

SIX SIGMA, STOCK RETURNS AND OPERATING PERFORMANCE

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Abstract

Since the 1980s, industrial organizations have adopted practices such as Six Sigma to maintain and enhance competitiveness. Six Sigma may reduce agency cost thereby generate a competitive advantage for firms. Also it may be an instrument to managers for signaling quality to their customers and investors. The purpose of this study is to look at the long run stock price and the operating performance of Fortune 500 companies that were identified to have implemented Six Sigma compared to the overall market performance as well as the performance of industry and size matched firms. Even though our sample firms improved several variables after implementing Six Sigma, their operating performances were not quite close to the performances of the matching firms. After implementing Six Sigma, compared to the industry and size matched firms, the only variable that improved out of 14 variables we looked at, is the growth in staff levels. The findings may contribute to understanding the reasons that underlie the so-called jobless recovery.

SIX SIGMA, STOCK RETURNS AND OPERATING PERFORMANCE

Managers are increasingly held accountable for delivering maximum shareholder value while also providing improved relationships with stakeholders, particularly customers. Since the 1980s, industrial organizations have adopted practices such as Six Sigma to maintain and enhance competitiveness. At once, the goals of these systematic programs are greater satisfaction of customer needs and requirements as well as upgraded efficiency through lower costs and enriched product quality. Realization of these goals would lead to larger profits and higher shareholder wealth.

Six Sigma can be viewed as an attempt to communicate organizational attributes to parties, customers and investors, who cannot observe them directly. The purpose of this paper is to examine and analyze long-run stock prices and operating performances of *Fortune* 500 companies that were identified to have implemented Six Sigma versus other companies in their industry. The 2006 *Fortune* 500 is used so that five-year performance metrics can be developed. Companies implement Six Sigma at different levels. The corporate level is an enterprise-wide initiative with corporate commitment and support. The business unit level is deployment and support by a corporate executive or business unit executive. The pilot level is organized and supported as trial initiatives in a selected business unit. The belt level is limited to selected projects organized around personnel who have green belt or black belt certification. In 2006, 108 companies in the *Fortune* 500 were identified, with the initial start date, as they

had implemented Six Sigma¹. Of these 108 companies, eighty-five had implemented Six Sigma at the corporate level, fourteen at the business unit level, four at the pilot level, and five at the belt level.

LONG-RUN STOCK RETURNS TO INVESTORS IN SIX SIGMA FIRMS

The long-run stock performance of sample firms is examined by analyzing three different mean returns, *viz.*, market-adjusted returns, buy-and-hold returns, and unadjusted returns of firms that have implemented Six Sigma versus industry- and size-matched firms. The hypothesis is that the Six Sigma process compels management to pursue process improvement and cost-cutting projects that will enable firms to generate higher returns for investors.

Market-adjusted abnormal returns are calculated as the difference between a particular firm's returns and returns of the benchmark index, S&P 500, and equally weighted market index. Abnormal returns are calculated using the event study methodology with monthly returns. December of the implementation year is designated as t=0. Abnormal returns are estimated over eight years (96 months) centered on t=0 from -3 to +5 (from -36 months to +60 months). Thus, the market-adjusted model is

$$AR_{it} = R_{it} - R_{mt}$$

where AR_{it} is the abnormal return of stock i and month t, R_{it} is the return of stock i at month t, and R_{mt} is the market return on month t. The mean abnormal return is computed as

¹ Over the past 20 years, use of Six Sigma has saved Fortune 500 companies an estimated \$427 billion, according to research published in the January/February 2007 issue of iSixSigma Magazine. We used the same list of companies that were investigated at this research.

$$AAR_t = \frac{1}{N} \sum_{i=1}^N AR_{it}$$

where N is the number of stocks with return information. The cumulative abnormal return in $[t_i, T]$ is

$$CAR_{i,T} = \sum_{t=t_1}^T AR_{it}$$

The mean cumulative abnormal return is computed as

$$ACAR_{i,T} = \frac{1}{N} \sum_{t=t_1}^T \sum_{i=1}^N AR_{it}$$

Then, t-tests are conducted by dividing abnormal returns by their contemporaneous cross-sectional standard errors.

Buy-and-hold returns are returns realized for buying shares and holding the shares for a period of -36, -24, -12, 12, 24, 36, 48, and 60 months. Following Byun and Rozeff (2003), the buy-and-hold abnormal returns can be calculated as

$$BHAR_{it} = \prod_{t=1}^n (1 + R_{it}) - \prod_{t=1}^n (1 + R_{mt})$$

where BHAR is the buy-and-hold abnormal returns, R_i is returns for firm i , R_m is returns on the market index, and n is the end of the holding period. Abnormal returns for each month are obtained from the average across the sample. These returns are cumulated over three years before and five years after Six Sigma implementation. The t-tests are ascertained through dividing abnormal returns by their contemporaneous cross-sectional standard errors.

