

Quality management in heavy duty manufacturing industry:

TQM vs. Six Sigma

Abstract

‘Is TQM a management fad?’ This question has been extensively documented in the quality management literature; and will be tackled in this research through a critical literature review on the area. ‘TQM versus Six-Sigma’ debate, which has also been a fundamental challenge in this research filed, is addressed by a thematic and chronological review on the peer papers.

To evaluate this challenge in practice, a primary research in heavy duty machinery production industry have been conducted using a case-study on, J C Bamford Excavators Ltd (JCB), the largest European construction machinery producer. The result highlights that TQM is a natural foundation to build up Six-Sigma upon; and not surprisingly the quality yield in a TQM approach complemented by Six-sigma is far higher and more stable than when TQM with no Six-Sigma focus is being put in place; thus presenting the overall finding that TQM and Six Sigma are compliments, not substitutes. The study will be concluded with an overview on quality management approaches in the heavy duty manufacturing industry to highlight the way forward for the industry.

Key Words: TQM, Six Sigma, Heavy Duty Machinery Manufacturer (HDM)

The battle between TQM and Six Sigma

Manufacturing industries are the wealth-producing sectors of the economy (Freidman, 2002), with service industries being seen as wealth-consuming sectors. Manufacturing industry is the second largest sector within the European Union and around 1 in 10 of all enterprises in the EU-27's non-financial business economy are classified as manufacturers, contributing to 22.6% of employment rates and 26.8% of non-financial business economy value added (Eurostat, 2013); thus highlighting the importance of manufacturing industries. Furthermore, manufacturing industry in the UK, although has underperformed service industry, employed around 2.5 million people in in the country and was accountable to 10% (£139 Billion) of national economic output in 2012 (Rhodes, 2014). More specifically, 3.38% of the UK manufacturing national economic output is comprised from the heavy duty machinery production; worth just over £4.7 billion in 2009 (JCB, 2009). This sector will be studied in this paper as the target industry.

Due to the swelling levels of competition in the manufacturing industry, high levels of quality, continuous improvement and cost reduction are the fundamental factors in enabling organisations to gain a world-wide market edge and thus meeting customers' needs more effectively (Tennant, 2001). Furthermore, it has been stated that the management of quality holds equal importance to the quality of management (Evans and Lindsay, 2002). With this being said, despite a previous limit of Quality Management approaches, over the past fifty years a plethora of quality improvement initiatives have been produced and amassed.

TQM: Is it still alive?

In recent decades, there had been extensive documentation of quality management practises, often resulting in concepts being misunderstood; causing many to be termed the latest "management fad" (Dahlgaard and Dahlgaard-Park, 2006. p. 263). Upon review of literature, TQM appears to be one of the most deliberated management fads over recent decades. Beginning

in the mid-1990's, articles have appeared that have “touted the demise and death of Total Quality Management”, questioning the credibility and value of the management approach (Green, 2006. pp. 1281-1282). Reflecting upon the failures of organisations endeavouring to apply the TQM approach (Mann, 2008), it was anticipated that TQM's fate would emulate the “dinosaur-like extinction” of the old management by objectives (Albrecht, 1992. p. 271); which was once anticipated to transform the world of business during the peak of its success (Dahlgaard-Park, 2011). The discussion surrounding the “fall” of TQM (Douglas, 2006), and the need to “give TQM a decent burial” (Albrecht, 1992. p. 272), has not been constrained to academics; the media and businesses have progressively joined the surge of criticism (Yong and Wilkinson, 1999. p. 138) most notably Byrne (1997), who declared that TQM is “as dead as a pet rock”. More recent studies also indicate that TQM restrains ability to innovate and flexibility of the companies to change especially in uncertain and fast moving industries (Steiber and Alänge, 2012; Cole and Matsumiya, 2008), which suggest TQM can be a management fad.

However, one way to measure whether TQM has followed the fad behaviour is to observe the number of seminar and conferences on the topic (Dahlgaard-Park, 2011) as well as the number of academic publications (Naslund, 2008). Figure 1 has been produced to demonstrate the number of TQM publications over the last two decades; searching three main journal databases (ScienceDirect, Emerald and ABI/INFORM (ProQuest)) for papers with TQM in the titles from 1990.

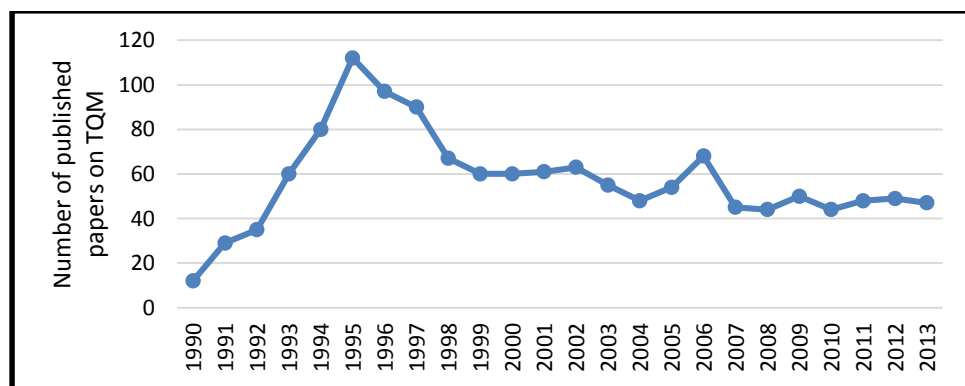


Figure 1 – Frequency of TQM publications from 1990.

