Vol-2, Issue-2 PP. 472 -480 ISSN: 2394-5788

GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

LEAN SIX SIGMA AND DATA ANALYTICS: INTEGRATING COMPLEMENTARY ACTIVITIES

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Abstract

Lean Six Sigma and data analytics are widely used in many areas such as government, industry, healthcare, education and to-date have been complementary but not widely integrated. Six Sigma and Lean started out as two separate paradigms and then became combined for maximum impact. Using the same idea this paper explores the rationalization for consolidating Lean Six Sigma with advanced analytics in an effort to become even more effective at taking improvement projects to the next level. This is a timely and important research in an era of the "internet of everything" and the proliferation of "BIG DATA" in the commercial world.

Keywords: "BIG DATA", Six Sigma, Analytics, Quality, Improvement, Lean, Data Mining

1. INTRODUCTION

The popularity of the Lean Six Sigma quality paradigm has been accompanied by the popularity of advanced data mining techniques. This is especially due with the proliferation and attention "BIG DATA" has been receiving in both the public and private sectors. The definition of "BIG DATA" has many variations but similar themes across the expert community (Franks, 2012; Dumbill, 2012; Gobble, 2013). "BIG DATA is often defined as more data made possible by the internet and every time somebody uses a wireless device. "BIG DATA" was also the topic of interest at recent World Economic Forum in Davos Switzerland which points to how important this subject is to our world leaders which included representatives from both business and governments. "BIG DATA" was also featured as a strategic direction for firms in recent editions of the Harvard Business Review and the McKinsey Quarterly, Finally, most recently Gobble (2013) discussed how "BIG DATA" represents the next evolution in innovation. Advanced analytics is defined as a combination of multivariate statistical techniques, evolutionary algorithms and machine learning algorithms programmed to estimate a function or perform some sort of supervised learning. Lean Six Sigma is a more recent combination which both started out as separate paradigms. Six Sigma is officially known to have started with the firm Motorola. However, interestingly enough, the Japanese are credited to have stumbled onto Six Sigma independently when taking over a

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television manufacturing business from Motorola in 1970. The new management decided to change the way the operations were conducted after the acquisition. They (Japanese Management) made sure that they placed a high emphasis on all the activities leading to production. Finally, because of their zealous approach they started manufacturing T.V sets with just 5% defects against the original records under Motorola (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

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Bill Smith, along with Mikel Harry, all engineers at Motorola, were intrigued at the success the Japanese firm that acquired their business had been able to realize with this new approach. Given this, they had written and codified a research report on the new quality management system that emphasized the relationship between a product's performance in the market and the modifications required at the manufacturing point (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

.The main conclusion from the report is that minimizing the defects at each stage of production resulted in better performance in the marketplace. This led to the idea that logical filters could be used to identify and solve production problems. Eventually, the then CEO of Motorola, Bob Galvin became a chief proponent of the four stage filters implemented at Motorola known as *Measure, Analyze, Improve and Control*.

The report clearly indicated that the lesser the number of non-conformities at each stage of production, the better is the performance. This report was no less than a revolution because it paved the way for the implementation of the 'logical filters' as a key tool to solve problems. Bob Galvin, the then CEO of Motorola became a leader in this system, and with his help later this four stage logical filter became the skeleton of the present day Six Sigma. The four stages were known as Measure, Analyze, Improve and Control (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

Later in 1980, Six Sigma began to coalesce when engineers created the term Six Sigma for the quality management process at Motorola. Motorola copyrighted the term in addition to implementing the process throughout their organization.

Motorola's corporate policy committee then started to get involved setting goals for further improvisation of this process even declaring publicly that Six Sigma would enable Motorola to achieve ten times betters quality.

Other key corporate contributors to the early development of Six Sigma were Unisys Corp in 1988 and Asea Brown Boveri in 1993. In fact, ABB is known for giving Six Sigma its final finishing touch by putting emphasis on customer satisfaction and the voice of the customer.

Lawrence (Larry) Bossidy the former Vice-Chairman of General Electric who was in the running against Jack Welch to become the Chairman and CEO went over to Allied Signal after (now Honeywell) after Jack Welch beat him and a host of others out for the top job although he stayed on with Jack until 1991. Since Larry was close in age to Jack Welch and the mandatory retirement age was 65 for CEOs he knew he would never be a CEO of a Fortune 500 company unless he went to run a company other than GE.