Using the two measures, abnormal returns are shown in Table 1. Panel A shows market-adjusted returns for firms that implemented Six Sigma along with industry- and size-matched firms. Panel B shows buy-and-hold returns. Panel C shows unadjusted returns. Results show that Six Sigma firms outperform the market before and after implementation. Evidently, Six Sigma implementation is accepted by investors to mean that managers are committed to continual improvement of processes and efficient use of resources. Statistically, buy-and-hold abnormal returns are significantly higher than the S&P 500 and equally weighted indices after implementing Six Sigma, 7.48% in one year and up to a cumulative return of 48.34% after five years. Two years after implementation, abnormal returns are even more statistically significant at the one percent level. The positive effects of Six Sigma on abnormal returns are evidenced immediately after implementation, especially after three years. This result also might be an indicator of reduced agency cost as Six Sigma is increasingly into daily operations.

[TABLE 1 HERE]

When these returns are compared to those of industry- and size-matched firms, abnormal returns are somewhat disappointing. Unadjusted mean cumulative abnormal returns from months -36 to 0 of matching firms are 57.35% compared to 50.81% for Six Sigma firms. The difference in mean returns increases each year. However, the gap is closed three years after Six Sigma implementation even though abnormal returns remain lower after five years.

The percentage of firms achieving positive mean cumulative abnormal returns (CAR) increases with time. Only 59% of sample firms achieved positive buy-and-hold CARs one year prior to Six Sigma implementation, 72% showed positive buy-and-hold CARs after five years.

In summary, firms that implement Six Sigma outperform the market as well as the S&P index, their performance is not at parity with firms of the same size in their industry.

EFFECTS ON OPERATING PERFORMANCE AFTER SIX SIGMA

Next, pre- and post-Six Sigma operating performance is examined relative to that of industry- and size-matched firms. Five different measures of operating performance are analyzed: liquidity analysis, activity analysis, management efficiency, earnings ability, and labor. Fourteen ratios are analyzed. Details of the ratios are explicated in Appendix A.

Liquidity Analysis

The current ratio is a liquidity ratio that measures a firm's ability to pay short-term obligations. A higher current ratio indicates more capability to meet obligations. A current ratio of less than one indicates that a firm would be unable to pay its obligations if these legal responsibilities came due at once. The quick ratio measures a firm's ability to meet its short-term obligations with its most liquid assets. A higher quick ratio indicates a better financial position. Net working capital is a measure of a firm's efficiency and its short-term financial health.

Activity Analysis

Activity analysis ratios measure the efficiency with which a firm's resources have been employed. The asset turnover ratio measures a firm's efficiency in using its assets to generate revenue. A higher asset turnover ratio indicates greater efficiency. The accounts receivable turnover ratio quantifies a firm's effectiveness in extending credit as well as collecting debts.

The inventory turnover ratio shows the periodic frequency that a firm's inventory is sold and replaced. High levels of inventory are financially unhealthy since investment with a rate of return of zero. High levels of inventory also expose a firm to the risk that prices will fall. Since Six Sigma is centered on process improvement, implementation is expected to improve these activity ratios.

Management Efficiency

Operating efficiency measures such as the cost-to-income ratio and expense-to-asset ratio are used as proxies for management efficiency². Lower calculated ratios inversely reflect higher management efficiency. Because of centered emphasis on process improvement, management of Six Sigma firms is expected to be more efficient after than before implementation.

Earnings Ability (Profitability)

Six Sigma is expected to result in lower costs and fewer defects that require rework or scrap. Therefore, profitability of Six Sigma firms is expected to rise following implementation. Gross profit margin and return on assets (ROA) are measures of profitability. However, a number of concerns lead to arguments that ROA is biased upward. Consequently, return on equity (ROE) is an alternative measure of profitability. Higher ratios indicate improvement in performance.

Labor (Growth in Staff Levels and Employee Productivity)

To determine whether significant changes in employment and labor productivity ensue from implementation of Six Sigma, three labor-related ratios are analyzed³. The ratio of asset-to-number of employees can be used as a proxy for overstaffing. Growth in staff levels can be analyzed to determine whether Six Sigma firms reduced staffing after implementation. The ratio of total revenue-to-number of employees can be used to measure employee productivity. Due to greater emphasis on process improvement and lower costs, Six Sigma firms are more likely to reduce employment and improve employee productivity after implementation.

