AN EMPIRICAL ANALYSIS OF LEAN SIX SIGMA IMPLEMENTATION IN SMES – A MIGRATORY PERSPECTIVE

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ABSTRACT

The purpose of this paper is to investigate the migratory nature of Lean Six Sigma (LSS) implementation in manufacturing based SMEs in the UK. The companies were surveyed at two points over a five year period. These periods were before and after the 2008 recession point and were identified in order to assess the level of LSS implementation as a result of the tougher economic climate that has prevailed in the manufacturing industry since 2008. Analysis is carried out on a sample of 96 manufacturing SMEs from a range of manufacturing sectors in the UK. Data was gathered from company CEOs via a triangulated method of questionnaire, direct observation and interviews. The findings show the dynamic nature of LSS implementation in SMEs. Further work will be required to extend the LSS categorisation system to provide a wider category set that further defines the dynamical nature of LSS implementation.

Keywords: Lean Six Sigma, Strategy Migration, Paradigm Adoption.

1   INTRODUCTION

Lean and agility are widely considered as Business Process Improvement (BPI) strategies that have facilitated high levels of sustainable growth in many manufacturing industries throughout the world (Hines & Rich, 1997) Over the years many academics and practitioners have attempted to integrate the two approaches through proposing the concept of 'Leagility' (Childerhouse & Towill, 2000) and later, 'Agilean' (Cox et al, 2007) since it was hoped and proven in some cases that an integrated system of creating a Lean yet highly responsive manufacturing system was beneficial to a range of companies dealing with the increased threat of globalization and low labour cost competition. Over the past ten years or so Six Sigma has been hailed as a key business improvement approach that is capable of achieving significant improvements in business process performance. Companies such as Motorola and GE have based their business process strategy around the Six Sigma concept.

As companies have continued to seek ways of delivering greater business performance at lower cost, the concept known at Lean Six Sigma has come to the forefront. Early developers of the Lean Six Sigma approach (George, 2002) seemed to concentrate on a simple connection between Lean and Six Sigma proposing that the business should be "Leaned up" first and then Six Sigma could then be introduced as a mechanism to reduce variation in a process and thus improve quality. Others proposed that the 'Lean' part of Lean Six Sigma could be brought in at the Improve stage of the Six Sigma DMAIC process thus effectively demoting Lean to a secondary process (Breyfogle, 1999). Later development of Six Sigma showed its application as an effective general business process improvement strategy (Amheiter & Maleveff, 2005). However, Six Sigma and Lean Six Sigma and its associated DMAIC cycle can be seen as a simple yet powerful five stage methodology however, it can be argued that it has limited strategic capability in its current form (Thomas et al, 2009). Above all, manufacturing SMEs need to be cognisant of the need to implement a coherent BPI strategy to run alongside its production management and technology strategies in order that the company becomes

sustainable and fit for purpose (Pham et al, 2009) . As competition from low labour cost economies increases, manufacturing companies (especially SMEs) continue to move towards the implementation and effective operation of Lean Six Sigma to remain competitive by offering higher levels of product customisation and technical services while maintaining Quality Cost and Delivery (QCD) performance in the global manufacturing market.

1.1   WHY SMES

At a base level, the requirement to develop a robust BPI programme in order to improve productivity, quality, range of products and other performance measures is now paramount (Zhang et al 2004). Despite the clear evidence for a need to develop and implement BPI approaches into SMEs to ensure survival and sustainable growth, many companies are reluctant to move towards the application of LSS (and other methodologies) since they feel that major investment is required and the full benefits of applying LSS in to companies is only really felt by larger companies. Also, SMEs in many instances believe that the benefits that LSS implementation brings to the average SME are not fully appreciated by companies (Kumar and Antony, 2008). This, along with the fact that SMEs perceive that they do not have the statistical infrastructure to support LSS severely limits their success in various BPI initiatives (Thomas et al, 2009).

Therefore, with some development already undertaken in delivering effective Six Sigma solutions in to SMEs, this paper attempts to identify the migratory characteristics observed in relation to the implementation of LSS into the business processes of manufacturing based SMEs in the UK. This paper attempts to answer the following questions:
1.   Are we able to identify whether the rate of LSS implementation in manufacturing SMEs has grown between the two survey periods and hence establish whether the recession has influenced companies to employ LSS in an attempt to reduce waste and increase operational performance?
2.   Are we able to identify whether SMEs have continued to increase the use of LSS in their respective companies and have migrated towards becoming expert in development and application of LSS?.