Back in 1995, the direct reports to the Chairman and CEO of GE known as the Corporate Executive Council or the CEC discussed the need for a quality program. Due to decreases in customer satisfaction, product quality and efficiency in

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some of the businesses many individual units were implementing their own quality programs (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

Jack Welch had been skeptical of the quality programs that were the rage in the 1980s. He felt that they were too light on delivering results but heavy on slogans. However, after hearing his former right-hand Larry Bossidy, boast about the benefits he was reaping from a quality initiative he had launched at AlliedSignal which included lowering costs, increasing productivity, and realizing more profits out of operations he quickly changed his mind (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

As a next step Jack Welch asked Larry Bossidy to speak at the CEC which was a council of key GE executives. Larry was a little apprehensive as he thought the leaders may resent the fact that he was coming back and telling them how to do their jobs. This was especially true since Jack himself was not present due to being in the hospital undergoing open heart surgery. However, the GE leadership team was highly impressed and agreed that this was just the thing they needed. Then the GE Operational Excellence Machine began to focus on Six Sigma which I was very much a part of where I worked at the time. It came very swift after the GE Executives returned from the CEC. Pete Van Abilean was named the Six Sigma lead and at first separate organizations were created in each business to lead the quality effort. Training was not optional and the word from Jack was that Six Sigma careers would be the hot promotable jobs of the future and those who did not receive training would not be eligible for a promotion. This one action created a massive effort for people to be trained and for vendors willing to provide the training. My trainer was actually the student assistant of Dr. Edwards Deming and had much perspective as to how Deming would have responded to the problem. Most employees at GE over the two year time period achieved at least a Green Belt Certification. The regular full-time quality organization along with the functional quality leads like myself became Black Belt and Master Black Belt Certified. Eventually, GE halted certification altogether due to the fact that BBs and MBBs were being poached at a concerning rate. Overall, the quality initiative at GE is said to have generated billions of dollars in benefits (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

There is a long list of other firms which have successfully implemented Six Sigma after Allied Signal and GE which include Bank of America, Advanced Micro Devices. Amazon, McKesson Corporation, Northrup Grummon, PepsiCo and many more.

Minnesota Mining and Manufacturing or 3M was one of the few failures with the introduction to Six Sigma in a very large scale. When the CEO and Chairman Jack Welch retired several candidates (like Larry Bossidy with Jack) were in the running for the top job. Jeff Immelt was finally selected and this resulted in the exodus of Bob Nardelli to Home Depot and Jim McNerney to 3M. Jim very quickly adopted Six Sigma when he took the helm of 3M. However, he faced resistance from the engineers who grew up in a firm which was proud of its innovations by accident. This was a place where things like Post-It notes (super strong glue that ended up low-tack and reusable) and Velcro (burrs on an engineer's dog after hiking in the woods) were discovered by accident. Six Sigma tries to eliminate variations in a process. By doing this it has been criticized for stifling innovation. This was exactly the claim of the engineers at 3M. Eventually, Six Sigma was put to rest at 3M. Interestingly, Jim McNerney ended up later at Boeing where he was finally able to implement Six Sigma with some terrific results (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

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Other companies which have not had great success which use Six Sigma include Eastman Kodak and Sears. Six Sigma is not the panacea for all the problems in a firm and cannot compensate for a failed strategy. Sears faced some tough competition from lower cost competitors including Wal-Mart and Kodak was focused on film and failed to accurately forecast the disruptive force of digital photography.

On the flip side some firms have realized amazing results with Six Sigma. For example, Bank of America was able to realize big gains in their retail operations using Six Sigma. The computer firm Dell also has been credited with creating an excellent value chain using Six Sigma. Ford Motor Company used Six Sigma to produce quality cars that today are competing successfully with Japanese and German imports.

In terms of the technical aspects of Six Sigma a key focus is on the 12-step DMAIC program. DMAIC is a cyclical process which stands for Define, Measure, Analyze, Improve and Control.

The first thing to focus on in Six Sigma is the concept of a defect. In Six Sigma a defect occurs whenever a product or service does not meet the customer's expectations or specifications. DPMO stand for defects per million opportunities. This is the foundation of the Sigma calculation as 3.4 defects per million opportunities is equivalent to a Six Sigma process. The concept of Six Sigma means 3 standard deviations of the mean in a two-tailed distribution. Sigma is the Greek symbol for standard deviation. However, it's not exactly three standard deviations due to adjustments for population drift. Many processes are not capable of reaching Six Sigma. Some, like airline and food safety exceed Six Sigma. If the airlines operated at 6 Sigma there would be at least one airline accident per month. This is unacceptable and the reason why the airlines typically operate at around 12 Sigma. It's too bad they didn't also apply this to also reduce lost luggage! The airlines operate their luggage services at an estimated 3 Sigma. Water utilities also operate at above Six Sigma levels. At 6 Sigma there would be several minutes of bad quality water running through the network every month which would be unacceptable for most consumers (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

Even though some processes are not capable of reaching Six Sigma the overall goal is continuous improvement and meeting customer expectations. Most firms operate at or around 3 Sigma so unless there is a logical reason not to increase quality which is fully accepted by customers there is much room for improvement (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014).