Data shown by Figure 1 corresponds with results highlighted by Naslund (2008,p.276); TQM experienced enormous popularity in the mid-1990's. Despite this early popularity, reports presenting a lack of results, problems with implementation, and TQM failure, started to appear later; thus leading to a significant drop in the number of published TQM articles (Naslund, 2008. p. 276).

Furthermore, literature has highlighted one of TQM's shortfalls being the inability to remove recognised root causes, thus causing organisations to revert back to their original performance due improvement gains being lost over time (Black and Revere, 2006). In addition, Dahlgaard-Park (2011) identified that negative criticism of TQM comes in two forms: the lack of consensus about the true definition of TQM, and the way in which some organisations have failed to implement the approach correctly. Lau and Anderson (1998) presented that the July 1995 'Quality Progress' magazine contained thirteen articles on TQM; with twelve different definitions of TQM given amongst them. Amongst other things, TQM has been defined as, "...a culture..." (Dahlgaard et al., 1998), "...a philosophy..." (Oakland, 1993), "...an approach..." (Dale, 1999) and "an Strategy" (Bohan, 1998. pp. 13-14). It can be said, therefore, that is a result of the lack of clarity that correct and full implementation of TQM has failed; TQM supporters will have had little direction of what to target and apply (Bergquist et al., 2005). These different definitions, however, then were categorised into two main types, by Mann (2008): 1- Definitions that takes ultimate goals of a system to describe TQM; 2- Definitions that explain the activities and functions to be addressed to target the system's goals.

According to research, various academics have undertaken studies, concluding that TQM has failed to bring about financial improvements within organisations. The finding most cited in Quality Management commentaries - the damaging survey carried out by Kearney (1992) - concluded that around 80% of TQM initiatives have failed; with the reason for the failure being

the gap between what practitioners advocated and what was realistically being implemented (Kolesar, 1995). Green (2006, p. 1282) supports this view, stating that TQM is an “elusive goal” leading to idealistic organisational expectations and the desire for instant results. Professor Neogy (in Antony, 2007), believes that the reason for the failure of TQM is not because of its philosophy, but due to the lack of a framework for correct application. Therefore, in order to adopt TQM, it was necessary for organisations to hold a deeper understanding of what it was about (Green, 2012; Dahlgaard-Park, 2011); generally leading to many organisations turning their back on TQM (Douglas, 2006).

Despite reports of TQM being a concept that is hard to understand and difficult to implement, Bergquist et al. (2005) believe that TQM still generates benefits if used properly, and is apparently flourishing in organisations as evident by the number of international and national quality award winners (Van Der Wiele et al., 2002). Whilst there are many reports declaring the death of TQM, there are also studies that reinforce the merits of employing TQM as a powerful quality roadmap, and highlight the many benefits and values of such a management approach (Sanchez and Blanco, 2013; Yong and Wilkinson, 1999). Bergquist et al. (2005) go further to argue that critics will always find dissatisfied organisations, and will therefore continue to produce harmful academic articles.

In response to such criticisms against TQM, various researchers have presented that, in reality, organisations with a successful TQM implementation outperform other organisations financially (Andersson et al., 2006). This is supported by a study of 60 companies that had practiced TQM for a period of at least five years, and due to this long-term commitment they managed to see an improved profit margin (Lemak and Reed, 1997). Similarly, a survey of 350 HR managers, performed by the Institute of Personnel Management (1993), found that 76% of organisations had experience with Quality Management; 65% of which rated TQM as “successful”, with a mere 5% reporting their initiatives were “unsuccessful” (Yong and Wilkinson, 1999. p. 138). In

addition, an example of where TQM has brought about substantial improvements and is considered a success is AT&T Transmission Systems Business Unit (Evans and Lindsay, 2002, p. 50); within six years of implementation, the same period that five major competitors experienced financial losses, the unit achieved a 10-fold improvement in equipment product quality and \$400million in cost improvements. These success stories support that TQM is no “quick fix” that success and financial gains are delivered only in the long term (Dahlgaard and Dahlgaard-Park, 2006, p. 272).