In order to answer these questions, a two stage survey was developed. The initial survey was undertaken between 2006 and 2008. However, soon after survey closure in 2008, the UK went in to recession. The authors then identified an opportunity to revisit the companies surveyed on the initial investigation in order to investigate how company attitudes towards the implementation of LSS had changed and whether the companies had increased the level of LSS implementation as a result of the recession. Therefore, a second survey was undertaken between 2009 and 2011 and measured the rate at which the same SMEs had adopted Lean Six Sigma (LSS) during the period between the surveys.

2   THE SURVEY – ITS DESIGN AND IMPLEMENTATION

An initial large scale survey into identifying the attitudes and capabilities of SMEs towards LSS implementation was initiated in 2006. From an initial survey sample of 150 companies, 96 manufacturing SMEs agreed to take part in the survey work. These were subsequently visited and assessed over a two-year period. A team made up of manufacturing researchers were recruited to undertake the survey work. The second survey was initiated in 2009 and ran for 18 months with the same team being present. However, only 91 of the original companies were still in operation. The same methods and approach to the survey work was undertaken in both cases.

The manufacturing SMEs were identified from their UK Standard Industry Classification codes (SICs) and a range of manufacturing sectors were targeted. Companies were considered SMEs against the appropriate definition for SME categorisation at the time of the survey (turnover, No of employees, ownership profiles etc). Table 1 shows the number of SMEs assessed per industrial sector. The table also shows the number of companies by size, which fall into each industrial sector area. The industrial sectors were pre-defined under the terms of funding and were considered to be the high value industrial sectors within the UK. The table also shows the number of SMEs in each category which were considered Original Equipment Manufacturers (OEMs). All other SMEs were considered to provide sub-contract services to customers at tier one or two in their respective supply chains.

Table 1: The Number of Companies Assessed by Industrial Sector and Company Size

Size of SME (Staff Employed)	Industrial Sectors				
	Aerospace	Automotive	Medical	Electronics	Construction
1-50	2	12	3	8	5
51-150	6	10	8	12	13
150-250	2	8	3	2	2
TOTALS	*10*	*30*	*14*	*22*	*20*

Triangulation of the survey data was achieved through direct observation at the company premises as well as interviews with key personnel within the organisations. The same questionnaire was used by the project team for the both surveys in order to ensure consistency of results and analysis. Partly quantitative and partly qualitative the questionnaire captured specific company performance data whilst allowing a section for open answers by the respondents so that maximum information could be drawn from each company. The researchers aimed at senior level managers and in most cases the Managing Directors of the SMEs in order to draw from them their strategic opinions and thoughts on LSS Implementation and whether it was relevant for their companies to develop LSS strategies. As well as capturing the level and extent of LSS adoption and use, the questionnaire also covered the following quantitative data: Financial data – turnover, materials and labour costs, growth profile, operating costs, investment in BPI and experience of previous BPI initiatives over the past five years. Company profile –number of employees, direct and indirect staffing ratios. The questionnaire also captured the following qualitative data: Business type; Attitude to BPI; Attitude to Developing Business; Operational & Business Processes; Skills and Knowledge Base; Drivers and stimulators for LSS Implementation.

From the questionnaire feedback, the team were able to assess the information and start to identify a coherent assessment process for the data obtained. In this case the project team broke the feedback into three areas of investigation namely; Business Type, Lean Six Sigma activity and performance characteristics. Considering these three main sets of characteristics allowed the survey to demonstrate the correlation between the LSS activities being implemented and how the activities were affected by the commercial pressures and business strategies and systems that exist within SMEs. A simple classification system was developed; this is shown in Table 2. Here the table classifies the responses by providing a numerical grade of 1-3 to the responses to the questions. Classification in this way allowed for quick and effective report calls and data analysis. Calculating the modal values for the data sets allowed for overall categorisation of the companies. The initial analysis of the survey data showed that the SMEs could be split into three distinct categories each having specific characteristics when measured against the assessment criteria (modal values of 1 = Category C, Modal values of 2 = Category B etc).

