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Six Sigma and Competitive Advantage

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ABSTRACT *It is claimed that the Six Sigma programme brings competitive advantages to companies that implement it. This paper studies the validity of this claim by positioning Six Sigma in the paradigms provided by the literature on competitive strategy. The main functionality of Six Sigma projects is to improve operational effectiveness and efficiency. A continual improvement of operational effectiveness and efficiency is vital in order to avoid competitive disadvantage, however it is all but straightforward to convert the results into sustainable profitability. It is more about staying in the race than about getting ahead. In order to use Six Sigma strategically, a company should do more than just conduct Six Sigma projects by the book, but develop the competencies that the programme can bring to an organization. These competencies – disciplined and effective problem solving and decision behaviour – have the potential to be a source of competitive advantage, when integrated with a company's strategy.*

KEY WORDS: Competitive strategy, total quality management, quality improvement, resource-based strategy

Introduction

Organizations that implement Six Sigma choose to invest in the systematic exploration of opportunities for quality improvement, cost reduction and efficiency improvement. Six Sigma offers well established statistical research and experimentation methodologies to conduct this kind of project effectively. Several variants of the programme are current (compare, for example, the approaches described in Harry, 1997; Breyfogle, 1999; Pyzdek, 2001).

The programme is characterized by its customer driven approach, by its emphasis on decision making based on quantitative data and by its priority on bottom-line results. Part of the Six Sigma programme is a 12-step 'Breakthrough Cookbook' (Inner MAIC-loop). It tackles problems in four phases: Measure (M), Analyze (A), Improve (I) and Control (C). In more recent accounts of the methodology a five-phase structure is proposed, in which a Define (D) phase precedes the other four. Each of the phases M, A, I and C encompasses three steps, which guide a project leader in the execution of a

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quality improvement project (see Harry, 1997). Besides a stepwise project methodology, the programme offers an extensive toolkit of statistical and non-statistical techniques, and an organizational structure. Improvement projects are carried out by project leaders who can relate to the problem at hand. These ‘black belts’ (BBs) and ‘green belts’ (GBs) are trained in project management and statistical experimentation methods. BBs and GBs are supported by so-called yellow belts, mostly operators who have relevant hands-on experience. To ensure that the BBs and GBs focus on the interests of the organization, the progress of the project is reviewed by ‘champions’.

It is claimed that Six Sigma brings competitive advantages to companies that implement it (Harry, 1998, to mention just one article that makes this claim). The validity of this claim could be tested empirically. Alternatively, the validity of this claim could be grounded in theory, and that is what this paper intends to do. Starting from the argumentation that is frequently given – Six Sigma reduces cost of poor quality – we compare the Six Sigma programme with the literature on competitive strategy, identifying as we come along what advantages Six Sigma can bring and what an organization has to do in order to gain them.

Cost of Poor Quality

Traditionally, Six Sigma is classed among initiatives for quality improvement and total quality management. The benefits of quality improvement initiatives are argued from their potential to:

1. Increase customer satisfaction by improving product quality;
2. Reduce production costs by lowering costs associated with poor quality (see, for example, Reed *et al*., 2000; or Gryna, 2001, chs. 1 and 2).

Cost Of Poor Quality (COPQ) is the monetary loss of products and processes that are not achieving their quality objectives (Gryna, 2001: 19). COPQ is related mainly to *conformance quality* (as opposed to *quality of design*; for a definition of this distinction, see Gryna, 2001: 6). COPQ is traditionally subdivided in categories as prevention costs, appraisal costs and failure costs (the PAF categories, attributed to Feigenbaum). COPQ and the PAF components are used in the literature to establish a relationship between conformance levels and production costs. Several models for this relation are current (Plunkett & Dale, 1988, give an overview and discussion), and most of them are in graphical form; Figure 1 is an example. The main idea is that investments in prevention improve conformance levels, and thus reduce costs associated with internal or external failure. Some models portray an economically optimal conformance level (just below 99% in Figure 1), other models deny the existence of such an optimum (Burgess, 1996).

Besides reduced COPQ, quality improvement is claimed to have benefits stemming from customer satisfaction. In particular, customer satisfaction is claimed to result in advantages such as increased market share or decreased price sensitivity.

