997, 2, Shah and Ward 2007).

Despite the mixed results and studies, lean still maintains its popularity and remains widely utilized by firms around the world (Mackelprang and Nair 2010). The basic building blocks of the lean system include work cells with cross-trained operators, quick setup and changeovers, single-piece flow that is pulled by customer demand, and a continuous improvement philosophy to combat waste. Other common components include total preventive maintenance (TPM), quality circles, andon cords, and target costing. Primary measures of success include minimization of throughput times, setup times, flow distances, defects, rework, equipment down times, inventories, administrative transactions, obstacles to visibility and clutter (Schonberger 2007). More than just implementing a few principles, implementation of lean requires support from the culture and management of the companies. One author adds, “The creation of a supportive organizational culture is an essential platform for the implementation of lean manufacturing. High-performing companies are those with a culture of sustainable and proactive improvement… the ability to operate in diverse environments is a pre-requisite for managers… Management should have clear vision and strategic initiatives, a good level of education and the willingness to support productivity improvement initiatives like lean manufacturing” (Achanga 2006). Without the support of management and a company culture upholding the principles and implementation of the lean initiatives, firms may not reap the benefits they seek.

Womack and Jones give five essential steps for the proper and effective implementation of lean 1) Precisely specify value by specific product, 2) identify the value stream for each product, 3) make value flow without interruptions, 4) let the customer pull value from the producer, and 5) pursue perfection (Womack and Jones 1996, 10). The lean system works to eliminate all steps that are not considered to add value to the end product.

Toyota has stood out, as an elite manufacturer for decades and what is interesting is that Toyota has allowed thousands of executives from businesses all over the world to tour Toyota's plants in Japan and the United States. Many of the executives and companies become frustrated by their inability to replicate Toyota's performance; many visitors assume that the secret of Toyota's success must lie in its cultural roots (Bowen 1999).

With all the success that Toyota has had with lean manufacturing and instituting the TPS, it would seem logical that Toyota has given the roadmap for others to follow in their footsteps. But what is interesting is that for all its success overseas, Toyota hasn't developed a facility that is as efficient as the ones in Japan. Toyota hasn't been able to duplicate its own system or match its own efficiency outside of Toyota City. Many feel that this is because their system is big, unique, and therefore hard to duplicate (Taylor III 1997). So does lean manufacturing require a customized implementation that is dependent upon the company's unique culture and circumstances? This is an interesting thought considering Toyota struggled to mimic its own system. Many feel the root of this problem could stem from the suppliers (Taylor III 1997). Toyota is known for their great supplier relationships and this could be a big part of their success in Japan. It has been said that a skilled and loyal supplier base could be a key source for obtaining a competitive advantage (Zipkin 1991).

Lean is a popular technique to improve lead times, quality, and customer satisfaction (Shah and Ward 2003). Any system that can obtain such results is beneficial. The productivity and financial gains promised by implementing the lean methodology are tremendous, and companies who accomplish these tasks should expect to have higher financial returns than those who do not (Womack, Jones and Roos 1990, Womack and Jones 1996, George 2002, Krafcik 1988, Shah and Ward 2003, Williams 2010).

The TPS house diagram (Figure 1) is built on the foundation of philosophy. Lean needs to be everyone's job and cannot solely be placed on management. Toyota builds people and focuses on teamwork. The house is built with other essential principles of lean like continuous improvement, Just-in-time and Jidoka or making problems visible. The results of the structure are better quality, at a lower cost and with a shorter lead time (Liker 2004).

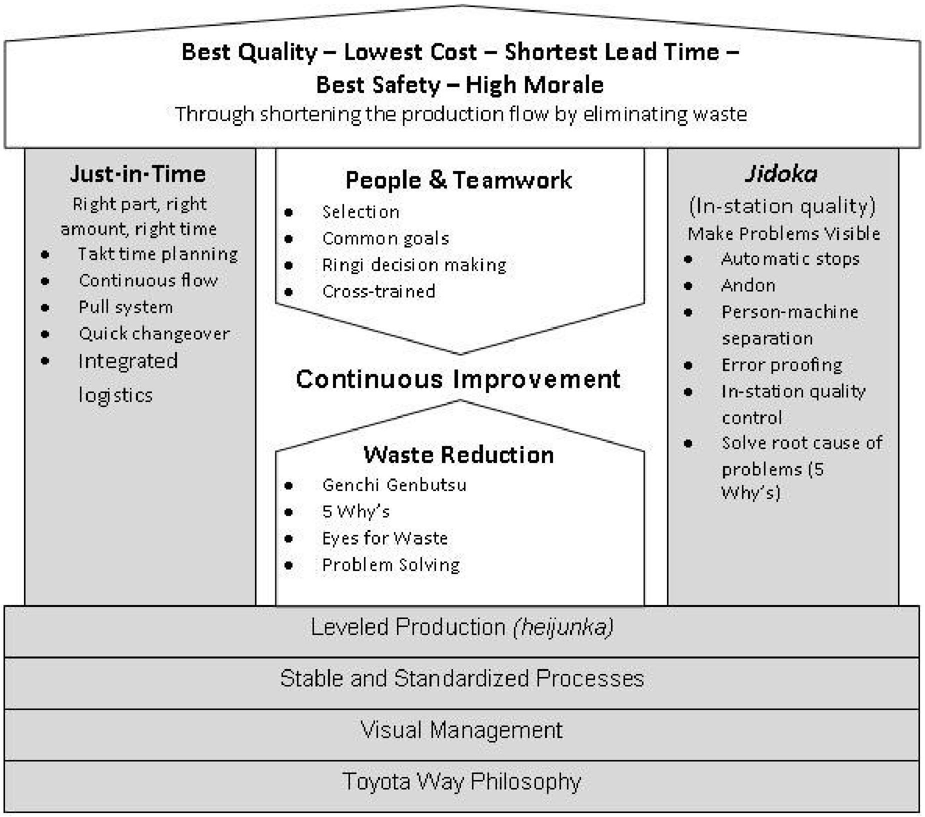

Figure 1 TPS House (Liker 2004)

2.3 Measurement of a Lean System

In spite of all the work that has gone into the study and analysis of lean, the concept remains underdeveloped for two reasons. First, it lacks a generally accepted definition. Many authors define lean in terms of its objectives, which can vary or overlap depending on the firm. The second problem is; no study has properly developed a way to measure lean. With no real way to measure lean, it is difficult to compare the leanness of two competing firms (Bayou & Korvin 2008). Other authors have also said the definition of lean production is rather vague and confused (Lewis 2000, Bartezzaghi 1999).

In 2007 Shah and ward defined lean as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability" (Shah and Ward 2007). This is a fitting definition that will be suitable for this research. As far as a measurement for lean, the number of times a company completely replaces its inventory in a year is an objective measurement of the leanness of an organization. This measurement of inventory turns is found to correlate with the best long-term lean trends (Schonberger 2007). Using this measurement of lean, two similar companies can be compared to determine their effective use of lean.

2.4 **Strategy**

Business Strategy or Strategic Management is defined as "an ongoing process that evaluates and controls the business and the industries in which the company is involved; assesses its competitors and sets goals and strategies to meet all existing and potential competitors..." (Lamb 1984). Strategy can help a company to outperform rivals by establishing a difference that it can preserve. The company must deliver greater value to customers or create comparable value at a lower cost, or do both (Porter 1996). Some strategists believe that competitive advantage is not obtained from adopting principles that others can easily copy of imitate, but by being different, in other words deliberately choosing a different set of activities to deliver a unique mix. In order to maintain an advantage, significant barriers to implementation must be created (Porter 1996).

As mentioned before, investor Warren Buffett said he seeks businesses with sustainable competitive advantages. To expound upon this he uses the metaphor of a moat. He suggests that buying a business is like buying a castle surrounded by a moat. It is best to find a moat that is deep and wide to fend off all competition. Economic moats are almost never stable. They are normally growing or shrinking and it's best to buy into a company where the moat is growing (Mauboussin & Bartholdson 2002).

Some strategists feel even though lean initiatives have led to numerous benefits, the assumption cannot be made that lean principles directly provide a sustainable competitive advantage, and that this is dependent on a number of complex and interdependent issues (Crute 2008). Speaking of lean one author stated "certain resources can be strategic, but only if they cannot be copied or replaced by external rivals" (Lewis 2000). This study will be beneficial in finding out if the principles of lean manufacturing are imitable or if they really can provide a competitive advantage that is sustainable.

Information Velocity (IV) is a crucial part of manufacturing strategy and can be a great predictor of lean. IV is defined as the ability to respond correctly to highly uncertain market demands (George 2006).

$$IV = \frac{Variety\ and\ Profit\ Information\ Transmitted\ by\ Market\ Demand}{Lead\ Time\ to\ Create\ or\ Destroy\ Offerings, or\ Satisfy\ Demand} \quad \textbf{(2-1)}$$

Many methods for measuring information velocity have been tried. In 1967, Lawrence and Lorsch tried to determine the types of organizations that will be successful under diverse economic and technical conditions. They did this by measuring the internal uncertainty in a system (Tosi, Aldag and Storey 1973). Some have criticized their research because their concept of volatility was tied too closely to top manager's perceptions of environmental uncertainty (Snyder and Glueck 1982). Their research suggests that effectiveness derives from structuring an administrative arrangement appropriate to the nature of an organization's external environment (Bourgeois III 1985).

In 1973 Tosi and his research team sought to assess the model used by Lawrence and Lorsch. They made some specific changes in an attempt to increase validity by doing things like using a larger sample and including middle managers rather than only top-level executives. Their study used 3 volatility measures that were calculated for each industry and firm represented in the study: market volatility, technological volatility, and income volatility (equations 2.2, 2.3, and 2.4).

$$\textit{Market Volatility} = \frac{\sqrt{\frac{\sum_{i=1}^{X}(Y_i - \bar{Y})^2}{X}}}{\bar{Y}} \tag{2-2}$$

Where:

X is the number of years

Y_i is sales revenues for year i

$\bar{Y}$ is average sales revenues over X years

$$\textit{Technological Volatility} = \frac{\sum_{i=1}^{X}\left(\frac{A_i + B_i}{C_i}\right)}{X} \tag{2-3}$$

Where:

X is the number of years

A_i is research and development (R&D) expenditures for year i

B_i is capital expenditures for year i

C_i is total assets for year i

In Tosi et al.'s (1973) research, the correlation coefficients between the Lawrence and Lorsch subscale totals and the industry and firm volatility measures were analyzed and the findings were less than favorable. "When subscale scores are correlated with alternative measures of uncertainty, the results are disappointing. Internal reliability assessments and factor analysis of the scales suggest that the instrument is methodologically inadequate" (Tosi, Aldag and Storey 1973).

$$\textit{Income Volatility} = \frac{\sqrt{\frac{\sum_{i=1}^{X}(Y_i - \bar{Y})^2}{X}}}{\bar{Z}} \quad \textbf{(2-4)}$$

Where:

X is the number of years

Y_i is earnings before interest and taxes (EBIT) for year i

$\bar{Y}$ is average earnings before interest and taxes (EBIT) over X years

$\bar{Z}$ is corporate sales for X years

2.5 Agility and Supply Chain Flexibility

"Agility is a business-wide capability that embraces organizational structures, information system, logistics processes, and, in particular mindsets" (Christopher 2000).

