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Evaluating Six Sigma Implementation Effectiveness through Statistical Process Control

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Abstract

Six Sigma is a widely implemented methodology that utilizes common quality management techniques. It has been described as a way to improve company processes and overall company performance by reducing variation at the detailed level. The main reason for a company to utilize this methodology is to drive improvement in the company's revenue. Generally, a company's closing stock prices indicate the up-to-date accomplishments and financial status of the company. Lately, a company's stock price has been identified and used as a valid indicator of Six Sigma's success in a company. With this assumption, this study investigates companies that implemented Six Sigma by identifying successful and unsuccessful companies using the stock price information. In addition, the statistical process control method is employed to find if Six Sigma has improved consistency and reduced variation of stock prices of companies after its implementation. Key success factors for Six Sigma implementation has been identified from various literature sources and was related and compared to the success or failure of identified companies. The success factors also reveal the importance of leadership in the in the successful implantation of Six Sigma in companies.

Keywords: Organizational Performance, Six Sigma, Statistical Process Control, Stock Levels, Successful Companies, Total Quality Management

1. Introduction

The economic success of any organization is measured by their net profit. Organizations seek innovative approaches for continuously improving their product

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and service quality to survive in the global competitive market (Kumar, Antony, Madu, Montgomery, and Park, 2008). In order to yield higher levels of profitability and organizational performance, various techniques such as zero defects, quality circles, total quality management (TQM), and business process re-engineering (BPR) have been widely implemented (Jarell and Easton, 1997). These techniques have their own uniqueness in terms of the development of construct, research methodology, quality management treatment as single or multiple constructs, performance measurement in one level or multiple levels, and data analysis. These differences in techniques have led to mixed results in the correlation of quality management and the organization's performance (Ittner and Larker, 1977; Kaynak, 2003; Molina, Llorens-Montes, and Ruiz-Moreno, 2007).

1.1 Six Sigma Methodology and Impacts on Organizational Performance

Six Sigma is a popular management methodology that encompasses both management and technical components in a standardized framework of Define-Measure-Analyze-Improve-Control (DMAIC) for process and product improvement (Snee, 2000). Due its successful implementation in major companies in more than two decades, the benefit of Six Sigma is very well documented (Kumar, Antony, Madu, Montgomery, and Park, 2008). The explicit objective is the key success in a Six Sigma project. Six Sigma explicitly states that it enhances the 'sigma level' of performance measures that reflect customer needs and requirements. This objective yields the ultimate reduction in process variation through sustained effort (Harry, 1998; Hahn, Hill, Hoerl, and Zinkgraf, 1999). Other quality improvement efforts that are similar to Six Sigma such as the quality awards, quality certification, and other quality initiatives on the stock prices have been published as well (Goh, Low, Tsui, and Xie, 2003; Przasnyski and Tai, 1999). Likewise, the response in stock price returns for Total Quality Management companies has been extensively studied (Hendrics and Singhal, 1996; Adams, McQueen, and Seawright, 1999; Jarell and Easton, 1997). Wilson (2004) addresses the quantitative benefits of the ISO 9000 and the Baldrige awards. He evaluated the financial data of organizations with ISO 9000 and found that the costs were greater than the benefits.

Further investigation of stock performance of organizations were also performed with Baldrige award winners, but were reported to be inaccurate due to too small of a sample size (Wilson, 2004).

Published literatures illustrate that Six Sigma led to financial gain in Fortune 200 Companies (Lucier and Seshadri, 2001; Goh, Low, Tsui, and Xie, 2003; Hammer, 2002; Harry, 1998.) Key metrics that were considered in the research are return on equity (ROE), earning per share (EPS), Private Equity (PE) return, and total return price (TRP). Even with all of the hype in successful Six Sigma implementations, a recent publication (Chakravorty, 2010) reported that 60% of all corporate Six Sigma companies were unsuccessful in the implementation of Six Sigma.

1.2 Critical factors for Quality Implementation

Bullington, Easley, and Greenwood (2002) developed a genesis-maintenance framework to understand the critical success factors in the initiation and maintenance phases of quality improvement processes. The theory of genesis-maintenance classifies the critical success factors into early success factors versus maintained success factors. There are some factors that happen to be detrimental to success. In a similar fashion, the framework used in this paper focuses on whether there are factors that contribute to the success or failure of Six Sigma in an organization. By studying organizations that have been successful and continue to be successful in their use of Six Sigma processes, the critical success factors can be identified and the proper emphasis of these factors can be determined. The critical success factors identified during research are management commitment, customer focus, quality culture, supplier relationships, and the other factors listed in Exhibit 5.

Hirtz, Murray, and Riordan (2007) report a lack of literature on the importance of leadership on quality advocated by Deming and Juran for successful quality management. Further investigation by the authors on the correlation between leadership style and perceived level of quality management revealed that transformational leadership is positively related to the successful implementation of quality management in administrative/service area, and passive styles of leadership negatively impact efforts to implement quality management.

