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Six Sigma adoption: Operating performance impacts and contextual drivers of success

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ABSTRACT

We assess the operational impacts of Six Sigma program adoptions through an event study methodology, comparing financial data for 200 Six Sigma adopting firms against data for matched firms, which serve as control groups for the analyses. We employ various matching procedures using different combinations of pre-adoption return on assets (ROA), industry, and size as matching criteria. By comparing performance outcomes across a hierarchy of operating metrics, we establish a pattern of Six Sigma adoption effects that provides strong evidence of a positive impact on ROA. Interestingly, these ROA improvements arise mostly from significant reductions in indirect costs; significant improvements in direct costs and asset productivity are not evident. We also find small improvements in sales growth due to Six Sigma adoption. Cross-sectional analyses of the performance results reveal that distinctions in Six Sigma impacts across manufacturing and service firms are negligible. Interestingly, we find that the performance impact of Six Sigma adoption is negatively correlated to the firm's quality system maturity (indicated by prior ISO 9000 certification). Further analyses of manufacturing and service firms reveals that Six Sigma benefits are significantly correlated with intensity in manufacturing, and with financial performance before adoption in services. We discuss the implications of these findings for practice and for future research.

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1. Introduction

Since its origins in the mid-1980s, the Six Sigma program for process improvement has become widely embraced. One report suggests that many Fortune 500 firms have adopted Six Sigma (Nakhai and Neves, 2009). Early successes in high profile companies such as Motorola, Allied Signal (now Honeywell), and General Electric helped to both popularize and legitimize the approach, and dozens of books have been devoted to the topic.

The practitioner literature documents substantial cost savings and other benefits from Six Sigma program adoptions (Pande et al., 2000; Harry and Schroeder, 2000). However, some still question whether these benefits sufficiently exceed the costs of adoption. Corporate-wide adoption of Six Sigma often involves considerable investments in consulting support, training, organizational restructurings, and associated information and reporting systems. For example, over a four year period (1996–1999) General Electric reportedly spent more than $1.6 billion on Six Sigma investments. Researchers report that training costs are typically as much as $50,000 per trained worker (Antony, 2006; Fahmy, 2006). The net operating effects of these types of investments have not been rigorously examined. Most scholarly work to date involves perceptual data from surveys, or financial studies of a few select companies (Goh et al., 2003; Zu et al., 2008; Gutierrez et al., 2009; Braunscheidel et al., 2011). In fact, some writers have even questioned the validity and originality of Six Sigma, calling it "repackaging," a "fad," and a "PR ploy" (Clifford, 2001; Rowlands, 2003).

Other questions pertain to the types of benefits provided by Six Sigma, and their limitations. A number of researchers discuss the potential for capability gains in one area of performance to be offset by added constraints or losses in another. In particular, Six Sigma potentially creates a trade-off between gains in efficiency versus growth. Several important studies suggest that process improvement regimes can stifle innovative exploration in favor of exploitation, thus impeding sales growth (Abernathy, 1978; Tushman and O'Reilly, 1996; Benner and Tushman, 2002, 2003; Naveh and Erez, 2004). Moreover, recent anecdotes from companies like General Electric and 3 M indicate that managers believe Six Sigma practices may severely constrain innovation needed to drive growth (Brady, 2005; Hindo, 2007).

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Limitations might also stem from the context within which Six Sigma is adopted. Like many process improvement programs, Six Sigma originated in manufacturing firms; many of its principles and tenets were developed in a setting of asset-intensive, repeatable processes. The name itself, "Six Sigma," refers to limits in measurable variations of outputs that were established in Motorola's manufacturing processes. In addition, researchers maintain that a firm must possess certain resources and make certain commitments in order to make Six Sigma successful (Antony et al., 2008; Schroeder et al., 2008). Hence, Six Sigma methods and tools may be more or less effective in certain technological and operational contexts.

In this article, we examine the operating performance impacts of Six Sigma adoptions. The study seeks answers to the following three research questions. First, does Six Sigma adoption consistently produce a significant net effect on operating performance? Given the widespread adoption and continued popularity of this program, we consider this a very important question. A sizable literature on the efficacy of other process management strategies exists, providing mixed results. However, researchers argue that Six Sigma is different from other process management approaches; it is distinguished by its requisite organizational structures, structured methods, and emphasis on customer-oriented metrics (Linderman et al., 2003; Sinha and Van de Ven, 2005; Schroeder et al., 2008). Given these proposed distinctions, it is important to determine whether or not managers should have reason to expect that Six Sigma will provide benefits that exceed alternative programs for improvement.