Many believe agility provides organization flexibility that is not captured in the principles of a lean system. This agility provides firms with the opportunity to quickly adapt to the unique wants of the consumer (Christopher 2000, Hallgren 2009). It is recognized that lean does offer benefits such as elimination of waste and a focus on a cost system, while agility focuses on flexibility. Both have their uses but are not the same (Hallgren 2009). In summary in today's more challenging business environment with high volatility and unpredictability the focus on agility is essential (Christopher 2000).

Manufacturing flexibility is considered to be a response to environmental uncertainty; Supply chain flexibility in contrast embraces a process-based view and also includes the core processes procurement/sourcing and distribution/ logistics (Merschmann & Thonemann 2011).

As product life cycles are getting shorter due to technological advancemtns, supply chain flexibility much like agility or lean aim to offer quicker responsiveness to customer demand. Merschmann and Thonemann suggest that "In environments with high uncertainty companies with high supply chain flexibility perform better than companies with low supply chain flexibility" and "In environments with low uncertainty… the opposite holds: Companies with low supply chains flexibility perform better than companies with high supply chain flexibility" (Merschmann & Thonemann 2011).

Eroglu and Hofer claim a similar result, that there must be an optimum level of inventory or leaness. The idea is that firm performance and lean have a parabolic relationship. As a firm increases in lean for quicker lead times, there is an increase in financial performance, but only up to a certain point before there are diminishing returns (Eroglu & Hofer 2011).

3 METHODOLOGY

3.1 Introduction

This chapter outlines the methods and analysis that will be used to gather the necessary data. The performance indicators used to measure lean production, IV, financial performance, sustainability, and the data collection process are all defined.

3.2 Qualifiers

The focus of this research is on publicly traded manufacturing companies within the United States. The reasons for this are: 1) Publicly held companies are required by the government to provide specific financial information to the shareholders and the public. This type of information is published in annual reports like 10-K and can be found online at the Security Exchange Commission website or specialized databases such as WRDS, 2) Inventory in manufacturing companies is more easily quantified than in service companies. Earlier it was stated that leanness would be measured through inventory turns, which can be calculated from information available in published annual reports (Schonberger 2007).

The United States Department of Labor defines a manufacturer as "engaged in the chemical or mechanical transformation of raw materials or processed substances into new products." This study focuses on companies considered to be manufacturers and includes only companies that have a Standard Industrial Classification (SIC) code between 2000 and 3999, inclusive. The SIC manual is published by the U.S. Office of Management and Budget and a complete listing of the codes and descriptions is available in the appendix.

3.3 Financial Performance Indicators (Independent Variables)

While different combinations of lean tools and techniques help describe a system, Michael George suggests the emphasis should be on financial metrics because “the voice of the customer is represented within the value creation that leads to increased revenue retention and growth rates of the company”. George also mentions areas of financial improvement tier-one auto suppliers have made by implementing lean with the addition of Six Sigma (George 2006). Below is a list of financial metrics of lean (Table 1).

Table 1: Financial Metrics of Lean Production

Financial Metric:	Financial Metric:
• Operating Margin	• Economic Profit (ROIC% - WACC%)
• Gross Profit	• Enterprise Value
• Operating Profit	• EBITDA
• Capital Turnover	• Manufacturing Lead Time
• Work-in-Process (WIP) Inventory Turns	• On-Time Delivery
• Return on Invested Capital (ROIC)	• Quality Performance (External CTQ)
• Weighted Average Cost of Capital (WACC)	• Cost of Goods Sold

A series of variables will be used to quantify the financial benefit to companies. The following financial indicators were used in other research studies to compare elements of lean systems: Return on Assets (ROA), Return on Sales (ROS), and profits (Kinney and Wempe 2002, Claycomb, Germain and Droge 1999). Financial indicators are superior measures of leanness compared to the tools and techniques that are implemented in a system (George 2002). ROA and ROS were used in previous studies of lean concepts and will be used as dependent variables in the current study. The formulas for ROA and ROS are found below.

3.3.1 Return on Assets (ROA)

The ROA is an indicator of a company's profitability relative to its total assets. In other words, ROA informs a knowledge seeker how efficiently management is using its assets to generate earnings. Performance on generic manufacturing capabilities (e.g. quality, cost, dependability, flexibility, etc.) is also linked to ROA (Corbett and Claridge 2002). It is calculated by dividing a company net income by its total assets (equation 3.1). ROA is generally calculated quarterly or annually and is displayed as a percentage. Manufacturers that are more lean can generate more profit with their given assets through efficient processes, quick changeovers, and a more efficient system.

$$Return\ on\ Assets\ (ROA) = \frac{Net\ Income}{Average\ Total\ Assets} \qquad \textbf{(3-1)}$$

3.3.2 Return on Sales (ROS)

ROS is a ratio commonly used to assess a company's operational efficiency and is known as the "operating profit margin." This metric provides insight to management and potential investors into how much profit is produced per dollar of sales. It is measured by dividing net income before interest and taxes by sales (equation 3.2). Lean companies could theoretically succeed in ROS by increasing net income through reduced costs, and by increasing sales through faster lead times with a more responsive system and by higher quality.

$$Return\ on\ Sales\ (ROS) = \frac{Net\ Income\ (Before\ Interest\ and\ Tax)}{Sales} \qquad \textbf{(3-2)}$$

3.4 Lean Variables

Determining if a company is lean is a difficult thing to do. Many that feel they are lean are surprised when experts say they are not (Liker 2004). To perform an in depth analysis to determine the leanness of companies is outside the scope of this project. There are too many variables that would be impossible to quantify and compare for the purpose of this study. Many metrics would be difficult to obtain without an inside knowledge of a company's operational data. The only information publicly available is the annual financial report (Cavallini 2008).

Production indicators are assumed to drive financial results in manufacturing firms (Cavallini 2008). The average number of quarterly inventory turns will be assigned as an independent variable to the FPIs previously mentioned. Inventory turns (equation 3.3) represent a ratio of the number of times a company's inventory is sold and replaced, and stands as one of the few lean indicators available in public records. As mentioned before, inventory reduction is an integral aspect of a lean system (Claycomb, Germain and Droge 1999). As inventory is reduced, the inventory turns ratio will increase. In other words companies with a greater number of inventory turns are considered more lean than companies with a smaller number of turns (Schonberger 2007).

$$Inventory\ Turns = \frac{Cost\ of\ Goods\ Sold\ (COGS)}{Average\ Inventory} \tag{3-3}$$

3.5 Information Velocity Variable

The initial concept of IV is too broad with which to perform experiments, as discussed in chapter 2. For the purposes of this study, IV is simplified to a combination of three variables: instability, unpredictability, and inventory turns.

Entropy of information is a measure of the uncertainty associated with some variable (Shannon 1948). In the case of IV, the information transmitted by market demand, no matter the certainty, is defined as entropy because the amount of information transmitted from the market is explained with a level of certainty. IV, therefore, is increased when little information on market demand is known. The denominator of the IV formula in chapter 2 will be simplified to the lead-time from customer order to delivery. When a greater lead-time is required to satisfy customer demand, information velocity is reduced and increases as the lead-time gets reduced. This designation allows for a simplification of information velocity:

$$Information\ Velocity\ (IV) = \frac{Entropy}{Lead\ Time} \quad \textbf{(3-4)}$$

The instability variable measures the level of certainty or entropy in a market by capturing the weighted variation in sales revenue. The literature review provided in Chapter 2 concluded that the most widely accepted measure of environmental volatility is Dess and Beard's instability equation. However, firm-level information on the five variables applied to the formula is not widely available to researchers, so sales revenue will be substituted as the variable used in the equation. This substitution was explained by Keats and Hitt (1988) who observed convergence between the instability (dynamism) measure derived from sales and operating income. This set of empirical evidence became the basis of using variations in industry revenue as the key indicator when assessing environmental dynamism" (Simerly and Li 2000). The equation will then be adapted to the following:

$$Instability = \frac{Standard\ Error\ of\ the\ Regression\ Slope\ Coefficient}{Mean\ Value} \quad \textbf{(3-5)}$$

In equation 3.5, revenue is the independent variable (X), a financial performance indicator is the dependent variable (Y) and the average revenues are found in the denominator.

Although the instability measure captures weighted variation in sales revenue, predictability should discount the instability measure as shown by Dess and Beard (1984) who suggest that "turnover, absence of pattern, and unpredictability are the best measures of environmental stability-instability." This research will distinguish unpredictability from environmental instability by measuring the difference between the predicted revenues based on a regression line of same-quarter revenues in past years and the actual revenue data point. Wholey and Brittain (1989) used the correlation coefficient (R^2) for sales regressed on sales lagged one year signifying that a large R^2 value (close to 1.000) will suggest that a previous year's sales will predict the current or future year's sales. However, this method did not fit the often-cyclical nature of manufacturing. Unpredictability is calculated using the following equation:

$$Unpredictability = |Predicted_{rev} - actual_{rev}| \quad \textbf{(3-6)}$$

The need for a measure of unpredictability in information velocity is depicted in the Campbell Soup Company. Sales revenues for Campbell are highly cyclical as illustrated in Figure 2. The instability equation will consider the cyclical quarterly revenue fluctuations as volatile, when it is actually extremely predictable, proving the instability measure can be misleading.

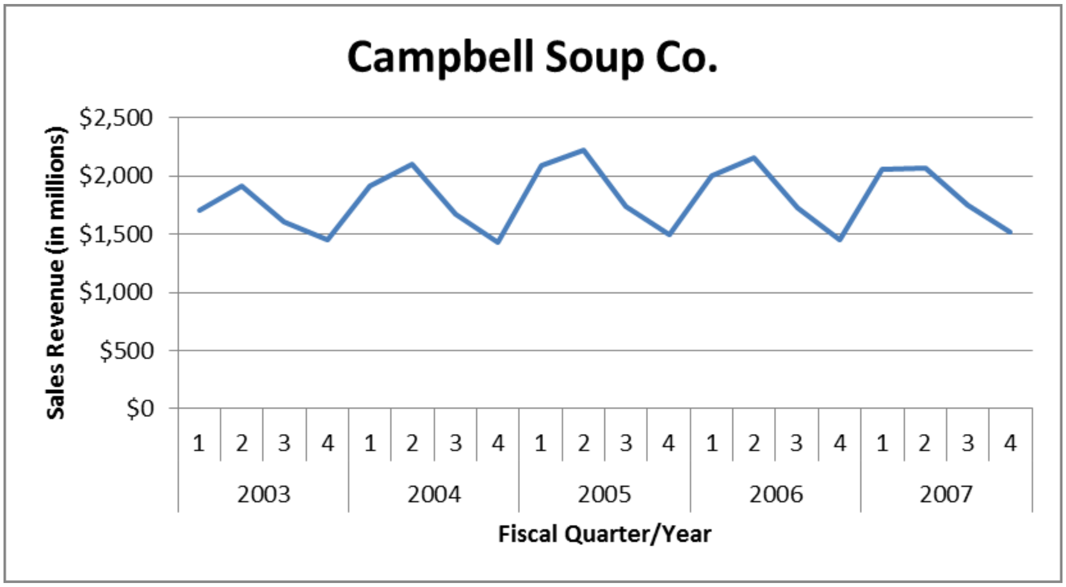

Figure 2 Campbell Soup Company Sales Revenues

Most companies do not publish lead times and they are often kept under strict confidentiality. Schonberger (2007) suggests the inverse of inventory turns (equation 3-3) is a viable substitute for lead-time. This assumption allows for an even greater simplification of information velocity:

$$IV = Instability \times Unpredictability \times Inventory\ Turns \quad \textbf{(3-7)}$$

The simplified equation compensates for the unknown market information through instability and unpredictability and for a company's ability to quickly satisfy demand. Environmental volatility is measured by multiplying instability and unpredictability. This helps to clarify prevent consistent companies, like Campbell Soup Company, from being considered as truly volatile. In addition, a faster response time reduces lead-time, and subsequently, increases inventory turns, concluding that when market volatility is held constant, a faster response time leads to an increase in IV.