Published articles on the critical factors for Six Sigma implementations identified that the most important factor is the establishment of the relation between a Six Sigma project and the organization's business strategy (Antony and Banuelas, 2002.) The critical success factor concept, first introduced by Daniel in 1961 and refined by Rockart in 1979, identifies the factors which ensure successful organizational performance to an organization's goals.

Critical factors defined during research include management involvement and commitment, cultural change communication, organizational infrastructure and training, poor quality, unhealthy labor environment, lack of coherent brand identities, and adverse supplier relations (Antony and Banuelas, 2002; Breyfogle III, 2003).

2.Problem Statement and Objectives

Research has been done to study the impact of Six Sigma on stock performance (Goh, Low, Tsui, and Xie, 2003). In Goh et all paper, Six Sigma's impact on stock performance was evaluated on two different studies. One is stock prices' reaction on the day when Six Sigma activities are made publicly and the second is the long run stock performance of Six Sigma companies. The authors in Goh et. all paper state that "If profit and market share are generated from a Six Sigma program, increase in stock prices should be realized in long term". Also they state "As stock values are one of the direct financial performance indicators, it would be useful to understand the impact of Six Sigma on the wealth of shareholder and the behavior of stock prices in the short and long run." (Goh, Low, Tsui, and Xie, 2003).

Another demonstration that stock performance can be used as a valid indicator to assess the impact of Six Sigma in an organization is the study conducted by QualPro, which compared the stock performance of companies that implemented Six Sigma with the performance of the Standard and Poor's 500 stock index. (Richardson, 2007)

Earlier researchers have determined that Six Sigma affects the company stock performance. As a research aim for this study, we seek to address the lack of effective methodology for evaluating Six Sigma organizations by going further in detail to analyze the company performance with the use of companies' financial reports before and after the Six Sigma implementation.

The primary objective of this study is to classify companies into a high or low performance categorization using the historical stock information of chosen Six Sigma companies. Then four companies consisting of two pairs, each consisting of a high performing and low performing company are analyzed in depth for their successes and failures respectively. The Statistical Process Control (SPC) method is employed to find the stock consistency of the companies after Six Sigma implementation and also if there are any variation in stock performance over time.

The SPC method is employed to further support the claim that the Six Sigma implementation had an effect on stock performance by reducing variation and has seen consistent improvement over time. Meanwhile, critical success factors for Six Sigma implementation are found from the literature and are compared with the four companies to check if the factors influence the Six Sigma success or failure in the companies.

3. Methodology

This research was performed in four phases: Phase 1 was the identification of Six Sigma companies, Phase 2 was the economic analysis and manipulation of historical stock information, Phase 3 was the evaluation and categorizing of high and low performing organizations and defining critical success factors for companies that successfully implemented and maintained Six Sigma and Phase 4 is the analysis of SPC charts to determine if stock variation reduced or did not reduce for each high and low performing organization.

3.1 Phase 1: Identification of Six Sigma Companies

In this phase, 65 Fortune 500 companies were selected from different industrial sectors including finance, healthcare, conglomerates, technology, services, basic materials, consumer goods, and industrial goods. The Six Sigma implementation dates and the stock performance from 5 years prior to the implementation and 10 years after implementation were collected. Due to challenges in retrieving the stock performance data prior to Six Sigma implementation, the list was reduced to 43 companies.

3.2 Phase 2: Economical Analysis of Six Sigma Companies

One of the methods to establish average minimum attractive rate of return (MARR) is to use the rate of return actually achieved over past particular number of years (White, Case, and Pratt 237,278-295). The financial performances of the 43 companies selected in Phase 1 were evaluated by calculating the future value using the MARR while taking into consideration the inflation rate for these time periods. An initial investment of $1,000 five years before the Six Sigma implementation and a second investment of $1,000 during the year of Six Sigma implementation were assumed.

Inflation rates were included in the future value calculations using average MARR. The rate of return was calculated as a log ratio between the closing price of the stock on the last day of the year and the closing price of the stock on the first day of the year: ("faculty.washington.edu"; Ultsch 505-511).

$$R = \ln \frac{P_1}{P_0} \ldots\ldots\ldots\ldots (1)$$

Where:

R= Rate of return per year;
P_1=Closing price of stock on the last day of the year;
P_0= Closing Price of the stock on the first day of the year.

The rate of return for every year was calculated using equation (1). The average rate of return was calculated over: (a) five years before Six Sigma implementation, (b) five years after Six Sigma implementation, and (c) ten years after Six Sigma implementation. Similarly, an average inflation rate was calculated over a 15 year period and to compute the future values. The inflation data was taken from Tim McMahon's "Inflationdata.com". We compute the performance of a company by calculating its future values using Hartman's FW using (1) average MARR and (2) average inflation rates (2007).

$$F = P * e^{(r*N)} \ldots\ldots\ldots\ldots (2)$$

Where:

F = Future value of the investment;
P = Present Value of the investment;
r = Rate (MARR or Inflation Rate)
N = Number of years

The difference between the future value due to the expected actual rate of return and future value due to inflation would provide us an approximate profit or loss incurred by the company due to Six Sigma implementation.

$$FV_{realreturn} - FV_{onlyinflation} = actualprofit \ldots\ldots\ldots\ldots (3)$$

The difference (Δ) between the profit/loss incurred 5 years before Six Sigma implementation and the profit/loss incurred after 10 years of implementation would illustrate the company's performance due to Six Sigma implemented. The difference in profits was the basis for our classification of companies into high and low performing companies. The companies were classified within each sector due to limitation in the data availability.

