AN ANALYSIS OF SIX SIGMA AT SMALL VS. LARGE MANUFACTURNING COMPANIES

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SIX SIGMA AT SMALL MANUFACTURNING COMPANIES

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Six Sigma, is a business strategy using quality improvement tool, began in the 1980's. An important problem in business has been how to implement Six Sigma at small sized companies. Many large companies are beginning to mandate Six Sigma to their supply base (smaller manufacturing companies) as a condition of future business. This is a problem because Six Sigma implementation can require millions of dollars in investment, dedication of the best resources and training of many employees in a business. Many small manufacturing companies do not have this time or the financial resources to invest in the long-term benefits of Six Sigma. Yet, there still exists a need to implement Six Sigma in these smaller companies

This study will analyze the performance of large and small manufacturing companies deploying Six Sigma. The objective is to determine whether the long-term benefits of Six Sigma programs are really worth the cost investment for smaller manufacturing companies. Quantitative and qualitative measurements are used as variables for comparison. The reported revenue, costs and savings of five Fortune 500 companies who have implemented and managed successful Six Sigma programs are examined. A data collection instrument is developed to study the small manufacturing companies.

Results show that there were apparent challenges in Six Sigma deployment regardless of company size. However, the benefits of Six Sigma deployment at small manufacturing companies were very apparent. Through the research it was found that small manufacturing companies have the capacity to implement successful Six Sigma programs. Recommendations for further study and an increased research population is also suggested for future research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

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To my family, my mom and dad and brother, we did it! Heaven only knows how much you mean to me. Thank you for always supporting me and motivating me to do my best. With your love and God's grace I have been able to complete another chapter in my storybook life. Thank you Lord!

1.0 INTRODUCTION

In today's marketplace, continuous quality improvement is one of the key answers to business problems. Six Sigma is industry's newest recognized quality improvement program. Six Sigma is a statistical measure of variability. Variation is the cause of defective and out-of-control processes. Defects that reach the customer are significant problems. When a company has achieved a Six Sigma rate of improvement, it has limited defects to 3.4 per million opportunities, in other words virtually defect-free performance. Very few global companies have attained Six Sigma. Most companies, however, are operating at levels of around four sigma, or approximately 6,000 defects per million, according to estimates in Pyzdek's (2003a) Six Sigma Handbook.

Six Sigma was developed at Motorola, during a time when their business and manufacturing costs were increasing. They needed to improve profitability by producing products to meet customer requirements. When Six Sigma programs were first developed, they targeted high-end savings programs, typically able to achieve cost savings of $170,000 per project. Industry leaders like Motorola, Honeywell (formerly Allied Signal), General Electric, Ford Motor Company, Caterpillar and other major corporations were able to achieve these savings. Their success has filtered down to other companies.

Six Sigma has yielded tremendous cost savings while reducing defects, enhancing customer satisfaction, and increasing customer retention at many companies. It has been perceived as a performance improvement strategy available only to the largest companies in the world; however, Six Sigma is now providing improved levels of productivity and financial performance to small and mid-sized corporations.

From this study a data collection instrument was developed to survey small manufacturing companies on their Six Sigma practices. The Small Business Association (SBA) has established a size standard for most industries in today's economy. The SBA defines a small manufacturing company as having 500 employees or less (SBA, 2004). This size standard will stand as a basis for this study, however, due to lack of response from companies of this size, the author allowed companies of 501-1000 employees to input data into this research. These companies are small manufacturing plants that are divided into various businesses and plants. They have more than 500 employees in the entire organization. However, the individual plants are categorized as small businesses.

The main objective of this research was to analyze the benefits of Six Sigma at small manufacturing companies based on the initial cost sacrifice relating to training, time and staffing of quality professionals. The study analyzed five well-known large companies in the area of Six Sigma quality. Background information on Six Sigma as a statistical business strategy is provided to ensure that the reader gains an understanding of Six Sigma. A study is completed on the large companies from published literature. The literature on the five large companies shown in Section 3.0, focuses on how Six Sigma was used to increase company revenue and savings. The Six Sigma literature also introduces the various staffing levels involved in Six Sigma and how these staffing methodologies can lead to direct revenue savings at a company. This includes a summary of data gathered from company annual reports.

Following the literature review, Section 4.0 covers the approach and methodology used to determine if Six Sigma is financially beneficial for smaller manufacturing companies. The research examines factors such as company size and quality training programs. There is also a discussion of the study scope and target population in this section. The results section (section 5.0) analyzes the response rate of the data collection instrument and also gives a detailed analysis of the actual study results. The results are discussed in detail in the final sections of the dissertation leading to final recommendations and conclusions.

2.0 MOTIVATION FOR RESEARCH

As an intern at General Electric in the summer of 2002, the author was exposed to Six Sigma training. This experience was very challenging and sparked an interest in the author to learn more about Six Sigma. It was fascinating to see a huge corporation like General Electric spend so much money on a business strategy. This raised the question: Can the benefits of Six Sigma at small manufacturing companies outweigh the cost of implementing Six Sigma?

3.0 LITERATURE REVIEW

A great number of publications were found during this literature review that were specifically devoted to Six Sigma. These publications generally discussed the overall methodology of Six Sigma and how to implement Six Sigma programs. Through accessing annual reports, access was gained to raw data on the costs and benefits of Six Sigma at the five large companies, Motorola, GE, Ford, Honeywell (formerly Allied Signal) and Caterpillar. However, little information was found on the costs and benefits of Six Sigma at smaller companies. In doing this review, it was evident that this research would be important in contributing to studies on this subject.

3.1 WHAT IS SIX SIGMA?

Six Sigma is said to be a philosophical approach that demands the effective use of data to analyze business issues. The American Society for Quality website (ASQ, 2004) provides a large amount of information on Six Sigma and its impact on industry. Their website states that "the simplest definition for Six Sigma is to eliminate waste and to mistake proof the processes that creates value for customers." They describe Six Sigma as "a business strategy focused on variation reduction and defect elimination." ASQ states that Six Sigma provides a method to learn about processes so that sources of variation can be identified and eliminated to enable the organization to ultimately exceed customer expectations.

By definition, Six Sigma is less than 3.4 defective parts per million opportunities (DPMO), or a success rate of 99.9997 percent. It is a disciplined, data-driven approach and method for eliminating defects (or deviation). A “defect” is described as anything outside of customer expectations. Six Sigma has been defined as a tool kit or a set of techniques based on statistical process control (SPC) that can help companies make major improvements in product quality. Experts say companies that have embraced and implemented Six Sigma as part of their business strategy have seen huge impacts on their bottom line through their ability to reduce costs and increase efficiency.

3.2 HISTORY

Many measurement standards (C_{pk}, Zero Defects, etc) have been developed in the area of quality processing, but credit for coming up with the term “Six Sigma” was given to a Motorola engineer named Bill Smith. “Six Sigma” is currently a federally registered trademark of Motorola. A Six Sigma quality program was established at Motorola in 1987. This program was developed by Mikel J. Harry, and gained publicity when Motorola won the Malcolm Baldrige National Quality Award in 1988. Today many companies have adopted their own Six Sigma methodologies and programs.

3.3 HOW SIX SIGMA WORKS

Sigma (σ) is a character of the Greek alphabet, which is used, in mathematical statistics to represent the standard deviation. The standard deviation indicates how tightly all the various samples are clustered around a mean in a set of data points. Six

Sigma is a business method for improving quality by removing defects and their causes. It concentrates on outputs, which are important to customers. A defect can be any type of product or service that does not conform to a standard inspection unit or satisfy the customers. The method uses various statistical tools to measure processes.

The main goal of Six Sigma is continuous improvement and it is carried out through projects. The most common type of project methodology is the DMAIC (Define, Measure, Analyze, Improve and Control) method. First, the project and the process to be improved are defined. Then, the performance of the process is measured (Pyzdek, 2003a). The data is then analyzed and the bottlenecks and problems are identified. After analysis, improvement programs are defined and defects are removed. Six Sigma strives to improve customer satisfaction and in turn increase profitability, by reducing and eliminating defects.

One fundamental objective of Six Sigma quality is to reduce process output variation so that it will result in no more than 3.4 DPMO. Six Sigma processes are executed by Six Sigma green belts and Six Sigma black belts and overseen by Six Sigma master black belts. Six Sigma is a training intensive process, thus, in order for one to gain a better understanding of Six Sigma, one must understand the various levels of training needed to implement Six Sigma. We will later discuss the various levels of training in Six Sigma.

Most companies operate at four (6,200 DPMO) and three sigma (67,000 DPMO) (Microsoft, 2003). Jumping from three sigma (3σ) to Six Sigma (6σ) is a huge undertaking. For example, making the jump from four sigma (4σ) to five sigma (5σ) requires a 27-fold performance improvement. The move from five sigma (5σ) to Six

Sigma (6σ) requires another 60-fold improvement. There are dramatic improvements when the transition from one sigma level to another takes place, as depicted in the following examples from Hoerl and Snee (2003):

Dramatic Improvements

- If your water heater operated at four sigma, you would be without hot water for more than 54 hours each year. At Six Sigma, you would be without hot water for less than two minutes a year.
- With a four sigma packaging process, approximately six out of every 1,000 packages will be outside of specifications. At Six Sigma, only three packages in every million will miss specifications.
- If your electricity operated at four sigma performance, your lights would be out for an hour a week. At Six Sigma, you would be without lights for about two seconds a week.
- With a four sigma design process, six out of every 1,000 design elements relating to a new product are flawed before the product is fully commercialized, versus a Six Sigma process, where only about three of every one million design elements would be flawed.
- If your telephone operated at four sigma, you would be without service for more than four hours a month. At Six Sigma, it would be about nine seconds a month.
- At four sigma, about six out of every 1,000 invoices will contain incorrect information. At Six Sigma, mistakes will occur only about three times in every one million invoices.
- If your car operated at four sigma performance, you would spend 37 minutes in the repair shop for every 100 hours you operate the vehicle. At Six Sigma, you would have only 1.2 seconds of repair for every 100 hours of operation.

Improvements associated with moving towards Six Sigma have a huge effect on the bottom line savings and costs, as we will see later with the companies that are studied as part of this research.

3.4 SIX SIGMA DEPLOYMENT PROCESS

A Six Sigma deployment process can vary from company to company based on the level of commitment of an organization. We will establish a general deployment process intended to be flexible enough that it can apply to organizations of different sizes, industries and cultures. In *Leading Six Sigma,* Hoerl and Snee (2003) provide an illustration of a roadmap for Six Sigma deployment as shown in Figure 1.

This roadmap not only gives possible means of deploying Six Sigma, but it also takes into account the experiences of many companies. With four main steps (launching the initiative, managing the effort, sustaining the momentum and growing, and the way we work) this deployment model gives companies an outline of how to successfully implement a Six Sigma program. All organizations deploying Six Sigma go through each phase and yet each organization will progress through the phases differently (Hoerl and Snee, 2003). Each phase has unique challenges and issues and at times may overlap.

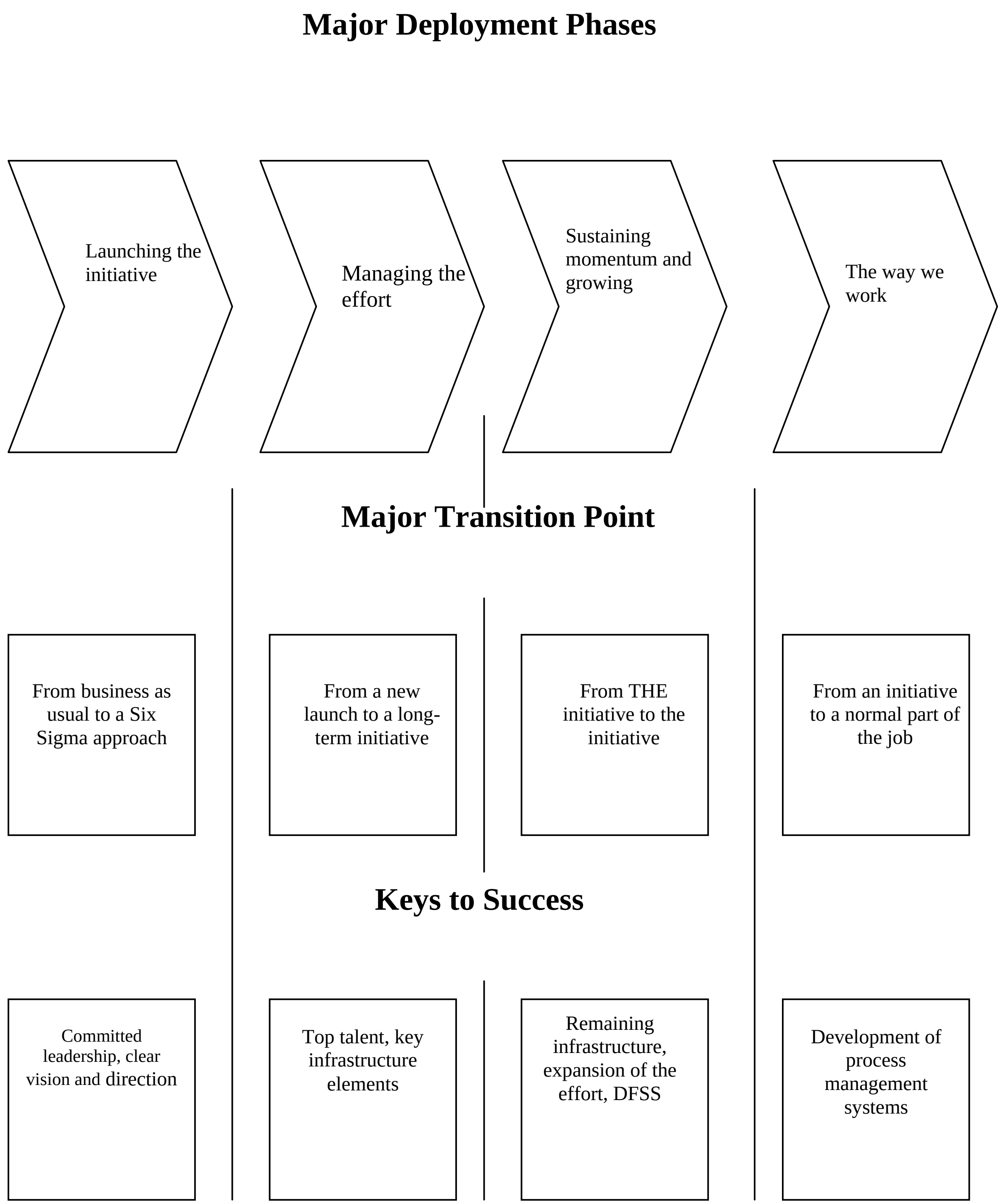

Figure 1: Six Sigma Deployment Process

Adapted from Hoerl and Snee, 2003

The four steps have been chosen by Hoerl and Snee to align with the major transition point in Six Sigma deployment. Hoerl and Snee (2003) note that few companies transition from being a non-Six Sigma company to being a Six Sigma company in one large step. Companies go through transitions with major opportunities for breakthroughs as well as pitfalls. It is therefore important that the transitions in Six Sigma deployment be planned properly.