3.6 Sustainability

Sustainability will be difficult to measure. Some studies arbitrarily define sustainability with a given number of years. For this study we will want to better analyze the time it takes if at all for other manufacturers to close the profit gap. To do this, we first want to see how long it takes for an average firm to implement lean production whether on their own accord, or duplicating that of an existing firm. We will then want to add a bit more time for rivals to see that they are trailing behind the firm's leanness. If after that amount of time the firm is conferring sustainable competitive advantage, we should be seeing the advantages enduring even after rivals have had time to observe the performance gap and implement their own initiatives using lean.

Second we will measure how long the ROA advantage lasts. This will take a lot of lagged data in the data set. However, do they stay at their optimum level indefinitely or is there any variance? More importantly, does that advantage dissipate over time or possibly grow?

One of the things we would like to study is if the advantage that is achieved from lean principles is easily imitable. As stated earlier in the research many have unsuccessfully tried to imitate the TPS, but others say that lean principles can easily be imitated (Porter 1996). This question brings us back to our sustainability question. Can these advantages be sustained, or can they quickly be copied and any advantage is slowly washed away.

3.7 Other Independent Variables

Other independent variables included in regression analysis are SIC codes, quarterly revenue, global company key, and interactions between several of the variables. All SIC codes are four digits, but the positioning of each digit communicates the type of industry for which a particular company is categorized (e.g. food and kindred products: 20XX; meat products: 201X; poultry slaughtering and processing: 2015).

Quarterly revenue is included to weigh company size. The global company key is a company specific identifier in the COMPUSTAT database and is included to distinguish firm-level from industry-level data.

3.8 Data Collection

Financial information from all publicly traded manufacturing (SIC 2000 to 3999) companies will be extracted. Financial data will be extracted from the Wharton Research Data Services (WRDS) using the COMPUSTAT North America database. This WRDS database is supported by the University of Pennsylvania and serves as a "comprehensive economic and financial data management system."

The raw data will be extracted into Microsoft® Excel and aggregated using pivot tables. FPIs including ROS and ROA will be calculated along with other indicators such as instability, predictability (equation 3.6), and inventory turns (equation 3.4). Each of these dependent variables were selected based on their insight into the level of leanness and the fiscal success to support the hypotheses that lean companies and lean industries have higher financial returns in dynamic industries.

3.9 Data Cleaning

The data was extracted from the WRDS database in .csv format. The data began to be cleaned using Microsoft Excel. The data cleaning process was very time consuming and relied on a lot of manual input that would be difficult to change with new data. For this reason, I moved away from Microsoft Excel and Microsoft Access was explored. This gave us the options to write formulas and edit columns like excel, but it gave us more options in running queries and pulling specific sets of data and sorting. This seemed to work well for a while but had limited programming functionality. A language-based software called R was introduced that seemed to have all the functionality needed with our data set. This meant we would need to start from scratch and lose the work that had been done so far. But once the code was written it was clean and we could quickly run quires or make adjustments. Cleaning the data in R was easier, but there was a big learning curve.

In cleaning the data several problems were encountered. There were many holes or incomplete data throughout the original extraction. For example if there were a quarter that had no revenue or inventory this would create a problem computing our ROA or inventory turns. There were several occurrences of NA's in our data set that would create this type of error as we tried to run to program. The NA's were deleted and so were companies that did not have a complete 20 years or 80 quarters of data. When the data was finished being cleaned we had gone from some 300,000 quarters of company data to less than 40,000. So many data pointes were eliminated that there was no competition left in the data set. With this limited amount of data it would be very difficult to see who the true competitors were and who truly had a competitive advantage. The advantage would be strictly based off the few companies that had a complete data set. This left many questions for us. With the problems this created the criteria was loosened up in the cleaning criteria. One original stipulation was that only companies that had over 100 million dollars in sales in a year could be included in this study. That high of sales was found to be irrelevant in the implementation of lean manufacturing and that restriction was dropped. The unpredictability equation could also be adjusted to help accommodate holes in the data. The unpredictability would measure how well the previous years or quarter's sales could predict the current sales. The way it was originally written the equation would not work with any missing data, but that was fixed in the programming.

Another problem was seeing if true competitors had been matched according to their SIC code. Several industries were analyzed to see if the competitors were present and many missing firms were discovered.

A different database was learned about within the WRDS database called Segments. This data extraction technique did not group based solely off the SIC. This database grouped firms into the Segments that each firm best fit. This new set of data was downloaded for a trial run. Upon cleaning the data it was discovered that the data history was very short and that the data set was only grouped off yearly data and not quarterly. This Segments data seemed very promising, but didn't quite work out. Perhaps in the next few years or so this Segments data can become more complete and offer quarterly data. With this information the original data extraction was selected for the study. The data was now clean and ready for our analysis.

3.10 Determining Competitive Advantage of Firms

To measure which firms had a competitive advantage in their industry an automated process needed to be developed. One of the challenges was that the industries varied so much in size. To overcome this challenge, the industries were divided into groups depending on how many firms were in the industry. Then depending on how many firms were in that industry rules were written for the level their ROA would need to be each year compared to the industry. It was determined that the minimum number of firms in an industry would need to be at least 3 in order to have a firm with a competitive advantage. From here 7 groups were created that would break the firms up. Table 2 shows the division of the groups and their statistics. The first column breaks the groups up based off how many firms are in that industry. The second column shows the number of industries within that group. The third column is the percentage of industries in that group that have at least one firm with a competitive advantage. As there are more firms in an industry the chance that at least one firm has a competitive advantage goes up. The last column is the percentage of firms that have a competitive advantage. When there are more firms in an industry, the chance that a firm will have a competitive advantage goes down.

Table 2 SIC Groups & Statistics

Group (number of firms in industry)	Industries in group	Percent of industries having a Competitive advantage	Percent of firms having a Competitive advantage
3-6	33	54%	15%
7-14	87	71%	10%
15-25	36	72%	7%
26-40	18	94%	6%
41-75	14	92%	4%
76-150	9	100%	3%
151+	2	100%	4%

For each group, specific rules were written for how a firm would have a competitive advantage. For example the first group of 3-6 firms would need to be the top performer in ROA 75% of the time. As the group size gets bigger the rules become a little more relaxed as it is more difficult to be the top performer with more firms in the industry. Through the rules the firms that had a competitive advantage in their industry could be selected. Table 3 below shows the rules for how these firms were selected. These rules were arbitrarily defined to make it more realistic for industries with more firms to receive a competitive advantage.

Table 3 Competitive Advantage Rules

	Industry Rank						
Group	1	2	3	4	5	6	7
3-6	75%						
7-14	65%	70%					
15-25	55%	65%	70%				
26-40	50%	55%	60%	65%			
41-75	45%	50%	55%	60%	65%		
76-150	40%	45%	50%	55%	60%	65%	
151+	35%	40%	45%	50%	55%	60%	65%

4 RESULTS

The results help to determine if a competitive advantage can be obtained by lean manufacturing principles and be sustained. The results first aim to replicate the work of Ryan Williams where he found correlation between lean manufacturing and financial performance. Then we look to see if an advantage can be sustained.

4.1 Correlation on ROA

The original research was done on data from 2003-2007 inclusive. To get a bigger picture on the sustainability portion the time was extended from 1990-2010. This gives 20 years of data where it can be seen from the beginning of lean to the present how well lean manufacturing has served those who have implemented it and if it is sustainable. Upon competition of the data cleansing and when everything was functioning in R, a series of regressions were run and it was discovered that there was significance on many of the factors from Ryan Williams regression. This correlation validates the work done by Ryan Williams that lean manufacturing rewards those that implement it with higher returns than those who do not. This information is shown in Table 4 below.

Table 4 Regression Results

Regression Summary	ROA 2003-2010		ROA 1990-2010	
Constant	-22.95	***	2.162	***
Time	0.012	***	-0.001075	***
Total Revenue (yearly)	-1.2E-07		1.27E-06	***
Instability	-0.89773	***	-0.04991	***
Inventory Turns	0.002892		-0.000416	***
Unpredictability	7.4E-07		-3.02E-07	
Information Velocity (x0.0001)	0.018085	***	0.01300	*
[Information Velocity]^2 (x0.001)	-6.3E-07	**	-5.61E-8	*
S=	0.2684		0.1343	
R-Sq=	4.90%		1.08%	
R-Sq (adj)=	3.60%		1.08%	

4.2 **Pairing the Right Firms**

One of the difficulties in the study was making sure the right firms were compared to their competitors. Firms are classified into the SIC industry into which they best fit. Many times firms that are not competitors in the same market can end up with the same SIC code. For example in the soft drink manufacturing industry Coca Cola and Eskimo Pie Corp. end up in the same industry. It is important to have similar firms in the same industry when comparing financial performance and inventory levels. The study is based off ROA and inventory turns and in some markets it is common to have more or less inventory or ROA. If a firm is classified in an industry where they don’t fit, this can drastically change the results of the study for that industry. As mentioned before this is one of the reasons the Segments data extraction within the WRDS database was experimented with.

Another problem with the groups is many firms didn't make the study because they were missing data for one reason or another. So this leads to the question if the right firms were paired together for the research. There are many examples where the right firms are paired together and others where it did not work so well. This is a downside to solely relying on corporate public data.

One of the purposes of this study is to look at the big picture for the manufacturing sector and understand if lean manufacturing provides a sustainable advantage. A study on a specific firm or industry could give better results. If a certain industry was the focus of study then time could be taken ensure that all the financial data for each firm that belongs in that industry is collected. The addition of knowing that only true competitors are being compared would put many of these doubts to rest.

4.3 **Regressions**

To answer the hypothesis of this thesis, linear and fitted regressions were run to answer the question "Does lean manufacturing provide a sustainable advantage to firms that implement it?" These regressions were run by first determining what firms had a competitive advantage. These firms were regressed against the average of all the remaining firms in that industry. There were 3 factors these firms were compared against.

The first is how their ROA compares to the other firms. To have a competitive advantage a firm must be in the top percentile of firms for a certain percentage of the time. This percentage will depend on the number of firms in the given industry. By definition competitive advantage firms will have a superior ROA. As the competitive advantage firm was regressed against the average it was good to get a better understanding of the trends for that industry. Some questions were: Was the firm gaining or losing its advantage? Was it something that was newly acquired or had they always had an advantage? What role did the recession or other factors have in that industry?