3.3 Phase 3: Evaluating and Comparing the Practices of High and Low Performing Companies

The success factors for Six Sigma implementation have been elaborately discussed in many sources including journal articles, research white papers, newspaper articles, blogs, industrial magazines, etc. For this research we considered 9 sources which included journal articles, conference proceedings, websites, weblogs, company's annual report, trade magazines, white papers, newspaper articles, and books. A total of 24 factors were identified to contribute for Six Sigma implementation as shown in table 5. From these 24 factors, only the factors that appeared in at least 60% on the 9 sources were selected as critical success factors. This yielded six success factors, as shown in table 6.

Upon evaluation of the finalized companies, it was determined that it would be more appropriate to compare company performances sector-wise. Two pairs of industries were studied, each consisting of a high performing and a low performing company. The high and low performing label was determined based on the change in value for the 15 year period that included 5 years before implementation and 10 years after implementation.

Then the high performing companies from each sector were selected as seen in exhibit 3 and the low performing companies from each sector were selected as seen in exhibit 4. The factors exhibited by the successful, high performing companies and the factors displayed by unsuccessful, low performing companies which failed to implement Six Sigma were examined in order to determine which of these factors had a strong correlation to success or failure.

Sources were obtained to study the Six Sigma implementation on these companies. The first pair of companies was classified under Conglomerate industry with Dow Chemical as the high performing company and 3M as the low performing company.

We read five articles which supported the implementation of Six Sigma at Dow Chemical and 6 articles to critique Six Sigma implementation at 3M.The other pair of companies belonged to the service industry. Quest Diagnostics was identified as a high performing company and Cigna as a low performing company. Three articles were identified for each of these companies to support their success and failure at implementing Six Sigma.

All of the articles related to the high performing companies were examined to determine if the companies met any of the six success factors. Similarly, a study was conducted for the low performing companies. Furthermore, it was investigated as to whether or not the low performing companies met any of the success factors. On the basis on this study, it defined which factors were associated with a company becoming closer to successfully implementing Six Sigma initiatives.

The success and failures of the high and low performing Six Sigma companies can be accounted for several different reasons. Goh (2010) noted the 6 triumphs and tragedies of Six Sigma. The triumphs: The use of a common, realistic metric for quality assessment and improvement, clear assignment of roles and responsibilities in performance improvement efforts, logical alignment of statistical tools, recognition of the time effects on processes, unprecedented synergy with modern information technology, and capabilities to grow for larger roles for business competitiveness. The tragedies: the belief that Six Sigma is universally applicable, obsession with personal attainments, the idea that professional statisticians are no longer needed, irresponsible hype of Six Sigma, a bigoted "In Data We Trust" mentality, and ignorance or neglect of what is important beyond DMAIC (Goh, 2010). Any number of these can be the reasoning for the Six Sigma companies' studies success or failures.

3.4 Phase 4: Statistical Analysis of high and low Performing Six Sigma Companies

Once the high and low performing companies were determined, yearly closing stock prices for each company was retrieved from Yahoo! Financial. Using chart run rules, notably used by the National Aeronautics and Space Administration, the SPC charts for each high and low company can be analyzed for variation and if the implementation of Six Sigma increased stock consistency.

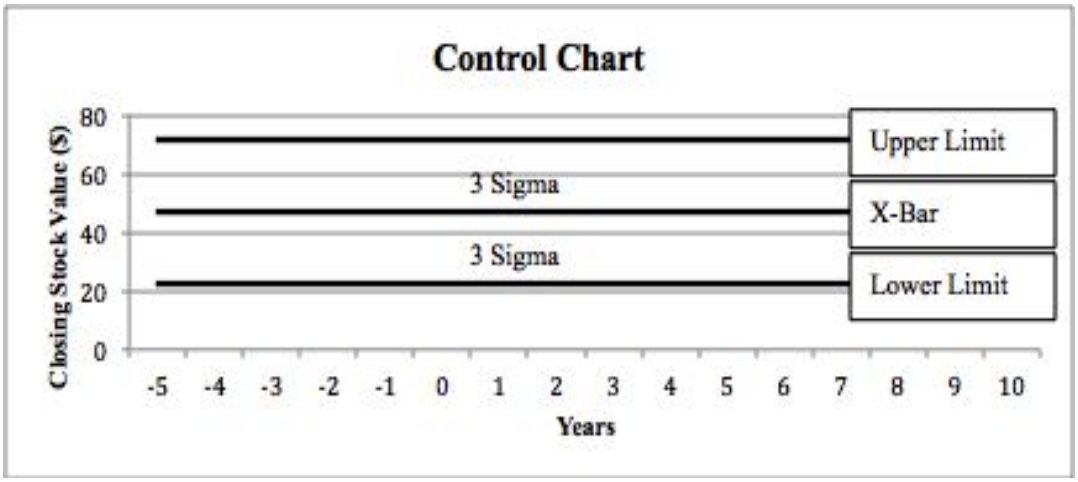

Figure 1: Yearly Stock Value Control Chart

Statistical Process Control charts use basic variables like average and range to determine if a system is within the allowed variation range. Based on the obtained data from the high and low performing organizations, an upper (4), lower (5), and x-bar value is calculated. These boundaries are used as reference for all high and low performing Six Sigma companies to provide a consistent variation comparison for all companies studied.