The Six Sigma literature frames its motivation in similar terms. The programme is claimed to be ‘customer driven’, and its ultimate objective is described as ‘customer satisfaction’ (Harry, 1997, ch. 3). Extra activities needed because of conformance problems are termed the *hidden factory* (Harry, 1997: 14.10). Non-conformance brings about higher costs, higher cycle times, more rework, etc. Harry’s (1998) Table 1 suggests a direct relation between conformance levels and cost of poor quality (although the origin and

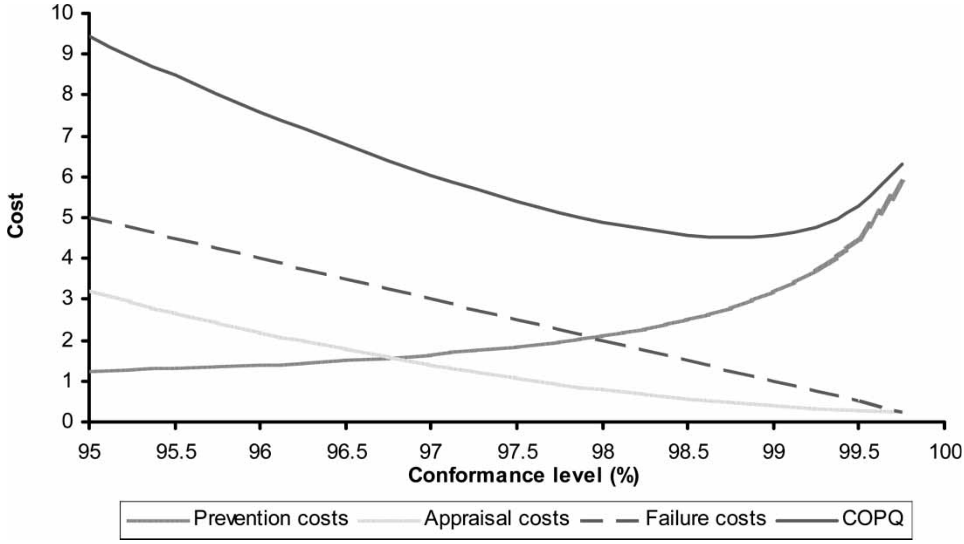

Figure 1. A graphical model for the relationship between conformance quality and production costs

substantiation of the numbers in the table are unclear) and the Sigma metric (Harry, 1997, ch. 8) that gives the programme its name is a measure of conformance quality. Improving conformance quality reduces costs, and this benefit goes directly to the bottom line (Bisgaard & Freiesleben, 2000-01). This effect is leveraged by increased product and process complexity (Harry, 1997: 14.14; Bisgaard & Freiesleben, 2000–01).

There are two main objections against this somewhat simplistic rendering. In the first place, it cannot be concluded from empirical evidence that superior quality leads automatically to sustainable competitive advantages (see Morgan & Piercy, 1996, and the references therein). Quality improvement should not be seen as an end in itself; it is all but straightforward to convert improved quality into advantages such as profitability, and, in general, gains in COPQ or design quality cannot be defended against erosion due to imitation by competitors. It is good to note that such a generic intent as quality improvement is unlikely to be strategic, since it lacks something unique. In order to translate quality improvement into competitive advantages, quality management should be integrated in and made dependent on an organisation's competitive strategy. There is a lot more to it to turn quality improvement into sustainable increases in profitability; the next sections deal with this complex issue.

The second objection is that the objectives of many Six Sigma projects go beyond what would traditionally be called quality. Cycle time reduction and productivity improvement through process optimization, efficiency improvement through process redesign, and cost reduction through optimization cannot be subsumed under conformance quality improvement, and can only be considered quality issues by stretching the meaning of that term. To avoid this sort of conceptual erosion we shall use the phrase *Operational Efficiency and Effectiveness* (OEE). OEE is based on the view that, in the end, Six Sigma projects should be beneficial to the company that pays for them; benefits for the customer are instrumental rather than the ultimate objective. For this reason, product quality (and its components design and conformance quality) are a less obvious perspective than process quality (Six Sigma projects improve processes rather than products), which consists of effectiveness and efficiency. For a process, being effective means that it delivers the right things, that is, things that represent value. A process that produces products that customers regard as poor quality, or a process that produces many products with defects, is not effective. Effective processes deliver value to customers, and the economical potential of effectiveness is derived from this fact. Being efficient, on the other hand, means being effective at low cost. Processes with a low yield or a lot of rework and scrap are not efficient. The economic potential of efficiency is based on improved cost-structure. The remainder of this paper takes this broader perspective and describes Six Sigma projects as aiming for superior OEE.