To study this a term called convergence date was created. This is a date calculated by comparing the slopes of ROA for the competitive advantage firm and the average of the remaining firms and determining when the two will meet. The idea was that if the date was in the future, then the firm was losing its competitive advantage and conversely if the date was in the past then the advantage is decreasing. The problem with this is it is impossible to know which one was converging on the other; the only thing known was the date at which they would converge. To know if the competitive advantage firm originally had the advantage these firms would need to be looked at manually to see who started out with the advantage.

The second factor that was regressed was information velocity. Upon further study the significance of this factor was not seen. The Information Velocity factor was designed to control for the volatility of the industry. Since this factor did not seem to have any impact, the competitive advantage firms were broken up into 3 groups, a high, medium, and low volatility group. This would help in understanding if industry volatility had any impact on competitive advantage firms. The idea is that competitive advantage firms should tend to be more lean and carry fewer inventories so the lean firms would perform better in a more volatile industry.

The last factor regressed was the inventory turns. This would tell us if the advantage these competitive advantage firms have on ROA could be attributed to inventory turnover. This factor was studied for the 3 groups mentioned before. From those groups 42% of low volatility, 51% of mid volatility, and 39% of high volatility firms have a competitive advantage that could be attributed to inventory turns. This totals out to about 45% for all firms. One of the reasons this is believed to be the case is that many of the industries do not have the right competitors paired together. This makes it difficult to compare two firms that don't compete with the same market. Some industries naturally have higher levels of inventory.

The figures below are the regressions that were created using a linear model that has a loess fit in the program R. This function gives a best fit for the data. This was a simple way each one of the competitive advantage firms could be visually analyzed and their trends compared.

Figures 3 & 4 below are two great examples where positive correlation between inventory turns and ROA can be seen. The two seem to mimic each other very closely. As there is an increase in inventory turns it leads to an increase in ROA.

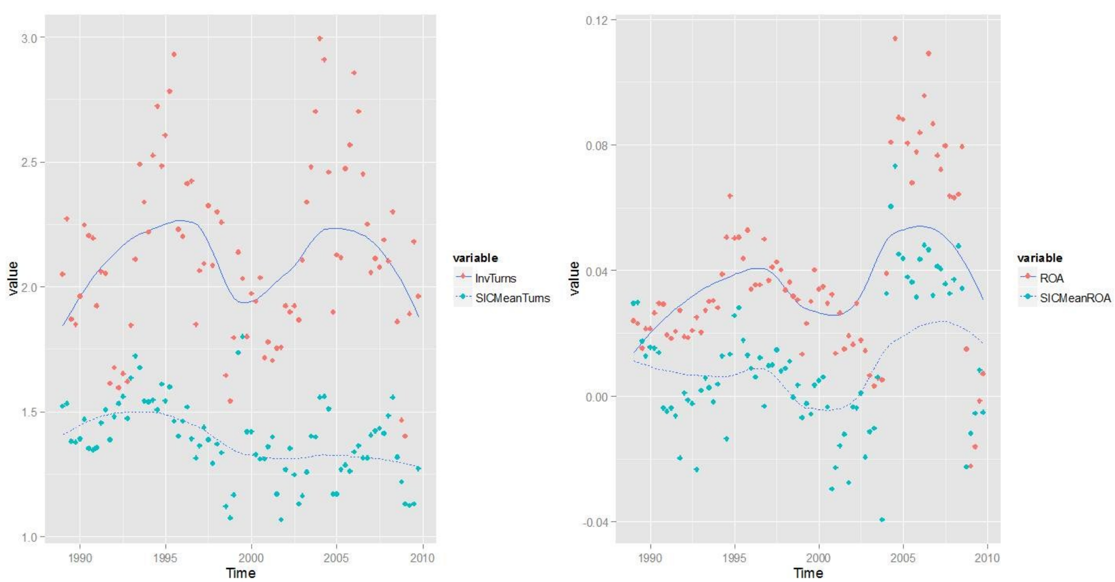

Figure 3 Nucor Inventory Turns & ROA

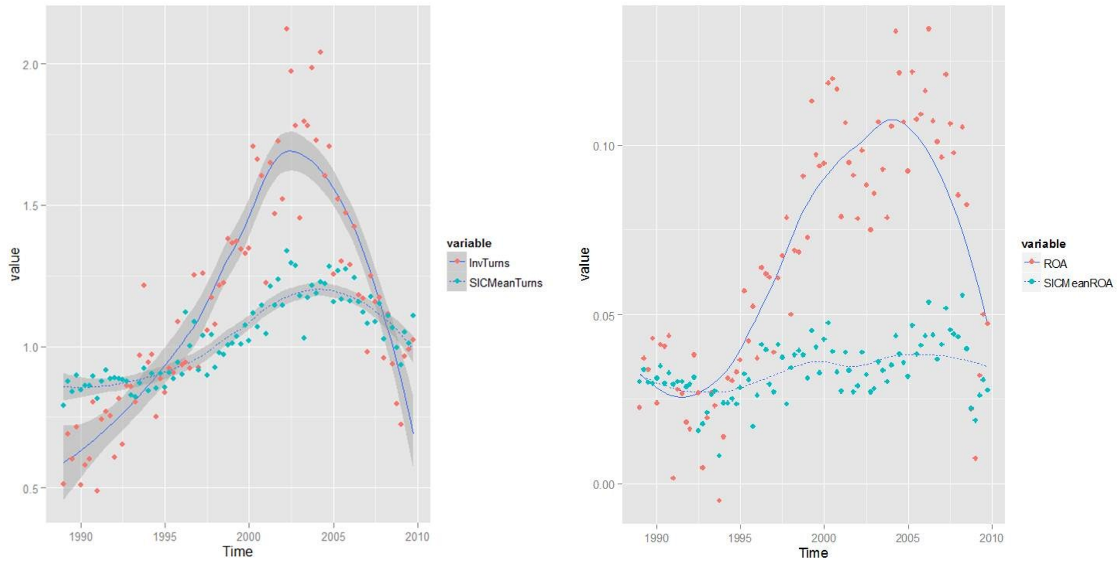

Figure 4 Graco Inc. Inventory Turns & ROA

Figure 5 below is an example where the study did not necessarily yield the results that were expected. The firm with the competitive advantage in ROA is Coca Cola but they were not above the average for the industry on inventory turns. This could be due to many factors mentioned previously like the pairing of firms or it could be due to other reasons like the branding Coca Cola has made over the years giving them superior ROA.

Figure 5 Coca Cola Inventory Turns & ROA

Figure 6 below is the example of Nike. Nike has a superior advantage on ROA and they also have an advantage on inventory turns. Nike has the bonus of branding, marketing and the included advantage of inventory turns all coming together to give them a competitive advantage.

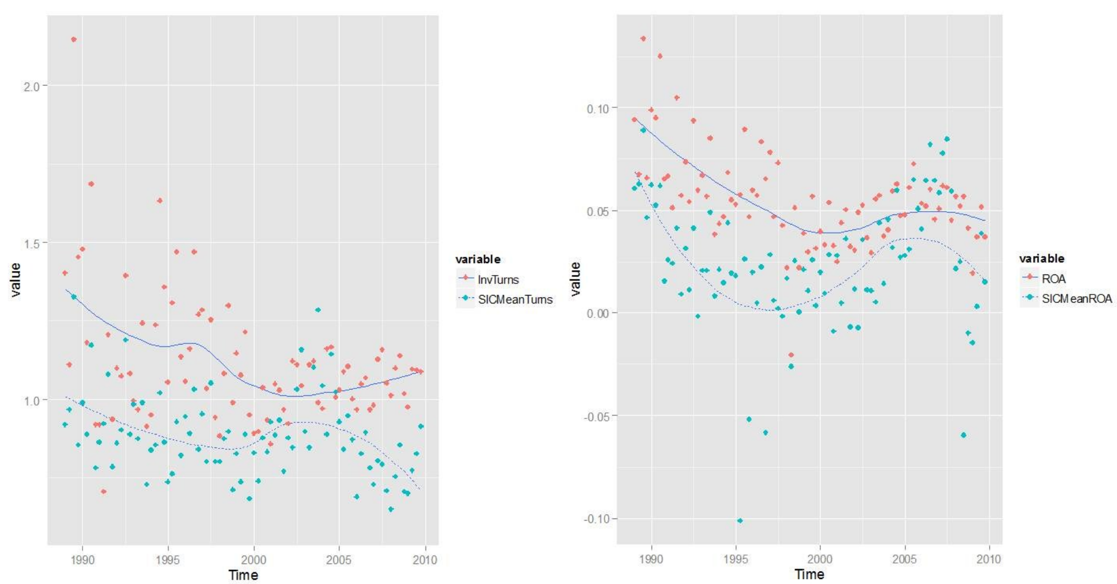

Figure 6 Nike Inventory Turns & ROA

In doing this study it is understood that not necessarily all firms that have a competitive advantage in ROA will have derived that advantage from inventory turns and the implementation of lean principles. It is understood that there are many factors leading to a competitive advantage. Some of these factors could be unique product mix, the difficulty to enter a new market, or branding and marketing.

Below in Figure 7 is the SIC industry group 2080. Within this group are the major soft drink manufacturers including Coca Cola, Pepsi, and Dr. Pepper. There are also some firms that might not belong in this industry like Eskimo Pie Corp., which specializes in a variety of frozen consumables, or Tech Flavors & Fragrances Inc., which manufactures a wide array of beverages, cosmetics, foods, liquors, and pharmaceuticals. As mentioned before this is one of the reasons the SIC groupings don't necessarily always group firms with the right competitors. On the left in figure 7 is the inventory turns for the various firms in SIC code 2080. Pepsico Inc. has a strong advantage in this category but as can be seen on the right they are not the clear favorite in ROA with Coca Cola doing quite well.