Effects on operating performance are examined first by comparing Six Sigma firm ratios from year -3 to year +5. Conclusions regarding trends in performance over the pre- and post-Six Sigma periods are compromised since data are adjusted for other possible factors that could affect these ratios. Consequently, any significant change for Six Sigma firms could be due to factors other than process improvement. To account for this possibility, industry- and size-adjusted median performance measures are reported for Six Sigma firms. Industry- and size-adjusted performance is calculated as the difference between ratios for Six Sigma firms and ratios for other firms of similar size in their industry.

², and ³ Otchere, Do privatized banks in middle- and low-income countries perform better than rival banks? An intra-industry analysis of bank privatization, *Journal of Banking & Finance* (2005)

Following Otchere (2005), the difference in median performance for each year from year -3 to year +5 is based on use of the Wilcoxon signed-rank test, calculated as

$$z = \frac{w - n(n - 1)/4}{\sqrt{n(n - 1)(2n - 1)/24}}$$

where z is the Wilcoxon test statistic, w is the sum of positive ranks, n is the number of observations, $n(n-1)/4$ is the mean of w , and $\sqrt{n(n - 1)(2n - 1)/24}$ is the standard deviation of w . The significance of the mean change in performance between the pre-Six Sigma period (year -3 to year -1) and the post-Six Sigma period (year 1 to year 5) also is examined by performing a t-test. Mean changes also are compared to industry- and size-matched firms.

Operating performance results are shown in Table 2. Panel A presents median ratios of Six Sigma firms, and Panel B shows median ratios of industry- and size-matched firms. Panel C shows the results of the Wilcoxon signed rank test for the difference in median ratios.

[TABLE 2 HERE]

For most of the sample period, results show that Six Sigma firms had lower liquidity than matching firms before and after implementation. The median current ratio of Six Sigma firms declines further after the first year of implementation. The current ratio improves after the third year, but the ratio is significantly lower than matching firms (1.33 versus 1.55) four years after implementation. On the other hand, Six Sigma firms are at parity with matching firms in terms of activity analysis and management efficiency. Three years after implementation, median inventory turnover improves to 8.03 compared to 6.32 for matching firms. However,

implementation of Six Sigma does not evidence improved efficiencies across the board as expected.

Results show that Six Sigma firms have significantly higher return on equity (ROE) before implementation compared to matching firms. Three years prior to implementation, the median ROE is 0.16 for Six Sigma firms, which is significantly higher than 0.11 for matching firms. The difference in ROE declines after implementation, dropping to a difference of only 0.03 five years after implementation. The median difference in growth of staff levels declines immediately after implementation. Two years after implementation, Six Sigma firms experience zero growth, whereas matching firms experience staff growth of 0.02.

[TABLE 3 HERE]

Table 3 shows the results of difference in mean tests for pre- and post-Six Sigma implementation. The only statistically significant difference in performance measured before and after implementation is growth in staff levels and employee productivity. Pre- and post-Six Sigma difference in staff level growth is -0.09 . After implementation, the employment productivity ratio of revenue to number of employees is 169.34 higher than before implementation. Thus, Six Sigma implementation reduces the number of employees but increases employee productivity. However, when compared to matching firms before and after implementation, performances other than staff growth are not significantly different.

The most common form of Six Sigma implementation is companywide. Most of the one-hundred-eight companies in the Six Sigma sample are committed at the corporate level. These companies can be regarded as more committed than those limited to business units, pilot

projects, or belt projects. Mean tests are conducted for the eighty-five firms that implemented Six Sigma at the corporate level.

[TABLE 4 HERE]

Table 4 shows the mean performances of firms that implemented Six Sigma at the corporate level compared to industry- and size-matched firms. Results are similar to those found earlier. The quick ratio improved 0.11. Growth in staff levels declined 0.11, and employee productivity increased 135.12. Pre- and post-Six Sigma performances compared to matching firms are similar with the exception of the inventory turnover ratio. The ratio for all 108 Six Sigma companies did not show any difference when compared to matching firms. The ratio for the 85 companies that implemented Six Sigma corporately resulted in a 59.77 reduction, statistically significant at 5%.

The earliest implementation of the 108 Six Sigma companies was 1987. Most companies first implemented in the 1990s and 2000s. The median implementation is 2001. To account for early implementation and look for advantages of early movers, the sample can be split into companies that implemented before 2001 and firms that implemented after 2001. Table 5 shows mean results of early movers, and Table 6 shows mean results of later implementers.

[TABLE 5 HERE]

[TABLE 6 HERE]

Results shown in Table 5 show that the mean gross profit margin of firms that implemented Six Sigma before 2001 is 0.07 lower than matching firms prior to implementation. This ratio gap closes to -0.06 after implementation, statistically significant at 10%. This finding indicates that the billions claimed as cost savings by Six Sigma companies do not carry down to the bottom line. Results shown in Table 6 are remarkably similar.