$UCL = X_{GA} + A_2 R_A$..... (4)

Where:

UCL = Upper Control Limit;
X_{GA} = Grand Average of Closing Stock Prices for all High/Low Organizations;
A_2= Control Chart Constant (.308);
R_A=Average Range for all High/Low Organizations;

$LCL = X_{GA} - A_2 R_A$..... (5)

Where:
LCL = Lower Control Limit;

4. Results

4.1 Phase 1: Identification of Six Sigma Companies

S.NO	Finalized Companies	Implementation Date
Sector 1	**Financial**	
1	BANK OF AMERICA	2001
2	AMERICAN EXPRESS	1999
3	AON	2002
4	CITIGROUP	1997
5	J.P.MORGAN CHASE	1998
Sector 2	**Health care**	
6	COVENTRY HEALTH CARE	2003
7	CIGNA	2003
8	COVANCE	2002
9	QUEST DIAGNOSTICS	2001
Sector 3	**Conglomerates**	
10	3M	2003
11	DOW CHEMICALS	1999
Sector 4	**Basic Materials**	
12	CHEVRON	2000
13	CONOCO PHILLIPS	2000
Section 5	**Consumer Goods**	
14	FORD	1999
15	JOHNSON CONTROL	1999
16	TENNECO AUTOMOTIVE	2001
17	WHIRLPOOL	1997
18	XEROX	2003
Sector 6	**Technology**	
19	CORNING	1994
20	DELL	2000
21	EMC GROUP	2000
22	HP	1994
23	IBM	1990
24	MICROSOFT	2004
25	PLEXUS	2002
26	TEXAS INSTRUMENTS	1993
Sector 7	**Services**	
27	BEST BUY	2003
28	CARDINAL HEALTH	1990s
29	FED EX	2006
30	HOME DEPOT	2001
31	MACY'S	2001
32	MCKESSON	1999
33	STARWOOD HOTELS	2001
34	TARGET	2003
35	UPS	2003
36	WAL-MART	2006
Sector 8	**Industrial Goods**	
37	BOEING	1999
38	GENERAL CABLE	2002
39	GENRAL ELECTRIC	1995
40	HONEYWELL	2000
41	RAYTHEON	1999
42	TEREX	2001
43	TEXTRON	2002

Table 1: List of Six Sigma Companies by Sector and Implementation

4.2 Phase 2: Economical Analysis of Six Sigma Companies

Table 2 shows the sample calculation of the financial performance of Dow Chemical. From the calculations the difference (Δ) is increasing within 5 years of Six Sigma implementation. However, the sustainability based on Six Sigma implementation is decreasing after 10 years even though it is positive. This warrants further investigation based on financial metrics. Tables 3 and 4 summarize the list of high and low performing companies. It should be noted that based on this information a company such as Home

	Rate of Returns for Dow Chemicals			FV (R)%	FV (r)%	Profit due to Six Sigma	% Profit/ Loss
	Year	MARR(R)%	Inflation (r)%				
	1994	17.41%	2.61%				
	1995	5.66%	2.81%				
	1996	9.70%	2.93%				
	1997	25.37%	2.34%				
	1998	-10.24%	1.55%				
5 Year Performance	**1999**	**9.58%**	**2.45%**	**$1,614.72**	**$1,130.21**	**$485**	**($51.55)**
Six Sigma Implementation	1999	39.65%	2.19%				
	2000	-128.76%	3.38%				
	2001	-3.00%	2.83%				
	2002	353.19%	1.59%				
	2003	31.09%	2.27%				
Avg. 5 Year Performance	**2001**	**58.13%**	**2.45%**	**$18,573.90**	**$1,130.43**	**$17,443.47**	**$1,641.35**
	2004	18.54%	2.68%				
	2005	-12.10%	3.39%				
	2006	-9.37%	3.24%				
	2007	-1.21%	2.85%				
	2008	-94.30%	3.85%				
Avg. 10 Year Performance	**2008**	**19.37%**	**2.83%**	**$6,939.33**	**$1,326.71**	**$5,612.62**	**$461.26**