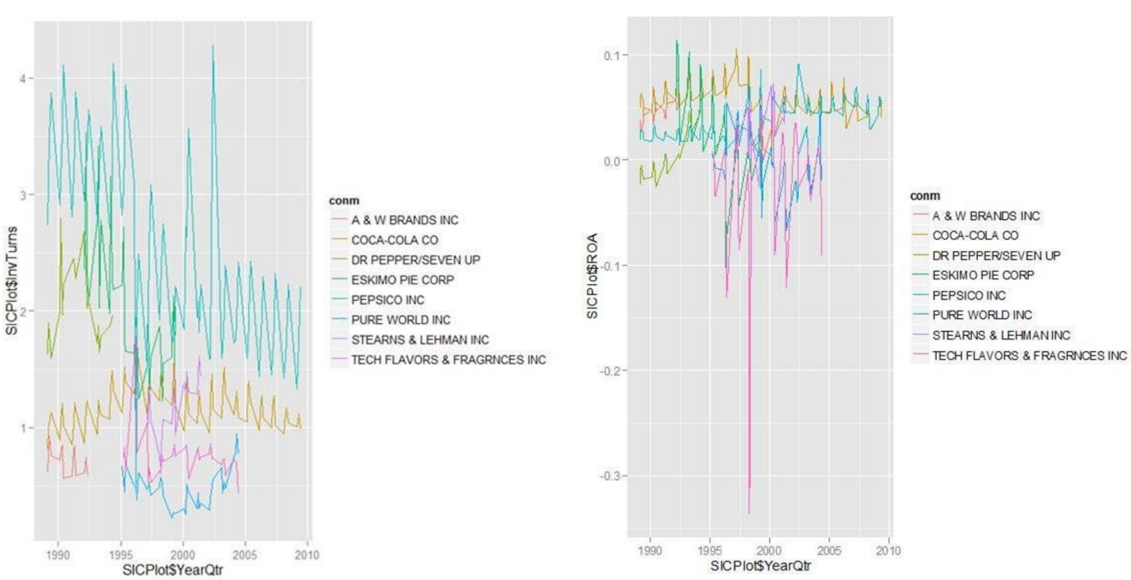

Figure 7 SIC Group 2080

SIC group 3021 shown in Figure 8 below is the Footwear manufacturing industry. There don't appear to be any non-footwear manufacturers in this group, but this group is missing a few footwear manufacturers like New Balance, Puma, and Adidas. Puma and Adidas are both German companies, and this study only covers publicly traded U.S. companies and New Balance is a private firm. This SIC group is clustered very tightly together, but Nike appears to be in the top quartile in inventory turns and ROA most of the time.

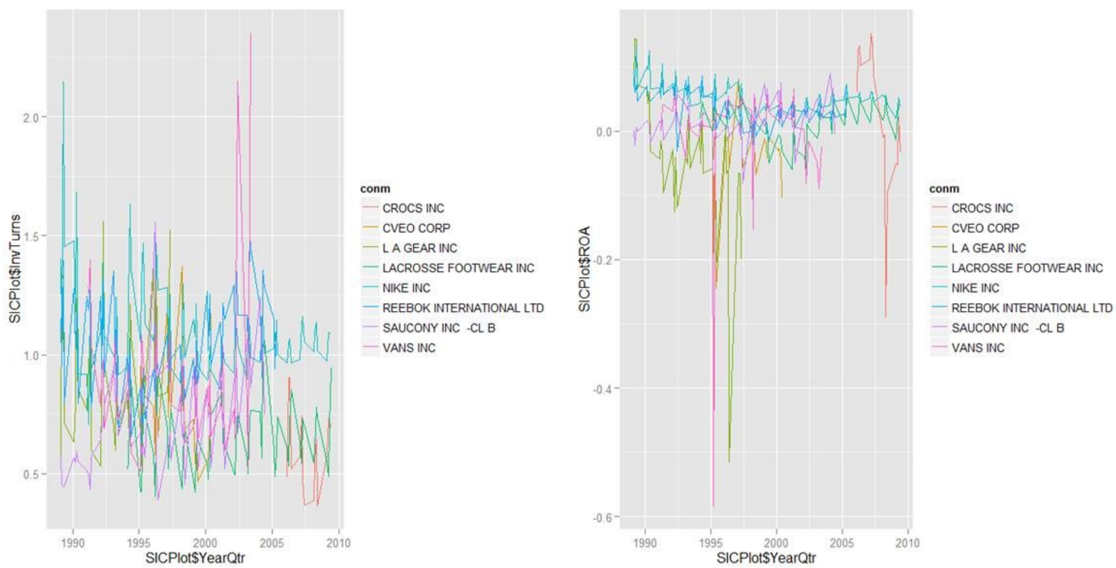

Figure 8 SIC Group 3021

4.4 Sustainability

The research shows there is some correlation between lean manufacturing and ROA but is the advantage sustainable? Toyota is known for being one of the pioneers of lean manufacturing. Toyota has been very open with its manufacturing system and many have tried to replicate it without great results (Bowen 1999). So can firms achieve a sustainable competitive advantage through the implementation of lean principles?

Figure 9 below shows firms that have a competitive advantage on ROA and how long they keep that advantage. A majority of these firms are predicted to keep their competitive advantage beyond 2020. The data is calculated using a linear convergence date. This linear model compares the slopes of ROA for the competitive advantage firm against the industry. The convergence date is where they are predicted to converge and change advantages. Figure 10 below gives a depiction of the competitive advantage firm keeping their advantage on ROA past 2020 and are overtaken at some point.

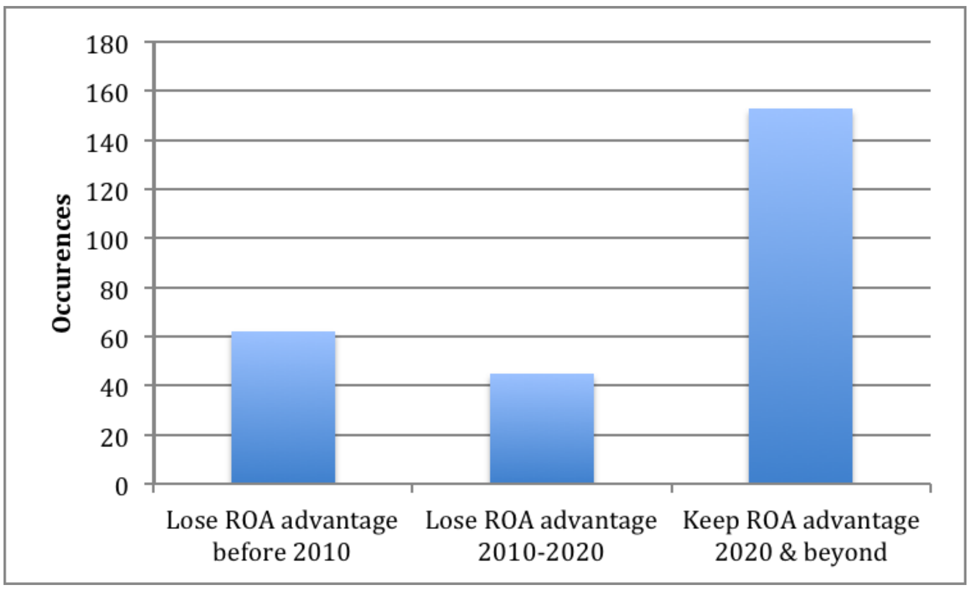

Figure 9 Convergence of Industry on Competitive Advantage Firm on ROA

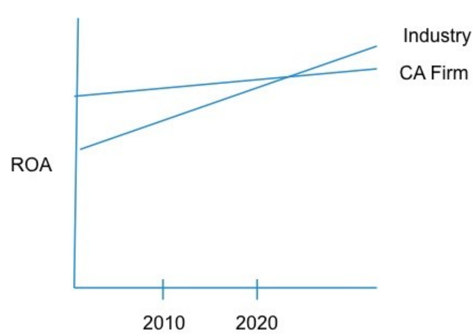

Figure 10 Depiction of Figure 9

Figure 11 shows firms that have a financial competitive advantage on ROA and their convergence based off inventory turns. As shown in the figure, there are mixed results on the firms that are able to maintain their advantage on inventory turns.

Many of the competitive advantage firms have developed fairly lean systems where they are not increasing their turns as much as the industry average. These simple linear comparisons explain why so many of the competitive advantage firms are losing their advantages, but it is not expected that the industries could maintain their current pace of growth against the competitive advantage firms.

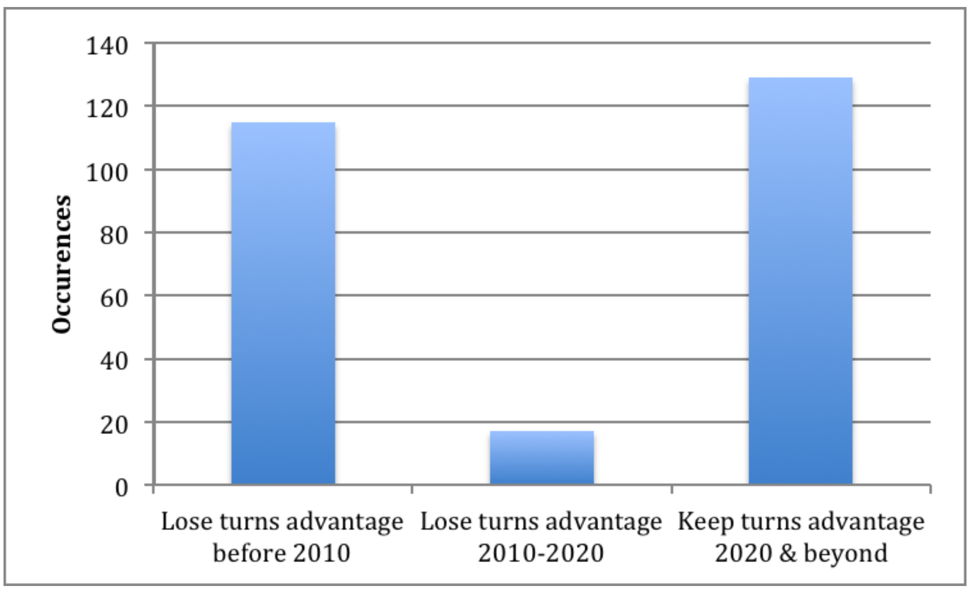

Figure 11 Convergence of Industry on Competitive Advantage Firm on Turns

Figure 12 below combines Figures 9 and 11 together. This figure includes the firms who have an advantage on inventory turns and shows when their advantages on ROA are predicted to be lost, if ever. Firms that maintain their advantage on inventory turns are much more likely to maintain their advantage in ROA.

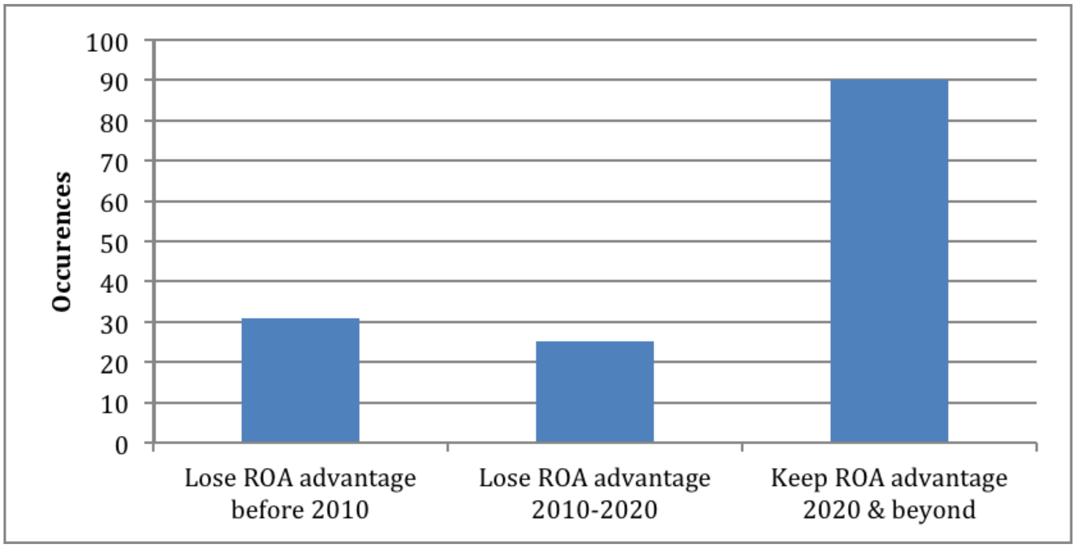

Figure 12 Has Inventory Turns Advantage & When They Lose ROA Advantage

Figure 13 shows firms that have a competitive advantage on ROA and how their inventory turns are performing. The first group shows that some firms have never had an advantage on inventory turns. The second group shows a large number of firms lose their competitive advantage on inventory turns prior to 2010. As explained before, this is expected using a linear model that does not account for change in the pace of turns for either group. As firms reach an optimum amount of inventory turns they are expected to have a smaller slope. Using a linear model assumes that both the firm and the industry will maintain their current pace of growth, therefore the industry will pass the competitive advantage firm.