A first conclusion is that the direct benefit of Six Sigma projects consists of their power to improve OEE. The economic potential of effectiveness is derived from the fact that more effective processes deliver more value. The economic potential of process efficiency is derived from its impact on cost-structure. But cashing these economic potentials in the form of increased profitability is not straightforward.

Strategy and Competitive Advantage

The next question is: what is the strategic importance of OEE (or COPQ for that matter)? How does superior OEE lead to higher profits? This question is not as simple as it may seem. A naïve line of reasoning would be: higher OEE means higher quality for lower costs. This can be cashed because it either enables a higher profit margin, or it allows one to reduce prices, resulting in a larger market share. But this claim that higher OEE results in higher profits or a larger market share can – at least for the long run – not be maintained. This is so because a competitive advantage based on superior OEE is a strategic position that can, in general, not be defended against imitation.

Porter (1996) argues that few companies have competed successfully on the basis of OEE over an extended period. The most obvious reason for that is the rapid diffusion of best practices: competitors copy best practices, thus improving their OEE as well. In a free market, this implies that increased OEE cannot be converted into higher profits: because of competition, prices will erode to the same extent as costs have declined (what economists call the principle of perfect competition). Competition based on OEE alone is mutually destructive for businesses that participate in this race, while the consumer gains all the benefits. The impressive increases over the 20th century in quality and efficiency of many production processes have resulted in very good and cheap products for consumers, but not in companies with a sustained high profitability.

As well as the principle of perfect competition, competitive convergence also explains why competing on OEE alone is not likely to make enterprises more profitable: the more companies fight each other over the same issues, and by copying each other's tactical moves, the more they look alike and the less chances the industry has to be profitable (both Hayes & Pisano, 1994, and Porter, 1996, make this point). If most companies in an industry implement Six Sigma, the effect will be better and cheaper products for the consumers, but no higher profits for the industry. The standard gets higher but no company gets ahead.

We conclude that competing on OEE alone is, generally speaking, a poor substitute for a competitive strategy, and increasing OEE by implementing Six Sigma does not automatically increase profitability. That said, it is important to emphasize that OEE is important nevertheless. Even companies with a good strategy must constantly strive to increase their

OEE, because any strategic advantage will be outweighed if the gap in OEE becomes too large. Although competing on OEE has no winners, companies cannot afford to fall behind in this race. Thus, Six Sigma projects help avoid competitive disadvantage.

We are convinced, however, that OEE is not the whole story, and that it is in fact possible to use Six Sigma to gain strategic benefits. If all a company does is invest in Six Sigma training and conduct BB and GB projects by the book, it may improve OEE, but does not create distinctive competencies. However, Six Sigma brings with it capabilities and skills that management can use to build competencies that cannot so easily be bought on the market or copied by competitors. These competencies open strategic options which, when properly fit into a company's competitive strategy, may result in sustainable advantages (the notion to focus not only on the direct functionality of an improvement programme, but also on the skills and capabilities it brings to the organization, is proposed by Hayes & Pisano, 1994). These capabilities could be summarized as: the capability to effectively create and utilize knowledge in the organization. The next section elaborates this idea.

Our second conclusion is that Six Sigma projects yielding superior OEE do not necessarily increase long-term profitability. Six Sigma has no strategic implications until it is given some by top management.

Effective Creation and Utilization of Knowledge

A naïve image of planning and decision making is that of the manager who has at his disposal all relevant knowledge, and then applies logic and mathematics to work out the implications and take decisions accordingly. In reality however, the knowledge from which the calculus starts is never given to a single mind, but is dispersed over many different persons, often in a tacit form, or even completely absent.