Table 2: Sample Calculation of Economic Metric for DOW Chemicals

S. No	High Performing	Stock Value 5 Years Before Implementation	Future Value 5 Years After Implementation	Future Value 10 Years After Implementation	Delta (Δ)
1	GENRAL CABLE	1352.3686	1399.872	39094.43	37742.07
2	TENNECO AUTOMOTIVE	-207.4446	344.7258	760.2807	967.7253
3	CARDINAL HEALTH CARE	-	190.3228	780.463	590.1402
4	DOW CHEMICALS	-51.5484	1644.347	461.2619	512.8103
5	TEXAS INSTRUMENTS	-85.6872	245.3067	301.6357	387.3229
6	J.P.MORGAN CHASE	72.765	34.8286	194.0062	121.2412
7	QUEST DIAGNOSTICS	-136.37	172.0623	42.0723	178.4424
8	CONOCO PHILLIPS	-66.2698	-25.4848	-12.64	53.6298

Table 3: High Performing Six Sigma Companies

Depot can be low performing but still provide a favorable rate of return while a company such as Conoco Phillips can be high performing and provide an unfavorable rate of return. The basis for these comparisons is on the 15 year period that starts 5 years before Six Sigma implementation and concludes 10 years after Six Sigma implementation for each company, listed in the exhibits under the heading of Delta (Δ).

S. No	Low Performing	Stock Value 5 Years Before Implementation	Future Value 5 Years After Implementation	Future Value 10 Years After Implementation	Delta (Δ)
1	HONEYWELL	105103	-148.43	-158.9	-10669.2
2	DELL	7777.413	-135.59	-203.7	-7976.11
3	HOME DEPOT	4282.066	3790.92	3217.82	-1064.25
4	CITI GROUP	778.6114	-62.37	-95.09	-873.7
5	CIGNA	742.8669	43.75	-66.23	-809.09
6	3M	21.4058	-147.28	-126.9	-148.31
7	CHEVRON	-22.6943	-91.77	-51.47	-28.78
8	FORD	65.0819	-171.94	-226.73	-291.81

Table 4: Low Performing Six Sigma Companies

4.3 Phase 3: Evaluating and Comparing the Practices of High and low Performing Companies

Table 5 summarizes the success factors for Six Sigma implementation from the different sources.

These are the factors that were found in companies that had successfully implemented Six Sigma. It is believed that all of these factors tie to a company's leadership and that leadership's effectiveness in deploying policy.

Table 6 provides the critical success factors for Six Sigma implementation. The success and failure of a Six Sigma implementation on the basis of these critical factors is explained with an example of a high performing and a low performing company.

Dow Chemicals is rated in Exhibit 3 as a high performing company. Dow has a customer centric Six Sigma philosophy (Marx, 2005). As taken from the Supply Chain Management Review, Tom Gurd, then a global supply chain director at Dow, remarked on their Six Sigma initiative suggesting that the company made an effort to thoroughly train its employees in the Six Sigma philosophy (Marx, 2005). Gurd mentioned that almost 60% of Dow's employees were exposed to Lean/Six Sigma concepts (Schlegel and Smith, 2005).

Success Factors	a1	a2	a3	a4	a5	a6	a7	a8	a9
Active involvement from the management	X	X	X	X	X	X	X	X	X
Acceptance to Change/culture	X		X	X	X			X	
Effective Communication	X				X	X	X	X	X
Organization structure	X				X			X	
Effective Training/Right people	X	X	X			X		X	X
Linking Six Sigma to the business objective/goals	X	X	X		X		X		X
Linking Six Sigma with other management tools/Not a stand alone	X							X	
Expand the initiative enterprise wide	X	X					X		
Link Six Sigma to customer	X				X			X	X
Link Six Sigma outside the company/Suppliers	X	X			X		X		
Lack of understanding of tools and techniques	X				X				X
Selecting right Six Sigma projects			X		X	X			X
Awareness of management skills	X					X			
Awareness through Awards/Recognition/Incentives		X		X	X				
Develop leadership knowledge		X		X	X	X			X
Maximum Utilization of resources			X		X	X		X	
Scope not too large/too high expectations (in a small time frame)			X	X			X		X
Good Data/Enough Data			X		X	X			X
Motivation (worker motivation)				X			X	X	

Table 5: Success Factors Determined by Various Factors

It is believed that this highlights the efforts of Dow Chemical to expand their Six Sigma campaign to an enterprise-wide endeavor, which represents one of the most important factors for the success of a Six Sigma implementation.

Case studies at Dow Chemical explain that their implementations of Six Sigma projects utilize the MAIC (Measure, Analyze, Improve, Control) methodology instead of the standard DMAIC template (Tannenbaum, 2003). In another case study, Dow's vision of Six Sigma's importance to the company is exemplified in their communications from the corporate level to their employees and customers. Their customer-driven attitude and acceptance of change culturally and organizationally reinforces the company leadership's commitment to the methodology (Tannenbaum, 2003).

Where Dow Chemicals has been an example of the positive changes possible with Six Sigma, the implementation of Six Sigma at 3M has never been smooth. The company is known for its innovation and creativity linked to its products. When James McNerney was announced as the CEO in December 2000, the company's stock improved nearly 20%. Under his vision, Six Sigma was implemented with an aim to lower costs and increase efficiencies. Thousands of employees were trained in the Six Sigma methodologies with a focus on customer satisfaction and leadership development.