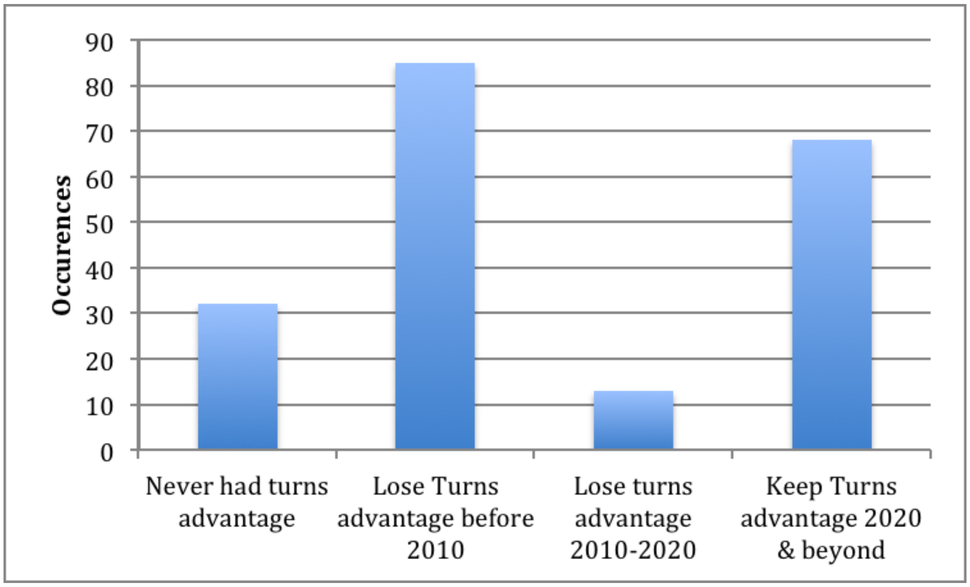

Figure 13 Has ROA Advantage & When They Lose Turns Advantage

Figure 14 shows the firms that lost their competitive advantage on ROA prior to 2010 and shows how their turns follow. The largest group is firms that have lost their inventory turns advantage. This could help explain why some firms have lost their advantage on ROA.

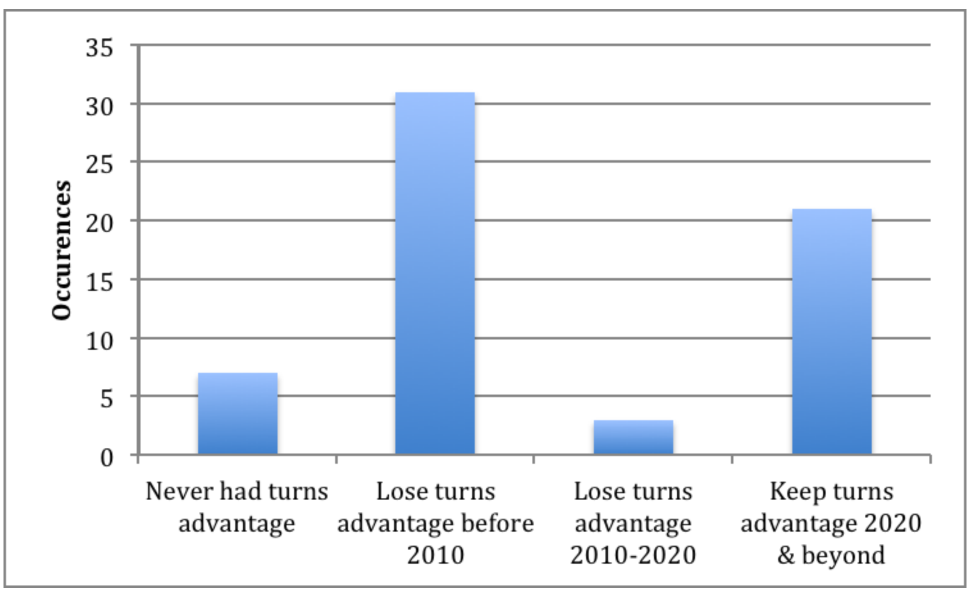

Figure 14 Lost ROA Advantage & When They Will Lose Turns

5 CONCLUSION

As the regressions were run comparing our data with the work of Ryan Williams we found similar results. There is positive correlation on many of the factors regressed. The insignificant correlation on inventory turns is explained by many of the data problems described earlier. It is difficult to test a hypothesis for all industries without a more in depth understanding of the firms in that industry. There are many variables such as firm size, inventory levels, and whether or not they are competitors in the same market.

The majority of Competitive Advantage firms are maintaining their advantage on the other firms in their industry. There are many reasons for this including inventory turns and implementation of lean manufacturing techniques. As mentioned before, 45% of the competitive advantage firms can have their advantage attributed to their level of lean implementation and their higher inventory turns. As firms become more lean they are more easily able to adapt to the changing market. This flexibility gives them a competitive advantage.

There are also many other factors that lead to competitive advantages. These other factors offer potential opportunities for future study.

Future study might include:

- A case study on a specific firm or industry and a more in depth comparison of lean manufacturing and inventory turns and their effects on financial performance.
- A more in depth study on the recession years from 2008-2010. This was a major event that was difficult for any firm to be prepared for.

- A study based off competitive advantage in inventory turns and how it affects financial performance. This study was based off financial performance and what role inventory turns play.

As seen throughout the study having clean and complete data is crucial in an attempt to study financial performance. There are many examples shown where inventory turns leads to an increase in ROA that is sustainable. This is not the case in every industry or for every firm. The recent recession also presents another variable and is difficult to understand its impacts on financial performance.

Figure 13 above is helpful to understand that about 60% of firms who have higher inventory turns are expected to maintain their ROA competitive advantage for at least 10 years. Not all firms with competitive advantages can be linked to inventory turns and lean manufacturing, but the ~45% who can, are likely to maintain their financial advantage. This correlation helps us understand that many firms are able to achieve and sustain a competitive advantage due to higher inventory turns and lean manufacturing techniques.

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APPENDIX A. TERMS

Lean Production- An integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability.

Information Velocity- The ability to respond correctly to highly uncertain market demands.

Strategy- An ongoing process that evaluates and controls the business and the industries in which the company is involved.

Sustainable Completive Advantage- The result of a business being either a particularly able player in its market (i.e. being better, which could mean being lower cost or more lean) and/or, being differentiated in what it offers.

JIT- A Manufacturing strategy that delivers exactly what the customer wants, in the exact quantity they want it, at exactly the right time.

Kanban- a scheduling system that tells what to produce, when to produce it, and how much to produce.

5S- A lean workplace organization strategy that eliminates all un-needed materials and tools from a work area. There are 5 primary phases of 5S: sorting, straightening, systematic cleaning, standardizing, and sustaining.

Inventory Turns- A ratio showing how many times a company's inventory is sold and replaced over a period.

APPENDIX B. SIC CODES

Global Company Key	Name	SIC
1013	ADC TELECOMMUNICATIONS INC	3661
1034	ALPHARMA INC -CL A	2834
1072	AVX CORP	3670
1078	ABBOTT LABORATORIES	2834
1161	ADVANCED MICRO DEVICES	3674
1209	AIR PRODUCTS & CHEMICALS INC	2810
1239	ALBERTO-CULVER CO	2844
1300	HONEYWELL INTERNATIONAL INC	3728
1356	ALCOA INC	3350
1380	HESS CORP	2911
1408	FORTUNE BRANDS INC	3490
1429	AMERICAN CRYSTAL SUGAR CO	2060
1478	WYETH	2834
1567	TRANE INC	3585
1593	AMERON INTERNATIONAL CORP	3270
1598	AMETEK INC	3823
1602	AMGEN INC	2836
1632	ANALOG DEVICES	3674
1651	ANDREW CORP	3357
1663	ANHEUSER-BUSCH COS INC	2082
1690	APPLE INC	3571
1704	APPLIED MATERIALS INC	3559
1706	ACTUANT CORP -CL A	3640
1722	ARCHER-DANIELS-MIDLAND CO	2070
1913	AVERY DENNISON CORP	2670
1932	BAT-BRITISH AMER TOBACCO PLC	2111
1976	BAKER HUGHES INC	3533
1981	BALDOR ELECTRIC CO	3621
1988	BALL CORP	3411
2044	BARD (C.R.) INC	3841
2086	BAXTER INTERNATIONAL INC	2836
2111	BECTON DICKINSON & CO	3841

Global Company Key	Name	SIC
2154	BEMIS CO INC	2670
2220	BIO-RAD LABORATORIES INC	3826
2255	BLACK & DECKER CORP	3540
2285	BOEING CO	3721
2337	ABITIBIBOWATER INC	2621
2346	BOWNE & CO INC	2750
2352	BRADY CORP	3990
2393	BRIGGS & STRATTON	3510
2403	BRISTOL-MYERS SQUIBB CO	2834
2410	BP PLC	2911
2435	BROWN-FORMAN -CL B	2085
2436	BROWN SHOE CO INC	3140
2577	CTS CORP	3679
2593	CABOT CORP	2890
2663	CAMPBELL SOUP CO	2030
2710	CONSTELLATION BRANDS	2084
2721	CANON INC	3577
2787	CARPENTER TECHNOLOGY CORP	3312
2817	CATERPILLAR INC	3531
2916	CHAMPION ENTERPRISES INC	2451
2953	CHECKPOINT SYSTEMS INC	3669
2982	CHESAPEAKE CORP	2631
2991	CHEVRON CORP	2911
3026	CHURCH & DWIGHT INC	2840
3041	MILACRON INC	3559
3062	CINTAS CORP	2320
3093	CLARCOR INC	3564
3121	CLOROX CO/DE	2842
3126	COACHMEN INDUSTRIES INC	2452
3138	COCA-COLA BTLNG CONS	2086
3144	COCA-COLA CO	2080
3170	COLGATE-PALMOLIVE CO	2844
3246	COMMERCIAL METALS	3312
3362	CONAGRA FOODS INC	2000
3497	COOPER INDUSTRIES LTD	3640
3505	MOLSON COORS BREWING CO	2082
3532	CORNING INC	3679
3580	CRANE CO	3490
3607	CHEMTURA CORPORATION	2820
3619	CROWN HOLDINGS INC	3411
3639	CUBIC CORP	3812
3650	CUMMINS INC	3510