The main concern is that the majority of reports portray an unfair indication of what TQM can potentially achieve; due to many organisations having advocated partial and ad-hoc TQM efforts, which are far from the full TQM (Yong and Wilkinson, 1999). Despite research suggesting that TQM has been tried and found inadequate, Evans (1995, p. 5) argues that in reality it has “been tried and found difficult, or tried, yet misunderstood”. Therefore, although it is argued that TQM is not a management fad (Douglas, 2006), the success of TQM does depend on several factors, such as: the organisational culture of the firm that applies TQM concepts (Green, 2012); sector and size of the firm (García-Bernal and García-Casarejos, 2012); how they define TQM in their organisations (Bergquist et al., 2005); how management teams are committed to TQM as a long-term quality approach (Talib et al., 2012) and how they sustain this system in their firms (Gimenez-Espin, et al., 2013). In other words, TQM is not an exact formula and one size definitely does not fit all. Nevertheless, TQM is flexible in its ability to fit particular organisations (Ehigie and McAndrew, 2005). After all:

“TQM is a philosophy, not a science. Philosophies are seldom suddenly born, and they almost never die; they simply get improved upon” Paton (1994, p.3).

Six Sigma: A replacement for TQM?

Upon review of the surrounding literature, it is evident to see that other Quality Management concepts, such as Six Sigma, have grown in popularity (Karthi et al. 2012; Mossa and Sajid, 2010). Over recent years, Six Sigma has been one of the few technically oriented initiatives to generate interest from business leaders, the financial community, and the popular media (Hoerl, 2001); with many organisations having moved their practices and strategies towards such an approach (Andersson et al., 2006). The significant success of Six Sigma success can be traced to Motorola, where between 1987 and 1997, the organisation accomplished a “fivefold growth in sales with profits climbing nearly 20 per cent per year”, (Klefsjö et al., 2001. p. 32). Similarly, Six Sigma’s positive financial impact has been displayed through Volvo Cars in Sweden, who claim that between 2000 and 2002, Six Sigma enabled a bottom-line contribution of over €55 million (Andersson et al., 2006).

Furthermore, it is claimed that Six Sigma overcomes the shortages that were evident within TQM, including the failure to break down internal barriers and unclear quality (Pande et al., 2000). This approach represents a new collective and multidimensional approach to quality (Harry, 2000), which has showed a much better record of effectiveness than TQM (Antony, 2004; Cheng, 2008); thus suggesting Six Sigma is a “replacement for Total Quality Management” (Green, 2006. p. 1283).

In the current situation of high global competition and a climate of cost reductions, Six Sigma achieves significantly more on areas (Grima et al., 2013), “where some existing TQM efforts have lost focus” (McAdam et al., 2005. p. 168). Andersson et al. (2006, p. 291) believe this is because “six sigma programmes talk the top managers’ language”, which is “the financial gains of the improvement”. It is also claimed that six sigma can bring competitive advantage to the organisations which manage it well (De Mast, 2006).

Six Sigma’s rise in popularity is also evident through the increased frequency of academic publications, as shown by Aboelmaged (2010), who reviewed the distribution of 417 Six Sigma articles over the period from 1992-2008. Using the same method as for Figure 1, research by Aboelmaged (2010) has been updated and the academic publications frequency on the Six Sigma topic has been summarised in Figure 2. Despite the apparent limited academic publications before 2000, literature on Six Sigma flourished between 2000 and 2005, with the frequency of journal articles significantly increasing over this period. Although the “blooming years for Six Sigma” were followed by a slight decline in mid of last decade, the escalation in growth of Six Sigma articles was significant thereafter (Aboelmaged, 2010. p. 271).

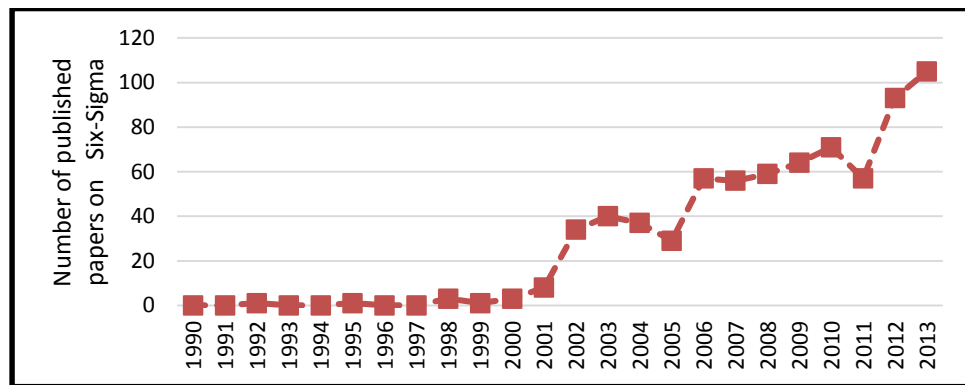


Figure 2 – Frequency of Six Sigma publications from 1990.