Launching the Initiative

The first step in the deployment process, launching the initiative, is when a company decides to implement Six Sigma. Implementing Six Sigma causes cultural changes in an organization. Hoerl and Snee (2003) suggest that there may be managers who are opposed to the Six Sigma philosophies. Yet the company will need a clear vision and direction at all levels of management.

Committed and strong leadership is extremely important during this step so that all issues can be addressed. However, equally as important is the overall company knowledge on why the organization is deploying Six Sigma and the long-term vision of the organization.

Managing the Effort

After the Six Sigma initiative has been implemented, the next key transition occurs when the first sets of projects are being completed and people start wondering where to go from there (Hoerl and Snee, 2003). To move this transition successfully, Hoerl and Snee state that you will need the involvement of the organization's top talent.

If Six Sigma is properly implemented, there will be support that will carry the effort. It is at this transition point that Six Sigma will either fizzle out as another short-lived fad or forge ahead as a properly managed business priority (Hoerl and Snee, 2003).

Sustaining Momentum and Growing

It is important to remember that even after a successful deployment of any business tool, there is a tendency to lose steam after a couple years. It is easy to turn to other emerging trends and tools once Six Sigma has been deployed contributing to why so many corporations go through a series of fads. This needs to be controlled in order to prevent the gradual slip of Six Sigma in organizational importance.

The Way We Work

The last transition point in deploying Six Sigma as defined by Hoerl and Snee (2003) may be the most difficult. At this point Six Sigma is moved from being an initiative to being the way we work. The concepts and methodologies of Six Sigma must become standard operating procedures in a company. Hoerl and Snee (2003) suggest that the best way of accomplishing this is to develop the Six Sigma improvement effort into an ongoing process management system. Since Six Sigma relies on projects and trained resources, these key components must be integrated to create a new way of working.

There are three common root causes described by Hoerl and Snee (2003) that explain why some businesses achieve significant success with Six Sigma, and others achieve minimal success. These key success factors are committed leadership, involvement of top talent and supporting deployment (Hoerl and Snee, 2003). The deployment roadmap integrates these three key success factors to guarantee a high probability of success.

There are many benefits of Six Sigma; however, Pande, Neuman and Cavanagh (2000) suggest five benefits. They state that Six Sigma generates sustained success because it is a way to continue double-digit growth. Secondly, it sets a performance goal for everyone in a company no matter the size. Thirdly, Six Sigma gets everyone focusing on a common goal. Six Sigma enhances value to customers because the focus on customers is at the heart of Six Sigma. Lastly, it accelerates the rate of improvement by borrowing tools and ideas from many disciplines.

3.5 TRAINING LEVELS IN SIX SIGMA

3.5.1 Green Belt

The ASQ website (ASQ, 2004) states that green belts are Six Sigma project leaders capable of forming and facilitating Six Sigma teams. They can manage Six Sigma projects from conception to completion. Pyzdek (2003a) gives various requirements for training a green belt. He states that green belt training usually consists of five days of classroom training and is conducted in conjunction with Six Sigma projects. Generally, green belt training covers project management, quality management tools, quality control tools, problem solving and descriptive data analysis. Six Sigma black belts help green belts define their projects prior to the training, attend training with their green belts and assist them with their projects after training. The green belt is the individual who does the work on the project. Many large companies mandate many of their employees to be green belt certified. While, the Six Sigma green belt is a vital role in implementing a successful Six Sigma program, it is the black belt who has the project leadership role.

3.5.2 Black Belt

The ASQ website (ASQ, 2004) defines a Six Sigma black belt as a full-time team leader responsible for implementing process improvement projects—DMAIC or define, measure, analyze, design and verify (DMADV)—within the business to drive up customer satisfaction levels and business productivity. DMAIC and DMADV are systematic, scientific and fact based continuous improvement process tools. They eliminate unproductive steps, focusing on new measurements and applying technology for improvement of processes (General Electric, 2004a).

In this research a Six Sigma black belt is defined as a certified professional who can explain Six Sigma philosophies and principles, including supporting systems and tools. The black belt should demonstrate team leadership, understand team dynamics and assign team member roles and responsibilities (Pyzdek, 2003a). Black belts usually have a good understanding of all aspects of the DMAIC model in accordance with Six Sigma principles. They have a basic knowledge of lean enterprise concepts and are able to identify non-value-added elements. Black belts typically receive 160 hours of classroom instruction, plus one-on-one project coaching from master black belts or consultants. The exact amount of training varies from company to company.

3.5.3 Master Black Belt

The master black belt is the highest level of technical and organizational proficiency within Six Sigma. Master black belts provide technical leadership, therefore, they must know everything the black belts know, as well as understand the mathematical theory on which the statistical methods are based. Master black belts must be able to assist black belts in applying the methods correctly in unusual situations. Statistical training is conducted by master black belts, whenever possible. However, if it becomes necessary for black belts and green belts to provide training, they should under the guidance of master black belts. The master black belt is qualified to teach other Six Sigma facilitators the methodologies, tools and applications in all functions and levels of the company.

3.5.4 Champion

The ASQ website (ASQ, 2004) defines Six Sigma champions as upper level managers who lead the deployment of Six Sigma. They serve as mentors to the black belts and liaisons to upper management. Six Sigma champions are high-level individuals who understand Six Sigma and are committed to its success. In larger organizations, Six Sigma will be lead by a full-time, high-level champion, such as an executive Vice-President. In all organizations, champions also include informal leaders who use Six Sigma in their day-to-day work. Six Sigma champions should attend green belt training, because it is important for champions to have a general knowledge of Six Sigma basics.

In discussing the various training levels in Six Sigma, it is important to understand that no official criteria for each belt color. Most large companies have standard training programs and requirements that employees must complete in order to be certified in the various training levels. However, there is no national standard in Six Sigma Training.

3.6 STAFFING LEVELS AND EXPECTED RETURN

The number of full-time personnel devoted to Six Sigma is typically a small percentage of the total workforce. Mature Six Sigma programs, such as those of General Electric, Honeywell, and others average about one percent of their workforce as black belts, with considerable variation in that number (Pyzdek, 2003a). There is usually about one master black belt for every ten black belts, or about one master black belt per 1000 employees. A black belt typically completes 5 to 7 projects per year, usually working with teams. Project teams are often lead by green belts, who, unlike black belts and master black belts, are not employed full-time in the Six Sigma program. Green belts usually devote between 5 and 10 percent of their time to Six Sigma project work.

Pyzdek (2003a) estimates the savings per project on Six Sigma as varying from organization to organization. Reported results average about $150,000 to $243,000 per project. He suggests that by completing 5 to 7 projects per year, per black belt, the company will add in excess of $1 million per year per black belt to its bottom line. It is estimated that for a company with 1,000 employees the estimated savings could be depicted as in Figure 2. It is important to note that Pyzdek's estimated savings may be optimistic for companies, in particular for small companies.

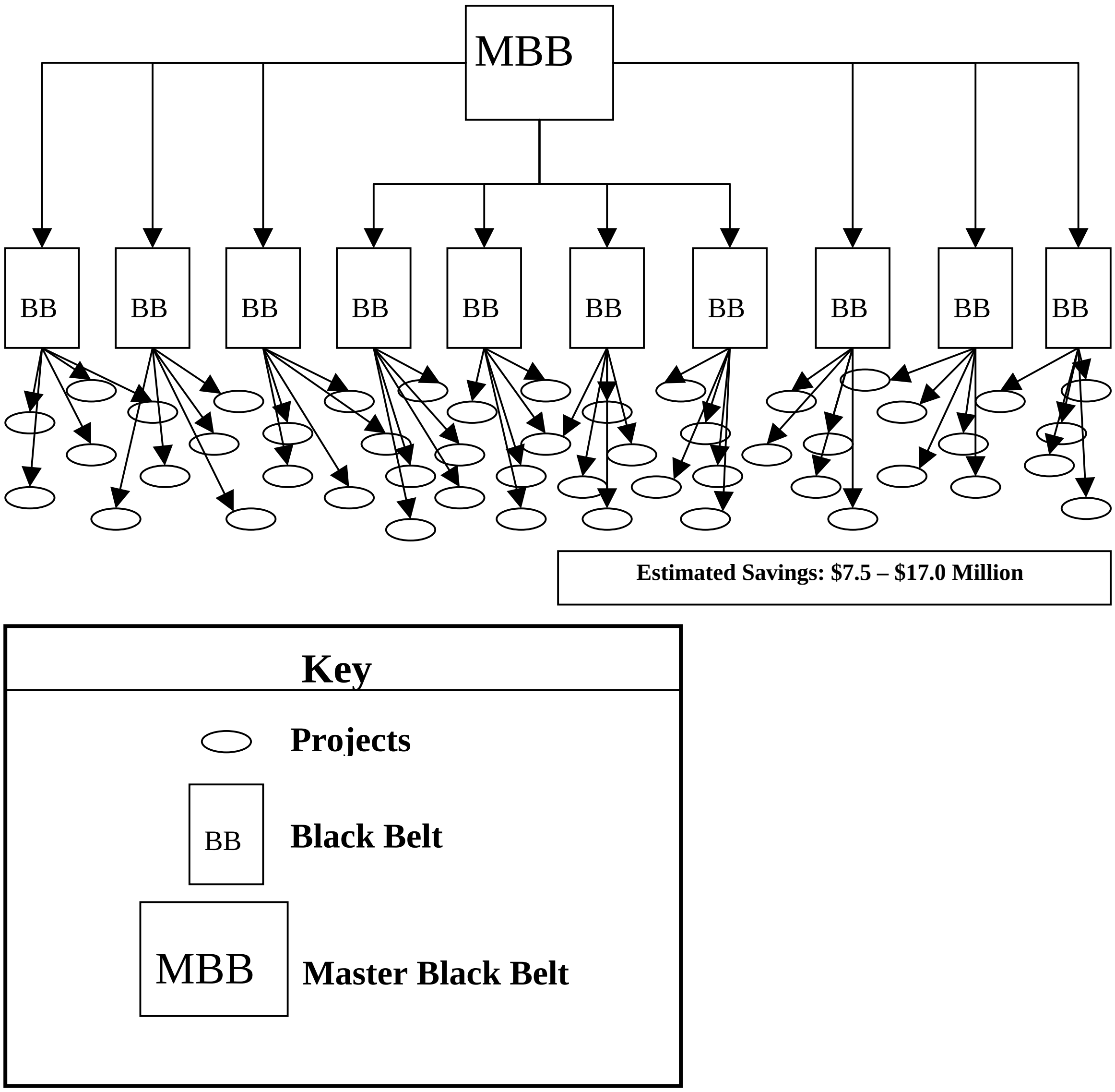

Figure 2: Estimated Savings per Project in Six Sigma Programs

3.7 SIX SIGMA AND THE FIVE LARGE COMPANIES

There are many Fortune 500 companies who are jumping on the "Six Sigma Bandwagon." However, there are very few, that have gained as much recognition for success with their Six Sigma programs like the five companies chosen to analyze in this research namely Motorola, GE, Honeywell (formerly Allied Signal), Ford and Caterpillar.

These five large companies have invented and redefined Six Sigma. The Motorola website (2004) states that they invented Six Sigma in 1986. Allied Signal (now Honeywell) deployed Six Sigma in 1994. The other companies have similar stories. As shown in Table 1, these companies have an average annual revenue of nearly $36 billion during the years in Six Sigma. They have a cost savings of approximately $76 million annually.

Table 1: Yearly Revenue at Five Large Companies

Companies	Years	Number of Years	Total Revenue ($B)	Revenue ($B)/year	Total Savings ($B)	Total Savings ($B)/year
Motorola	1986-2001	16	356.90	22.31	16.00	1.00
GE	1996-1999	4	382.10	95.53	4.40	1.10
Honeywell	1998-2000	3	72.30	24.10	1.80	0.60
Ford	2000-2002	3	43.90	14.63	1.00	0.33
Caterpillar	2000-2002	3	69.60	23.20	Not Reported	Not Reported

Motorola is the pioneer and founder of Six Sigma. Yet, General Electric (GE) is probably the most well known company in Six Sigma operations. With the leadership of arguably one of the best CEO's of our time, Jack Welch, GE made Six Sigma a way of life (Hendricks and Kelbaugh, 2002). GE operates in more than 100 countries and employs more than 300,000 people worldwide. In 2003, the company's annual revenue was at $134.2 billion. GE owns 13 businesses from aircraft engines and power generation to financial services and plastics (General Electric, 2004b). A company like this was important in the research to serve as a model for other companies.

Yet, one of the best success stories in Six Sigma comes from a company by the name of Honeywell, who attributed part of their success on the market to Six Sigma. Honeywell has over 108,000 employees in nearly 100 countries. As a Fortune 100 company, Honeywell reported $23 billion in sales for the year 2003 (Honeywell, 2004b). With four business segments, Honeywell is among the industry's best in Six Sigma practice.

Ford Motor Company known for its slogan "Quality is Job 1" has always kept quality as a top priority. Ford has over 327,000 employees (Ford, 2004). Although Ford is best known for its SUV and car sales, Ford also has business units in Ford Credit while having shares in Mercury, Lincoln, Jaguar and Aston Martin to name a few. Ford Motor Company implemented Six Sigma in 2001 and its Six Sigma program has developed into a world-class program.

Another company with minimal history with Six Sigma but impressive results is that of Caterpillar. For more than 75 years, Caterpillar Inc. has been building the world's infrastructure, and in partnership with Caterpillar dealers, is driving positive and sustainable change on every continent (Caterpillar, 2004). A Fortune 100 company, Caterpillar is the world's leading manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines. In 2003, Caterpillar posted sales and revenues of $22.76 billion and a profit of $1.1 billion with over 69,169 employees. (Caterpillar, 2004)

These five large companies have all reported huge benefits from Six Sigma. Before discussing each of these companies individually, it is interesting to calculate the expected financial results from the Six Sigma efforts of these companies. Based on the number of employees at each of these companies, one can estimate the potential cost – savings. Pyzdek's (2003a) *Six Sigma Handbook,* claims that 1% of the work force should be black belt certified.