Global Company Key	Name	SIC
3734	DANA HOLDING CORP	3714
3735	DANAHER CORP	3823
3863	DELUXE CORP	2780
3918	DRS TECHNOLOGIES INC	3812
3946	DIEBOLD INC	3578
4036	DONALDSON CO INC	3564
4040	DONNELLEY (R R) & SONS CO	2750
4060	DOW CHEMICAL	2821
4087	DU PONT (E I) DE NEMOURS	2820
4108	FLOWSERVE CORP	3561
4145	PERKINELMER INC	3826
4194	EASTMAN KODAK CO	3861
4199	EATON CORP	3714
4213	ECOLAB INC	2842
4321	EMERSON ELECTRIC CO	3600
4439	ERICSSON (LM) TELEFON	3663
4462	NEWMARKET CORP	2860
4503	EXXON MOBIL CORP	2911
4510	FMC CORP	2800
4600	FEDERAL-MOGUL CORP	3714
4768	FLEETWOOD ENTERPRISES INC	3716
4802	FLORIDA ROCK INDUSTRIES INC	3270
4809	FLOWERS FOODS INC	2050
4843	FOREST LABORATORIES -CL A	2834
4926	FULLER (H. B.) CO	2891
4988	GANNETT CO	2711
5020	GENENTECH INC	2834
5071	GENERAL MILLS INC	2040
5142	GERBER SCIENTIFIC INC	3559
5180	GLAXOSMITHKLINE PLC	2834
5229	GOODRICH CORP	3728
5234	GOODYEAR TIRE & RUBBER CO	3011
5250	GRACE (W R) & CO	2810
5252	GRACO INC	3561
5338	GREIF INC -CL A	2650
5492	HARRIS CORP	3663
5496	HARSCO CORP	3390
5505	HARTMARX CORP	2300
5518	HASBRO INC	3944
5568	HEINZ (H J) CO	2030
5589	HERCULES INC	2890
5597	HERSHEY CO	2060

Global Company Key	Name	SIC
5606	HEWLETT-PACKARD CO	3570
5608	HEXCEL CORP	2821
5650	HITACHI LTD	3570
5690	HNI CORP	2522
5709	HORMEL FOODS CORP	2011
5764	HUBBELL INC -CL B	3640
5824	PEPSIAMERICAS INC	2086
5860	ITT CORP	3812
5878	ILLINOIS TOOL WORKS	3540
5980	TERRA INDUSTRIES INC	2870
5987	GRIFFON CORP	3442
6008	INTEL CORP	3674
6025	FURNITURE BRANDS INTL INC	2510
6078	INTL FLAVORS & FRAGRANCES	2860
6081	NAVISTAR INTERNATIONAL CORP	3711
6097	INTL GAME TECHNOLOGY	3990
6104	INTL PAPER CO	2600
6109	INTL RECTIFIER CORP	3674
6140	INTERSTATE BAKERIES CORP	2050
6158	INVACARE CORP	3842
6242	SMURFIT-STONE CONTAINER CORP	2631
6266	JOHNSON & JOHNSON	2834
6268	JOHNSON CONTROLS INC	2531
6304	KLA-TENCOR CORP	3827
6375	KELLOGG CO	2040
6386	KENNAMETAL INC	3540
6433	KIMBALL INTERNATIONAL -CL B	3679
6435	KIMBERLY-CLARK CORP	2621
6529	LSI CORP	3674
6543	LA-Z-BOY INC	2510
6565	LAM RESEARCH CORP	3559
6573	LANCASTER COLONY CORP	2030
6574	LANCE INC	2052
6639	LEE ENTERPRISES INC	2711
6649	LEGGETT & PLATT INC	2510
6730	LILLY (ELI) & CO	2834
6737	LINCOLN ELECTRIC HLDGS INC	3540
6768	LIZ CLAIBORNE INC	2330
6774	LOCKHEED MARTIN CORP	3760
6821	LOUISIANA-PACIFIC CORP	2400
6830	LUBRIZOL CORP	2990
6946	MAGNA INTERNATIONAL -CL A	3714

Global Company Key	Name	SIC
6994	MANITOWOC CO	3530
7017	MARATHON OIL CORP	2911
7116	MATTEL INC	3942
7146	MCCORMICK & COMPANY INC	2090
7152	MCDERMOTT INTL INC	3730
7203	MEDIA GENERAL -CL A	2711
7228	MEDTRONIC INC	3845
7260	MEREDITH CORP	2721
7343	MICRON TECHNOLOGY INC	3674
7401	MILLER (HERMAN) INC	2520
7409	MILLIPORE CORP	3826
7420	MINE SAFETY APPLIANCES CO	3842
7435	3M CO	2670
7486	MODINE MANUFACTURING CO	3714
7506	MOLEX INC	3678
7549	MOOG INC -CL A	3728
7585	MOTOROLA INC	3663
7620	MURPHY OIL CORP	2911
7637	MYLAN INC	2834
7772	NATIONAL SEMICONDUCTOR CORP	3674
7798	NBTY INC	2834
7906	NIKE INC	3021
7921	NORDSON CORP	3569
7938	NACCO INDUSTRIES -CL A	3537
7980	NORTEL NETWORKS CORP	3661
7985	NORTHROP GRUMMAN CORP	3812
7991	TEREX CORP	3531
8009	NOVA CHEMICALS CORP	2860
8030	NUCOR CORP	3312
8215	OWENS-ILLINOIS INC	3221
8247	PPG INDUSTRIES INC	2851
8304	PALL CORP	3569
8463	PENTAIR INC	3561
8488	APPLIED BIOSYSTEMS INC	2835
8546	PHILIPS ELECTRONICS (KON) NV	3600
8549	CONOCOPHILLIPS	2911
8551	PHILLIPS-VAN HEUSEN CORP	2300
8582	SENECA FOODS CORP -CL B	2033
8606	PITNEY BOWES INC	3579
8692	POTLATCH CORP	2421
8762	PROCTER & GAMBLE CO	2840
8859	QUANEX CORP	3312

Global Company Key	Name	SIC
8867	QUANTUM CORP	3572
8902	RPM INTERNATIONAL INC	2890
8972	RAYTHEON CO	3812
9016	REGAL-BELOIT CORP	3621
9135	RICOH CO LTD	3861
9173	ROBBINS & MYERS INC	3443
9203	ROCKWELL AUTOMATION	3620
9217	ROHM AND HAAS CO	2821
9340	VALEANT PHARMACEUTICALS INTL	2834
9372	ST JUDE MEDICAL INC	3845
9459	SCHERING-PLOUGH	2834
9466	SCHOLASTIC CORP	2731
9472	SCHULMAN (A.) INC	2821
9555	SEALED AIR CORP	2670
9667	SHERWIN-WILLIAMS CO	2851
9699	SIGMA-ALDRICH CORP	2836
9771	SMITH (A O) CORP	3630
9772	SMITH INTERNATIONAL INC	2890
9778	SNAP-ON INC	3420
9815	SONOCO PRODUCTS CO	2650
9818	SONY CORP	3651
9921	SPARTECH CORP	3080
10000	STANDARD MOTOR PRODS	3690
10005	STANDARD REGISTER CO	2761
10016	STANLEY WORKS	3420
10056	STEPAN CO	2840
10115	STRYKER CORP	3842
10156	SUNOCO INC	2911
10195	SUPERIOR INDUSTRIES INTL	3714
10275	TDK CORP	3679
10405	ALLEGHENY TECHNOLOGIES INC	3312
10407	TELEFLEX INC	3841
10420	TELLABS INC	3661
10443	TENNECO INC	3714
10453	TERADYNE INC	3825
10466	TESORO CORP	2911
10498	TEXAS INDUSTRIES INC	3241
10499	TEXAS INSTRUMENTS INC	3674
10540	THOMAS & BETTS CORP	3640
10549	THOR INDUSTRIES INC	3790
10553	3COM CORP	3576
10581	TIMKEN CO	3562

Global Company Key	Name	SIC
10618	TORO CO	3523
10622	TOSHIBA CORP	3600
10793	TYSON FOODS INC -CL A	2011
10816	USG CORP	3270
10839	UNIFI INC	2200
10840	UNIFIRST CORP	2300
10857	UNION CARBIDE CORP	2860
10974	UST INC	2100
10983	UNITED TECHNOLOGIES CORP	3720
10991	SCIENTIFIC GAMES CORP	3570
11012	SENSIENT TECHNOLOGIES CORP	2860
11060	VF CORP	2300
11094	VALMONT INDUSTRIES INC	3440
11096	VALSPAR CORP	2851
11115	VARIAN MEDICAL SYSTEMS INC	3845
11191	VISHAY INTERTECHNOLOGY INC	3670
11217	VOLVO AB	3711
11257	FRONTIER OIL CORP	2911
11300	WASHINGTON POST -CL B	2711
11315	WAUSAU PAPER CORP	2621
11376	WEST PHARMACEUTICAL SVSC INC	3060
11399	WESTERN DIGITAL CORP	3572
11446	MEADWESTVACO CORP	2631
11465	WHIRLPOOL CORP	3630
11499	WILEY (JOHN) & SONS -CL A	2721
11537	WINNEBAGO INDUSTRIES	3716
11566	WOLVERINE WORLD WIDE	3140
11580	WOODWARD GOVERNOR CO	3620
11600	WORTHINGTON INDUSTRIES	3310
11609	WRIGLEY (WM) JR CO	2060
11636	XEROX CORP	3577
11721	OSHKOSH CORP	3711
11749	SKF AB	3562
12053	EMC CORP/MA	3572
12136	SUN MICROSYSTEMS INC	3571
12215	CYPRESS SEMICONDUCTOR CORP	3674
12216	LINEAR TECHNOLOGY CORP	3674
12233	GENZYME CORP	2836
12262	ASTEC INDUSTRIES INC	3531
12379	AMERICAN WOODMARK CORP	2430
12384	ROYAL DUTCH SHELL PLC	2911
12389	HARLEY-DAVIDSON INC	3751

Global Company Key	Name	SIC
12445	WATTS WATER TECHNOLOGIES INC	3490
12478	JOURNAL COMMUNICATIONS INC	2711
12578	VALHI INC	2810
12756	COCA-COLA ENTERPRISES INC	2086
12785	PILGRIM'S PRIDE CORP	2015
12788	HARMAN INTERNATIONAL INDS	3651
12868	QUIKSILVER INC	2320
12895	GEORGIA GULF CORP	2810
12945	PLEXUS CORP	3672
13003	JOY GLOBAL INC	3532
13323	SANDERSON FARMS INC	2015
13365	BARR PHARMACEUTICALS INC	2834
13407	WELLMAN INC	2820
13554	TIMBERLAND CO -CL A	3140
13623	CONMED CORP	3845
13634	EXIDE TECHNOLOGIES	3690
13700	DENTSPLY INTERNATL INC	3843
13971	METHANEX CORP	2860
13990	WARNACO GROUP INC	2300
14049	GERDAU AMERISTEEL CORP	3312
14163	MCCLATCHY CO -CL A	2711
14256	MAXIM INTEGRATED PRODUCTS	3674
14282	AMPHENOL CORP	3678
14311	POLARIS INDUSTRIES INC	3790
14324	ALTERA CORP	3674
14385	RESPIRONICS INC	3842
14450	WOLVERINE TUBE INC	3350
14489	DELL INC	3571
14503	IMPERIAL SUGAR CO	2060
14555	KINETIC CONCEPTS INC	2836
14620	ELECTROLUX AB	3630
14623	NOVELLUS SYSTEMS INC	3559
15106	BECKMAN COULTER INC	3826
15247	VALERO ENERGY CORP	2911
15267	IDEX CORP	3561
15334	AKZO NOBEL NV	2851
15343	MUELLER INDUSTRIES	3350
15406	BENETTON GROUP SPA	2330
15459	TREDEGAR CORP	3081
15704	THOMSON-REUTERS CORP (CDN)	2731
15708	ALLERGAN INC	2834
15709	PLUM CREEK TIMBER CO INC	2400