In addition, it is believed that Six Sigma has risen from the ashes of TQM and its shortages by introducing new concepts and approaches (Black and Revere, 2006); with literature suggesting that Six Sigma application of root-cause techniques discovers variability, and ensures a more thorough search than any other previous quality improvement. Perhaps due to Six Sigma being data-driven, using measurements to analyse problems and thereby improve the process or outcome, and enabling organisations to position their quality improvement effort in comparison to others (Grima et al., 2013); all of which can be compared to TQM, which has no way to measure quality (Black and Revere, 2006). In summary, it is argued that Six Sigma projects are

closely tied to business goals and objectives that are usually based around satisfying customer needs (Ingle and Roe, 2001).

Despite an obvious lack of criticism against Six Sigma except some methodology difficulties and implementation issues (Grima et al., 2013), some academics claim that it is merely an add-on project management tool (Nonthaleerak and Hendry, 2008), and a repacked version of TQM which has simply added and retracted a few components and been flogged under a different name (Bergquist et al., 2005). Additionally, some researchers question Six Sigma's originality, claiming that it has been around for many years in the form of problem solving, team building, and SPC, and that there is nothing new about it (Reed, 2000). The originality should, however, be appreciated in the form of its enhanced operational methods, tools and techniques, such as developments in statistical and operational methods of data analysis (Goh and Xie, 2003; McAdam et al., 2005).

Further description of Six Sigma states that it is merely, "old wine in a new bottle"; for the reason that most of the tools incorporated within it are several decades old (Thawani, 2004). Furthermore, academics state that the Six Sigma programme should not be considered as a replacement for TQM, for the reason that it is not as triumphant in improving customer satisfaction as the programme focusses primarily on financial savings (Andersson et al., 2006). Literature by Klefsjö, et al. (2001, p. 34) suggests that Six Sigma should be positioned in the larger context; simply as a methodology within the framework of TQM.

Six Sigma or TQM?

Various debates surround the issue of which 'roadmap' is best to follow when wanting to achieve world-class quality; with Dahlgard and Dahlgard-Park (2006) stating that alternative roadmaps to TQM are very hazardous to embark on without the correct company culture. Organisations require understanding that simple roadmaps like Six Sigma, will never work without a cultural

background or the core principles of TQM. Subsequently, Six Sigma should only be looked upon as a new 'roadmap' to follow, once TQM has already been successfully implemented, or once the organisation is in the process of implementing it (Dahlgaard and Dahlgaard-Park, 2006). On the other hand, TQM is reported to be a roadblock when implementing Six Sigma due to the time and capital investments of establishing and supporting such a programme only to start a fresh with an alternative programme (Revere and Black, 2003). Fortunately, organisations can integrate many Six Sigma models and concepts with existing TQM efforts, thus enabling a smooth adoption of Six Sigma, which is vital to the successful implementation of a quality management system (Cheng, 2008).

Conversely, Six Sigma is believed to be important to the success of TQM as it supports all six of the values within TQM, and illustrates a dynamic management system (Klefsjö et al., 2001). Lucas (2002) also supports this by saying that Six Sigma reinforces TQM efforts through a strategic approach. With both concepts sharing the same aim: waste and resource reduction resulting in improved customer satisfaction and financial results (Andersson et al., 2006).

Further research demonstrates that TQM's integration with Six Sigma metrics provides a measure of comparability used to aid quality improvement (Revere and Black, 2003). A survey by Cheng (2009) presented that 11 companies were shown to be effective in implementing Six Sigma through analysis of SPSS. This survey highlighted the possibility for companies to implement Six Sigma under the framework of TQM activities. In addition, research suggests that most of the organisations claiming Six Sigma success, such as Motorola and GE, also have well established TQM programmes in place (McAdam et al., 2005). Kinpo Electronics (KE) has achieved continuous improvement and competitive advantage via the combination of TQM activities and the Six Sigma approach (Cheng, 2008. p. 193-194); stating that KE's addition of Six Sigma to its business system, gave the organisation almost all of the elements of TQM - "the current business system + Six Sigma = TQM". Based on this formula, it is therefore believed

that in modern industry, TQM remains firmly in the position of the overall quality programme (Cheng, 2008).

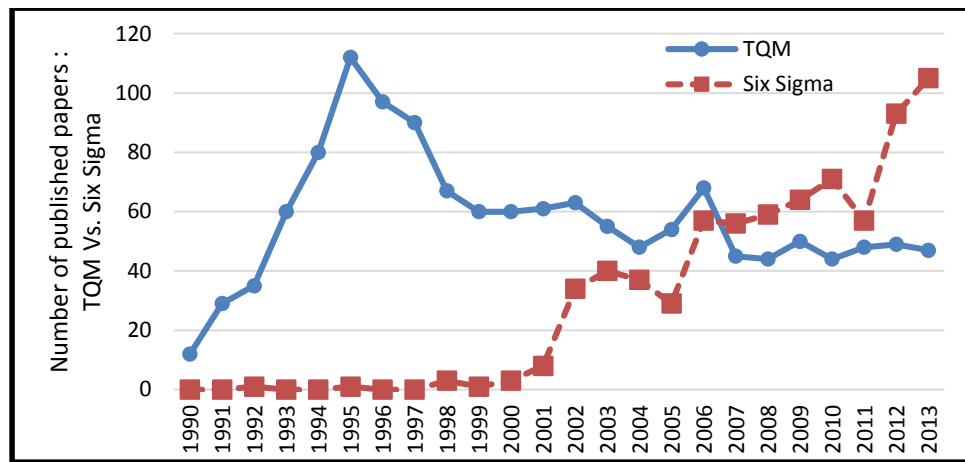


Figure 3 – Comparison between publications frequency on Six Sigma and TQM from 1990.