Our second research question addresses the nature of Six Sigma's impacts. What types of beneficial impacts are manifested in the operating data of Six Sigma adopters? By examining the components of both profit and growth-oriented financial outcomes of Six Sigma adopters, we develop insights into the types of impacts provided by the program. These results serve to inform the debate over the roles of process management programs in creating competitive advantages for their adopters; they also point to some interesting propositions for future research.

Our third research question is: are Six Sigma impacts related to operating contexts? As Six Sigma adoptions have grown to include a wider scope of businesses, researchers have begun to question the applicability and effectiveness of related tools and techniques in certain contexts. In addition, case studies and anecdotal evidence is suggestive of factors that may be critical to successful implementation. We study differences in Six Sigma success associated with industry (manufacturing or service), labor intensity, R&D intensity, prior operating performance, and quality maturity. Our examination of these factors provides insights into the sources of, and constraints on, process improvements emerging from Six Sigma adoption.

We address the foregoing questions through an event study methodology, comparing financial data for about 200 Six Sigma adopting firms against data for matched firms, which provide control groups for the analyses. We employ various matching procedures using different combinations of pre-adoption operating performance (measured by return on assets (ROA)), industry, and size as matching criteria. By comparing performance outcomes across a hierarchy of operating metrics, we establish a pattern of Six Sigma adoption effects that provides strong evidence of a positive impact on ROA. Interestingly, these ROA improvements arise mostly from significant reductions in indirect costs. Improvements in direct costs and asset productivities are not evident. We also find small improvements in sales growth due to Six Sigma adoption. From cross-sectional analyses, we determine that performance improvement due to Six Sigma adoption is not significantly related to industry (manufacturing or service) or R&D intensity. However, changes in performance are significantly correlated with the quality maturity of the adopting firms. Interestingly, firms with greater quality experience (as indicated by ISO 9000 certification) appear to benefit less from Six Sigma. For firms in service industries, operating performance before Six Sigma adoption is a significant determinant of performance changes. However, labor intensity is the most significant driver of performance benefits in manufacturing firms.

In the next section, we formulate hypotheses relating Six Sigma adoption to operating performance by drawing upon the literatures on process improvement in general, and Six Sigma in particular. Section 3 describes the sample data and event study method. Section 4 presents the results. Section 5 discusses the findings and their implications. Section 6 summarizes the conclusions and limitations of the study, and identifies opportunities for future research.

2. Theory development and hypotheses

Researchers have placed Six Sigma in the realm of operational improvement programs that are oriented toward improvements in quality or variability of process outcomes (Zu et al., 2008). There are several scholarly studies of the impacts of process improvement programs, yet none provide a rigorous examination of Six Sigma adoptions. The existing literature can be classified into three streams addressing the performance impacts of: (1) general process management strategies (Ittner and Larcker, 1997; Schmenner, 1991), (2) Total Quality Management (TQM) implementations (Hendricks and Singhal, 1996, 1997, 2001a,b; Ittner et al., 2001; Powell, 1995; Sila, 2007; York and Miree, 2004; Nair, 2006), and (3) ISO 9000 and other quality certifications (Corbett et al., 2005; Martinez-Costa et al., 2009; Westphal et al., 1997; Yeung et al., 2006; Naveh and Erez, 2004; Benner and Tushman, 2002; Benner and Veloso, 2008; Levine and Toffel, 2010). These research streams provide an overall positive, though mixed, set of conclusions regarding the effectiveness of respective process improvement programs. Importantly, however, researchers have argued that Six Sigma is distinguished from these other programs by several characteristics.

2.1. The distinctive characteristics of Six Sigma

Researchers describe Six Sigma as a data driven approach to problem solving, as a business process, as a disciplined statistical approach, and as a management strategy (Blakeslee, 1999; Hahn et al., 1999; Harry and Schroeder, 2000; Braunscheidel et al., 2011). While these monikers have been applied to other process improvement strategies as well, proponents and researchers argue that Six Sigma is different than other process improvement programs because it is exclusively a customer-driven and data-defined system (Breyfogle, 2003). Schroeder et al. (2008) suggest that Six Sigma must be different by virtue of the fact that it has been adopted by many firms that had already possessed quite mature quality management processes (e.g., 3M, Ford, Honeywell, American Express).

Perhaps more compellingly, Schroeder et al. (2008) and Zu et al. (2008) argue that, while Six Sigma shares some philosophical underpinnings and techniques with other quality and process management approaches, it is distinguished by four attributes of its unique organizational approach. Schroeder et al. (2008, p. 540) define Six Sigma as "an organized, parallel-meso structure used to reduce variation in organizational processes by employing improvement specialists, a structured method, and customer-oriented performance metrics with the aim of achieving strategic objectives." The typical parallel-meso structure for Six Sigma includes a centralized office within the firm that oversees a dispersed training and project execution hierarchy. The central office has several purposes. It creates an authority structure that acquires, develops, and assigns resources for training and improvement

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