Table 2: Expected Savings per Six Sigma Project at each Company

Companies	Number of Employees	Number of Years in Six Sigma	Black Belts (1% of workforce)	Total Number of Projects/ year (Based on 5 projects per Black Belt per year)	Total Expected Savings/ Year		Total Expected Savings ($B) (Total Number of Years in Six Sigma * Expected Savings)
					$150,000/ project ($M) –Minimum	$243,000/project ($M) - Maximum	
Motorola	100,000	16	1,000	5,000	750	1,215	12.0-19.4
GE	300,000	4	3,000	15,000	2,250	3,645	9.0-14.6
Honeywell	108,000	3	1,080	5400	810	1,312	2.4-3.9
Ford	327,531	3	3,275	16,375	2,456	3,979	7.4-11.9
Caterpillar	69,169	3	692	3,460	519	841	1.6-2.5

Each of the black belt's typically complete a minimum of 5 projects per year with saving resulting in $150,000 to $243,000 per project. Table 2 provides a financial summary of the five companies. It includes an estimate of the potential amount of black belts that can be produced by each company annually based on Pyzdek's (2003a) model. The table also provides the calculation for the expected annual savings at each of the five large companies. These values will later be compared to actual reported savings due to Six Sigma.

Based on the number of employees at each company, an amount is calculated for the expected amount saved per company per year using Six Sigma. Pzydek (2003) suggests that by completing 5 to 7 projects per year per Black Belt, a company can save an excess of $1 million to their bottom-line. Therefore, Motorola's potential cost-savings, as defined by Pyzdek (2003a) should have been at least $0.75 billion per year ($12 billion in total savings over the 16 year period) between 1986 and 2001. Figure 3 shows that their actual savings was $1 billion per year in its16 year deployment period ($16 billion in total savings). In this analysis we found that GE, Honeywell and Ford's actual reported savings were much lower than Pyzdek's (2003a) estimated savings from Six Sigma. While, Motorola's actual savings was higher than Pyzdek's (2003a) expected savings.

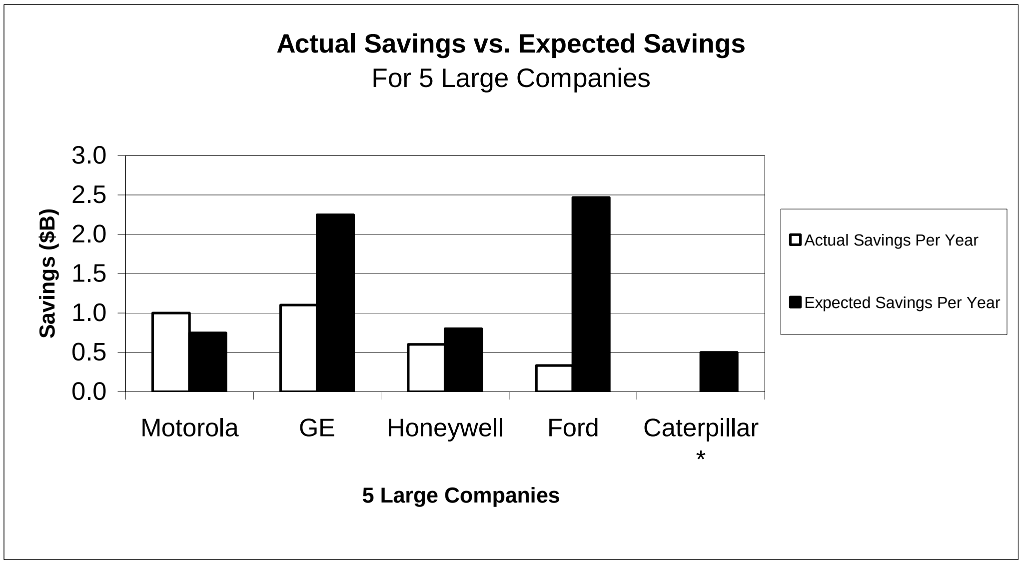

Figure 3: Actual Cost Savings vs. Estimated Cost Savings at 5 Large Companies

* Actual Savings For Caterpillar Were Not Reported

A probable explanation for these findings may be linked to the amount of time each company had spent with Six Sigma. Motorola had 16 years to build up a momentum of savings while the other companies (GE, Honeywell and Ford) in 3-4 years had not achieved the momentum for sustained savings associated with the completion of 5-7 projects per black belt per year. Arguably, GE, Honeywell and Ford would have still been training many of their employees through the 3-4 year period.

Next, more details are presented about the Six Sigma programs at each of the five large companies.

3.7.1 Motorola and Six Sigma

Motorola is said to be the “Father of Six Sigma”. Six Sigma was first invented at Motorola. It was at Motorola that Six Sigma evolved into a comprehensive quality management tool. Pande, Neuman, and Cavanagh (2000) suggest that while GE used

Six Sigma to strengthen an already thriving company, for Motorola it was an answer to the question: How do we stay in business?

In the 1980's and early 1990's, Motorola was one of many U.S. and European corporations who was being fiercely out-marketed by its Japanese competitors. Like many companies at the time, Motorola didn't have one "quality" program; it had several. The quality and reliability of Motorola's products were not what they should have been and customers were receiving too many out-of-box failures. Fortunately, the same Japanese that were destroying Motorola in the marketplace were the ones who provided a benchmark for how things could be done better. From the Japanese they learned that including all of your employees in the company brain trust was an effective means of increasing efficiency and morale (Larson, 2003).

In 1987, a new approach came out of Motorola's Communications Sector. The innovative improvement concept was "Six Sigma" (Pande, Neuman and Cavanaugh, 2000). The corporate leaders of Motorola toured all of its sites to explain that this new initiative would be the operating basis of Motorola for the future (Larson, 2003). Six Sigma offered Motorola a simple, consistent way to track and compare performance to customer requirements and an ambitious target of practically perfect quality. A key figure in the Six Sigma revolution was Bill Smith. Bill was a quality leader at Motorola who is credited with developing the mathematics of Six Sigma.

Motorola established the concept of opportunities-for-error to account for differing complexities. This made it easy to compensate for the differences in determining the numbers of opportunities for error among assembly manufacturing, process manufacturing, administrative tasks, and services operations using formulas that were developed empirically by Bill Smith (Larson, 2003). This was very important within Motorola and was key to Motorola's success with Six Sigma. Motorola's Six Sigma asked that processes operate such that the nearest engineering requirement is at least plus or minus Six Sigma from the process mean. This is accomplished by converting the Six Sigma requirement to equivalent conformance levels.

One of Motorola's most significant contributions was to change the discussion of quality from one where quality levels were measured in percentages (parts per hundred) to a discussion of parts per million or even parts per billion. Motorola correctly pointed out that modern technology was so complex that old ideas about acceptable quality levels were no longer acceptable.

As Six Sigma spread throughout Motorola, with the strong support of Chairman Bob Gavin, an initial target of ten times improvement over five years was drastically changed to a goal of ten times improvement every two years. Although the objective of Six Sigma was important, more attention was paid to the rate of improvement in the processes and products. In only two years after launching Six Sigma, Motorola was honored with the prestigious Malcolm Baldrige National Quality Award becoming one of the first companies to receive the prestigious award. The award identifies those excellent firms that are worthy role models for other businesses (Pyzdek, 2003a). In the decade between the implementation of Six Sigma in 1987 and 1997 many achievements can be noted at Motorola. There was a five-fold growth in sales, with profits climbing nearly 20 percent per year. Cumulative savings based on Six Sigma efforts have reached $14 billion. These results have puzzled many analysts, since Motorola was a company in jeopardy more than a decade ago.

3.7.2 Honeywell and Six Sigma

Honeywell is one of the many success stories involving Six Sigma. Among the who's who of organizations known for Six Sigma success, Honeywell ranks near the top. The company employs more than 108,000 people who work in 95 countries. The business is involved in products from aerospace to transportation products. In 1994, Rick Schroeder who at the time was Vice President of Operations at Allied Signal (now Honeywell) brought his Six Sigma experience from Motorola to Allied Signal. By 1999, Allied Signal was five years into its Six Sigma program, which headed the company's effort to capture growth and productivity opportunities. They reduced defects and waste in all of their business processes--resulting in a $600 million annual savings.

Following its merger in 1999, Allied Signal became Honeywell. In its 1998 Annual Report, the company credited Six Sigma with a six percent productivity increase and recorded profit margins of thirteen percent (Honeywell Annual Report, 1998). Table 1 displays Honeywell's Six Sigma deployment from 1998-2000 along with the other four large companies. Since its Six Sigma efforts were launched through 1998, the company's market value had climbed into a compounded 27 percent per year. Honeywell's Six Sigma leadership has helped it earn recognition as the world's best-diversified company from *Forbes* global edition and the most admired global aerospace company from *Fortune* (Pande, Neuman and Cavanagh, 2000).

In 2001, Honeywell was already approaching four sigma and many individual processes and businesses were well beyond that mark. However, the company did not want to settle for that level of performance. Their goal was Six Sigma. This standard was selected because it was understood in the business world as a tool for process perfection. Honeywell's Six Sigma efforts developed a strong reputation, both internally and externally, for accelerating improvements in all of the company's processes, products and services. It reduced the cost of poor quality through waste elimination and variation reduction.

Although the businesses that make up Honeywell today are very different, they have a common way to describe their work; by applying Six Sigma to all of their work processes. This has helped Honeywell achieve their goal of 15% growth and 7% productivity improvements. Honeywell has developed a new generation of Six Sigma. It is a proprietary system called *Six Sigma Plus*. This quality strategy was developed through the 1999 merger of the two companies, Allied Signal and Honeywell. Honeywell used the merger to combine the best practices of both companies. Through *Six Sigma Plus*, Honeywell's website states that it empowers its employees with the skills and tools necessary to create more value for its customers; improve its processes, products, and services, and grow the company by capitalizing on the power of the Internet through e-Business (Honeywell, 2004a).

Honeywell uses master black belts to guide Six Sigma Plus leaders. Management at Honeywell expects this newly gained knowledge to trickle down the corporate structure as soon as the training is completed. Employees who complete the program are expected to go back to their business and complete two to three Six Sigma projects per year. Additionally, they are to mentor as many as 10 groups of employees a year in their *Six Sigma Plus* learning curve (Honeywell, 2004a). Also key to training employees in *Six Sigma Plus* is Honeywell's Growth Green Belt Program. This program aims to bring Six Sigma quality to every aspect and department of the company.

At Honeywell employees who become skilled in *Six Sigma Plus* tools can earn certification in the following core areas of proficiency as described in the Honeywell (2004a) website:

- *Green Belt--A person with working knowledge of Six Sigma Plus methodology and tools, who has completed training and a project to drive high-impact business results.*
- *Black Belt--a highly skilled Six Sigma Plus expert, who has completed four weeks of classroom learning and, over the course of four to six months, demonstrated mastery of the tools through the completion of a major process improvement project.*
- *Master Black Belt--The Six Sigma Plus expert most highly skilled in the methodologies of variation reduction. After a yearlong project-based certification program, master black belts train and mentor black belts, help select and lead high-value projects, maintain the integrity of the sigma measurements, and develop and revise Six Sigma Plus learning materials.*
- *Lean Expert --A person who has completed four weeks of lean training and one or more projects that have demonstrated significant, auditable business results and the appropriate application of Six Sigma Plus lean tools.*

Honeywell has been so successful with *Six Sigma Plus* internally that it also offers its expertise externally to customers and suppliers. Honeywell has taken its Six Sigma program to new heights. In doing so, Honeywell has also helped other companies implement Six Sigma. Soon after a May 1995 address to GE executives by

Lawrence Bossidy, former vice chairman of GE and then CEO of Allied Signal, GE quickly became a leading supporter of and participant in the Six Sigma movement.

3.7.3 General Electric and Six Sigma

Hoerl and Snee (2003, p.10) wrote in *Leading the Six Sigma Way* that "there was no debating the merits of Six Sigma: were the reported results from Allied Signal (now Honeywell) or Motorola real? Would it apply to General Electric (GE)?" Yet, rather than debating these questions, virtually all the master black belts and managers were asking about how to implement Six Sigma as quickly and effectively as possible. This was what set GE apart from many other companies. In the GE culture, there was a lot of debating over important decisions, however, once the decision was made, there was very little ongoing debate on the correctness of a decision. Many of the skeptics left the company after the Six Sigma revolution.

GE is a large, unique, multi-business company with a learning culture that has transformed the diversity of its businesses and its size into a tremendous advantage. GE has an array of 250 business segments, 13 of them Fortune 500 size. Throughout all of these business segments, Six Sigma has exploded and has become a culture. GE has pursued business performance improvement and corporate profitability using a wide range of programs. In the 1980's, these programs resulted in a reduction in GE's total workforce from 400,000 to 300,000 and an increase in net profit from $3 to $4 billion annually. At that time, GE had an operating margin of just under 10 percent (Deming, 1993). If your company was as good as GE was in 1995, when Jack Welch launched their effort one might ask why did GE consider a Six Sigma initiative?

In 1995, General Electric CEO Jack Welch directed the company to undertake Six Sigma as a corporate initiative with a corporate goal to be a Six Sigma company by the year 2000 (Hendricks & Kelbaugh, 2002). GE states in its Annual Report for 1998 that they plunged into Six Sigma with a fierce passion. They invested more than a billion dollars in the effort.

GE, like few other organizations has developed a group of future business leaders (what GE calls the black belt or green belt) whose time are100% devoted to quality efforts. These future business leaders act as full-time leaders who guide teams through the methodology to achieve project goals. Eventually, these black belts are moved out of the quality effort and into leadership positions within GE.

The black belt concept at GE is unusual. Most organizations do not have the staffing or financial resources to devote full-time positions to lead teams. Instead, they establish the need for mid-level management to periodically lead teams on quality projects. At GE, part-time team leaders who have full-time responsibilities elsewhere are called green belts. The team leader has multiple responsibilities. They are responsible for the ongoing management of the team's work. They coordinate and run the meetings, ensuring that individual team member's complete tasks according to the milestones previously established and keep an ongoing link to the team sponsor.

At GE, the master black belt is typically not a full-time member of a team. This individual is usually the "internal quality consultant," who has the greatest technical skills and is seen as a team member (Harry and Schroeder, 2001). Team members are selected on the basis of their technical expertise for the project. Their major responsibility centers on implementing the steps in the quality model.