Figure 3, a combination of Figure 1 and 2, presents the comparison between TQM and Six Sigma publication frequencies. This figure illustrates that, despite a boost in Six Sigma popularity after 2000, the number of TQM publications remained fairly stable in this period; which itself highlights a firm and consistent attention of both academia and world of practice to TQM, while Six Sigma was on the grill!

In terms of the system, Johansson et al. (2012) in an empirical study of 138 Swedish firms showed that organisations often build up a tailored quality profile, which they retain and build up upon it over time. Similarly, TQM’s improvement activities, such as QCC, QIT, QA and the ISO system, all represent TQM’s basic mechanisms that must be secured and cannot be abandoned when implementing Six Sigma (Cheng, 2008). In summary, implementation of Six Sigma via TQM activities requires two shifts: moving from TQM’s quality index to reduce the system’s defect rate and to align with Six Sigma’s financial focus; and moving from PDCA to DMAIC and from inter-organisation activities to cross functional teams (Cheng, 2008). Klefsjö et al. (2006, p. 175) conclude:

“Feel free to use Six Sigma, but do try to integrate it with TQM, or else you may end up with too thin a soup that may separate and come apart”

Results

One of the world biggest heavy duty manufacturers (HDMs) of construction equipment is J C Bamford Excavators Ltd (JCB), shoulder to shoulder to the other four world class manufacturers, Caterpillar, Volvo, Kubota and Hitachi (JCB, 2009). JCB is located on four different continents, with manufacturing sites in the UK, Brazil, China, Germany, India and USA. JCB’s product range of over 300 types is distributed to over 150 countries all over the world (JCB, 2009). Having both TQM and Six Sigma experience in the production of their machines and engines, respectively, JCB was chosen to be studied in this research.

This research focusses upon results from two assembly lines; JCB Compact Products’ small machine production, and JCB Power Systems’ engine production. JCB’s Compact Products plant has traditionally implemented TQM as a base, in combination with their in-house ‘JCB Production System’. In comparison, the JCB Power Systems plant has put Six Sigma in action on the existing foundations of the TQM approach.

Upon direct comparison of the percentage of fault free products at both TQM and Six Sigma production lines, results show that the Six Sigma-TQM approach has impressively achieved 6 times less quality variation. However, the results do not represent the end product quality stage due to the confidentiality agreement with the company. This study also shows Six Sigma built upon TQM foundation achieves faster, better and more consistent results than TQM alone. Additional comments from the Quality Manager at JCB’s Power Systems plant recognise the importance of TQM; “Really, TQM is the base with Six Sigma adding value where applicable”, which highlights that Six Sigma’s successful implementation depends upon TQM’s valuable framework.

Nevertheless, these results do not discount TQM's success, as the quality manager at JCB's Compact Products believes that, since the implementation of TQM, "the improvement trend has been dramatic at Compact products since 2007"; thus indicating that TQM has not become a management fad and is still alive and well in practice.

This study has also highlighted that, in HDM, operations and quality management are traditionally benchmarked from the automotive industry and often incorporated into company production systems. This is supported by the quality managers at both JCB plants who state:

"JCB does benchmark against other organisations, mainly automotive OEM's such as Jaguar, Land Rover and Toyota. They actively seek out professionals from these organisations to bring the knowledge into the company; this is how the TQM approach started and the JCB production system"

"JCB aren't keen on implementing quality initiatives; instead they try to incorporate them into the JCB Production System, as a method of avoiding the management fads that occur every few years. Even though Six Sigma is implemented; it isn't implemented fully... they do have employees who have the same skills; they just don't go by the same name"

Despite the use of automotive benchmarks in HDM, it is fair to state that there are obvious differences between the two; with the niche HDM comprising of less standardised and smaller scales of production with higher variety of the products. Therefore this study also looks further at what quality management approach other HDMs are using.

In 2001, after periods of stagnant growth, Caterpillar combined Six Sigma with their existing lean approach to create phenomenal results; securing a 50% reduction in lead times and an 80% growth in revenues by 2005 (Byrne, Lubowe and Blitz, 2007). According to Dave Burritt,

Caterpillars VP and CEO, “6 Sigma has been applied to increase our percent of industry in all of our principal lines of business... Without question, we are in the best of times at Caterpillar, and the improvements would have been much less without 6 Sigma” (Byrne, Lubowe and Blitz, 2007). Furthermore, it is important to note that Caterpillar launched this quality management initiative long before the term ‘Lean Six Sigma’ was commonly used.