Table 2 Grading Criteria for Questionnaire Data

Quantitative Response Key

Company Turnover (£)
1 = <500,000
2 = >500,000 < 1500000
3 = > 1500000
Labour Costs
1 = <25% of product cost
2 = >25% <50% of product cost
3 = > 50% of product cost
Material Costs
1 = <25% of product cost
2 = >25% <50% of product cost
3 = > 50% of product cost

Growth Profile
1 = Declining
2 = Stagnation (some growth)
3 = Growing
Operating Costs
1 = <25% of Turnover
2 = >25 <50% of T/O
3 = > 50% of T/O
R+D Investment
1 = <25% of Turnover
2 = >25 <50% of T/O
3 = > 50% of T/O

Qualitative Response Key

1 = Negative Response
Little/No Knowledge
Little / No Experience
Little / No Interest
Poor / Non existent
2 = Normative Response
Some Knowledge
Some Experience
Some Application/Inconsistent
Could be improved
3 = Positive Response
Excellent Knowledge/Experience
High Levels of Interest
Excellent application
Excellence

3   SURVEY RESULTS AND ANALYSIS

The initial survey of 2006-2008 concluded that SMEs fell into three distinct categories of LSS implementation. Just over 11% of SMEs were highly advanced in their approach to the implementation and use of LSS and had developed robust and responsive business systems based upon a continuous culture of business process improvement. These companies were termed Category C companies and were generally seen as higher performing companies which primarily worked successfully in the automotive supply chain. Likewise, just under 64% of SMEs did not implement LSS and these were termed Category A companies. It was however in the central category those termed Category B that some 25% of companies aspired to implement LSS but believed that they had neither the technical capabilities of human resources to drive such initiatives to their full potential although some significant LSS work was being done in this category. This is where the second survey concentrates upon in order to ascertain primarily whether the Category B companies had actually migrated towards the greater implementation of LSS. Likewise, the second survey also investigates whether some of the Category A companies had actually started to move towards greater LSS development.

Through observing the performance and operating mechanisms of Category A companies, it was seen in most cases that company performance was improved as a result of an effective combination of appropriate information, product design and production technologies in order to create a high quality, cost-effective, rapid-responsive, flexible and productive manufacturing environment and that LSS was used to ensure that the functioning and interconnections between these production elements were kept at their optimal level of functionality. However, in reality many of the companies surveyed incorporated only one or possibly two of these elements into their company operations and as such, LSS was used as an isolated business improvement approach in either product design (through DFSS) or on the traditional production environment. Therefore, SME categorisation included the need to identify the 'amount' and level of production integration in companies. As with the previous survey, it was observed that in general, Category C companies were significantly more profitable and produced higher value products for the industrial sectors in which they supplied. It was observed that in these companies, they did not necessarily employ more staff but in many cases the LSS allowed the company to achieve higher outputs with less staff hence contributing to greater profitability. In general there was no movement of Category A companies migrating successfully Category C but a small movement of Category B companies moving into the Category C was observed.
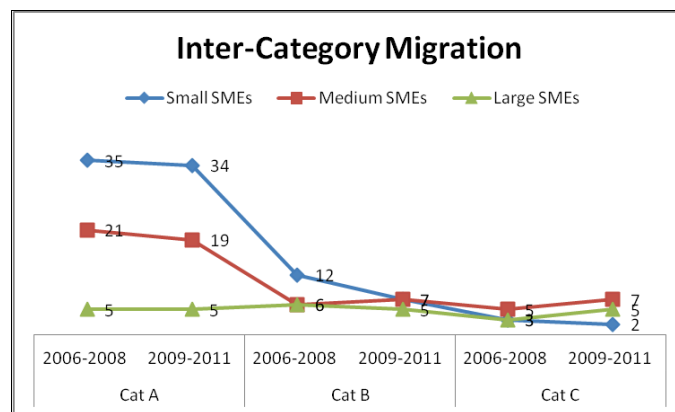

Figure 1: Composite graph of Inter-Category Migration

The results of the inter-category migration are shown in Figure 1. The number of companies that existed in the 2009-2011 survey had dropped by 5 from the previous survey (96 in 2006-2008 to 91 in 2009-2011). It is important to note here that whilst it could be considered that 5 companies had ceased trading within survey cycle, this is not entirely the case. Company failure which was observed by cessation of trading occurred in 2 Category A companies and 2 Category B companies. The remaining company was a Category C company who was bought out as part of a manufacturing group and hence ceased to be SMEs. In general, the loss of 4 companies from the 96 initially surveyed is seen as highly positive considering the economic climate and suggests that the Category A companies

especially, showed high levels of resilience to the tough economic even though they showed very little interest in implementing LSS. Therefore, there is possibly another set of factors that explain the ability of these companies to 'weather' the economic downturn and effective LSS implementation has little or no effect on their ability to survive.