Very few companies have had as much success with Six Sigma as GE. It is important to remember that jumping on the “Six Sigma bandwagon” is no guarantee for success. GE is a name recognized throughout the world (Hoerl and Snee, 2003). Yet, its name had nothing to do with its success in Six Sigma. For one to be successful at any initiative, success starts at the top. Jack Welch led GE’s Six Sigma charge with relentless energy and passion. His senior leaders drove Six Sigma. They ensured that their leadership team was fully on board and that there was a well thought out game plan for implementation. They provided resources, in terms of people and funding to properly support the effort. They expected results from the effort and they were willing to change internal policies and procedures to support implementation (Hoerl and Snee, 2003). In some ways, one could argue that having strong and effective leadership was the most critical factor for GE’s success and many other companies.

In 2001, GE had over 100,000 people trained and 6,000 quality projects underway (Welch, 2001). This was important, because GE was able to develop an infrastructure to support the Six Sigma effort. There was a network of processes, systems and organizational structure required to support Six Sigma. This network included designation of a leader, identification of specific roles and responsibilities for those involved, formal systems to obtain and utilize human and financial resources, and formal processes for project selection and review (Hoerl and Snee, 2003).

3.7.4 Ford and Six Sigma

Ford Motor Company has always been a leader in Total Quality Management. It is evident from their slogan, ‘Q1’ (Quality is Job #1), that they believe in using quality to manage the success of their company. In 1999, after dealing with issues of vehicle rollovers, recalls and production delays, Ford was prompted to re-evaluate and revitalize their quality program, with Six Sigma (QCI International, 2003). Ford began deploying Six Sigma in late 1999 when the director of quality for Ford's global truck business was looking for new ways to improve quality.

In an article for *Quality Digest*, Scott Paton (2001), editor in chief, gives a detailed overview of Ford’s Six Sigma training process. Once the top leadership at Ford had been trained, the company quickly began rolling out the process throughout Ford's entire global operations. Training for the master black belts, black belts and green belts followed management training. In the first year and a half of the initiative, Ford trained nearly 10,000 employees in Six Sigma. This was supported by the purchase of a $6 million training license from Six Sigma Academy (Paton, 2001).

In September 2001, nearly two years after establishing its Six Sigma program, Ford had over 2,300 black belts trained with the goal of attaining 2,500 black belts trained at all times. Ford also, had a goal to train all salaried professional employees to be green belts within four years of that time. They had 6,000 green belts trained and hoped to increase that number to 10,000 by the end of 2001.

The key personnel in Ford’s Six Sigma program are like most other programs. The green belts receive one week of training that includes a basic understanding of how Six Sigma works and an overview of the black belt tools. Green belts learn to help black belts complete projects faster and their training allows them to be able to monitor and control the improvement process. Ford divides green belt training into three different areas: technical, manufacturing and transactional based upon the type of employee receiving the training. Green belts often have the task of maintaining the improvement once the projects are complete.

Ford assigns black belts to the Six Sigma process full-time for two years. They receive four weeks of intensive training on Six Sigma tools, particularly those used in the DMAIC cycle, which is central to Six Sigma. Black Belts at Ford typically use tools such as process mapping, cause-and-effect diagrams, failure mode and effects analysis (FMEA), design of experiments (DOE), and mistake proofing in their daily work. Black Belts work on actual projects during their training. They follow each week of training with four weeks of application, during which they go out and work on a segment of a project. Black Belts must have a project approved and also have a project Champion before beginning their training (Paton, 2001).

Master black belts at Ford are of a selective class. These people are usually hand picked by management, project champions and other master black belts through a tier-one or tier-two ranking, which are Ford's highest levels of performance appraisal. The master black belt's mission at Ford is to teach, coach and mentor. They teach black belt and green belt classes, they coach black belts and green belts as needed to help complete projects, and they act as mentors to black belts. They also manage large complex projects called mega projects. These projects usually involve several black belts. In addition, master black belts coach senior leaders within Ford on how to apply Six Sigma within their departments.

The final level of personnel in the Six Sigma administration at Ford is that of the Champion. The project champion are employees, typically managers at Ford, who work with master black belts to identify Six Sigma projects and provide necessary resources to the key personnel involved. They usually receive three to five days of training. As of September 2001, Ford had trained more than 1,700 Project Champions (Paton, 2001).

Ford selects Six Sigma projects based on three main criteria: They must relate to customer satisfaction, the results must reduce defects by at least 70 percent and each project should average about $250,000 in cost savings. This cost savings amount is greater than Pyzdek's (2003a) estimated savings per project. Pyzdek (2003a) states that a project should save the company between $150K-$243K. Ford is exceeding these expectations, however it would be interesting to analyze how many projects per year are completed at Ford based on the strictness of the project selection criteria. On average, Ford's projects have exceeded the cost-reduction goal. Once projects have been identified and assigned, the black belts begin to work through the DMAIC cycle, asking key questions, using a variety of tools and focusing on delivering specific results.

Ford's investment in Six Sigma is no small matter. Aside from the $6 million training license, Ford invested thousands of hours in training, purchased new equipment, and installed new software (Ford, 2004). Yet the results are impressive. In 2000, Consumer Driven 6-Sigma contributed $52 million to the bottom line. Ford estimates a $300 million contribution from closed projects and a two-point increase in customer satisfaction in 2001 (Paton, 2001). It is estimated (Paton, 2001) that 1,000 Six Sigma projects have been completed and that about 3,000 other projects are in various stages of completion.

3.7.5 Caterpillar and Six Sigma

In August 2000 Caterpillar Inc., a $20 billion manufacturer of construction and earth moving equipment, decided to deploy Six Sigma. The initial effort included the training of 700 Six Sigma black belts. Jerry Palmer, a Caterpillar vice president, stated in a *Automation World* Article (Iversen, 2003) that Caterpillar's effort produced a rapid payback, with first-year gains exceeding first-year deployment costs. In 2003, Caterpillar had more than 1,900 black belts who are dedicated 100 percent to Six Sigma problem solving, and over 14,000 green belts who devote at least 20 percent of their time to Six Sigma projects. Other employees contribute as Six Sigma team members, while more than 2,000 Caterpillar managers have been assigned as "sponsors" overseeing Six Sigma projects. Over 22,000 employees worldwide, or nearly a third of Caterpillar's nearly 70,000 employees, are involved with Six Sigma (Iversen, 2003).

At Caterpillar, Six Sigma teams help grow the business, drive improvement in quality, and reduce the cost structure. Since the process is fact-based, people inside and outside the company have little room for argument. Six Sigma at Caterpillar uses problem-solving teams led by black belts to resolve strategic issues. Black belts, or project leaders, are trained extensively in all aspects of the business, and in turn train green belts and Six Sigma team members. Master black belts are trained even further;

they become trainers, coaches, and mentors of black belts, thus ensuring the methodology is used consistently throughout the company (Rozgus, 2003).

Like many large size companies, Caterpillar, is now pushing for their dealer and suppliers to become Six Sigma certified as a way to drive continuous improvement throughout its value chain. Jerry Palmer (Iversen, 2003) in the same *Automation World* article cited one instance in which a Caterpillar Six Sigma team helped a supplier reduce defects by 75 percent, while also significantly reducing costs.

4.0 APROACH AND METHODOLOGY

As Six Sigma becomes a “way of life” in Fortune 500 companies, many small companies are asking if Six Sigma deployment is right for them. Since, many of the larger companies are starting to mandate that their suppliers and dealers become Six Sigma certified; many small companies are trying to find out if Six Sigma is a cost-effective quality tool to implement at their companies. The main theme of Six Sigma, like many other quality tools, is to improve the bottom line. Thomas Pyzdek (2003b) states in an ASQ’s *Quality America* article that the cost of quality is 15% to 25% for companies operating three sigma (σ) and four sigma (σ), yet as a company moves to Six Sigma quality levels, their cost of quality decreases to a level of one to two percent.

There has been minimal data published on the costs and benefits of implementing Six Sigma at small manufacturing companies. Most of the literature discussed either the qualitative benefits of Six Sigma for large companies or the quantitative results that large companies achieve implementing Six Sigma. Little is discussed on the potential benefits of Six Sigma at small manufacturing companies. The author believes that it is possible to add to the body of knowledge that has been published and help increase the amount of material available on the cost and benefits of implementing Six Sigma at these smaller companies.

Initially, the author contacted quality professionals working in Six Sigma to get a perspective on how readily available the data would be. Many of the quality professionals contacted were trained in Six Sigma. These quality professionals dealt with Six Sigma costs in their daily jobs. They trained Six Sigma professionals and dealt with the potential benefits on a daily basis. To verify the quality and effectiveness of the questionnaire in the beginning of the study, a pilot was conducted. Although the data collected in the pilot could not be used in the final analysis, the insight was important in developing the study.

4.1 DATA COLLECTION INSTRUMENT

The author used www.surveymonkey.com as a tool to create the data collection instrument. Survey Monkey is a tool that enables one to create professional online surveys. A web browser is used to create a survey editor that allows you to select from a dozen (single choice, multiple choice, rating scales, etc.) different types of questions. This tool also allowed the user to view results as they are collected in real-time and also download the raw data into Excel or SPSS. Due to the increase in technological proficiency of many small companies the author felt that it would be beneficial to the companies to provide an Internet based data collection instrument. This would provide for quick results without the hassle or expense of a paper survey that would need to be mailed with follow-up mailings and telephone calls.

The author consulted Steve Fetch, a Senior Quality Engineer and Dr. Kim Needy, a professor in the Industrial Engineering Department at the University of Pittsburgh. These two served as consultants in putting together a prototype data collection instrument that would later be tested. Initially the author wanted to collect general information about the respondents, in case it were necessary to contact them for clarification. However, during the pilot stage of the study, the author realized from talking to various professional quality organizations, that in order to increase the response rate it would be beneficial to make the data collection instrument anonymous while still giving respondents the option of giving future contact information.

The initial data collection instrument was tested and re-written after five revisions. It was important to make the data collection instrument as short as possible in order to maximize the potential response rate. The author realized that many quality professionals did not have much time in their days to complete studies. Once the data collection instrument was completed, the author set out to gain contacts from many of the small manufacturing companies in the Pittsburgh region who were using Six Sigma.

The data collection instrument included an attached cover letter (see Appendix A) defining the purpose of the study and the importance of participation in the study. The first question of the data collection instrument gathered information on the size of the company being studied. Next, a discrete (yes/no) question was asked to clarify company practices as they related to Six Sigma quality. This question focused on Six Sigma based on the ASQ definition as displayed on the ASQ (2004) website. This ensured that respondents were clear on the definition of Six Sigma that was being studied. As the data collection instrument continues, there is an analysis of company daily operation as it relates to Six Sigma quality. The data collection instrument also contains questions to explore the cost and benefits of Six Sigma at the company. The last few questions in the data collection instrument gives the respondent a chance to reflect upon the effectiveness of Six Sigma training at their company. There is also a chance to give further contact information or to list any comments or concerns at the conclusion of the data collection instrument. The complete data collection instrument appears in Appendix B.

4.2 TARGET POPULATION

As stated previously, the target population consisted of small manufacturing companies located in the Pittsburgh, Pennsylvania region. The author believed that with such an abundant amount of manufacturers, this would be an ideal area to collect data on quality practices at manufacturing companies. Respondent backgrounds varied in level of experience with company quality information. It was not clearly whether respondents had direct exposure to the financial information of their companies like a CFO would have.

During the data collection period, it was apparent that the response rate would be low. This was analyzed and it was realized that this corresponded with Becky Dieter's hypothesis. Becky Dieter is a quality professional working for Catalyst Connections, who has several years of experience with Six Sigma. Becky Dieter felt that there was a low demand for Six Sigma programs among small manufacturing companies in the Pittsburgh region. Her reason focused on the lack of QS9000 automotive, aerospace and other manufacturing companies in the region. From the low response rate it appeared as though the adoption of Six Sigma at small manufacturing companies in Pittsburgh, Pennsylvania was low.

The main strategy in the research was to contact potential respondents via email. An estimated total of 350 quality professionals were contacted either directly or indirectly during this study. By direct contact it is implied that the mailing was addressed to a specific individual. Where as by indirect contact it is implied that the mailing was addressed to the "quality professional or manager." In addition to the mailings sent to the local professional societies other quality professionals were contacted from the

Manufacturing Assistance Center (MAC), Small Business Centers of various universities, Catalyst Connections and various personal contacts.

Initially, the Pittsburgh Chapters of the American Society for Quality (ASQ), Institute of Industrial Engineers (IIE), and Society of Manufacturing Engineers (SME) were the primary quality organizations contacted in the study. The link to the study was sent to the Presidents, Vice Presidents, and Newsletter Editors of each of these organizations. The intent of this selectiveness was due to the assumption that these organization representatives had the authority to make decisions on publicizing member directory information. The author hoped that these officers in the organizations would be able to send the data collection instrument directly to their members. The contact information for these organizational contacts was found on organizational websites.

The ASQ (2004) website was also a primary source of locating contact information on companies using Six Sigma. The ASQ's quality resource directory is a worldwide resource directory that can be used to locate companies that provide quality programs and services (ASQ, 2004). The author used this directory to search for contact information on companies that had an "area of expertise" in Six Sigma. With this directory and other contacts, the study spanned quality professionals from across the entire United States.

5.0 RESULTS

5.1 RESPONSE RATE

The initial goal of the study was to gain as many respondents through electronic mailing as possible. However, this posed some problems. From respondent feedback, it was discovered that many companies had firewall protection on email to reduce the input of unwanted emails from outside solicitors. Many of the contacts did not receive the email with its link to the data collection instrument. Of those emails that were successful at reaching contact mailboxes, sometimes the contact did not consider emails that were from “unfamiliar” addresses. Figuratively speaking, these contacts had internal mailbox firewalls. Since these two issues were prominent in the data collection system the author decided to follow-up the electronic mailings with personal phone calls. These follow-up phone calls were made to those contacts in which their phone numbers were provided.

There was a significant increase in the number of responses in the months of June and July as depicted in Figure 4. From approximately 350 quality professionals contacted, there were 24 data collection instruments collected, representing a response rate of nearly 6.9%. Of the 24 total respondents there were 3 respondents that did not fully complete the data collection instrument. There were also 3 quality professionals that did not practice Six Sigma, as defined by the ASQ definition, at their companies. This meant that a total of 6 cases did not have enough data to be considered for the study.