Now we will discuss where Lean came from. At first Six Sigma was both taught and practiced without the link to Lean. However, given the similarity and complementary aspects of each approach many practitioners found there to be benefits with combining these practices together. Similar to Six Sigma, Lean is a tool used by firms streamline manufacturing and services production processes. The main emphasis of Lean is on cutting out unnecessary and wasteful steps in the creation of a product or service so that only steps that directly add value to the product are retained and taken on a go-forward basis (Dumitrescu et al., 2010).

Lean is concerned with analyzing whether or not the customer is willing to pay for a portion of the process and whether or not the process is critical to the entire product or service delivery. If so, then this aspect of the process is determined to be something of value. Any part of the production that does not add value is to be eliminated leaving in its place a new, highly streamlined and profitable process in place that will flow smoothly and efficiently. Commonly used Lean tools include the 5Ss, Andon, Bottleneck Analysis, Continuous Flow Analysis, Just-In-Time, Kaizen, Kanban, KPI, PCDA, Root Cause Analysis and Value Stream Mapping (LeanProduction.com, 2015).

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The main difference between Lean and Six Sigma is that they identify the root cause of waste differently. Lean practitioners believe that waste comes from unnecessary steps in the production process that do not add value to the finished product, while Six Sigma practitioners assert that waste results from variation within the process. However, both Six Sigma and Lean systems have the same goal in that they both seek to eliminate waste and create the most efficient system possible taking different approaches toward how achieving this goal. For example, take a look at the Poka Yoke technique in Lean compared to the Control process we will be learning in Six Sigma. Both have very similar goals. Poka yokes also has an aspect that is interesting called *The Three T's* in which controls are set in place to test if task are being done properly. "*The Three T's* consist of the task to be done (i.e. was the car fixed right?), the Treatment accorded to the customer (i.e. was the service manager courteous?), and the Tangible or environmental features of the service facility (i.e. was the waiting area clean and comfortable?)" (Jacobs & Chase, 2011). Poka Yokes and the Three T's were revolutionary in their country of origin Japan since they encouraged the line workers to actually shut down production if they thought that quality standards were not being me in a product being assembled. This was the ultimate form of empowerment and is one of the reason why Toyota was able to set the standard in the industry for manufacturing quality vehicles. This is also very similar to the FMEA process which is tool in Six Sigma. FMEA stands for failure mode and effect analysis and is a process often implemented during the control phase of Six Sigma projects and ensures that the proper controls are in place to identify and detect defects and what to do if they are discovered (Dumitrescu et al., 2010; LeanProduction.com, 2015).

The fact of the matter is that given there is truth in both of the methodologies and both have been proven to be successful in the improvement of overall business performance in a variety of industries. In addition, these two disciplines have proven to be especially successful when working together - hence the creation of Lean Six Sigma which is what we are seeing as a leading combined practice in industry today. One example if where the two paradigms work together nicely is the Kaizen approach which is a rapid process improvement technique under Lean. Six Sigma DMAIC products typically take several months to complete the entire DMAIC cycle. However, when combined with the quick-win requirements of Kaizen they make a powerful combined team which can generate positive results for a business in just a few days. I once worked with a business unit in insurance that had the highest 13-month attrition rate of the group and for years could not reduce this to the norm for the industry. After a 2-day Lean Six Sigma Kaizen event which included teams across the business from customer service to senior managers this business was able to develop and implement improvement ideas which have resulted in a significant increase in persistency well above industry norms.

The reality is that the broader your toolkit, the better prepared you are to tackle the complex problems that businesses face in today's competitive marketplace. Lean Six Sigma allows quality practitioners this opportunity. Lean Six Sigma has become so prevalent in modern industry that many companies are practicing its principles without even being explicitly acknowledged (Dumitrescu et al., 2010; LeanProduction.com, 2015).

