Accepted Manuscript

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V. Arumugam , Jiju Antony , Kevin Linderman

PII: S0377-2217(16)30150-3
DOI: 10.1016/j.ejor.2016.03.022
Reference: EOR 13584

To appear in: *European Journal of Operational Research*

Received date: 23 September 2014
Revised date: 20 February 2016
Accepted date: 11 March 2016

Highlights

- Impact of goals and method in Six Sigma projects through knowledge created
- Examined through the lens of goal theory and sociotechnical systems theory
- The mediated-moderation model is tested using both the regression and path analysis
- The study develops a deeper understanding of technical and social aspects of projects
- Method and goal are able to compensate for one another to some degree.

The influence of challenging goals and structured method on Six Sigma project performance: A mediated moderation analysis

V. Arumugam
Strathclyde Institute for Operations Management
Department of Design, Manufacture and Engineering Management
University of Strathclyde, Glasgow, UK
Email: aru.vela@gmail.com

Jiju Antony
School of Management & Languages
Dept. of Business Management
Heriot-Watt University
Edinburgh, Scotland, UK

Kevin Linderman
Department of Supply Chain and Operations Management
Carlson School of Management
University of Minnesota
Minneapolis, MN 55455, USA

Corresponding author:
V. Arumugam
Blomstervangen 69
6800 Varde
Mob: +45 50 23 45 96
Email: aru.vela@gmail.com

Abstract

Over the past few decades, Six Sigma has diffused to a wide array of organizations across the globe, which has been fueled by the reported financial benefits of Six Sigma. Implementing Six Sigma entails carrying out a series of Six Sigma projects that improve business processes. Scholars have investigated some mechanisms that influence project success, such as setting challenging goals and adhering to the Six Sigma method. However, these mechanisms have been studied in a piecemeal fashion and don't provide a deeper understanding of their interrelationships. Developing a deeper understanding of these mechanisms helps identify the contingency and boundary conditions that influence Six Sigma project execution. Drawing on Sociotechnical System theory, this research conceptualizes and empirically examines the interrelationships of the key mechanisms that influence project execution. Specifically, we examine the interrelationship between Six Sigma project goals (Social System), adherence to the Six Sigma method (Technical System), and knowledge creation. The analysis uses a mediation-moderation approach which helps empirically examine these relationships. The data come from a survey of 324 employees in 102 Six Sigma projects from two organizations. The findings show that project goals and the Six Sigma method can compensate for one another. It also suggests that adherence to the Six Sigma method becomes more beneficial for projects that create a lot of knowledge. Otherwise the method becomes less important. Prior research has not examined these contingencies and boundary conditions, which ultimately influence project success.

Keywords: Six Sigma, goal theory, sociotechnical systems theory, structured method, mediated moderation.

1. Introduction

Over the past few years Six Sigma has increased in popularity and diffused to organizations across the globe in a wide array of industries (Antony, 2004; Linderman, Schroeder, Zaheer, & Choo, 2003; McAdam, Hazlett, & Henderson, 2005; Kwak & Anbari, 2006; Schroeder, Linderman, Liedtke, & Choo, 2008). Motorola first coined the term Six Sigma in 1986 to characterize their approach to measure defects and improve quality. Since that time Six Sigma has evolved into a business improvement strategy to enhance customer satisfaction, process improvement, learning, creativity and profitability (Choo, Linderman, & Schroeder, 2007a; Zu, Fredendall, & Douglas, 2008; Biedry, 2001; Byrne, George, Lubowe, & Blitz, 2007; Wiklund & Wiklund, 2002; Parast, 2011). Motorola initially reported that they saved approximately $2.2 billion within four years of implementing Six Sigma. Motivated by this financial success, several organizations from the manufacturing, service, healthcare to government have also deployed Six Sigma (Antony, Frenie, Kumar, & Cho, 2007; Kwak & Anbari, 2006; Schroeder et al., 2008).

Recently, scholars have empirically confirmed the organizational level benefits that firms gain from implementing Six Sigma (Shafer & Moeller, 2012; Swink & Jacobs, 2012).