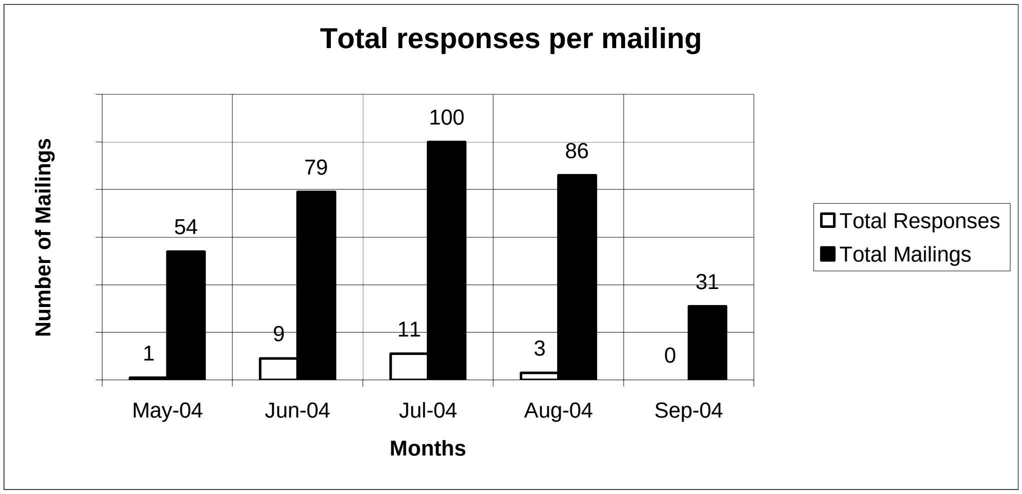

Figure 4: Amount of respondents per mailing by month

The 18 remaining cases represented complete questionnaires of companies who practiced Six Sigma as defined by the ASQ. These cases were used in the analysis. Considering just the 18 cases of good quality data and a population of 350 contacts, the response rate of this study was 5.14%.

5.2 DATA COLLECTION INSTRUMENT ANALYSIS

As mentioned earlier, there were a total of 24 respondents. Of these respondents 3 respondents did not fully complete the study. There were a total of 21 respondents who completed the questionnaire. Of the 21 completed questionnaires, 18 of these respondents stated that their company followed the ASQ definition of Six Sigma quality. Some respondents stated upon completion of the questionnaire that their company followed the ASQ definition of Six Sigma, although they did not label it in the same manner as ASQ.

Question # 1 asked respondents to indicate the number of employees on staff at their company. Figure 5 displays the number of respondents with respect to company size. Of the 18 responses displayed, 5 of the respondents stated that more than 1000 employees were staffed at their company. The data collection instrument was only sent to small manufacturing companies. Therefore, it is important to note, that these companies are small manufacturing plants with 1000 or less employees that are part of a large corporate structure that had a cumulative total of more than 1000 employees. These respondents reported their company size based on the overall size of the company with notes at the conclusion of the instrument on plant size. Therefore, these responses were included in the analysis.

The American Society for Quality defines Six Sigma as a method to eliminate waste. It is a tool to mistake-proof processes that create value for customers. Question #2 of the data collection instrument, asked respondents whether or not their company followed Six Sigma as defined by the ASQ. This was used to give the study uniform results. As seen in Figure 6, many companies applied the same definition of Six Sigma as ASQ.

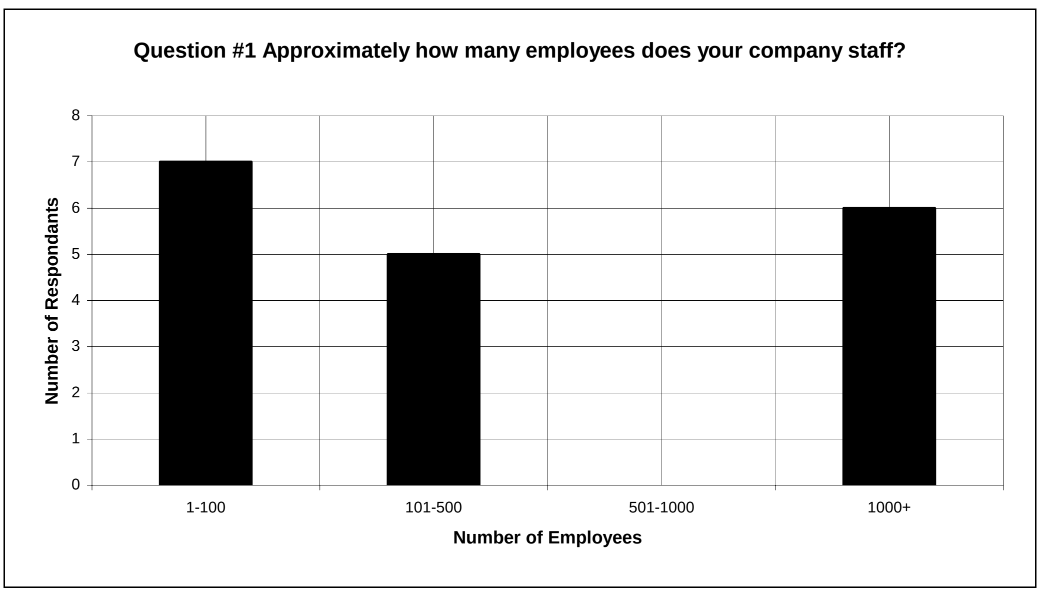

Figure 5: Company size – Small manufacturing companies

Of the 18 respondents, 86% agreed with this definition. Some respondents cited that they initially disagreed with the ASQ definition however, later realized that their company used different wordings for the definition, yet practiced the same methodology as the ASQ. The remaining 14% did not agree with the ASQ definition of Six Sigma. Some of these respondents stated that they did use Six Sigma tools but their definition was different compared to that of ASQ.

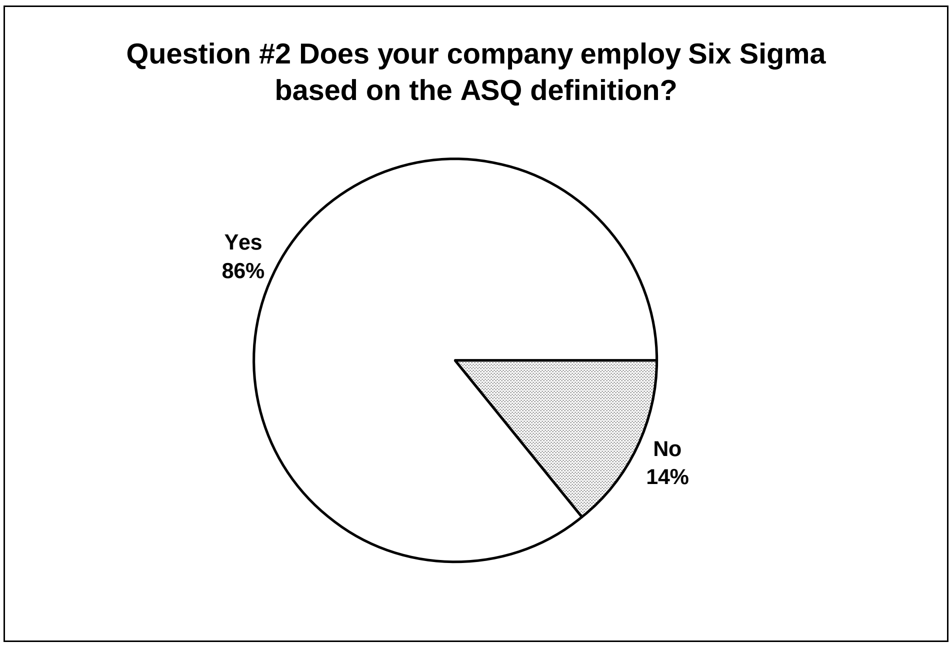

Figure 6: Use of Six Sigma as defined by ASQ

Question #3 listed a set of different quality components such as Continuous Improvement, Process Design/Redesign, Analysis of Variance, Balanced Scorecards, Voice of the Customer, Creative Thinking, Design of Experiments, Process Management and Statistical Process Control. The respondents were asked to respond as to whether each of the quality components was used in their daily operations. Figure 7 displays this data. From this data it is evident that many of the small companies are utilizing basic quality components used at the five large companies. The only significant exception in the data was with balanced scorecards, which could mean a lack of knowledge or expertise in this area.

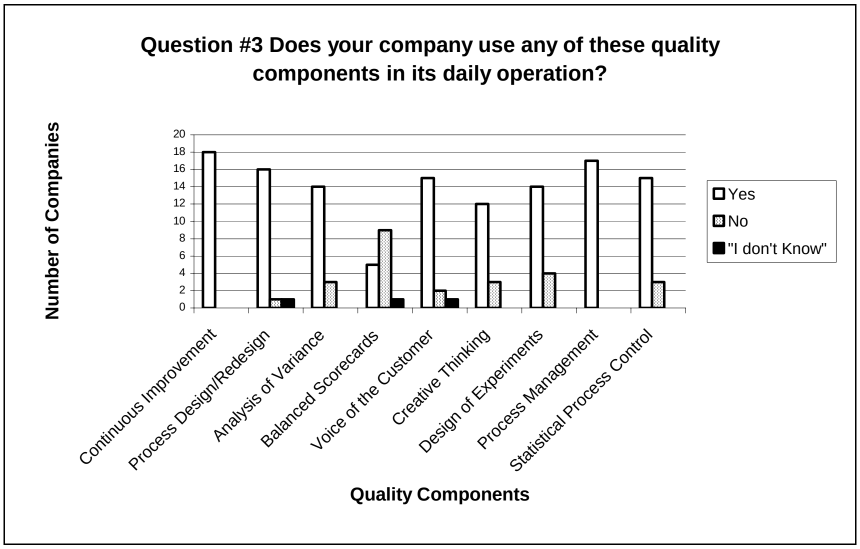

Figure 7: Usage of quality components in daily operations

Question #6 examines the impact of these quality components by asking for insight from the respondents on their view of the quality components. The respondents were asked to rate whether they thought these quality components had a high, medium or low impact on Six Sigma success at their company. Figure 8 depicts these results. Many respondents felt as though the quality components: Continuous Improvement, Voice of the Customer and Process Design/Redesign had the highest contribution in the success rate of Six Sigma at their companies.

Conversely, many respondents felt as though balanced scorecards had a minimal effect on the success of Six Sigma. It is important to understand that the balanced scorecard is a fairly new Six Sigma tool and has not yet had a high adoption rate by the small manufacturing companies studied in this work.

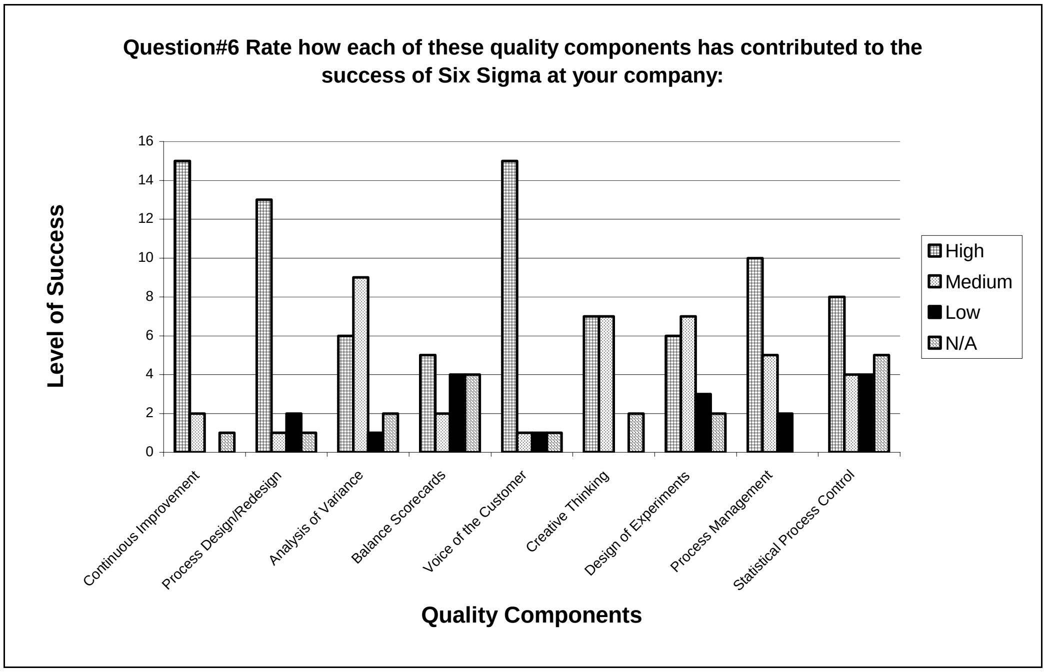

Figure 8: Success in using quality components

In evaluating the success of Six Sigma, it was important to understand the financial impact of Six Sigma at these companies. Initially the author hypothesized that since these companies staffed 500 or fewer employees they would have little revenue to expend on Six Sigma as compared to the large companies. From the data collection instrument the author found that many of these companies, surprisingly, spent more than $50K a year on Six Sigma as depicted in Figure 9.

Based on these results, the author thought that it was relevant to examine the estimated savings that potentially could be realized based on the number of black belts employed at each company. Referring back to Pzydek's (2003a) *Six Sigma Handbook* there is a direct correlation between the number of black belts staffed at a company and the amount of money that can be saved from Six Sigma. In Section 3.6 the various staffing levels of Six Sigma are examined and a chart for the expected Six Sigma savings per Black Belt at large companies was produced. Following this methodology, data is calculated for the expected amount of money that can be saved at small manufacturing companies using Six Sigma.