2. ANALYSIS AND CASE STUDY

In the same tradition that Lean was merged with Six Sigma as outlined above I will take the opportunity in this paper to explore the use of advanced analytics to extract insights from large datasets. Most of the statistical techniques which are taught in Six Sigma Green Belt and black Belt Training programs are exploratory data analysis or descriptive statistics. In fact, when advanced techniques are introduced they are often masked with new terms which make them more intuitive to non-technical users. The Critical x-analysis of the DMAIC 12-Step Approach is one example of this where one is

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really using correlation and simple regression analysis to come up with various hypotheses related to root causes. However, this analysis can certainly be strengthened with advanced analytics. There has been little research on the use of advanced statistics and Six Sigma. Ravichandran (2012) discussed the inclusion of rigorous test based methods in Six Sigma but to-date there has not been extensive research on the topic.

In this study I will use a case from a large global financial firm where an advanced analytics team actually incorporated Six Sigma into their current process and in addition to realizing that Six Sigma helped improve their analytics projects by having a more structured and measured approach to executing analytics activities they also discovered that the analytic activities also enabled projects not directly related to business analytics throughout the firm. The history on the team is that during the late 1990's an international modeling team at a large consumer finance company which consisted mostly of PhD's and MScs was helping GE's acquired businesses overseas do advanced data mining and analytics. In 1998 when Jack Welch required all employees to be certified as Green Belts in Six Sigma the individual team members were the first to be required to be Six Sigma trained as Master Black Belts. The reason was that since they had a great deal of quantitative skills they could serve as an excellent technical resource for quality projects in addition to getting some early wins as the quality paradigm was implemented throughout this extremely large organization with over 200,000 employees worldwide. At first the team served itself by putting all of its existing projects into Six Sigma format. It actually hired a quality manager who was certified as a Master Black Belt to facilitate helping to get the projects into Six Sigma. Not only did this effort help the overall business to meet its quota for Six Sigma projects but it also helped to "prime the pump" so to speak especially since the team had data readily available it enabled the rest of the organization to have enough time to collect their own data and/or begin a data collection process.

One of the additional benefits from having the team was first noticed in the MEASURE phase of the DMAIC cycle where the improvement teams focused on measuring the variation in the processes. A key focus on Six Sigma is eliminating variation in a process. Jack Welch the Chairman of GE was once quoted "variation is evil". Normal Six Sigma training does not include multivariate techniques such as Analysis of Variance. This team was able to use ANOVAs to identify the variation in processes and work with the businesses to eliminate them. Most managers in the business were not aware of how to use ANOVA and therefore were not able to optimally remove variation from their processes. If they were aware of ANOVA it was only through their statistics courses at university using the technique as an alternative to the t-test for hypothesis testing three or more mean differences. The use of advanced analytics to understand the sources of variation in the MEASURE phase of the DMAIC cycle enabled the business units to greatly reduce the variation in such processes as credit card customer service center queues and staffing models along with the underwriting process for personal loans.

Another area where advanced analytics played a key role is in the IMPROVE phase of the DMAIC cycle. In this example the company was looking to grow through the acquisition of personal loans and the retention of auto loans. When the business set out to improve these processes based on feedback from external and internal customers using the standard DMAIC approach the advanced analytics team being part of the improvement team was able to suggest the use of multivariate models to improve the effectiveness of these programs. For personal loans propensity to respond and propensity to convert models were developed using campaign data and then deployed against new prospect lists. For the auto loan attrition models early loan termination propensity models were developed to determine when customers were going to buy a new car and terminate their existing loans and then the finance company worked with its auto dealer partners to promote to the customer in order to get a repeat sale and repeat financing. Using the advanced models the business was able to increase the effectiveness of process improvement by over 100%. Moreover, there were other aspects of improvement (i.e. operational changes which were made during the DMAIC cycle but these improvements using advanced analytics proved to have unique economic value.

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The ANALYZE phase of the DMAIC cycle requires analysis of the data collected. Typically Six Sigma training program teach students the basics in exploratory data analysis techniques and rarely go into advanced multivariate analysis options. On the descriptive statistics side some of the visual Exploratory Data Analysis techniques for example which are available in JMP software offered by the SAS Institute could really serve to enhance the analysis of univariate data in Lean Six Sigma improvement projects. Another application of advanced statistics during the ANALYZE phase is when trying to find relationships between the dependent variable and the potential independent variables. Tools like the Ishikawa or Fishbone diagram and the critical x analysis are often used but these are primitive methods or primitive methods are often recommended compared to the more advanced regression analyses which can be done. Moreover, when there are no hypotheses created in advance a non-objective clustering analysis can be a useful tool for exploring the data distribution.