Volvo, one of the other players in HDM, has also converged several quality management paradigms with TQM and the Toyota Production System (TPS) since 1999 (Muffatto, 1999). Their adaptation of lean six-sigma has proven to be a success, with Six Sigma contributing over €55 million to their bottom line between 2000 and 2002 (Andersson et al., 2006); with these results owing to the stable foundations of such paradigms as TQM (Berg and Ohlsson, 2005).

Hitachi, another main competitor of JCB, experienced a 20% increase in its sales of one of its niche markets, post-adaptation of the Theory of Constraints (TOC), another operations management concepts, in the early 2000’s (Goldratt, 2009). Therefore, TOC can also be extended to the HDM market upon its immense result in Hitachi, only if, as Naor et al. (2013) explain, it gets senior managements’ support to become a formal operations management approach and continuous improvement philosophy.

This review of the quality management approaches in HDMs highlights that JCB, despite their much improved levels of quality upon adapting TQM and then six sigma, still needs to be fully aware of long road of competition ahead in managing its quality and operations.

Conclusion

To sum up, although this study established that implementing TQM in HDM manufacturing has generally been successful, the extent to which TQM may continue to improve quality in this area of practice can be questioned. It is mainly due to the relatively large operations performance variances that this approach may tolerate, comparing to other quality approaches, which indicate

that TQM may lose focus in time; thus supporting the claim by McAdam et al. (2005). Despite this drawback, TQM should not be treated as a management fad, due to the evidence of its success in systematic and continuous quality improvement, as argued with the case of JCB in this research.

Six sigma was also found as another successful quality management approach in HDMs showing a faster and better records of effectiveness at improving quality when it is built on the foundation of TQM, as shown in the case of JCB in this research.

Finally other operations improvement philosophies such as Theory of Constraints has recently emerged in HDM industry and proved to be highly effective and successful, which shows further potentials for future.

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References

- Aboelmaged, M.G. (2010), "Six sigma quality: a structured review and implications for future research", *International Journal of Quality & Reliability Management*, Vol. 27, No. 3, pp. 268-317.
- Albrecht, K. (1992), "No eulogies for TQM". *The TQM Magazine*, Vol. October, pp. 271-272.
- Andersson, R., Eriksson, H., Torstensson, H. (2006), "Similarities and differences between TQM, six sigma and lean", *The TQM Magazine*, Vol. 18, No. 3, pp. 282-296.
- Antony, J. (2004), "Some pros and cons of six sigma: an academic perspective", *The TQM Magazine*, Vol. 16, No. 4, pp. 303-306.

- Antony, J. (2007), "Is six sigma a management fad or fact?", *Assembly Automation*, Vol. 27, No. 1, pp. 17–19.
- Berg, A., Ohlsson, F. (2005), *Lean Manufacturing at Volvo Truck Production Australia: Development of an implementation strategy*, MSc thesis, Lulea University of Technology.
- Berquist, B., Fredriksson, M., Svensson, M. (2005), "TQM: terrific quality marvel or tragic quality malpractice?", *The TQM Magazine*, Vol. 17, No. 4, pp. 309-321.
- Black, K., Revere, L. (2006), "Six Sigma arises from the ashes of TQM with a twist", *International Journal of Health Care Quality Assurance*, Vol. 19, No. 3, pp. 259-266.
- Bohan, G. (1998), "Whatever happened to TQM? Or how a good strategy got a bad reputation", *National Productivity Review*, Vol. 17, No. 4, pp. 13-16.
- Byrne, G., Lubowe, D., Blitz, A. (2007), "Using a Lean Six Sigma approach to drive innovation", *Journal of Strategy and Leadership*, Vol. 35, No. 2, pp. 5-10.
- Byrne, J.A. (1997), "Commentary: Management Theory or Fad of the Month?", *Bloomberg Business Week*. Available at <http://www.businessweek.com/stories/1997-06-22/commentary-management-theory-or-fad-of-the-month> (accessed date November 17, 2011).
- Central Intelligence Agency. (2010), "The World Fact book: European Union", *Central Intelligence Agency*. Available at <https://www.cia.gov/library/publications/the-world-factbook/geos/ee.html> (accessed date November 27, 2011).
- Cheng, J.L. (2008), "Implementing Six Sigma via TQM improvement: an empirical study in Taiwan", *The TQM Journal*, Vol. 20, No. 3, pp. 182-195.
- Cheng, J.L. (2009), "Six Sigma and TQM in Taiwan: An empirical study of discriminate analysis", *Total Quality Management & Business Excellence*, Vol. 20, No. 3, pp. 311–326.
- Cole, R.E., Matsumiya, T. (2008). "When the pursuit of quality risks innovation." *The TQM Journal*, Vol. 20, No. 2, pp. 130-142.

