Lean Six Sigma and Big Data: Continuing to Innovate and Optimize Business Processes

by

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Abstract

Lean Six Sigma is widely used in many areas such as government, industry, healthcare and education. Big Data which is being collected in ever-increasing amounts due to digital commerce is viewed by futurists as holding many promises to solve some of our greatest problems in society and create new commercial ventures. This paper explores how Lean Six Sigma can be applied to accelerate the process of extracting key insights from Big Data and also how Big Data can bring new light and innovation to projects requiring the use of Lean Six Sigma. A case study approach using examples from both manufacturing and the service sector will be used in this research.

Keywords: Big Data, Six Sigma, Innovation, Lean, Analytics, Quality, Improvement, Lean, Data Mining

Introduction

The popularity of the Lean Six Sigma quality paradigm has been accompanied by 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 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; Fogarty, 2015).

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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; Fogarty, 2015).

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; Fogarty, 2015).

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 (ABB) 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 some of the businesses many individual units were implementing their own quality programs (Eckes, 2000; Catalina, 2012; Vijaya, 2013, Barjaktarovic & Jecmenica, 2014; Fogarty, 2015). 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; Fogarty, 2015).

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 Black Belts and Master Black Belts 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; Fogarty, 2015).

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; Fogarty, 2015).

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; Fogarty, 2015).

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; Fogarty, 2015).

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; Fogarty, 2015).

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; Fogarty, 2015).

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 meet in a product being assembled. This was the ultimate form of empowerment and is one of the reasons 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; Fogarty, 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; Fogarty, 2015).

Analysis and Case Studies

The advantages of incorporating Big Data into Lean Six Sigma projects can be described at several levels. Firstly it has the advantage of being able to improve the impact of merging advanced analytics with Lean Six Sigma projects. This is due to the fact that 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 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 some research to date on the use of advanced statistics and Six Sigma. Ravichandran (2012) discussed the inclusion of rigorous test based methods in Six Sigma. Fogarty (2015) evaluated 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.

Given this recent evidence that advanced analytics can serve to enhance the Lean Six Sigma process we are further hypothesizing that adapting the current approaches to linking Lean Six Sigma with advanced analytics to the world of Big Data will enable practitioners to be able to take advantage of the massive stores of information being accumulated to better measure the process and to search for the insights which can fuel process improvements and innovation. We further hypothesize that some of these insights will unable to be unlocked except through analyzing Big Data.

If Six Sigma practitioners believe the above hypothesis to be correct then they should begin to focus on the *Internet of Things* and learn how this overall trend could potentially be used to fuel their Six Sigma improvement project. Two companies GE and Cisco are currently making big bets on the Internet of Things. Interestingly, they are both very different companies with GE being a conglomerate with products ranging from light bulbs to aircraft engines and Cisco being a company that makes routers, switches and other technological devices. However, when it comes to the Internet of Things they are competing in the same space in terms of investing in activities which can allow businesses to realize gains through the internet. Both of these companies have a particular DNA which makes them solid contenders in the race to win in this space. GE for example, an execution focused industrial giant business which was also Lean Six Sigma pioneered and developed all things electric starting with the commercialization of the invention of Thomas Alva Edison. Moreover, GE developed deep analytical capabilities unlike many of its industrial peers with the rapid growth of GE Capital over the previous three decades.

Cisco on the other hand was an early pioneer in routing technology and can be solidly credited with being a key enabler in the growth of the internet. What better company to also help to now unlock the power of Big Data onto industry. Cisco, by the way is another strong user of

Lean Six Sigma. I had the chance to interact with many Cisco employees who work across multiple functions and they are all fully engaged in this strategy.

In terms of case studies on the documented benefits of using Big Data for process improvement so far Manenti (2014) noted that

> Intel, in 2012, reported that it saved $3M by using Big Data for preventative analysis on a single microprocessor chip production line. Extending the process to more chip lines they estimate a savings of over $30 million over the next few years. He also reported that GE Aviation estimated that it could increase production speeds by 25% through use of : big data analytics to enable *in process* inspection. Moreover, GE intends to use Big Data analytics to cut down inspection after the building process is completed by another 25%. Those numbers will add up over time and as the use of Big Data proliferates through manufacturing processes (p. 2).