Six Sigma takes a project-based approach to improvement, where deployment involves carrying out a series of process improvement projects that employ the Six Sigma method. As a result, project performance becomes an important determinant for the successful implementation of Six Sigma (Arumugam, Antony, & Linderman, 2014; Nair, Malhotra, & Ahire, 2011; Ray & Das, 2010; Parast, 2011). Understanding how Six Sigma leads to organizational benefits necessitates understanding what leads to Six Sigma project performance. Although scholars have investigated the organizational benefits of Six Sigma, only a few studies have examined what leads to Six Sigma project performance. Scholars have theoretically identified key factors that lead to Six Sigma project success (e.g., Arumugam et al., 2014; Choo et al., 2007a; Linderman et al., 2003; McAdam & Lafferty, 2004; Schroeder et al., 2008; Soti, Ashish, Ravi Shankar, & Kaushal, 2010), but only a few studies have empirically investigated these factors (e.g., Arumugam et al., 2013; Choo, Linderman, & Schroeder, 2007b; Linderman, Schroeder, Zaheer, & Choo, 2006; Nair et al., 2011). Since projects underpin the Six Sigma approach, it's critical to have a detailed understanding of the precise mechanisms that lead to project performance. That is, taking a more micro-level view of Six Sigma to examine the precise mechanisms that lead to project success can help better understand what ultimately leads to successful Six Sigma deployment at the organizational level (Arumugam et al., 2014; Parast, 2011).

Scholars have drawn on behavioural theories (Braunscheidel, Hamister, Suresh, & Star, 2011), goal setting theory (Linderman et al., 2003), agency theory (Lloréns-Montes & Molina, 2006), and work motivation theory (Buch & Toelentino, 2006) to understand Six Sigma project success. While these theories provide useful concepts to understand project success, scholars have studied these concepts in a piecemeal fashion (Linderman et al., 2003; Schroeder et al., 2008; Nonthaleerak & Henry, 2008; McAdam, Hazlett, & Henderson, 2005; Lloréns-Montes & Molina, 2006). Scholars have not developed a coherent and overarching theory that underpins Six Sigma. Developing a comprehensive understanding of the contingencies and boundary conditions of projects will help understand the foundation to successfully deploying Six Sigma.

This study aims to develop a deeper understanding of Six Sigma by taking a comprehensive approach to investigating Six Sigma Project execution. We examine the role of project goals, use of the Six Sigma method, and knowledge creation on project performance. The findings of this research reveal that the Six Sigma method (hereafter called Method), project goals and knowledge creation relate to one another in interesting ways that affect project performance. We draw on Social-Technical Systems (STS) theory as an overarching theory to integrate these concepts, which helps understand how these concepts come together to enhance project performance. The results show that Method moderates the relationship of goals and knowledge on project performance. Drawing on Social-Technical Systems theory, the results suggest that the use of the Six Sigma Method may be less efficient for projects with very challenging goals. By integrating these concepts and drawing on Social-Technical Systems theory, we help understand the contingencies and boundary conditions where Six Sigma has the biggest impact on performance.

We contribute to the literature in the following five ways. First, we empirically investigate the precise relationship of the Six Sigma project's goals, use of the Method, and knowledge creation on project performance. Prior research has taken a piecemeal approach to investigate these factors (Anand, Ward, & Tatikonda, 2010; Arumugam et al., 2013; Choo et al., 2007b; Choo, 2011; Linderman et al., 2006), but doesn't take a comprehensive approach to understand the mechanisms and contingencies related to these factors. Second, we draw on *Sociotechnical Systems (STS) theory* (Pasmore, 1988; Trist & Bamforth, 1951) as an overarching theory to clarify the relationship between project factors and contingencies that influence Six Sigma success. Sociotechnical Systems (STS) theory argues that the compatibility between the technical system and social system enhances performance. Our study investigates both the technical aspects (e.g. Six Sigma method) and social aspects (e.g., goal setting) of Six Sigma projects, which align with the Sociotechnical Systems perspective. More specifically, we combine the concepts from quality management, knowledge management, goal theory, and use Sociotechnical systems theory to explain how these concepts relate to one another to enhance project performance. This study provides empirical evidence how technical and social components of quality practices lead to learning and knowledge creation to impact performance.