SUMMARY OF FINDINGS

Pre- and post-Six Sigma performances of 108 *Fortune* 500 firms have been comprehensively analyzed. Market adjusted as well as buy-and-hold abnormal returns were analyzed to determine if Six Sigma companies outperformed the market. Findings show that Six Sigma companies indeed outperformed the market and exceeded the S&P index. However, Six Sigma company performance was not on parity with firms of similar size in the same industries. This unexpected finding may be attributed to intense competition within respective industries.

Improvements in operating performance of companies that implemented Six Sigma were investigated by examining fourteen ratios dealing with liquidity, activity, management, earnings, and labor. Improved results and better performance were expected. Even though Six Sigma companies improved performance in some of the fourteen areas, they suffered by comparison to matching firms. The only performance variable that compares favorably with matching firms is growth in staff. This finding may contribute to understanding the reasons that underlie the so-called jobless recovery.

Overall, findings indicate that implementing Six Sigma may reduce agency costs in the long run and help companies to catch up with abnormal returns for matching firms. Findings

suggest that managers may be using Six Sigma as a signal to investors and customers that they are committed to improving quality. Investors seem to believe in this commitment in the long run. Although operating performances do not show significant differences after implementation, abnormal returns increase.

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Appendix A

Appendix A: Definition of Ratios		
Measures	Ratios	Definition
Liquidity analysis	Current ratio	Current assets/current liabilities
	Quick ratio	Quick assets/current liabilities
	Net working capital ratio	Current assets-Current liabilities / Total Assets
Activity analysis	Asset turnover ratio	Sales/Average total assets
	Accounts receivable turnover ratio	Sales/Average accounts receivable
	Inventory turnover ratio	Cost of goods sold/Average inventories
Management efficiency	Cost-to-income	Operating expenses/operating income
	Expense-to-assets	Operating expenses/average assets
Earnings ability	Gross profit margin	Net profit/Revenue
	Return on asset (ROA)	Net profit before interest and tax/average shareholders equity
	Return on equity (ROE)	Net profit after tax/average shareholders equity
Labor	Growth in staff levels	% change in the number of employees
	Employee productivity	Revenue/number of employees
	Over employment proxy	Total assets/number of employees

TABLE 1

Long run abnormal returns

Event Period	Six Sigma Firms		Industry & Size Matched Firms		Difference
	Mean CAR	% Positive	Mean CAR	% Positive	Mean CAR
Panel A: Market-adjusted returns					
-36-0	21.23 (3.205)***	68%	31.19 (9.366)***	76%	-9.96 (-0.9407)
-24-0	13.09 (2.401)***	64%	22.68 (9.255)***	75%	-9.59 (-1.1674)
-12-0	6.42 (1.999)**	62%	10.60 (7.147)***	70%	-4.18 (-0.6208)
0-12	9.36 (3.608)***	70%	12.74 (8.478)***	73%	-3.38 (-0.6506)
0-24	19.65 (4.814)***	76%	25.35 (11.917)***	83%	-5.70 (-1.0602)
0-36	26.79 (4.412)***	74%	29.18 (11.141)***	81%	-2.39 (-0.4902)
0-48	38.98 (6.021)***	82%	29.64 (9.588)***	76%	9.34 (0.9419)
0-60	46.86 (6.021)***	82%	35.61 (10.475)***	79%	11.25 (-0.8140)
Panel B: Buy and hold returns					
-36-0	22.00 (1.194)	58%	39.54 (6.529)***	68%	-17.54 (-0.9407)
-24-0	15.24 (0.591)	55%	29.94 (7.480)***	70%	-14.70 (-1.1674)
-12-0	8.53 (1.395)*	59%	12.39 (5.816)***	66%	-3.86 (-0.6208)
0-12	7.48 (2.602)**	65%	13.73 (7.147)***	70%	-6.25 (-0.6506)
0-24	15.89 (3.406)***	69%	30.91 (10.808)***	80%	-15.02 (-1.0602)
0-36	24.24 (3.004)***	67%	36.51 (8.922)***	74%	-12.27 (-0.4902)
0-48	40.23 (4.010)***	72%	37.64 (6.925)***	69%	2.59 (0.9419)
0-60	48.34 (4.010)***	72%	51.53 (7.036)***	69%	-3.19 (0.8140)