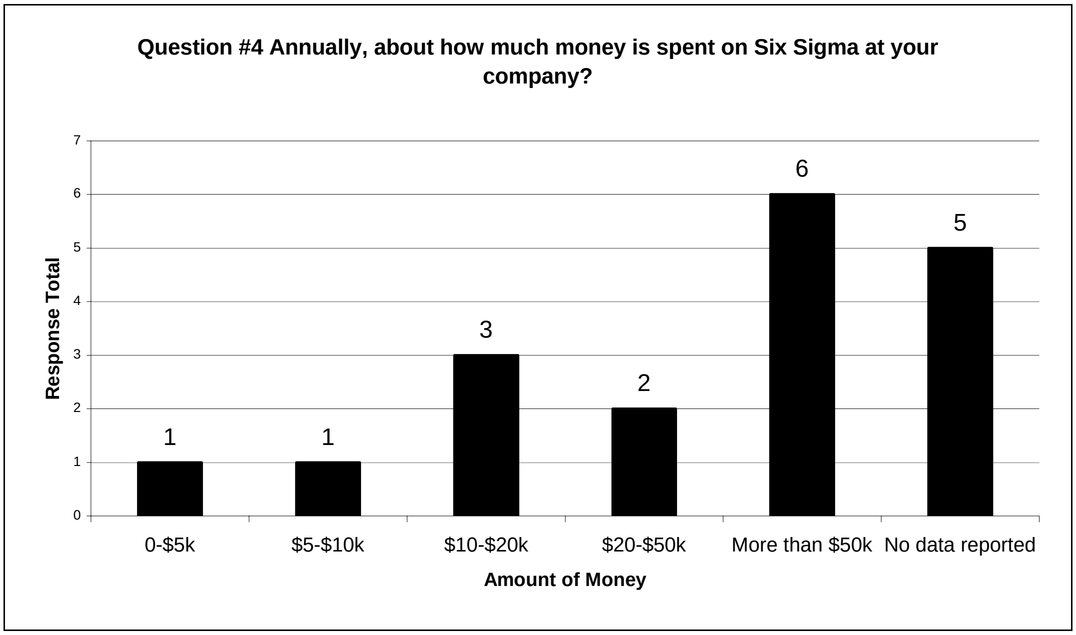

Figure 9: Amount spent on Six Sigma

Table 3 is an analysis of the expected savings per Six Sigma project at 10 of the 18 companies polled for this study. Results are shown for only 10 of these companies since the other respondents did not provide information on the number of black belts at their company. Therefore, it would not be possible to compare their expected savings to their actual reported savings. Figure 10 displays a graphical analysis of the expected versus actual number of black belt projects per company.

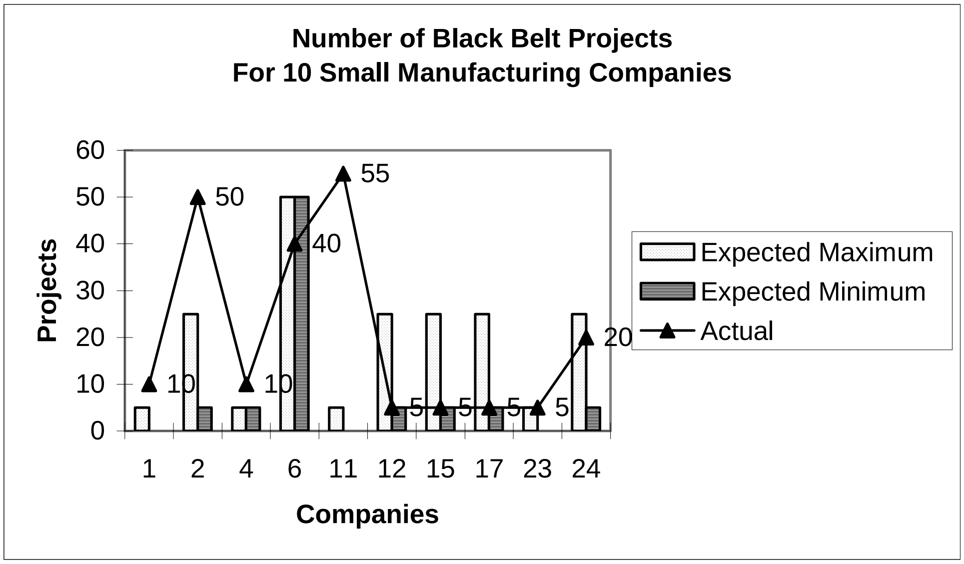

Figure 10: Number of Black Belts at 10 Small Manufacturing Companies

From this analysis, the majority of these small manufacturing companies are doing well in comparison to the expected number of projects that they could potentially complete per year relative to their company size.

Table 3: Expected Savings per Six Sigma Project at Small Manufacturing Companies

Companies	Number of Employees	Expected Number Black Belts (1%)	Expected Number of Projects per Black Belt	Expected Savings/ Year (Based on average # of projects *savings per project)	
			(Based on 5 Projects per BB per year)	$150,000/ Project	$243,000/Project
Company 1	1-100	0-1	0-5	$375K	$607.5K
Company 2	101-500	1-5	5-25	$2,250K	$3,645K
Company 4	1-100	0-1	0-5	$375K	$607.5K
Company 6	1000+	10+	50+	$3,750K	$6,075K
Company 11	1-100	0-1	0-5	$375K	$607.5K
Company 12	101-500	1-5	5-25	$2,250K	$3,645K
Company 15	101-500	1-5	5-25	$2,250K	$3,645K
Company 17	101-500	1-5	5-25	$2,250K	$3,645K
Company 23	1-100	0-1	0-5	$375K	$607.5K
Company 24	101-500	1-5	5-25	$2,250K	$3,645K

Table 4 is an analysis of the total potential savings at the 10 small manufacturing companies. This information is based on Pyzdek's (2003a) *Six Sigma Handbook* approach and the information gathered from the data collection instrument. From this analysis, it is found that many of the small companies have the potential to save between $1 million to $40 million on Six Sigma. The savings value is calculated using the initial number of black belts staffed at each company to produce an estimate of the number of possible projects completed each year. The savings per project is calculated by multiplying the number of black belt projects times the projected amount saved per project ($150-$243K). The total savings is found to be the maximum amount saved minus the amount spent per year on Six Sigma.

Table 4: Total Potential Savings at 10 Small Manufacturing Companies

Companies	**Amount Spent on Six Sigma Training**	**Maximum Amount Spent on Six Sigma**	**Actual Number of Black Belts**	**Potential Number of Projects per Black Belt** (Based on 5 projects per BB per year)	**Expected Minimum Savings Per Project (Savings=$150K * Potential Number of Projects)**	**Expected Maximum Savings per Project (Savings =$243K * Potential Number of Projects)**	**Expected Total Savings (Minimum Savings based on # of BB - Amount Spent per year)**
Company 1	$20-50K	$50,000	2	10	$1,500K	$2,430K	$1,450K
Company 2	$20-50K	$50,000	10	50	$7,500K	$12,150K	$7,450K
Company 4	$0-5K	$5,000	2	10	$1,500K	$2,430K	$1,495K
Company 6	$50K	$50,000	8	40	$6,000K	$9,720K	$5,950K
Company 11	Unreported	0	11	55	$8,250K	$13,365K	$8,250K
Company 12	$10-20K	$20,000	1	5	$750K	$1,215K	$730K
Company 15	Unreported	0	1	5	$750K	$1,215K	$750K
Company 17	Unreported	0	1	5	$750K	$1,215K	$750K
Company 23	$50K+	$50,000	1	5	$750K	$1,215K	$700K
Company 24	$10-20K	$20,000	4	20	$3,000K	$4,860K	$2,980K

Comparing the total savings to the amount spent on Six Sigma, the average company surveyed was spending less than 1% (0.80%) of its potential total savings on Six Sigma. This is an argument in support of Six Sigma implementation at small manufacturing companies.

Question #7 explored the various challenges facing small manufacturing companies in implementing Six Sigma programs. It was an open-ended question; therefore, the respondents had the opportunity to give their thoughts without being limited to specific answers. The results were coded into categories for data analysis. Respondents cited cultural change, cost and lack of management support as the biggest challenges in implementing Six Sigma as depicted in Figure 11.

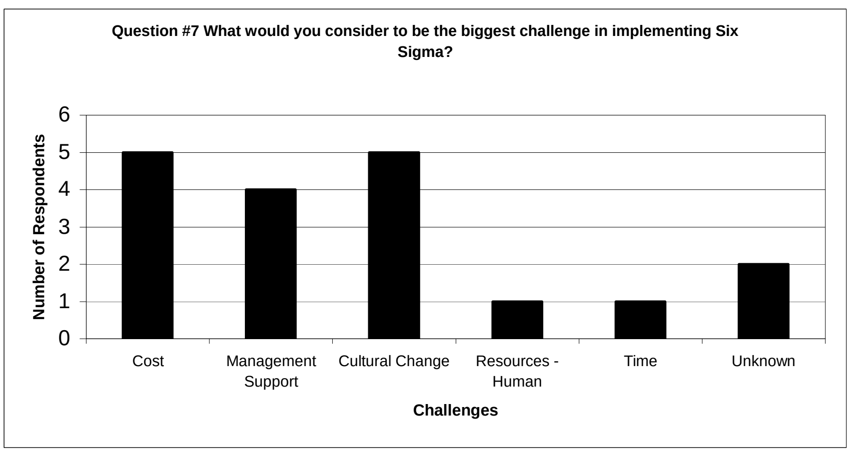

Figure 11: Challenges of Implementing Six Sigma

One respondent stated “Convincing the people on the floor on the need for taking the time to obtain accurate process information so that sound decisions can be made using this data” (a cultural change) was the biggest challenge. While another respondent remarked that “cost via actual training material and personnel” (cost) would be the biggest challenge. Another respondent felt that “for Six Sigma to be successful, executive management must be dedicated to continual process improvement and understand that controls put in place must be followed " (lack of management support). While there were various answers to this question, it was interesting to see that there was consistency in the answers and that many respondents felt passionate about their response.

Questions #5 and #8 focused on both the type of training being pursued at these companies and to whom this training is being given. Results from Question #5 are shown in Figure 12. An overwhelming amount of respondents said that training was internal at their company with many respondents stating that existing black belts and green belts were responsible for training other employees. One respondent stated that "an internal two-week course is given for green belt certification; this included completion of a project using the skills. An additional two-week course is offered for green belts that want to achieve black belt certification. Mostly exempt employees are being trained but a few hourly folks are too." This was an interesting response, because it showed that this company spent a good amount of time training its employees in Six Sigma. This same company that employed 100 or fewer employees, was spending $20-50K a year on Six Sigma. Conversely, one respondent stated that they chose external training at their company, which focused mainly on top-level management training. The respondent said "external training is used for quality professionals like product managers and general managers, while no one has been through black belt training yet." This was a business group within a larger organization. The business group was a small manufacturing company. This business group was spending $5-10K per year on

Six Sigma however, the larger organization had over 1000 or more employees. This data shows the amount spent on Six Sigma did not correlate to the size of the company.

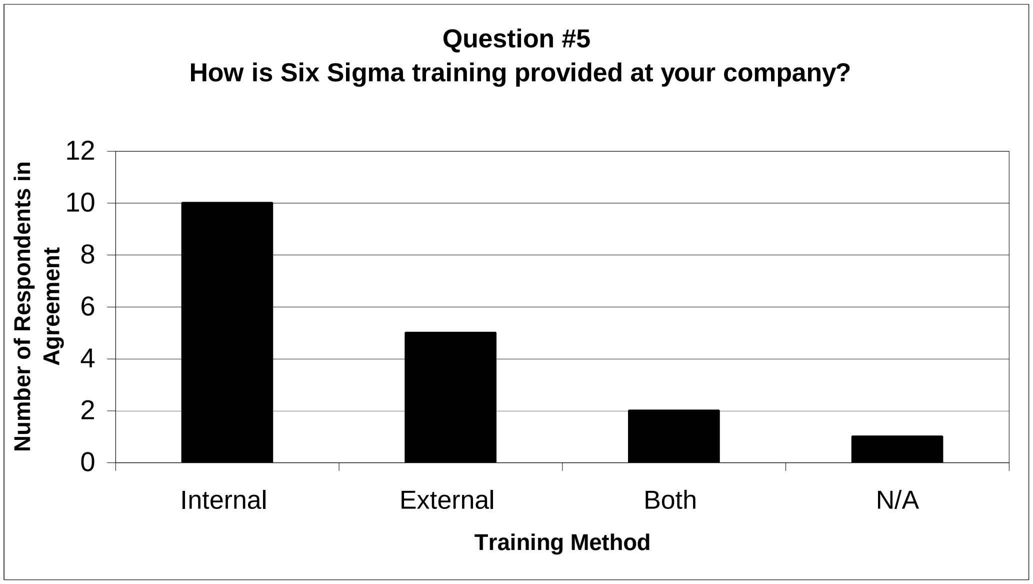

Figure 12: Training Methods at Small Companies

In Question # 8 we investigated the various levels of Six Sigma (green belt, black belt, master black belt and champion) as described in Section 3.5. It was most important to analyze the number of black belts in each company as this Six Sigma training level can arguably be considered the most important training level needed in Six Sigma. As seen in Figure 13, there were 94 green belts, 80 black belts, 34 master black belts, and 54 champions in total reported by the respondents. In correlation with this result, Pyzdek's (2003a) *Six Sigma Handbook* states that Six Sigma black belts are the core need in a company.

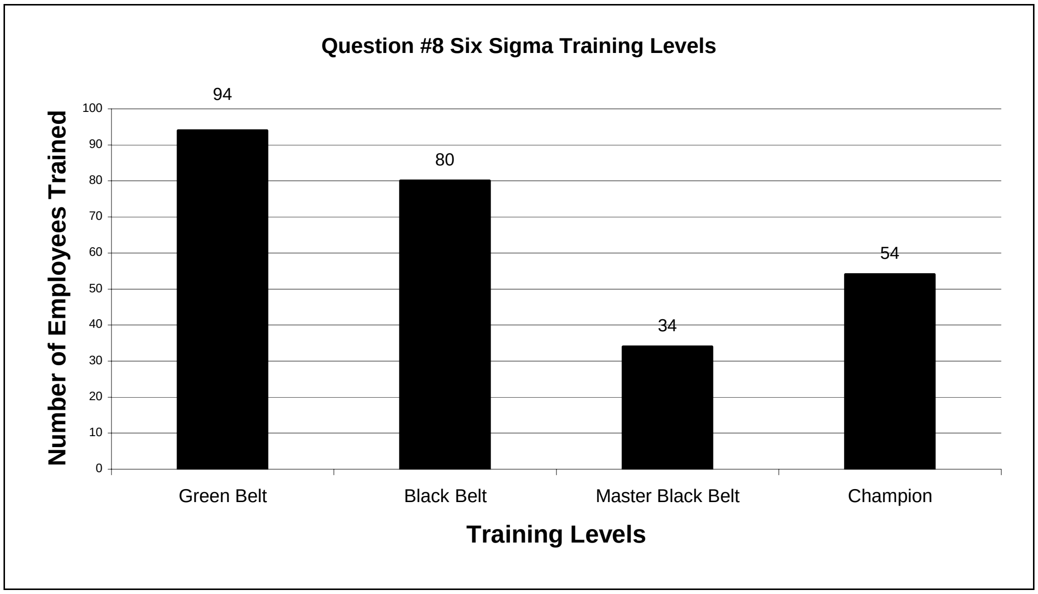

Figure 13: Six Sigma Training Levels

Black belts are vital in analyzing the potential cost savings of Six Sigma at companies, because Six Sigma programs are typically structured around a black belt working full-time on business problems.