However, the company known for its innovation and creativity struggled when McNerney left as the Six Sigma implementation lacked balance between efficiency and innovation and was soon reduced in the laboratories and in R&D. Too much discipline had ceased the creativity in the employees. The Six Sigma implementation was scrutinized for the lack of innovative sizzle in 3M's research labs (Hindo, 2007). 3M's failure in achieving success with Six Sigma is indicative of companies that have experienced changeover in management. As is often the case, once McNerney was replaced, the company's emphasis changed based on a new CEO and the direction that they wanted to take the company.

1	Active involvement from the management
2	Acceptance to change/culture
3	Effective Communication
4	Effective Training/Right People
5	Linking Six Sigma to business goals/objectives
6	Developing leadership knowledge

Table 6: Key Leadership Factors

The companies considered were classified under two industries: Conglomerate and Service. Dow Chemicals and Quest Diagnostics were identified to be high performing companies in each of their respective industries and 3M and Cigna were identified to be low performing companies in their respective industry sector.

From the literature, we identified that both Dow Chemical and 3M observed all six factors important for Six Sigma implementation. However, in the service industry, Quest Diagnostics observed all six factors while Cigna failed to observe four out of the six. The difference in the adoption of success factors across different industries allows investigation into other factors in addition to the critical success factors that contribute to Six Sigma initiatives. Further investigation of the literature revealed these factors which are summarized in Table 7.

1	NO Change in CEO during the Six Sigma initiative
2	Areas of application
3	Avoiding aggressive application of Six Sigma
4	Appointing a separate infrastructure and body to support quality in the company
5	Encouraging team work
6	Global documentation
7	Continued Commitment

Table 7: Critical Factors for Six Sigma Success

From these seven factors, the following five factors were reported in at least 60% of the literature. 1) No change in CEO during the Six Sigma initiative, 2) Identifying the right areas for implementing Six Sigma, 3) Appointing a separate infrastructure/body to support Quality programs in the company, 4) Encouraging team work, and most importantly, 5) Continued commitment to a achieve a successful Six Sigma initiative.

From the five factors critical to the Six Sigma implementation, failure to follow two factors led to unsuccessful Six Sigma initiative in the low performing companies. The failure factors were: 1) Change in CEO during the Six Sigma initiative, and 2) Identifying wrong areas of application for Six Sigma implementation.

The success of Quest Diagnostics in identifying the use of Six Sigma in health care has been due to a well-documented process over a substantial period of time.

The company's website provides information which confirms that Quest Diagnostics found the right areas/projects in the company where Six Sigma implementation was necessary and proved beneficial (Six Sigma Quality: Six Sigma Quality, 2013). The case studies further support the factor of not implementing Six Sigma as a standalone tool (Our Commitment to Quality and Six Sigma, 2000). An employee at Cigna, in his blog, explains the implementation of Six Sigma in the organization which led to the company's success in initiation and inability to sustain the improvements within a short time (Javinett, 2010).

4.4 Phase 4: Statistical Analysis of High and low Performing Six Sigma Companies

Once we discovered the high and low performing Six Sigma companies based on the MARR economic analysis, SPC charts for each of the high and low companies were developed and analyzed for patterns. The calculated metrics, listed in Table 8 and 9, are the calculated metrics based on the high and low performing Six Sigma companies yearly stock prices 5 years before and 10 years after implementation.

High Performance Mean and Boundaries			
X-Bar	Standard Deviation	Upper Control Limit	Lower Control Limit
46.86352	21.47222	71.6721456	22.0548856

Table 8: Calculated Metrics for High Performing Companies

Low Performance Mean and Boundaries			
X-Bar	Standard Deviation	Upper Control Limit	Lower Control Limit
53.41789	17.5112303	71.6761306	35.1596506

Table 9: Calculated Metrics for Low Performing Companies

With the calculated metrics, individual control charts were developed and referenced for each Six Sigma company. General Cable, as an example, showed low closing stock prices before Six Sigma implementation (year 0) and had a great increase 5 years after. However, large increases and decreases are not necessarily a good or bad event in terms of variation reduction. Based on Six Sigma methodologies, variation reduction is more consistent and better predicted. It is inherently more reliable if a system has a lower, more consistent performance level rather than inconsistent peaks and valleys.

General Cable sees low closing stock prices prior to implementation and a spike 5 years after. After, however the true success of Six Sigma is identifiable after the spike in closing stock price, where the price has less variation and remains in the boundaries of the high performing organizations.