Panel C: Unadjusted returns

-36-0	50.81 (3.324)***	74%	57.35 (8.218)***	77%	-6.54 (-0.1669)
-24-0	30.09 (2.308)**	69%	41.59 (7.995)***	77%	-11.50 (-0.5680)
-12-0	14.09 (2.105)**	68%	21.02 (7.549)***	75%	-6.93 (-0.6068)
0-12	11.75 -0.48	60%	19.12 (8.106)***	77%	-7.37 (-0.4552)
0-24	26.95 (3.527)***	75%	41.88 (8.329)***	78%	-14.93 (-0.4773)
0-36	35.42 (3.121)***	73%	52.87 (7.772)***	76%	-17.45 (-0.5719)
0-48	52.41 (3.324)***	74%	56.75 (6.770)***	73%	-4.34 (0.1151)
0-60	66.23 (2.917)***	72%	70.53 (7.438)***	75%	-4.30 (0.3417)

This table shows the mean cumulative abnormal returns for the Six Sigma firms as well as Industry and Size matched firms. The returns are market adjusted mean cumulative abnormal returns, buy and hold returns (BHAR) and unadjusted returns. The returns are from -36 to month 60. The figures in parantheses are t-statistics and the symbols ***, **, * indicates significance at the 1%, 5% and 10% level respectively.

TABLE 2
OPERATING PERFORMANCE MEASURES

Year	Liquidity Analysis			Activity Analysis			Management Efficiency		Earnings Ability			Labor		
	Current Ratio	Quick Ratio	Net Working Capital	Asset Turnover	A/R Turnover	Inventory Turnover	Cost-to-income	Expense-to-assets	Gross Profit Margin	ROA	ROE	Growth in Staff Levels	Employee Productivity	Over Employment Proxy
Panel A: Median Ratios of Six Sigma Firms														
-3	1.33	0.73	0.09	0.86	5.89	6.41	4.92	0.71	0.30	0.04	0.16	0.01	223.70	304.59
-2	1.31	0.77	0.08	0.89	5.95	6.18	5.29	0.73	0.30	0.04	0.17	0.02	221.96	318.65
-1	1.26	0.75	0.08	0.85	5.67	6.59	5.36	0.70	0.29	0.04	0.15	0.03	241.96	350.94
0	1.30	0.75	0.10	0.80	5.84	6.54	5.26	0.66	0.29	0.03	0.14	0.00	239.54	375.49
1	1.30	0.78	0.08	0.80	5.90	7.05	5.58	0.66	0.28	0.04	0.15	-0.01	254.01	402.47
2	1.29	0.77	0.09	0.84	5.82	7.54	5.82	0.73	0.28	0.03	0.15	0.00	260.08	423.94
3	1.35	0.81	0.09	0.78	6.06	8.03	5.75	0.67	0.28	0.03	0.15	0.00	284.34	415.80
4	1.33	0.80	0.09	0.77	6.02	7.86	5.80	0.63	0.29	0.03	0.14	0.00	290.95	451.83
5	1.36	0.83	0.08	0.81	6.14	8.19	5.71	0.69	0.29	0.04	0.15	0.01	310.53	450.95
Panel B: Median Ratios of Industry and Size Matched Firms														
-3	1.51	0.92	0.16	0.77	5.54	5.45	5.12	0.65	0.33	0.03	0.11	0.02	245.88	406.49
-2	1.49	0.89	0.14	0.74	5.70	6.08	5.55	0.65	0.30	0.03	0.12	0.03	242.77	374.67
-1	1.38	0.92	0.12	0.78	5.40	6.27	5.99	0.66	0.29	0.03	0.11	0.02	228.34	367.48
0	1.40	0.89	0.09	0.69	5.21	5.45	6.08	0.61	0.30	0.03	0.12	0.01	236.22	371.88
1	1.46	0.86	0.12	0.80	5.77	6.34	6.12	0.67	0.29	0.03	0.11	0.02	253.61	419.41
2	1.43	0.83	0.10	0.74	5.87	6.07	6.57	0.64	0.30	0.03	0.12	0.02	290.56	448.08
3	1.49	0.90	0.14	0.78	5.78	6.32	4.78	0.65	0.29	0.04	0.12	0.01	304.57	472.60
4	1.55	0.93	0.12	0.80	6.17	5.98	5.15	0.68	0.30	0.04	0.12	0.01	311.84	492.41
5	1.52	0.91	0.12	0.83	6.04	6.97	5.56	0.67	0.31	0.04	0.12	0.01	325.74	451.39
Panel C: z-statistics for difference in median (Six Sigma - Industry and Size Matched Firms)														
-3	-1.843*	-2.555	-1.582	1.435	0.349	1.347	0.252	1.247	-0.283	1.377	3.182***	-0.671	-0.470	-1.582
-2	-1.505	-1.950***	-1.477	1.269	0.148	1.039	-0.350	0.971	0.344	0.653	2.710***	-1.466	-0.086	-0.892
-1	-1.951*	-2.190**	-2.359**	0.707	0.545	0.853	-0.971	0.510	0.284	0.801	2.344**	0.064	-0.009	-0.483
0	-1.503	-1.763*	-1.293	1.032	0.801	1.553	-0.448	0.881	-0.540	0.842	3.208***	-1.656*	0.313	-0.392
1	-1.981**	-1.489	-1.771*	0.577	-0.118	1.236	-0.025	0.561	-0.539	0.958	3.523***	-2.197**	0.079	-0.223
2	-1.611	-0.985	-0.974	0.702	-0.066	1.253	0.123	0.771	-1.191	-0.044	1.978**	-2.696***	0.130	-0.149
3	-1.622	-1.347	-1.296	0.803	0.169	1.802*	0.475	0.773	-1.402	-1.158	1.724*	-1.380	0.071	-0.297
4	-2.137**	-1.469	-1.593	0.390	-0.370	1.858*	0.044	0.463	-1.214	-1.439	0.537	-0.613	-0.065	-0.213
5	-1.355	-1.185	-1.042	0.552	0.106	1.561	-0.013	0.517	-1.018	-0.424	1.820*	0.344	0.250	-0.051