Given these cases it's easy to imagine how Six Sigma may benefit from using Big Data especially as the delivery system to realize these big potential improvements and therefore and we are calling for a more formal integration of the two initiatives for manufacturing.

Another manufacturing Big Data case study discussed by Auschitzky et al. (2014) was a biopharmaceutical company which sought to reduce inconsistency in capacity and quality of its manufacturing processes which could attract regulatory attention. Using Big Data Analytics the team conducted a segmentation analysis of its manufacturing processes based on activity. Doing this it identified processes interdependencies and identified none parameters which could impact vaccine yield. The team them modified target processes according to the insights generated from the analysis and were able to increase vaccine production by 50% resulting in a savings between $5 and $10 million USD annually.

On the services side the equivalent of the Internet of Things is social media, mobile and e-commerce. The entire business practice of utilizing this data is sometimes referred to as SOLOMO which stands for Social, Local and Mobile. Businesses are fast waking up to the advantages of using this data and other unstructured data captured by the business to develop better relationships with their customers but have yet to think about how the information gathered from these activities can also lead to process improvement in things like underwriting, customer service, accounts receivable collections, etc.

IBM Consulting (2015) recommends that harnessing the full potential of social business occurs in two steps. Firstly, firms should extend their existing core business processes through social tools. Secondly, firms should put into place the process changes that drive social behavior. For example, the marketing benefits of social media and big data are already well established with allowing customers to have greater interaction (and to actually be a participant) in a firm's branding campaign. However, there is an emerging benefit to the use of social media and Big Data to enable process improvement. Edwards and Amos (2011) discuss how a new mini-industry has emerged using these techniques, known as *customer experience management*, or *CEM*. Companies in this space are providing customer feedback to operations, while partnering with *web-scraping* companies to listen to random chatter online. Edwards and Amos (2011) further point out that a well-managed loop that links customer experience feedback with recommendations on social networks like Twitter, Facebook, Linkedin and Yelp, can boost operational performance and service quality, increase traffic and greater customer satisfaction. Edwards and Amos (2011) provided a case study with Debenhams, an upscale department store in the United Kingdom below is the transcript of this case:

> . . .a customer complained through an online survey about a poor meal they received at the store's restaurant. "Ordered turkey dinner. Very dried out. Overcooked vegetables in greasy, cold gravy." The store manager called the customer that night, apologized, and sent a coupon for two free meals. The customer was invited to post their happiness with the problem's resolution on Facebook, and did. The store manager made sure the kitchen turned out better turkey dinners. The result: a satisfied customer, better kitchen operations, and free social network advertising. Debenham's effectively took what would have been a one-off customer experience problem and turned that customer into a Debenham's advocate online and improved its operations to reduce the possibility of future disgruntled customers (p. 1).

Outside of SOLOMO companies in the service industry are also using advanced data mining and Big Data to crack big problems. For example, Hamm (2012) discussed how Infinity Property and Casualty Co. is using Big Data and predictive analytics to spot insurance fraud. The results of this activity according to Infinity managers was an increase in the success rate in pursuing fraudulent claims from 50% to 88% and a reduction in the cycle time required to refer questionable claims for investigation by 95%. Moreover, Infinity has realized an underwriting profit every year since this activity which is a rarity in the auto insurance market.

Given the literature and strong case studies outlining the use of Big Data to enable process improvement and innovation in services there is a strong recommendation for the integration of Lean Six Sigma and Big Data.

Conclusions

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. This is especially true since its time for Lean Six Sigma to have a refresh.

A limitation of this study is that the use cases are for manufacturing and service process improvement in general and have not been focused specifically on applying within the Lean Six Sigma paradigm. It's also early days in the use of Big Data being applied to process improvement and innovation so there is still much that we just don't know yet. Therefore any applications of Big Data to the more mature Lean Six Sigma paradigm is bound to undergo several future iterations of changes.

As a suggestion for future research use case pilots should be conducted on using Big Data in DMAIC projects and the incremental impact of using the data combined with the quality paradigm should be validated. If it proves that there is incremental value then the tie-up between Lean Six Sigma and Big Data can either be facilitated from a broad perspective (similar to Lean and Six Sigma) or a more local perspective (i.e. creating new Lean Six Sigma tools incorporating Big Data).

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 using Lean Six Sigma for process improvement and innovation.

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