3.1   INTRA-CATEGORY MIGRATION

In addition to the three fundamental categories identified, the second survey investigated the intra-category migration that occurred in the survey companies. Intra-category migration aims to identify the companies who continued to develop and advance the LSS methodology but had not developed their expertise to a level that meant they were able to move in to the higher category (i.e from B to C for example). The grading approach shown in Table 2 was used again to measure the migration within the category on the basis of observing the application and implementation of the LSS tools and techniques on a 'little', 'some' or 'good' grading. This migration analysis provided much needed new information on the dynamical nature of LSS development in companies. Figure 2 provides a graphical representation of the intra-category migration. The findings from this work are shown below:

- 15% of companies migrated from Category A towards Category B. These Category A companies had by the time of the second survey, realised that survival of the business may rely on adoption of improvement methodologies such as LSS, to prevent competition from low cost economies and increased local competition and as such were starting to develop basic LSS methods and tools.
- Category B companies migrating towards Category C totalled only 11% (1 company). These companies were considered to have made the transition toward forward-planning of LSS development with a view to leading the market and ensuring sustainability of the business.
- The survey did not find any appreciable development or enhancement of the LSS methodology in companies considered to be in Category C in this survey. This does not suggest that the companies could not improve but rather indicated a more worrying trend that little or no innovation was taking place to extend or enhance LSS in their business processes and systems. Figure 2 shows graphically the intra-company migration profiles of Category A and B companies.
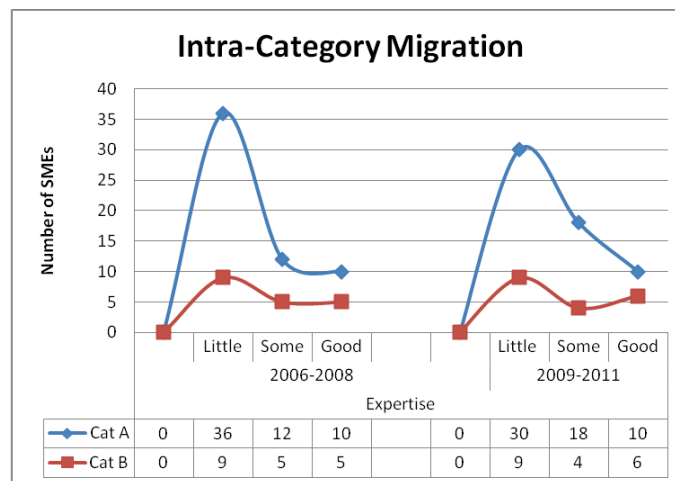

	Little	Some	Good		Little	Some	Good
Cat A	0	36	12	10	0	30	18	10
Cat B	0	9	5	5	0	9	4	6

Figure 2: Composite graph of Intra-Category Migration

4   CONCLUSIONS AND RECOMMENDATIONS

In general the migration of SMEs towards LSS implementation is relatively static over the four survey cycle. Only small shifts of companies are seen from one category type to the other. However, in more specific terms the larger SMEs were seen as being more likely to transfer across category boundaries.

More specifically, when focusing on the research objectives set at the start of this paper, the following results were obtained;

Q1. Are we able to identify whether the rate of LSS implementation in manufacturing SMEs has grown between the two survey periods and hence establish whether the recession had forced companies to employ LSS to increase operational performance?

No evidence was found to support the fact that the recession had increased company awareness of the need to adopt LSS in order to reduce waste and hence operational costs. With only an average 4-6% of companies migrating across the category boundaries, the statistical evidence supports the qualitative analysis that the adoption of LSS has been poor. In fact, the actual number of companies falling in to Category A (little or no adoption of LSS) had remained static over the survey period.

Q2 Are we able to identify whether SMEs have continued to increase the use of LSS in their respective companies and have therefore migrated towards being experts in LSS application?

Yes, the team observed more intra-category migration (increased activity within each category without moving across the categories) of approximately 13% on average in each of the cases. This suggests that LSS is being developed and implemented more but progress is still quite slow

To extend the issue highlighted in Question 2, the important finding from this programme of work was seen when analysing the intra-category migration. It was observed that a high degree of intra-category movement was observed in both Category A & B companies although no development and enhancement was seen in Category C companies. Some 13% on average of companies within these categories had shown significant development of their LSS systems and were well on their way towards category boundaries. These companies showed distinct migration from their previous position but have not made the jump in to the next category for a number of reasons (LSS not being fully developed, internal manufacturing systems not being fully synchronized etc.). Of the companies who had implemented LSS it was clear that the need for such implementation was driven by their customers rather than an internal decision from within the company. Therefore, the survey showed that most LSS adopters also primarily worked within the automotive supply chains.

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