This table contains the median operating performance measures of the sample Six Sigma firms on Liquidity Analysis, Activity Analysis, Management Efficiency, Earnings Ability, and Labor

(employment levels and labor productivity). Panel A presents the ratios of the Six Sigma firms while Panel B presents the ratios of the industry and size matched firms. Panel C exhibits the z-

statistics for the Wilcoxon signed rank test of the difference in median ratios between the two samples. The symbols ***, **, * denote significance at 1%, 5%, and 10% respectively (2-tailed test).

Table 3
Difference in mean test

Ratio	Six Sigma firms mean performance				Pre-Six Sigma				Post-Six Sigma			
	Post	Pre	Post-Pre	t-statistic	Six Sigma	Matching	Difference	t-statistic	Six Sigma	Matching	Difference	t-statistic
Current Ratio	1.37	1.33	0.04	0.5292	1.33	1.645506	-0.32	-2.9827***	1.37	1.638786	-0.27	-3.0854***
Quick Ratio	0.89	0.80	0.08	1.3767	0.80	1.055291	-0.25	-3.2683***	0.89	1.100571	-0.21	-2.5661**
Net Working Capital	0.10	0.09	0.01	0.2749	0.09	0.138186	-0.05	-2.2308***	0.10	0.13221	-0.03	-1.8319*
Asset Turnover	1.01	1.01	0.00	-0.0076	1.01	0.875365	0.13	1.1677	1.01	0.852917	0.15	1.1442
A/R Turnover	8.11	8.19	-0.08	-0.0461	8.19	8.758556	-0.57	-0.4335	8.11	22.1397	-14.03	-1.5550
Inventory Turnover	50.32	46.45	3.87	0.1116	46.45	35.34184	11.11	0.2494	50.32	94.31861	-44.00	-0.9287
Cost-to-income	7.46	7.30	0.16	0.0956	7.30	-5.19459	12.49	1.1451	7.46	7.481808	-0.03	-0.3670
Expense-to-assets	0.89	0.88	0.01	0.068	0.88	0.765368	0.12	1.0368	0.89	0.735245	0.15	1.1461
Gross Profit Margin	0.35	0.35	-0.01	-0.1912	0.35	0.345756	0.01	0.2086	0.35	0.359788	-0.01	-0.2545
ROA	0.03	0.04	-0.01	-0.7326	0.04	0.009833	0.03	1.5133	0.03	0.040989	-0.01	-0.5231
ROE	0.11	0.09	0.02	0.2704	0.09	0.008602	0.08	0.9861	0.11	0.11302	-0.01	0.0294
Growth in Staff Levels	0.03	0.12	-0.09	-2.6105***	0.12	2.068984	-1.95	-1.0823	0.03	0.109365	-0.08	-2.2049**
Employee Productivity	517.30	347.96	169.34	2.2117**	347.96	545.9235	-197.97	-1.2474	517.30	473.8812	43.41	0.3321
Over Employment Proxy	1276.39	836.67	439.72	1.5279	836.67	1880.665	-1043.99	-1.7465*	1276.39	1776.182	-499.79	-1.1521

This table shows the pre- and post-Six Sigma mean ratios and the relevant t-statistics for the sample based on Liquidity Analysis, Activity Analysis, Management Efficiency, Earnings Ability, and Labor (employment levels and labor productivity). The pre-Six Sigma mean ratios are calculated over the year -1 to year -3 period and the post-Six Sigma mean ratios are calculated over the year +1 to year +5 period. The symbols ***, **, * denote significance at 1%, 5%, and 10% respectively.