Respondents were polled on their opinion of the effectiveness of Six Sigma. Questions #9-12 dealt specifically with the respondent's opinion of Six Sigma at their companies. Question #9 asked the respondent's opinion on whether or not Six Sigma has improved customer satisfaction at their company. Figure 14 shows that 78% of the respondents agreed or strongly agreed that Six Sigma improved customer satisfaction at their company, while 22% were neutral.

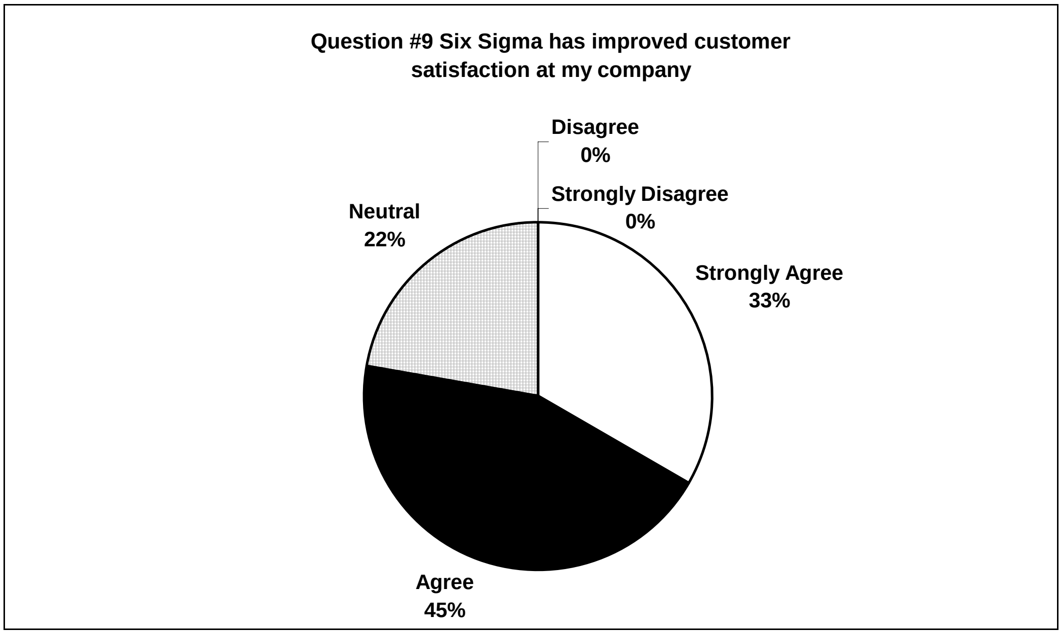

Figure 14: Can Six Sigma improve customer satisfaction?

One of the major objectives of this research was to examine whether the benefits of Six Sigma outweigh the costs of implementing Six Sigma at small manufacturing companies. Question #10 polled the respondents on their perception on whether the benefits of Six Sigma outweigh the costs of Six Sigma. As shown in Figure 15, 88% of the respondents gave a positive response on their view of the benefits of Six Sigma at their company, 6% were neutral, while 6% disagreed with this question.

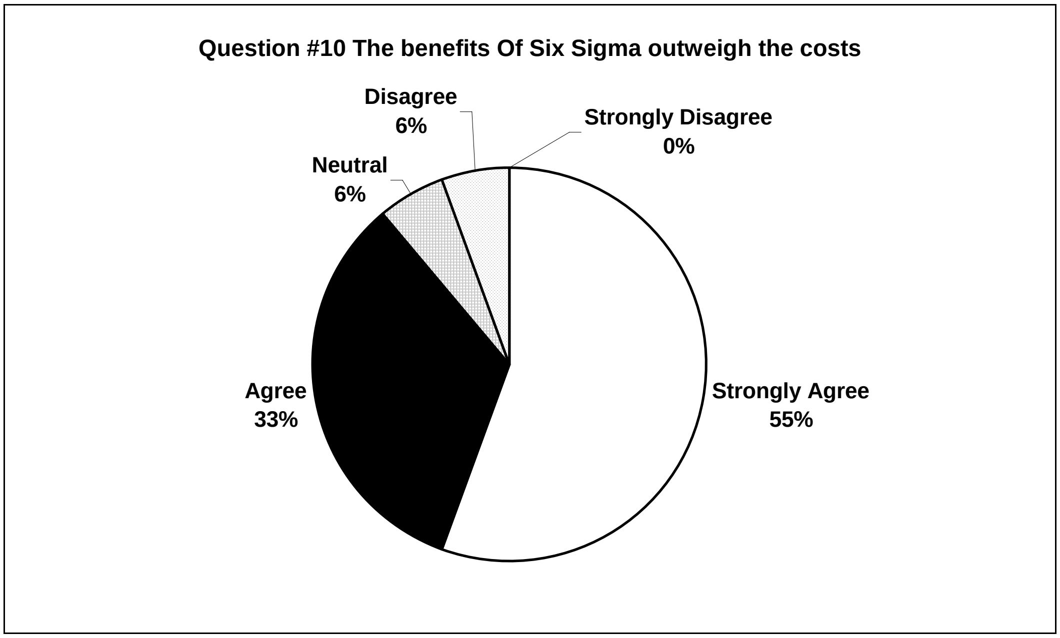

Figure 15: Do the benefits of Six Sigma outweigh the cost?

Question #11 asked respondents to consider whether Six Sigma improved profitability at their company. As shown in Figure 16, 81% agreed that profitability improved while 19% were neutral.

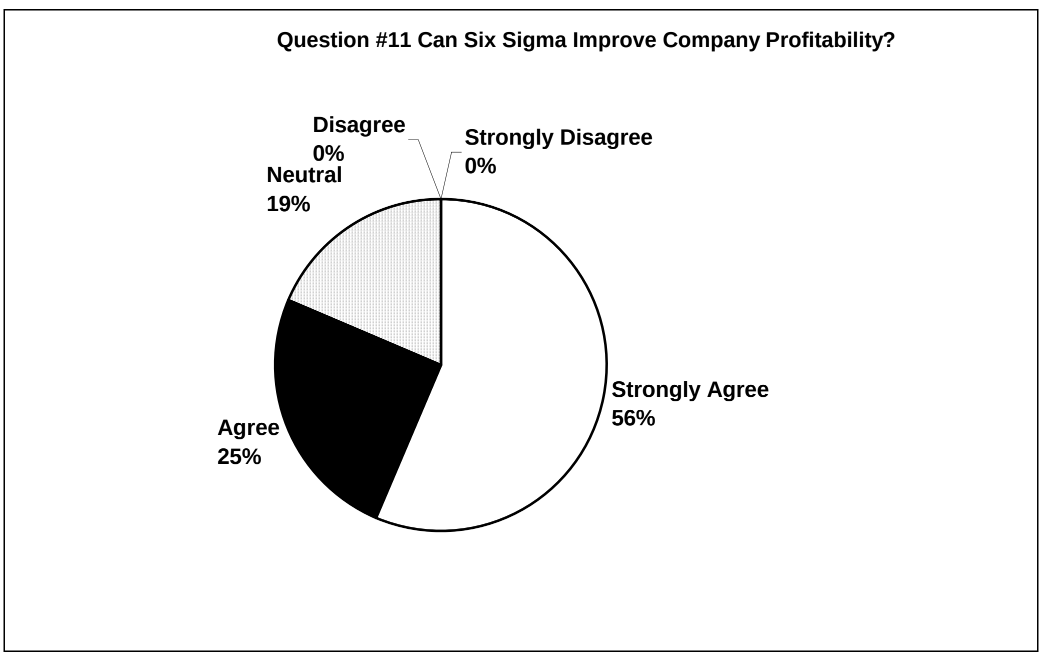

Figure 16: Can Six Sigma improve company profitability?

Question #12 asked respondents to consider whether Six Sigma had increased employee job satisfaction at their company. Figure 17 shows that 66% of the respondents agreed that Six Sigma had improved employee job satisfaction while, 28% were neutral and 6% disagreed.

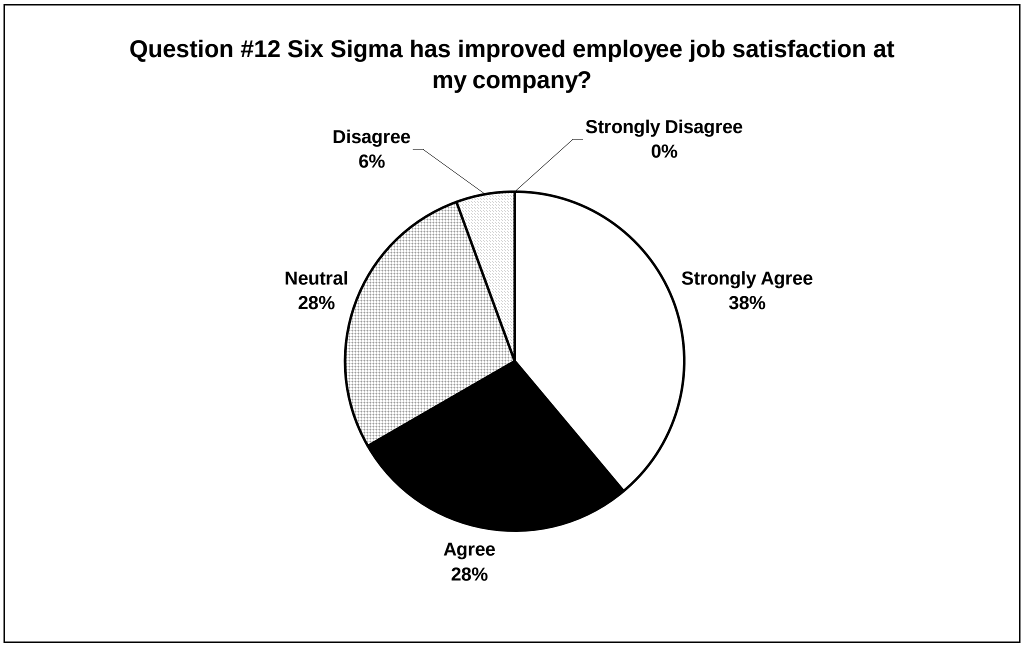

Figure 17: Can Six Sigma improve employee job satisfaction?

For future research it would be interesting to explore, specifically how and in what ways Six Sigma can improve employee job satisfaction. For example, perhaps an increased emphasis on training plays a role in job satisfaction.

5.3 SUMMARY OF MAJOR FINDINGS

Small manufacturing companies are using Six Sigma. However, based on the level of difficulty in gathering information from these companies, the author concludes that many of these companies may not have the resources to document their Six Sigma deployment. Based on the findings of this study, several arguments surrounding Six Sigma implementation at small manufacturing companies can be addressed with respect to size, challenges, training, satisfaction and cost/savings.

Size

When evaluating the size of the company, it was found that the size of the company did not limit the amount of money being spent on Six Sigma. For example, there were companies who staffed 1-100 employees and spent more than $50K a year on Six Sigma. These companies were spending as much as other companies who staffed 500 employees and spent similar amounts on Six Sigma.

Challenges

Upper management support, cost of implementation and fear of cultural change are the major challenges facing small companies in implementing Six Sigma. However, these challenges are not limitations, they served as a handicap to some of the companies studied.

Training

Small manufacturing companies are training their employees predominantly, through internal master black belts and black belts. Of the companies studied, a total of 80 of their employees were trained black belts. Therefore, many of the companies are knowledgeable on Six Sigma training and staffing implementation.

Satisfaction

Of the small companies studied, 66% agreed that Six Sigma could improve job satisfaction and 78% agreed that Six Sigma improved customer satisfaction. These results were generally positive; we can conclude that Six Sigma improves the level of satisfaction at the company.

Cost/Savings

Most of the respondents in this study had 500 or fewer employees. Comparing the total savings to the amount spent on Six Sigma, the average company surveyed was spending less than 1% (0.80%) of its potential savings on Six Sigma per year. The small manufacturing companies being studied could potentially save a great amount of money with a Six Sigma program. However, one must speculate that the salary amounts and other indirect costs may not have been included in their cost estimates resulting in a low estimate of Six Sigma cost estimated by respondents. This may have been due to the positions of the respondents completing this survey. Some respondents may not have had this information that would be easily available to a CFO or higher-level manager.

When respondents were asked their opinion on whether the benefits outweighed the cost of Six Sigma, 88% of the respondent population agreed. 81% of the respondents felt that Six Sigma had increased their company profitability. This supports the argument that there is a savings benefit in implementing Six Sigma at small manufacturing companies.

5.4 SIX SMALL COMPANIES NOT STUDIED

Of the 24 data collection instruments collected, 3 respondents that did not fully complete the data collection instrument. There were also 3 quality professionals that did not practice Six Sigma, as defined by the ASQ definition, at their companies. This meant that a total of 6 cases did not have enough data to be considered for the study. Although these cases were not used in the study, there are some conclusions that we can gain from these 6 companies. It is through their response that the author realized that the survey should have been more explicit. Although some companies may not practice Six Sigma as defined by the ASQ, they may still use quality tools such as process control. This made it important to add a lessons learned section to the document in order to give future researchers tips on how to develop a survey for collection of data.

5.5 COMPARISON OF SMALL VS. LARGE COMPANIES

When comparing small companies to large companies the study found that although there were some differences in their Six Sigma programs, the majority of information pointed towards similar Six Sigma programs. Top management support, fear of cultural change and implementation cost were the biggest challenges in Six Sigma deployment for these companies. It was important to compare the challenges faced at small manufacturing companies to those of large companies to analyze whether they were facing similar issues.

The five large companies, each had strong management support in their Six Sigma implementation. For example, leaders like, Jack Welch-CEO of GE, became one of the most important figures in GE's successful implementation of Six Sigma. Jack made Six Sigma a way of life at GE by providing employees with incentives for deploying Six Sigma. In addition to showing strong management support, this calmed employees who had a fear of cultural change. Similarly, when Ford Motor Company decided to deploy Six Sigma, its top management was trained first on Six Sigma quality to provide a top-down level of support. Therefore, we can conclude that management support, serving to alleviate fear of cultural change, is a vital role in Six Sigma deployment. Furthermore, many small companies stated that the cost barrier of implementing Six Sigma served as a challenge in deploying the quality tool. However, many of the companies did not let these challenges halt their Six Sigma deployment.

Through this study it was found that small companies are not afraid to place their resources (money, time and employees) into Six Sigma. Regardless of size, many companies are embracing quality improvements that ultimately result in increased profitability. However, small companies at times may be limited in their resources as compared to large companies. For example, GE devotes full-time positions to lead teams on quality management. Smaller companies typically, do not have the financial or staffing resources to support Six Sigma initiatives full-time. Therefore they often rely on mid-level management leading projects.