The final CONTROL phase of the DMAIC cycle typically uses tools such as Failure Mode and Effect Analysis or FMEA, Risk proofing and Control Charts. Risk proofing was one area in the Control phase where the team was able to use advanced analytics to enhance predictability. They were able to do this primarily by incorporating some of their skills at credit card risk scoring analysis to predict defects in other areas such as fraud in Six Sigma projects where fraud was considered a defect. The same can be applied in a manufacturing setting to heavy machinery which is likely to fail at some point. If more information could be provided on when and how this equipment is likely to fail then this could be useful in the Control Phase of a Six Sigma Improvement Process.

Given the case studies outlined above we have evidence that the combination of Lean Six Sigma and advanced analytics go hand in hand due to their process oriented nature and rigorous search for the truth in data. Moreover, these paradigms combined will yield improved results over their separate application. In particular it was noted that advanced analytics could be used in the Measure and Analyze Phase of the DMAIC improvement process. During the measure phase a focus on advanced statistical techniques going beyond the simplistic control chart could really allow businesses to understand how a process is working.

3. CONCLUSIONS

The results of this case study and analysis show the promise of combining advanced analytics to the already effective Lean Six Sigma Quality paradigm. With the success at combining Lean and Six Sigma it only seems natural to also include advanced analytics and the rigorous data-driven approach to Lean Six Sigma lends itself well to this further combination.

One of the potential weaknesses of this research is that the use of advanced analytics is still in its infancy stage especially with the popularity and investments being made across the BIG DATA spectrum and therefore we are risking setting up processes which will change over time.

Therefore, an area for further research would be to adapt the current approaches to linking Lean Six Sigma with advanced analytics to the world of "BIG DATA" to be able to take advantage of the massive stores of information being accumulated to search for the true causes of phenomenon which could be embedded in the current literature unable to be unlocked except through analyzing "BIG DATA". Given the potential of "BIG DATA" to solve some of the world's most vexing causal inference problems and the lack of the structure around the use of "BIG DATA" I think the linking of the paradigms is extremely promising.

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I think the combined use of all of these techniques will yield some new knowledge of business processes embedded in the data but previously unobtainable due to technology and methodology limitations and I am looking forward to further exploration and uncovering this knowledge along with other colleagues who are interested in advancing the practice of Lean Six Sigma.

4. REFERENCES

[1] Barjaktarovic, L., Jecmenica, D. (2014) Six Sigma Concept, *Acta Technica Corvininesis – Bulletin of Engineering*. vol. 7 no. 3, pp. 103-108.

[2] Catalina, S. (2012) Six Sigma as a Strategic Tool for Companies, *Young Economists Journal*. vol. 7 no. 19, pp. 94-102.

[3] Dumitrescu, C., D. Tent, I., O., D., Dumitrescu, E., Ivonne, C. (2010) Lean Six Sigma Principles, *Annal of DAAAM & Proceedings*, pp. 433—435.

[4] Dumbill, E. (2012) What is Big Data? An Introduction to the Big Data Landscape. [Blog post, January 2011.] *O'Reilly Strata* . http://strata.oreilly.com/2012/01/whatis- big-data.html.

[5] Eckes, G. (2000). *The Six Sigma Revolution: How GE and Others Turned Process into Profits.* New York: Wiley.

[6] Franks, B. (2012) Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics. New York: Wiley.

[7] Gobble, M., A. (2013) Big Data: The Next Big Thing in Innovation. *Research and Technology Management*, vol. 56, no. 1, pp. 64-66.

[8] Harvard Business Review (2012) Spotlight on Big Data. *Harvard Business Review* 90(10) (October).

[9] Jacobs, F. R. & Chase, R. (2011). *Operations and Supply Chain Management*. (13th ed.) Boston, MA: McGraw-Hill Irwin.

[10] Lean Production.com (2015) *Online Source for Lean-Based Information and Tools*. In: http://www.leanproduction.com/

[11] Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C.

[12] and Hung Byers, A. (2011), Big Data: The Next Frontier for Innovation, Competition, and Productivity, McKinsey Global Institute.

[13] Ravichandran, J. (2012) A Review of Preliminary Test-Based Statistical Methods for the Benefit of Six Sigma Quality Practitioners, *Statistical Papers.* vol. 53, no. 3, pp. 531-647.

[14] Vijaya, S., M. (2013) Synergies of Lean Six Sigma. *IUP Journal of Operations Management*, vol. 12, no. 1, pp. 21-31.

GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

[15] World Economic Forum. 2012. Big Data, Big Impact: New Possibilities for International Development . Geneva, Switzerland: *World Economic Forum*. http://www.weforum. org/reports/big-data-big-impact-new-possibilities-international-development.