Table 4

Difference in mean test for Firms That Implemented Six Sigma Corporate-wide

Ratio	Six Sigma firms mean performance				Pre-Six Sigma				Post-Six Sigma			
	Post	Pre	Post-Pre	t-statistic	Six Sigma	Matching	Difference	t-statistic	Six Sigma	Matching	Difference	t-statistic
Current Ratio	1.37	1.30	0.07	0.9767	1.30	1.73	-0.43	-3.2135***	1.37	1.68	-0.31	-3.2458***
Quick Ratio	0.88	0.78	0.11	1.7445*	0.78	1.06	-0.28	-3.6278***	0.88	1.12	-0.24	-2.7821***
Net Working Capital	0.10	0.08	0.01	0.6658	0.08	0.15	-0.07	-2.9720***	0.10	0.14	-0.04	-2.1095**
Asset Turnover	0.99	1.00	-0.01	-0.1203	1.00	0.93	0.08	0.7364	0.99	0.88	0.11	1.0143
A/R Turnover	7.24	7.43	-0.19	-0.1445	7.43	9.65	-2.22	-1.1212	7.24	27.67	-20.43	-1.5213
Inventory Turnover	15.14	13.40	1.74	0.3833	13.40	44.85	-31.45	-1.1701	15.14	74.92	-59.77	-1.9690**
Cost-to-income	6.87	6.97	-0.09	-0.0501	6.97	-12.09	19.05	1.0602	6.87	8.33	-1.45	-0.7111
Expense-to-assets	0.87	0.87	0.00	-0.0345	0.87	0.81	0.06	0.6114	0.87	0.76	0.11	1.0038
Gross Profit Margin	0.33	0.34	-0.01	-0.2172	0.34	0.34	0.00	0.0400	0.33	0.36	-0.03	-0.8618
ROA	0.03	0.04	-0.01	-0.8342	0.04	0.03	0.01	1.0628	0.03	0.04	-0.01	-0.6113
ROE	0.13	0.07	0.06	0.8565	0.07	0.03	0.04	0.3081	0.13	0.10	0.04	1.2298
Growth in Staff Levels	0.02	0.13	-0.11	-2.5640**	0.13	2.40	-2.27	-1.0692	0.02	0.13	-0.11	-2.3966**
Employee Productivity	430.45	295.33	135.12	2.2389**	295.33	533.59	-238.26	-1.3790	430.45	466.23	-35.79	-0.4517
Over Employment Proxy	819.84	603.78	216.06	1.2218	603.78	1483.81	-880.03	-1.4020	819.84	1339.35	-519.51	-1.5666

This table shows the pre- and post-Six Sigma mean ratios and the relevant t-statistics for the sample based on Liquidity Analysis, Activity Analysis, Management Efficiency, Earnings Ability, and Labor (employment levels and labor productivity). The pre-Six Sigma mean ratios are calculated over the year -1 to year -3 period and the post-Six Sigma mean ratios are calculated over the year +1 to year +5 period. The symbols ***, **, * denote significance at 1%, 5%, and 10% respectively.

Table 5

Difference in mean test for Firms That Implemented Six Sigma Before 2001

Ratio	Six Sigma firms mean performance				Pre-Six Sigma				Post-Six Sigma			
	Post	Pre	Post-Pre	t-statistic	Six Sigma	Matching	Difference	t-statistic	Six Sigma	Matching	Difference	t-statistic
Current Ratio	1.27	1.26	0.01	0.1019	1.26	1.68	-0.42	-2.4059**	1.27	1.59	-0.32	-2.8626***
Quick Ratio	0.78	0.76	0.02	0.2778	0.76	1.05	-0.28	-2.7739***	0.78	1.04	-0.26	-2.7227***
Net Working Capital	0.08	0.08	0.00	-0.1915	0.08	0.14	-0.06	-2.2057**	0.08	0.13	-0.05	-2.0666***
Asset Turnover	1.02	1.03	-0.02	-0.1333	1.03	0.89	0.15	1.2601	1.02	0.91	0.11	0.6665
A/R Turnover	5.81	5.62	0.19	0.2663	5.62	9.02	-3.40	-1.5353	5.81	20.77	-14.97	-1.1609
Inventory Turnover	14.23	12.18	2.05	0.6278	12.18	39.14	-26.96	-0.8339	14.23	13.77	0.46	0.1082
Cost-to-income	6.70	7.28	-0.58	-0.1799	7.28	-8.50	15.78	0.7137	6.70	0.80	5.90	-0.6733
Expense-to-assets	0.90	0.92	-0.01	-0.1054	0.92	0.78	0.14	1.2187	0.90	0.80	0.10	0.6456
Gross Profit Margin	0.27	0.28	-0.01	-0.2952	0.28	0.35	-0.07	-2.0134**	0.27	0.33	-0.06	-1.7447*
ROA	0.02	0.03	-0.01	-0.5735	0.03	0.00	0.03	0.6955	0.02	0.02	0.00	-0.1514
ROE	0.11	0.00	0.11	0.8562	0.00	-0.03	0.03	0.1523	0.11	0.06	0.06	1.2227
Growth in Staff Levels	0.03	0.14	-0.11	-2.0241**	0.14	1.86	-1.72	-0.6786	0.03	0.18	-0.16	-1.7342*
Employee Productivity	353.98	251.53	102.45	1.6282*	251.53	516.84	-265.31	-1.2796	353.98	366.70	-12.73	-0.1546
Over Employment Proxy	708.68	470.88	237.80	1.0501	470.88	2085.33	-1614.46	-1.4565	708.68	741.36	-32.68	-0.1150