Hayek and the Austrian school of economics identified the utilization of knowledge dispersed among many different agents as the central problem of economical planning:

> The economic problem of society is [...] how to secure the best use of resources known to any of the members of society, for ends whose relative importance only those individuals know. [...] It is a problem of the utilization of knowledge which is not given to anyone in its totality. (Hayek, 1945)

Whether for society as a whole or for a business enterprise, decision makers face the problem that the data necessary for planning are dispersed among numerous individuals. In order for this knowledge to be used for planning it should either be transferred to the decision makers, or decision making should be decentralized to the individuals who have the data.

In this context, Jensen (1998, ch. 4) defines *specific knowledge* as knowledge that is difficult and costly to transfer (Hayek, 1945, speaks of 'knowledge of particular circumstances of time and place') – think of operators who see how their process is running, who know the peculiarities of incoming material and the typical problems of their machines, foremen who know the particulars of their planning, salesmen who know the idiosyncrasies of certain customers, developers who have highly specialized knowledge of certain components of a product, etc. Because it is costly to transfer specific knowledge, getting specific knowledge used in decision making requires an organization to delegate many decisions to agents who have the required specific knowledge.

Knowledge necessary for decision making is not only dispersed, important parts of it are available only as tacit knowledge, for example in the form of unspoken 'know-how' (Hayek, 1952). Finally, knowledge can be in a pre-knowledge stage: although the raw data are available or can be easily collected, these data are not yet analysed and processed in the form of knowledge. Think of all the information that computer logs could yield up when properly analysed, or think about how much information experimentation could create for process optimization.

It is its power to facilitate people at all levels of an organization to learn how their processes work and to put this new knowledge to effective use which is the core capability that Six Sigma can bring to an organization (Wruck & Jensen, 1994, make this claim for total quality management programmes, which are taken to include Six Sigma).

In the first place, Six Sigma trains agents all over the organization ('Black belts' (BBs) and 'Green belts' (GBs)) in the use of statistical and non-statistical methods for investigation, and trains them in a scientific attitude towards problem solving. The stepwise strategy that BBs and GBs follow is basically a variant of what is called Scientific Method (as is shown in de Mast, 2003). It forces BBs and GBs to make a proper problem definition and a data-based diagnosis before attempts at solving the problem are undertaken. Moreover, Six Sigma offers an organizational structure and a culture that stimulate an investigative and experimental attitude in all levels of an organization. Thus, Six Sigma enables an efficient and effective creation of new specific knowledge.

Secondly, Six Sigma enables an effective utilization of specific knowledge by delegating decisions to the agents who collect the required specific knowledge (BBs, GBs). Delegation brings about the control problem that BBs and GBs may take decisions optimizing the wrong criteria (e.g. their own interests, the values of their profession, or misconceived ideas of the organisation's interests) (see Jensen, 2001, ch. 4). Six Sigma solves this problem by having champions periodically review BB and GB projects, and make them responsible to ensure that projects focus on the organization's strategic objectives.

In the third place, Six Sigma champions the definition and implementation of relevant measures and metrics (CTQs) all over the organization, and the linkage of these measures to form performance indicators, thus enabling an efficient coordination and integration of processes in the organization. For example, Six Sigma tools like quality function deployment (QFD; Breyfogle, 1999, ch. 13) and Pareto analysis (Breyfogle, 1999, ch. 5) assist in linking customer demands to product features, and in assessing the relative importance of various problems.

If a Six Sigma organization is more effective in creating and utilizing knowledge at all levels of the organization, what strategic options does this fact bring? One answer to that question is found in regarding Porter's (1980) three generic approaches for competitive strategy: (1) overall cost leadership; (2) product differentiation; (3) focus. One could argue that Six Sigma projects drive a strategy of cost-leadership by increasing efficiency, or a strategy of product differentiation by a superior design quality. This would be too simple, though: for a competitive strategy based on any one of Porter's generic approaches it is important that it distinguishes a company from its competitors in a non-imitatable manner, for instance by exploiting a trade-off. If cost leadership or product differentiation is attained by improving OEE, it does not provide a strategic advantage that can be defended against imitation. To be of strategic importance, cost leadership and product differentiation should be driven by something other than OEE.