5.6 VALIDATION OF RESULTS

Initially, this study focused on Six Sigma at small manufacturing companies in Pittsburgh, Pennsylvania. Through this research the author was exposed to various quality professionals in the Pittsburgh region. Becky Deiter was one of these quality professionals. She developed the Six Sigma training material for Catalyst Connections in Pittsburgh, Pennsylvania. Catalyst Connections is a company focused on advancing the performance of manufacturing and technology based companies throughout southwestern Pennsylvania. In doing this research it was necessary to validate the results with a trained Six Sigma quality professional. Becky Deiter was chosen based on her extensive background in Six Sigma. Becky has been working in Six Sigma quality extensively, for the past five years.

In early conversations with Becky Deiter she cited that there was not a large demand for Six Sigma at small manufacturing companies in the Pittsburgh region. She thought that this was due to the lack of QS9000 automotive and aerospace companies in the region. Therefore, she projected that there would be limited information on Six Sigma for smaller companies in the Pittsburgh region. This hypothesis was correct given the small number of respondents. It also lead to an expansion of the study beyond the Pittsburgh based companies. After the completion of the study, the results and conclusions of the study were sent to Becky for examination. After which, a phone interview was conducted to obtain her assessment of the results.

Becky agreed with the findings of the study. She stated “Six Sigma has transformed quite a bit, from the early days of very expensive training to now where training can be very inexpensive.”

Finally, Becky felt as though the Pittsburgh region was “begging for heavy Six Sigma implementation.” Becky suggested that since there is a limited amount of large manufacturing companies in the Pittsburgh region there is a limited push for Six Sigma at the smaller companies who are usually their suppliers. She cited an example such as Ford Motor Company. Since many of Ford’s suppliers are in the Ohio and Michigan region, there are more small company suppliers in this region than other areas in the country. These small companies provide a potential population of cases for future data collection on this subject. In Becky’s words, “I believe until Six Sigma came along and was embraced as a true way of eliminating waste, many quality tools were in place, however, quality professionals were not taking it seriously.”

6.0 CONCLUSION

Implementing Six Sigma at a company, large or small, must be a company-wide initiative. All companies can save money by reducing the causes of defects in products and improving sales through greater customer satisfaction. This is the definition of Six Sigma. Larger companies like GE, Motorola, Honeywell, Caterpillar and Ford have the resources to implement Six Sigma at full force. However, smaller companies must split their resources between projects and management of tools. Since Six Sigma has become a quality standard, many smaller companies are trying to decide whether or not to implement Six Sigma.

In this research it was found that larger companies also need time to implement Six Sigma before seeing considerable results. Through analysis of Thomas Pyzdek's model and large companies like GE, Motorola, Honeywell, Caterpillar and Ford, we found that there is an apparent learning curve associated with Six Sigma success. The savings a company saw appeared to grow, at least initially, after the company has gained a few years experience with Six Sigma. Also, larger companies were supporting Six Sigma initiatives on a full-time level. Many of these companies had full-time employees devoted specifically to Six Sigma.

This study objectively analyzed the performance (challenges, benefits and cost) of Six Sigma programs at small manufacturing companies in comparison to larger manufacturing companies, to get a clear answer on whether the benefits of Six Sigma really outweigh the costs of Six Sigma. The motivation for this research was based in part on the improved popularity of the Six Sigma quality tool at larger companies, and the increasing pressure from many large companies to their supply base (small manufacturing companies) mandating Six Sigma deployment.

Overall, the data shows that there are benefits and challenges in implementing Six Sigma at small manufacturing companies. However, the study did not present significant differences between the challenges for small companies and large companies. The three most important requirements for successful Six Sigma deployment were found to be management support, cost of implementation and fear of cultural change. These three requirements served as challenges for all companies regardless of size.

The benefits of Six Sigma are great. Companies reported increased profitability and employee and customer satisfaction associated with Six Sigma implementation. Based on the findings of this study, we can conclude that benefits such as trained quality professionals in statistical control, increased profitability, improved employee job satisfaction, and success in quality components are important reasons to deploy Six Sigma.

When analyzing the amount of money and resource spent on Six Sigma at small companies, it was found that there was little difference in the expected savings. Six Sigma projects have the potential to yield at least $150,000 in savings. However, in order to yield this high-end savings, companies need well-trained black belts to lead projects. This is where training becomes important. Large companies like Ford reported spending millions of dollars on Six Sigma training. However, their expected savings was not as high as calculated based on Pyzdek’s (2003a) model. Ford reported an estimated savings from Six Sigma of $1 Billion in 3 years. While Pyzdek's (2003a) model expected a $7.4-$11.9 savings from Six Sigma. This was 71% less savings than expected for a company of that size. The smaller companies reported spending thousands of dollars on Six Sigma. Although, no information was given on the amount saved by these small companies, the author found that the small companies spent less than 1% of its potential savings on Six Sigma per year (based on Pyzdek's model)

Results from quality professionals all around the United States were analyzed in this study. Many respondents remained anonymous making it difficult to understand the demographics of the data collection instrument results. Companies like GE, Motorola and Honeywell reported saving billions of dollars with their Six Sigma initiatives. The formal Six Sigma deployment structure as defined by Pyzdek's (2003a) *Six Sigma Handbook* provided significant financial results in large organizations

A main difference between a small and large company is simply the size of the company. From the study it was found that small manufacturing companies have the capacity to implement successful Six Sigma programs. However, the size of the company may limit its number of projects. The short term costs for training and the length of time to complete projects may cause more of an impact to small companies than to large companies. However, large and small companies faced similar problems in Six Sigma deployment. In the end larger companies may have had more resource to allocate to resolutions.

7.0 LESSONS LEARNED

There were many lessons learned through this research study and therefore, it was important to include a section on this very subject. Although many companies were contacted, the response rate was low. This may have been due to the method of polling or maybe the way the questions were asked. This brought up the question: What questions should we have asked? Questions such as: What was the amount of revenue from Six Sigma at each company? How much was allotted for Six Sigma per year in training, employee salary and process improvement? What was the industry sector answering the survey? Why were these companies implementing Six Sigma? How much time was allotted for Six Sigma implementation? However, it is important to note that the author wanted the data collection instrument to be as short as possible to maximize rate of response.

Another important subject was better description of size when choosing companies to survey. In hindsight the author should have asked more clearly and specifically for data when it came to the size of the small companies research. There was some confusion on the author’s definition of a small company and what was asked on the data collection instrument.

Through the research it was realized that an online data collection instrument might not have been the best way to maximize response rate. One suggestion was to interview potential respondents with a face-to-face meeting. This would increase the number of response and cut back on follow-up and mailing time.

This section was also created in order to highlight the many accomplishment of this study. Through this study the author was able to gain information from companies on Six Sigma as a business strategy. Information was analyzed on five Fortune 500 companies and their success in Six Sigma deployment. From this information, the author developed a data collection instrument to poll smaller companies on their usage of Six Sigma as a business strategy. The author was able to get positive feedback from some respondents. Some respondents were so interested in the study, that they asked for the survey results and reports be sent to them upon completion of the research. Many of these comments and lessons learned were used as the background for recommendations of future work.

8.0 FUTURE WORK

The results obtained from this study conclude that the benefits of implementing Six Sigma at small manufacturing companies do outweigh the costs. These results were limited by the sample size. Therefore, a future study with the same scope of work and a higher sample size would potentially result in a more decisive conclusion. Future research should consider targeting specific regions in the country highly populated with large manufacturing companies in order to gain more respondents. These regions would likely, have many smaller companies close by who are suppliers to the larger companies. The author also suggests an interview approach when polling respondents. This structured interview could increase the response rate. One of the things that the research lacked was investigating those companies that had not implemented Six Sigma and why they hadn't implemented this quality business strategy at their companies. This would be an interesting area to research in order to gain understanding on why some companies decide not to take on the implementation of Six Sigma.

Another recommendation for future work is to better quantify the benefits of Six Sigma at small companies. This could include the request of data on annual Six Sigma savings as well as the annual revenue of each small company. Annual reports from large companies could serve as comparison to financial data received from small companies. Many of the smaller companies and larger companies needed more time in Six Sigma in order to sustain valuable results. This was seen in companies such as Motorola who deployed Six Sigma for over 16 years. The issue of evolution would be a key area to research for future work.

A greater emphasis on the various staffing levels in Six Sigma would be another area to research in the future. As suggested by Becky Dieter, the study could be extended to include yellow belts and champions. Yellow belts have become an important part of the Six Sigma training world. Limited information was discussed in the study concerning the importance of champions and yellow belts in Six Sigma deployment.

One can hypothesize that the respondents who were spending the most money on Six Sigma were the ones who agreed that Six Sigma was improving customer profitability at their company. This hypothesis is based on an examination of the results from Question #4 (Figure 9), where 32% of the respondents were spending more than $50K a year on Six Sigma. In order to prove this hypothesis, it would be necessary to extend this research to this area.

More information should also be gathered on the amount of money spent on Six Sigma at small companies. It would be necessary to examine why the amount spent on Six Sigma at these small companies was so low. Could this be because many of the respondents' only included training costs not salary costs in their estimates? Or was it possibly because the small manufacturing companies studied pursued Six Sigma part-time as opposed to the full-time pursuit by larger manufacturing companies?

Other types of industries should be included in the scope of the study for future work. The analysis could focus on the benefits of Six Sigma based on different industries such as service, manufacturing and even technology. There should also be an emphasis on the amount of information collected from each company. This should include gathering annual data on companies for an estimate of the learning curve associated with savings. It would be important to define the types of projects tackled by the smaller companies and the exact amount of projects each company was pursuing per year. This also brought about the realization that future research could examine those companies that have not implemented Six Sigma and why they haven't moved towards this business strategy.

APPENDIX A

SURVEY LETTER

Dear Quality Professional:

This study is being conducted by the University of Pittsburgh, Department of Industrial Engineering by a graduate student named Yewande Adeyemi in order to better understand whether the benefits of Six Sigma outweigh the cost of implementing Six Sigma at small manufacturing companies. This research will help me in determining how Six Sigma can be beneficial to small manufacturing companies. At the completion of the study, I plan to distribute results that focus on the quantitative benefits of Six Sigma based on the data provided by respondents.

I would greatly appreciate your completing this short online data collection instrument. It should take only 10 minutes to complete. Since the validity of the results depended on obtaining a higher response rate, your participation is crucial to the success of this study**.** Your completion of this data collection instrument indicates your consent to participate in this study. Please be assured that your responses will be held in the strictest confidence, and will only be used for research purposes. As soon as I receive your completed responses, your information will be tabulated and analyzed to aid in determining the benefits and costs of Six Sigma. If the results of this study were to be written for publication, no identifying information will be used.

The potential benefits to you from participating in the study are to get an outside perspective on Six Sigma at your company. In addition, the study may be helpful to increase your understanding of what quantitative benefits and costs are associated with Six Sigma at your company. Respondents will have the opportunity to receive feedback regarding the study results by requesting copies of the finalized data tabulations.

Contact information.
If you have any questions about this study, feel free to contact me at:

Miss Yewande Adeyemi
Department of Industrial Engineering
1048 Benedum Hall
Pittsburgh, PA 15261
(412)-624-9830 (office)
(412)-624-9831 (fax)
yeast@pitt.edu

Thank you for your participation,
Yewande Adeyemi

APPENDIX B

DATA COLLECTION INSTRUMENT

SIX SIGMA AT SMALL MANUFACTURING COMPANIES

1. Approximately, How many employees does your company staff?

___ 1-100

___ 101-500

___ 501-1000

___ 1000+

___ Other (please specify)

2. The American Society for Quality (ASQ) defines Six Sigma as a method to eliminate waste and to mistake proof the process that create value for customers. Does your company employ Six Sigma based on this definition?

___ Yes

___ No

3. Does your company use any of these components in its daily operation? (If you answer "no " to 3 or more, please discontinue the survey).

	Yes	No	I don't know
Continuous Improvement	__	__	__
Process Design/ Redesign	__	__	__
Analysis of Variance	__	__	__
Balanced Scorecards	__	__	__
Voice of the Customer	__	__	__
Creative Thinking	__	__	__
Design of Experiments	__	__	__
Process Management	__	__	__
Statistical Process Control	__	__	__

4. Annually, about how much money is spent on Six Sigma at your company?

___ $0-$5K
___ $5-$10K
___ $10-$20K
___ $20-$50K
___ More than $50K

Comments:

____
____
____

5. How is Six Sigma Training provided at your company? Note: Points that you may wish to elaborate on include: -Internal vs. External Training -Who is being trained? -Length of Training, etc. (Open-Ended Question)

____
____
____
____

6. Rate how each of these "components" contribute to the success of Six Sigma at your company:

	High	Medium	Low	N/A
Continuous Improvement	__	__	__	__
Process Design/ Redesign	__	__	__	__
Analysis of Variance	__	__	__	__
Balanced Scorecards	__	__	__	__
Voice of the Customer	__	__	__	__
Creative Thinking	__	__	__	__
Design of Experiments	__	__	__	__
Process Management	__	__	__	__
Statistical Process Control	__	__	__	__

7. What would you consider to be the biggest challenge of implementing Six Sigma at your company? (Open-Ended Question)

____
____
____
____

8. How many employees of each level of training are at your company?

	1	2	3	4	5	6	7	8	9	10	>10	N/A
Green belt	_	_	_	_	_	_	_	_	_	_	_	_
Black belt	_	_	_	_	_	_	_	_	_	_	_	_
Master black belt	_	_	_	_	_	_	_	_	_	_	_	_
Champion	_	_	_	_	_	_	_	_	_	_	_	_

9. Six Sigma has improved customer satisfaction at my company.

___ Strongly Agree
___ Agree
___ Neutral
___ Disagree
___ Strongly Disagree

10. The benefits of Six Sigma outweigh the costs.
___ Strongly Agree
___ Agree
___ Neutral
___ Disagree
___ Strongly Disagree

11. Six Sigma has improved my company's profitability.
___ Strongly Agree
___ Agree
___ Neutral
___ Disagree
___ Strongly Disagree

12. Six Sigma has improved employee job satisfaction at my company.

___ Strongly Agree
___ Agree
___ Neutral
___ Disagree
___ Strongly Disagree

13. May we contact you if follow-up information is necessary?
___ Yes
___ No

14. Contact Information:

____
____
____
____
____

15. Comments or Concerns:

____
____
____
____
____

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