Global Company Key	Name	SIC
16476	LEVI STRAUSS & CO	2300
16477	LEAR CORP	2531
16582	POTASH CORP SASK INC	2870
17420	ATLAS COPCO AB	3560
17436	BASF SE	2800
17828	DAIMLER AG	3711
20185	SCOTTS MIRACLE-GRO CO	2870
20196	LUXOTTICA GROUP SPA	3851
20338	COTT CORP QUE	2086
20779	CISCO SYSTEMS INC	3576
21496	ORBITAL SCIENCES CORP	3760
22049	DOREL INDUSTRIES INC	2511
22325	XILINX INC	3674
22815	TRIMBLE NAVIGATION LTD	3829
23084	BENCHMARK ELECTRONICS INC	3672
23220	ALLIANT TECHSYSTEMS INC	3480
23252	ETHAN ALLEN INTERIORS INC	2511
23671	NOKIA (AB) OY	3663
23767	ATMEL CORP	3674
23945	CEPHALON INC	2834
23978	UNITED STATES STEEL CORP	3312
24283	DEL MONTE FOODS CO	2000
24405	ZEBRA TECHNOLOGIES CP -CL A	3560
24463	NATIONAL BEVERAGE CORP	2086
24625	TOTAL	2911
24701	VITRO SAB DE CV	3220
24720	WABASH NATIONAL CORP	3715
24782	PERRIGO CO	2834
24800	QUALCOMM INC	3663
24943	INTERTAPE POLYMER GROUP INC	2670
24978	CALLAWAY GOLF CO	3949
25119	MOHAWK INDUSTRIES INC	2273
25124	PRAXAIR INC	2810
25130	NCI BUILDING SYSTEMS INC	3448
25180	AGCO CORP	3523
25279	BOSTON SCIENTIFIC CORP	3841
25291	QUEBECOR WORLD INC -SUB VTG	2750
25305	ARACRUZ CELULOSE SA	2611
25313	STERIS CORP	3842
25389	GRAPHIC PACKAGING HOLDING CO	2631
25405	GENERAL CABLE CORP/DE	3350
25773	CREATIVE TECHNOLOGY LTD	3577

Global Company Key	Name	SIC
25777	CARAUSTAR INDUSTRIES INC	2631
25870	MINERALS TECHNOLOGIES INC	2810
26019	HAYES LEMMERZ INTL INC	3714
27760	NAUTILUS INC	3949
27845	WATSON PHARMACEUTICALS INC	2834
27965	MICROCHIP TECHNOLOGY INC	3674
28004	REVLON CONSUMER PRODUCTS CP	2844
28018	GYMBOREE CORP	2300
28118	FOSSIL INC	3873
28169	AGRIUM INC	2870
28176	APTARGROUP INC	3089
28194	POLYONE CORP	2821
28195	JABIL CIRCUIT INC	3672
28262	NATUZZI SPA	2510
28295	TITAN INTERNATIONAL INC	3312
28518	SHILOH INDUSTRIES INC	3460
28742	BORGWARNER INC	3714
28844	COCA-COLA FEMSA SAB DE CV	2086
28883	SOC QUIMICA Y MINERA DE CHI	2870
28917	MONACO COACH CORP	3711
28940	BELDEN INC	3357
29001	OM GROUP INC	3341
29156	UNIVERSAL FOREST PRODS INC	2421
29241	JDS UNIPHASE CORP	3663
29341	FOAMEX INTERNATIONAL INC	3086
29392	EASTMAN CHEMICAL CO	2821
29511	CYTEC INDUSTRIES INC	2890
29751	ALBEMARLE CORP	2890
29830	ROCK-TENN CO	2650
29942	RALCORP HOLDINGS INC	2000
29955	BIOVAIL CORP	2834
29968	AK STEEL HOLDING CORP	3312
30032	EAGLE MATERIALS INC	3270
30098	GARDNER DENVER INC	3560
30170	FLEXTRONICS INTERNATIONAL	3672
30219	BLYTH INC	3990
30260	SIMPSON MANUFACTURING INC	3420
30310	CONSOLIDATED GRAPHICS INC	2750
30436	EMBOTELLADORA ANDINA SA	2086
31142	STMICROELECTRONICS NV	3674
31205	FOMENTO ECONOMICO MEXICANO	2086
60894	CAMERON INTERNATIONAL CORP	3533

Global Company Key	Name	SIC
60898	BWAY CORP	3411
60979	WABTEC CORP	3743
60992	MEMC ELECTRONIC MATRIALS INC	3674
61095	PALM HARBOR HOMES INC	2452
61153	GRAFTECH INTERNATIONAL LTD	3620
61214	ASML HOLDING NV	3559
61519	SCHWEITZER-MAUDUIT INTL INC	2621
61552	LEXMARK INTL INC -CL A	3577
61567	LAUDER (ESTEE) COS INC -CL A	2844
61574	WATERS CORP	3826
61591	NETAPP INC	3572
61596	BUCKEYE TECHNOLOGIES INC	2611
61763	ELIZABETH ARDEN INC	2844
62221	COLUMBUS MCKINNON CORP	3530
62290	REVLON INC -CL A	2844
62516	CENTURY ALUMINUM CO	3350
62640	LORAL SPACE & COMMUNICATIONS	3663
62685	BUILDING MATERIALS CORP AMER	2950
62836	POLYMER GROUP INC	2200
62897	TUPPERWARE BRANDS CORP	3089
63138	IMATION CORP	3695
63447	GUESS INC	2330
63483	DURA AUTOMOTIVE SYS -CL B	3714
63637	MILLENNIUM CHEMICALS INC	2810
63876	TRIUMPH GROUP INC	3728
63892	NATIONAL OILWELL VARCO INC	3533
63914	CNH GLOBAL NV	3523
64030	STEEL DYNAMICS INC	3312
64389	SILGAN HOLDINGS INC	3411
64690	AUTOLIV INC	3714
64853	RF MICRO DEVICES INC	3674
64891	POLO RALPH LAUREN CP -CL A	2320
65009	EXTERRAN HOLDINGS INC	3533
65142	COMMSCOPE INC	3357
65248	ARCELORMITTAL SA	3312
65399	ARVINMERITOR INC	3714
65590	STONERIDGE INC	3679
65643	FAIRCHILD SEMICONDUCTOR INTL	3674
65676	INTERMEC INC	3577
65772	METTLER-TOLEDO INTL INC	3826
66016	CORN PRODUCTS INTL INC	2040
66290	STEELCASE INC	2522

Global Company Key	Name	SIC
66440	TEKNI-PLEX INC	3080
66544	ASSOCIATED MATERIALS LLC	3089
66708	BROADCOM CORP	3674
100080	BAYER AG	2800
100477	JAMES HARDIE INDUSTRIES NV	3270
101020	STORA ENSO OYJ	2621
101310	NOVARTIS AG	2834
101718	UPM-KYMMENE CORP	2621
102345	METSO OYJ	3530
102422	SAPPI LTD	2670
102696	LOGITECH INTERNATIONAL SA	3577
105089	CEMEX SAB DE CV	3241
105936	COLUMBIA SPORTSWEAR CO	2300
110039	AMKOR TECHNOLOGY INC	3674
110533	SAUER-DANFOSS INC	3590
110685	L-3 COMMUNICATIONS HLDGS INC	3663
111941	GERDAU SA	3312
112033	KING PHARMACEUTICALS INC	2834
112158	CELESTICA INC	3674
112759	USEC INC	2810
116526	CONEXANT SYSTEMS INC	3674
117768	NVIDIA CORP	3674
117861	AMERICAN AXLE & MFG HOLDINGS	3714
117862	ARCH CHEMICALS INC	2800
118122	DELPHI CORP	3714
118577	LIFE TECHNOLOGIES CORP	2836
119216	VARIAN INC	3826
119417	PEPSI BOTTLING GROUP INC	2086
120774	BROCADE COMMUNICATIONS SYS	3576
120877	REYNOLDS AMERICAN INC	2111
121142	SKECHERS U S A INC	3140
122380	LENNOX INTERNATIONAL INC	3585
124254	OMNOVA SOLUTIONS INC	2821
124996	EPCOS AG	3670
125094	UNITED REFINING CO	2911
125533	PACTIV CORP	3089
126554	AGILENT TECHNOLOGIES INC	3825
126721	TELEDYNE TECHNOLOGIES INC	3663
127254	APPLERA CORP-CONSOLIDATED	3826
128978	PACKAGING CORP OF AMERICA	2650
132740	INFINEON TECHNOLOGIES AG	3674
133170	GRANT PRIDECO INC	3533

Global Company Key	Name	SIC
133366	EDWARDS LIFESCIENCES CORP	3842
134932	ON SEMICONDUCTOR CORP	3674
136648	VISTEON CORP	3714
138143	MEDIANEWS GROUP INC	2711
139662	AVAYA INC	3663
141459	GARMIN LTD	3812
141760	EQUISTAR CHEMICALS LP	2860
142260	OIL STATES INTL INC	3533
142811	FMC TECHNOLOGIES INC	3533
142953	KRAFT FOODS INC	2000
144066	ROCKWELL COLLINS INC	3728
144435	BUNGE LTD	2040
144559	ZIMMER HOLDINGS INC	3842
146017	ACUITY BRANDS INC	3640
146075	BERRY PLASTICS HOLDING CORP	3089
147202	WIMM BILL DANN FOODS	2020
147449	ALCON INC	3851
148210	CHEVRON PHILLIPS CHEM CO LLC	2911
148221	GRAHAM PACKAGING HLDGS CO	3089
148271	KOPPERS INC	2860
148276	LAND O'LAKES INC	2020
148309	PLIANT CORP	2670
148870	ADVANCED MEDICAL OPTICS INC	3845
148950	ENPRO INDUSTRIES INC	3050
201140	CIA DE BEBIDAS DAS AMERICAS	2082
201395	TAIWAN SEMICONDUCTOR MFG CO	3674
206457	LUKOIL OIL COMPANY	2911
210418	ABB LTD	3613
213288	EMBRAER-EMPRESA BRAS AERO SA	3721
213412	ADVANCED SEMICON ENGINEERING	3674
220546	STATOILHYDRO ASA	2911
221261	COCA-COLA HELLENIC BOTTLING	2086
221545	INDUSTRIAS BACHOCO SAB DE CV	2015
221821	NIDEC CORP	3621
222111	PETROBRAS-PETROLEO BRASILIER	2911
222519	GRUMA SAB DE CV	2040
224604	DELTA GALIL INDUSTRIES LTD	2340