On the other hand, the capabilities and skills that the programme adds to the organization fit well with strategies based on cost leadership or product differentiation. Thus, management could use Six Sigma to build competencies in knowledge creation and utilization that can support a strategy based on cost-leadership or differentiation. This approach is built on the competitive advantages existing in the company's strategy, and uses Six Sigma competencies only to leverage these advantages. Hamel & Prahalad (1993) call this 'resource leverage'.

Let us, as an example, study how Six Sigma can leverage a competitive strategy based on quality. It should be clear by now that improving quality by running Six Sigma projects is in itself not a strategy, and is unlikely to bring competitive advantages. Quality management and strategy formulation should converge into an integrated process (Calingo, 1996). The organization should choose what type of positional advantage it pursues with its quality strategy (low-cost or differentiation) and what notion of quality is meant (objective or perceived quality) (Morgan & Piercy, 1996). Trying to do both leads to conflicting and contradictory priorities and activities; the organization would be what Porter (1980) calls 'stuck in the middle'. The Six Sigma implementation and projects should be aligned with the chosen strategy. For example, a strategy based on differentiation on objective quality would suggest an emphasis on quality in research and design, and in product and service engineering. Six Sigma projects should be selected that aim to improve product attributes such as durability, delivery and features. However, for a strategy based on low-cost, Six Sigma projects should be selected purely on hard cost reductions. For a quality-based strategy based on perceived quality rather than objective quality, the company should probably make Six Sigma initiatives completely subordinate to market research and field intelligence.

Whatever the strategy turns out to be, it has to be translated into objectives, and many of these will need organized effort to be achieved. A Six Sigma organization has at its disposal a taskforce, spread over all departments in the organization, and fully trained in running improvement projects effectively. Thus, Six Sigma is deployed as an instrument for conducting the work that a company's strategy implies.

The third conclusion is that companies who buy the procedures and tools of Six Sigma, and conduct BB and GB projects by the book, can improve their OEE, but that is more or less it. Companies that go further and use the Six Sigma programme to build knowledge creation and utilization competencies in the organisation can use these competences to leverage the company's competitive strategy.

In the next section we shall go one step further. The competencies that a company can build using Six Sigma are complex and tacit in nature, and for these reasons hard to imitate: competitors cannot buy them on the market, but have to build them, which will take years (Teece *et al*., 1997). Thus, the competencies a company can build using Six Sigma can in themselves be sources of sustainable competitive advantage. A similar line of reasoning is developed by Reed *et al*. (2000) to argue the sustainability of advantages from total quality management; see also Tena *et al*. (2001).

Six Sigma Competencies as Resources for Competitive Advantage

The 'resource-based' approach to competitive strategy focuses on competitive advantages that stem from a firm's idiosyncratic and difficult to imitate resources (Teece *et al*., 1997). Skill acquisition, management of intangible assets and learning become fundamental strategic issues. If a firm's skills, competencies and capabilities are valuable for a customer, unique and difficult to replicate, they can be a source of sustainable profitability.

It was argued in the preceding section that the main competencies that can be built using the Six Sigma programme, are an effective creation and utilization of knowledge. The continual effort of Six Sigma projects to understand processes and systems, model them by transfer functions, and define crucial measurements, will result in a better general understanding of how production and service processes work. These competencies enable a superior coordination and integration of processes, learning, and reconfiguration and transfiguration, which, Teece *et al*. (1997) argue, can be sources of competitive advantage. Reconfiguration and transfiguration relate to a company's resilience, the ability to dynamically reinvent business models and strategies as circumstances change. In order to sustain in a more and more turbulent world (Teece *et al*., 1997, speak of a 'Schumpeterian world'), a company's resilience becomes all-important. Organizations should continually morph their strategy, conform it to emerging opportunities and incipient trends. In order to do so, people all over the organization should be trained in picking up signals. Moreover, variety is essential: organizations should steer clear of grand, imperial strategies and devote themselves instead to launching a swarm of low-risk experiments (both Hamel & Välikangas, 2003, and Hayes & Pisano, 1994, make similar points). What is needed is the decentralized, adventurous, experimental attitude that Six Sigma embodies.