- Dahlgaard, J.J., Dahlgaard-Park, S.M. (2006), “Lean production, six sigma quality, TQM and company culture”, *The TQM Magazine*, Vol. 18, No. 3, pp. 263-281.
- Dahlgaard, J.J., Kristensen, K., Kanji, G.K. (1998), *Fundamentals of Total Quality Management*, Chapman & Hill, London.
- Dale, B.G. (1999), *Managing Quality*, Blackwell Publishers, Oxford.
- De Mast, J. (2006), “Six Sigma and Competitive Advantage”, *Total Quality Management & Business Excellence*, Vol. 17, No. 4, pp. 455-464.
- Department For Business Innovation And Skills. (2011), Manufacturing, *Department for Business Innovation and Skills*. Available at <http://www.bis.gov.uk/policies/business-sectors/manufacturing-and-materials/manufacturing> (accessed date November 29, 2011).
- Douglas, A. (2006), “TQM is alive and well”, *The TQM Magazine*, Vol. 18, No. 1, pp. -.
- Ehigie, B.O., McAndrew, E.B. (2005), “Innovation, diffusion and adoption of total quality management (TQM)”, *Management Decision*, Vol. 43, No. 6, pp. 925-940.
- Evans, J.R., Lindsay, W.M. (2002), *The Management and Control of Quality*, Thomson, Cincinnati.
- Evans, R. (1995), “Perspectives: In defence of TQM”, *The TQM Magazine*, Vol. 7, No. 1, pp. 5–6.
- Friedman, D. (2002), *No Light at the End of the Tunnel*. Los Angeles Times, 16 June.
- García-Bernal, J., García-Casarejos, N. (2012). “Economic analysis of TQM adoption in the construction sector.”, *Total Quality Management & Business Excellence*, Vol. 25, No. 3-4, pp. 209-221.
- Goh, T.N., Xie, M. (2003), “Statistical Control of a Six Sigma Process”, *Quality Engineering*, Vol. 15, No. 4, pp. 587-592.
- Goldratt, E. M. (2009), Standing on the Shoulders of Giants –Production concepts versus production applications. *Revista Gestão & Produção*, Vol. 16, No. 3, pp. 333-343

- Green, F.B. (2006), "Six-Sigma and the Revival of TQM", *Total Quality Management & Business Excellence*, Vol. 17, No. 10, pp. 1281-1286.
- Gimenez-Espin, J. A., Jiménez-Jiménez, D., Martínez-Costa, M. (2013), "Organizational culture for total quality management.", *Total Quality Management & Business Excellence*, Vol. 24, No. 5-6, pp. 678-692.
- Green, T.J. (2012), "TQM and organisational culture: How do they link?", *Total Quality Management & Business Excellence*, Vol. 237, No. 2, pp. 141-157.
- Grima, P., Marco-Almagro, L., Santiago, S., Tort-Martorell, X. (2013). "Six Sigma: hints from practice to overcome difficulties." *Total Quality Management & Business Excellence*, (ahead-of-print), 1-11.
- Harry, M.J. (2000), "A new definition aims to connect quality performance with financial performance", *Quality Progress*, Vol. 33, No. 1, pp. 64–66.
- Hellsten, U., Klefsjo, B. (2000), "Perspectives: TQM as a management system consisting of values, techniques and tools", *The TQM Magazine*, Vol. 12, No. 4, pp. 238-244.
- Hoerl, R.W. (2001), "Six Sigma Black Belts: What Do They Need to Know?", *Journal of Quality Technology*, Vol. 33, No. 4, pp. 391-406.
- Ingle, S., Roe, W. (2001), "Six Sigma. Black Belt Implementation", *The TQM Magazine*, Vol. 13, No. 4, pp. 273-280.
- Institute of Personnel Management. (1993). *Quality: People Management Matters*, Institute of Personnel Management, London.
- JCB, (2009), Story of JCB, *JCB*. Available at <http://www.jcb.com/promotions/storyofjcb/storyofjcb.aspx> (accessed date January 12, 2012).

- Johansson, E., Witell, L., Elg, M. (2013). "Changing quality initiative—does the quality profile really change?", *Total Quality Management & Business Excellence*, Vol. 24, No. 1-2, pp. 79-90.
- Karthi, S., Devadasan, S. R., Muruges, R., Sreenivasa, C. G., Sivaram, N. M. (2012). "Global views on integrating Six Sigma and ISO 9001 certification", *Total Quality Management & Business Excellence*, Vol. 23, No. 3-4, pp. 237-262.
- Kearney, A.T. (1992), *Total Quality: Time to Take off the Rose Tinted Spectacles*, IFS Publications, Kempston.
- Klefsjo, B., Bergquist, B., Edgeman, R. (2006), "Six Sigma and Total Quality Management: different day, same soup?", *International Journal of Six Sigma and Competitive Advantage*, Vol. 2, No. 2, pp. 162-178.
- Klefsjo, B., Wiklund, H., Edgeman, R. (2001), "Six Sigma seen as a methodology for Total Quality Management", *Measuring Business Excellence*, Vol. 5, No. 1, pp. 31-35.
- Kolesar, P.J. (1995), "Partial quality management: an essay", *Production and Operations Management*, Vol. 4, No. 3, pp. 195-200.
- Lau, R.S.M., Anderson, C.A. (1998), "A Three-Dimensional perspective of Total Quality Management", *International Journal of Quality & Reliability Management*, Vol. 15, No. 1, pp. 85-98.
- Lemak, D., Reed, R. (1997), "Commitment to total quality management: is there a relationship with firm performance?", *Journal of Quality Management*, Vol. 2, No. 1, pp. 67-86.
- Lucas, J.M. (2002), "The essential of Six Sigma", *Quality Progress*, Vol. 35, No. 1, pp. 27-31.
- Mann, R.S. (2008), "Revising a TQM research project: The quality improvement activities of TWM", *Total Quality Management & Business Excellence*, Vol. 19, No. 7-8, pp. 751-761.