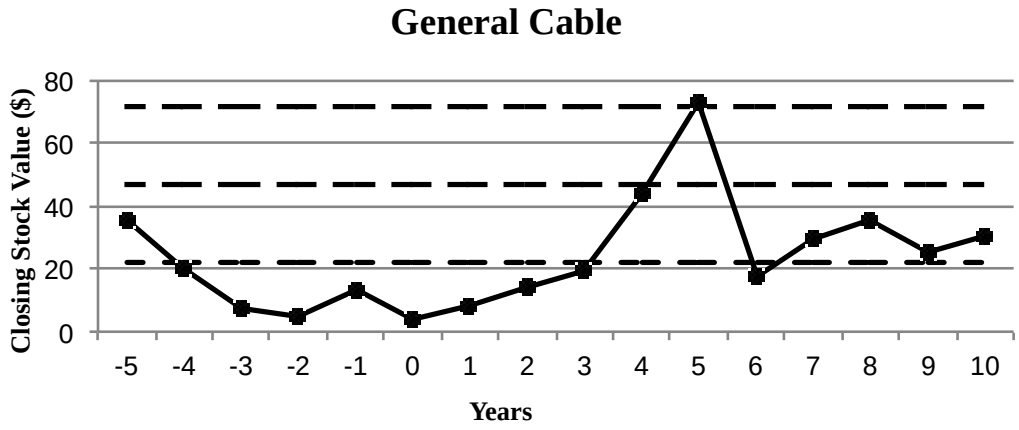

Figure 2: General Cable Control Chart

Another example of a high performing organization is J.P. Morgan Chase. Similarly to General Cable, J.P. Morgan Chase, 5 years prior to implementation, had great inconsistencies with performance. After implementation, the variation greatly reduces and remains with the standard 6 sigma level or quality.

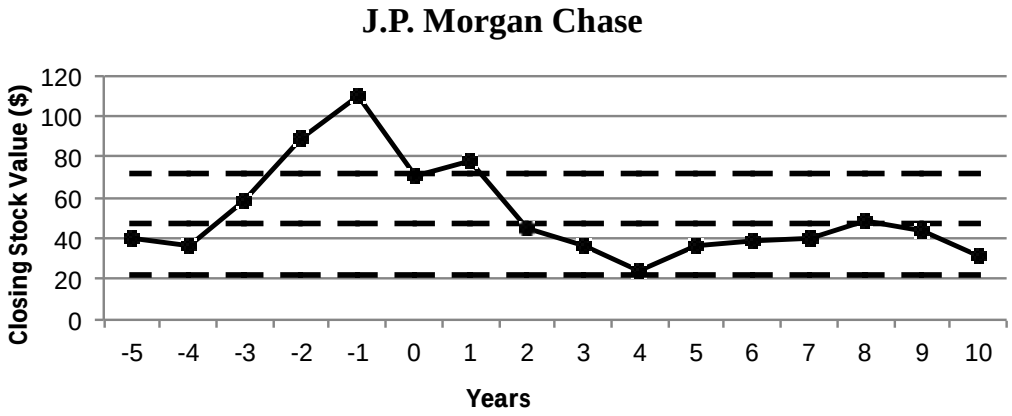

Figure 3: J.P. Morgan Chase Control Chart

In addition to identifying the performance effects of Six Sigma, it can be seen that external events out of control of the company can also affect the closing stock price. J.P. Morgan implemented Six Sigma in 1998 and on the 10th year after, 2008, one of the largest stock market crashes occurred in the history of the US. This shows that even with the event of an industry wide collapse, the fact that J.P. Morgan remained within the control boundaries presents the benefit of consistency developed under effective Six Sigma implementation. With low success Six Sigma companies, variation reduction is visually absent. Even after the implementation of Six Sigma, the level of variability is exceedingly high, representing that Six Sigma is not effectively being used. With the low performing organizations, the chart run rules established by NASA can be identified in most if not all of the SPC charts. For example, Cigna established Six Sigma in 2003. Cigna, in the previous 5 years leading to implementation, saw very high peaks and valleys in the closing stock prices for each year. After Six Sigma establishment, the trend continues and does not reduce like in the high performing organizations.

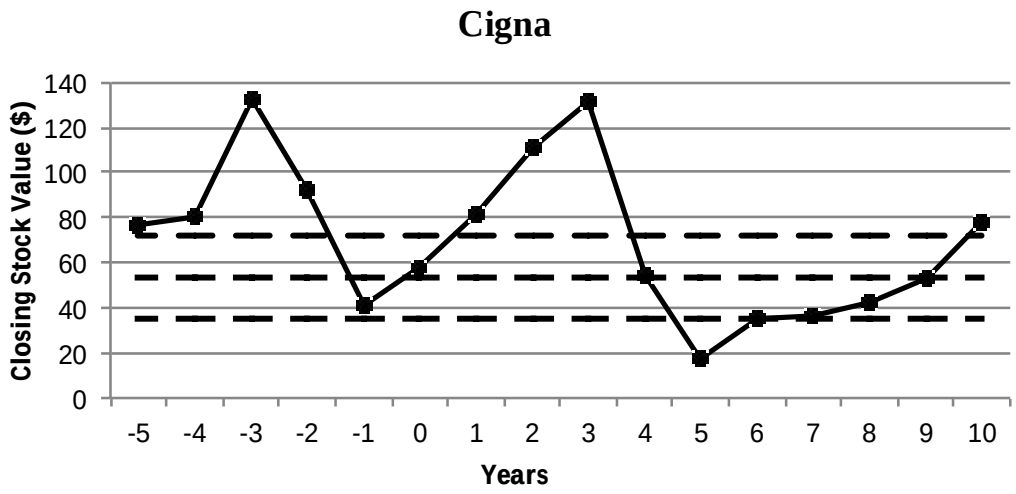

Figure 4: Cigna Control Chart

Another example of breaking the established chart run rules is Chevron. Not as drastic as Cigna, it has a pattern of several peaks and valleys which considers variation not in control, even if it is within the upper and lower limits. Even though the closing stock prices are elevated after the implementation of Six Sigma, the effectiveness of the program is low due to the high variability.