This table shows the pre- and post-Six Sigma mean ratios and the relevant t-statistics for the sample based on Liquidity Analysis, Activity Analysis, Management Efficiency, Earnings Ability, and Labor (employment levels and labor productivity). The pre-Six Sigma mean ratios are calculated over the year -1 to year -3 period and the post-Six Sigma mean ratios are calculated over the year +1 to year +5 period. The symbols ***, **, * denote significance at 1%, 5%, and 10% respectively.

Table 6

Difference in mean test for Firms That Implemented Six Sigma After 2000

Ratio	Six Sigma firms mean performance				Pre-Six Sigma				Post-Six Sigma			
	Post	Pre	Post-Pre	t-statistic	Six Sigma	Matching	Difference	t-statistic	Six Sigma	Matching	Difference	t-statistic
Current Ratio	1.43	1.37	0.06	0.5659	1.37	1.77	-0.40	-2.2061**	1.43	1.69	-0.26	-1.9987**
Quick Ratio	0.95	0.83	0.12	1.4584	0.83	1.07	-0.24	-2.3445**	0.95	1.13	-0.17	-1.5053
Net Working Capital	0.11	0.10	0.01	0.4615	0.10	0.14	-0.04	-1.4686	0.11	0.14	-0.02	-0.9197
Asset Turnover	1.00	0.99	0.01	0.0628	0.99	0.83	0.16	1.1239	1.00	0.86	0.14	0.9152
A/R Turnover	9.64	9.79	-0.15	-0.0548	9.79	9.92	-0.13	-0.0430	9.64	26.26	-16.61	-1.1181
Inventory Turnover	76.28	70.50	5.78	0.0979	70.50	55.12	15.38	0.3177	76.28	132.96	-56.68	-0.8315
Cost-to-income	7.97	7.31	0.66	0.3642	7.31	-18.49	25.80	1.1540	7.97	7.27	0.70	0.4017
Expense-to-assets	0.88	0.86	0.02	0.1328	0.86	0.72	0.13	0.9729	0.88	0.74	0.14	0.9358
Gross Profit Margin	0.40	0.40	0.00	-0.0283	0.40	0.36	0.03	0.8753	0.40	0.37	0.03	0.6987
ROA	0.04	0.05	0.00	-0.4313	0.05	-0.02	0.06	1.6225	0.04	0.05	0.00	-0.4147
ROE	0.10	0.15	-0.05	-0.9212	0.15	-0.08	0.23	1.3616	0.10	0.14	-0.03	0.5694
Growth in Staff Levels	0.03	0.11	-0.08	-1.7153*	0.11	2.86	-2.75	-1.0451	0.03	0.07	-0.04	-2.3450**
Employee Productivity	628.77	413.28	215.49	1.8106*	413.28	647.66	-234.38	-1.0853	628.77	562.61	66.16	0.4900
Over Employment Proxy	1663.87	1084.46	579.40	1.2852	1084.46	3047.43	-1962.96	-1.7106*	1663.87	2385.48	-721.62	-1.0994

This table shows the pre- and post-Six Sigma mean ratios and the relevant t-statistics for the sample based on Liquidity Analysis, Activity Analysis, Management Efficiency, Earnings Ability, and Labor (employment levels and labor productivity). The pre-Six Sigma mean ratios are calculated over the year -1 to year -3 period and the post-Six Sigma mean ratios are calculated over the year +1 to year +5 period. The symbols ***, **, * denote significance at 1%, 5%, and 10% respectively.