- McAdam, R., Hazlett, S.A., Henderson, J. (2005), "A critical review of six sigma: exploring the dichotomies", *The International Journal of Organizational Analysis*, Vol. 13, No. 2, pp. 151-174.
- Muffatto, M. (1999), "Evolution of production paradigms: the Toyota and Volvo cases", *Integrated Manufacturing Systems*, Vol. 10, No. 1, pp.15 – 25.
- Moosa, K., Sajid, A. (2010). "Critical analysis of Six Sigma implementation", *Total Quality Management & Business Excellence*, Vol. 21, No. 7, pp. 745-759.
- Eurostat (2013), "Manufacturing Statistics – NACE Rev.2", Europe (NACE), Available at http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Manufacturing_statistics_-_NACE_Rev._2#Further_Eurostat_information (accessed date Feb 28, 2014).
- Naor, M., Bernardes, E. S., Coman, A. (2013). "Theory of constraints: is it a theory and a good one?", *International Journal of Production Research*, Vol. 51, No. 2, pp. 542-554.
- Naslund, D. (2008), "Lean, six sigma and lean sigma: fads or real process improvement methods?", *Business Process Management Journal*, Vol. 14, No. 3, pp. 269-287.
- Nonthaleerak, P., Hendry, L. (2008), Exploring the six sigma phenomenon using multiple case study evidence. *International Journal of Operations & Production Management*, Vol. 28, No. 3, pp. 279-303.
- Oakland, J.S. (1993), *Total Quality Management*, Second Edition, Butterworth-Heinemann, Oxford.
- Pande, P.S., Neuman, R.P., Cavanach, R.R. (2000), *The Six Sigma Way*, McGraw-Hill, New York.
- Park-Dahlgaard, S.M. (2002), *The human dimension in TQM – learning, training and Motivation*, Linköping University Electronic Press, Linköping.
- Park-Dahlgaard, S.M. (2006), "The quality movement: where are you going?", *Total Quality Management & Business Excellence*, Vol. 22, No. 5, pp. 493-516.

- Paton, S. (1994), "Is TQM dead?", *Quality Digest*, Vol. 14, No. April, pp. 1-5.
- Reed, M. (2000), "Six Sigma eavesdropping on the Net!!!!", *Quality Australia*, Vol. 15, No. 1, pp.10.
- Revere, L., Black, K. (2003), "Integrating Six Sigma with Total Quality Management: A Case Example for Measuring Medication Errors", *Journal of Healthcare Management*, Vol. 48, No. 6, pp. 377-391.
- Rhodes, C., (2014), "Manufacturing", *House of Commerce, Economic policy and statistics section*, Available at <http://www.cbi.org.uk/business-issues/manufacturing-and-innovation/manufacturing/> (accessed date February 28, 2014).
- Sanchez, L., Blanco, B. (2013). "Three decades of continuous improvement." *Total Quality Management & Business Excellence*, (ahead-of-print), 1-16.
- Steiber, A., Alänge, S. (2012). "Do TQM principles need to change? Learning from a comparison to Google Inc." *Total Quality Management & Business Excellence*, Vol. 24, No. 1-2, pp. 48-61.
- Talib, F., Rahman, Z., Qureshi, M.N., "Prioritising the practices of total quality management: An analytic hierarchy process analysis for the service industries.", *Total Quality Management & Business Excellence*, Vol. 22, No. 12, pp. 1331-1351.
- Tennant, G. (2001), *Six Sigma: SPC and TQM in Manufacturing and Services*, Gower, Hampshire.
- Thawani, S. (2004), "Six Sigma – strategy for organizational excellence", *Total Quality Management & Business Excellence*, Vol. 15, No. 5–6, pp. 655–664.
- Van Der Wiele, A., Williams, A.R.T., Dale, B.G. (2002), "Total Quality Management: Is It a Fad, Fashion, or Fit?", *Quality Management Journal*, Vol. 7, No. 2, pp. 65-79.
- Yong, J., Wilkinson, A. (1999), "The state of total quality management: a review", *The International Journal of Human Resource Management*, Vol. 10, No. 1, pp. 137-161.