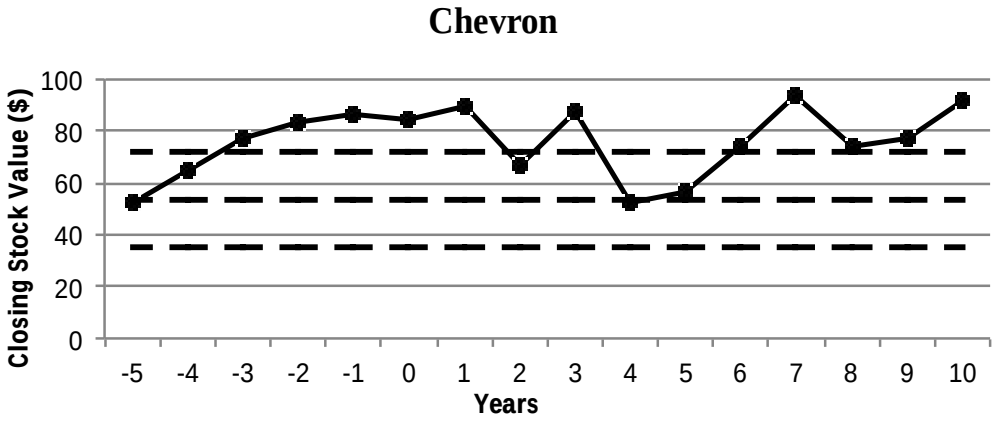

Figure 5: Chevron Control Chart

These are examples of low performing organizations and all of the established low performing Six Sigma companies lacked variation reduction after implementation.

4.5 Management's Perspective on Implementing Six Sigma

One of the main takeaways from this study is that though Six Sigma can be implemented in a company, it may not be best for the company. Six Sigma is a tool just like TQM, JIT, or Lean. It may work in specific instances but on the same token it may not work in all instances.

As has been shown in Table 6, there tended to be six success factors that were found in the literature. Most of these factors tied directly back to management which in essence means that management is a main driver in Six Sigma success. Management has to be active participants in the project. Workers see through the propaganda very easily and if the workers see that management is not engaged then they will assume that the projects are not priority to them. Management also has to be able to communicate well with their employees so that the employees know there is a plan and what their roles are in the plans. This includes training the right workers so that they have the knowledge they need to be successful in their jobs. This training also includes leadership training for the employees. This reinforces the ideal of a plan and is a method for the company to show they are committed to an employee and are investing in the company's future. A lack of any of these activities by management has been identified as a factor for an unsuccessful Six Sigma implementation.

5. Conclusion

The goal of this article is to identify the critical success factors for Six Sigma implementation and establish the use of SPC charts for analyzing Six Sigma organizations. Literature reviews indicated that 3M, known for its innovation and creativity, had challenges with Six Sigma initiatives when their CEO changed. This paper contributes to the body of knowledge by attempting to tie critical success factors of Six Sigma implementation using economic analysis to determine the minimum attractive rate of return. The findings provide the reader an insight to the importance of leadership in Six Sigma implementation. Additionally, the research accomplished suggests that implementing Six Sigma can be directly identified in closing stock values. By applying chart run rules, similar to the ones Six Sigma uses, variation can be determined as reduced or magnified post Six Sigma implementation. Findings from this research show that implementing Six Sigma does not necessarily result in improved stock performances of an organization. Other external factors also contribute significantly to the success of a Six Sigma initiative.

For example, Bank of America and J.P. Morgan Chase both faced an industry wide collapse in 2008 and were greatly affected in terms of stock prices. Because of the correlated fluctuations in price levels in companies within the same industry, a moving average may be considered for use in future studies (de Mast & C. B. Roes, 2004).The major limitation of the study is that size of the companies was not considered in this research which will have ramifications on the current findings. Another limitation of this study is that stock performance alone cannot be a valid indicator for the organization success as identified by this research. Future studies should evaluate other critical parameters including globalization, internal and external loyalty and other qualitative metrics of business operations in addition to the company's leadership qualifications and its correlation with the contributing success factors. Additionally, the study should yield a questionnaire that will allow a manager to determine whether their company is ready to implement Six Sigma and serve as a predictor of Six Sigma implementation success. This will allow the company to determine if they are in the proper conditions for a successful implementation or if they will likely fail during the implementation.

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