In order to profit from the competitive advantages that competencies related to Six Sigma can bring, top management should plan the incorporation of these competencies in the organization in such a way that they are difficult to imitate. This involves integrating in and committing to long-term paths of competence development: competencies that can be bought on the market or easily built convey no competitive advantage. Thus, companies that invest in Six Sigma training, material and software, and that conduct a number of BB or GB projects will increase their OEE, but companies that commit themselves to the long-term trajectory of really integrating the philosophy, attitude and skills of Six Sigma in their organisation can use Six Sigma to gain competitive advantage.

An example of such a long-run trajectory is provided by the General Electric Company (GE). In its annual reports it is stated over and over again that it sees its learning, sharing and action-driven culture as its path to sustainable competitive advantage. This vision is stated, for example, in the 1998 Annual Report as follows: 'That appetite for learning, and the ability to act quickly on that learning, will provide GE with what we believe is an unsurmountable and sustainable competitive advantage.'

This learning culture was built from the 1980s onwards by eradicating the many organizational, hierarchical and cultural boundaries that were seen as the main impediments to learning. As a first step, GE started the Work-Out initiative, supplemented by a reward system supporting learning behaviour. In the second half of the 1990s it started the Six Sigma initiative, which built further on the idea to exploit a learning culture as competitive advantage: 'The biggest opportunity for us to use this horizontal learning to accelerate growth is Quality. [.] Quality improvement, under the disciplined rubric of Six Sigma methodology, will define the way we work' (1996 Annual Report).

Six Sigma was more easily incorporated in GE's culture than at other companies: 'GE had another huge advantage that accelerated our quality effort: we had a Company that was open to change, hungry to learn and anxious to move quickly on a good idea' (1997 Annual Report). Determined to use Six Sigma to build lucrative competencies, GE linked Six Sigma to leadership development. The BB role at GE is a full time, but temporary assignment (typically two years). GE had the clear intention to use the BB training and the temporary assignment as a BB to develop future business leaders who have a 'continuous improvement' mindset (Hoerl, 2001). In the words of the then CEO Jack Welsh: 'The generic nature of a Black Belt assignment, in addition to its rigorous process discipline and relentless customer focus, makes Six Sigma the perfect training for growing 21st century GE leaderhip' (2000 Annual Report), and: 'Six Sigma is quickly becoming part of the genetic code of our future leadership' (1997 Annual Report).

The first three years of Six Sigma resulted in impressive gains in operating efficiency. The next step on the trajectory was: 'Our challenge, as we move toward 2000, is to turn our Company vision 'outside in,' to measure the parameters of the customers' needs and processes and work toward zero variability in serving them' (1998 Annual Report). Here we see an example of a company that integrates Six Sigma in its strategy and embarks on a year-long trajectory of competence building.

Conclusion

This paper studies what strategic benefits implementation of Six Sigma could bring to a company. The question is addressed by placing the programme in the literature on competitive strategy. The first functionality of Six Sigma projects is to reduce cost of poor quality, or – sharper – increase operational efficiency and effectiveness in general. Continual improvement of OEE is necessary – however many competitive advantages a company has, they will be outweighed if the gap in OEE with rivals becomes too large – but will in general not lead to a sustainable increase in profitability (the gain is for the consumers).

Six Sigma can do more, however, than just eliminate competitive disadvantages. Besides improved OEE, Six Sigma adds a whole range of new capabilities and skills to an organization. These skills could be described as: scientific and disciplined problem solving and decision making behaviour, and effective distribution of information over the organization. These skills help tackling the general problem of economic planning under constraints to knowledge. These competencies can be used to leverage a company's competitive strategy.

However, when managed well, these competencies have the potential to represent competitive advantages in themselves. An organization that does not merely buy Six Sigma training and conduct Six Sigma projects by the book, but commits itself to a many years' trajectory of embedding the Six Sigma attitude and philosophy in the organization, can cash advantages stemming from superior integration of processes, faster learning, and higher resilience.

Top management should make a choice for what purpose it wishes to employ Six Sigma, that is, which results they aim to achieve, and integrate Six Sigma in this wider vision. It is a myth that just implementing the programme results 'automatically' in results.

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