Third, we apply a robust analytical method to examine the effects of moderation and mediation within a single research model. Edwards & Lambert (2007) proposed this approach which incorporates both path analysis and regression analysis. This approach overcomes some of the methodological problems in studying moderation-mediation effects. By using this more rigorous approach, we better clarify the relationships of the factors that underpin Six Sigma project success. This analytical approach helps assess the direct, indirect, and total effects of challenging goals on project performance at low and high levels of the structured Method – which prior studies have not done. It offers new insights into contingencies and boundary conditions that affect project performance.

Fourth, most research in goal-setting theory focuses on individual goals (Kleingeld, van Mierlo, & Arends, 2011; Locke & Latham, 1990). Limited research has examined goal setting in the context of projects (Kleingeld et al., 2011). This study contributes to our understanding of how goals relate to knowledge and influence project performance. By incorporating knowledge into our research, we can now understand the relationship between goals, knowledge, and the Method on Six Sigma project performance. Finally, by investigating the impact of the structured Method and challenging goals on knowledge, this study also contributes to an emerging body of literature that investigates the antecedents to learning in teams (Arumugam et al., 2013; Edmondson, 1999, Choo et al., 2007b).

The rest of the paper is organized as follows. Section 2 introduces Six Sigma, challenging goals, goal theoretic perspective of Six Sigma, and Sociotechnical System theory. Section 3 develops our research model and hypotheses. Section 4 explains the research methods, data collection, and measures. Section 5 presents analyses and results. Section 6 includes a discussion of theoretical and practical implications followed by the limitations of the research.

2.0 Literature review

2.1 Origins and conceptual development of Six Sigma

Motorola developed Six Sigma in 1986 as a response to the need to improve quality and reduce defects in their products. From 1987 to 1993 they reduced defects in their semiconductor devices by 94% (Montgomery & Woodall, 2008). Six Sigma focuses on reducing the variability of critical quality metrics around specified target values. The term Six Sigma refers to both a metric of process performance and a method to improve processes. The metric refers to the level of process capability in statistical terms, where a Six Sigma process would not make more than 3.4 defects per million units produced (Montgomery & Woodall, 2008).

Some scholars view Six Sigma a new administrative innovation (Jacobs, Swink, Linderman, 2015) that emerged from the Total Quality Management (TQM) movement. Six Sigma offers a new deployment approach and structure over TQM (Goh, 2002; Parast, 2011; Schroeder et al., 2008; Zairi, 2002). The deployment approach involves carrying out a series of process improvement projects that involve cross-functional teams using the Six Sigma method. Senior managers identify, prioritize, and select projects based on criteria such as cost savings, customer satisfaction, and overall organizational goals (Banuelas, Tennant, Tuersley, & Tang, 2006; Harry & Schroeder, 2000; Lee-Mortimer, 2007; Kumar, Antony, & Cho, 2009; Kwak & Anbari, 2006; Ray & Das, 2010). These projects seek to enhance process capability that should ultimately improve financial performance. Although the current literature helps to understand Six Sigma, there remain unanswered questions about the underlying theoretical basis of what leads to Six Sigma project success (Antony, 2008; Arumugam et al., 2014; Linderman et al., 2003; McAdam & Hazlett, 2010; Schroeder et al., 2008).

Six Sigma has a social structure where employees have different roles in the execution of Six Sigma projects. These roles include Master Black Belts, Black Belts, and Green Belts (Schroeder et al., 2008; Zu et al., 2008; McAdam et al., 2005). The different roles receive different levels of training in Six Sigma and have different responsibilities (Linderman et al., 2003; Schroeder et al., 2008). A Black Belt works on Six Sigma projects on a full-time basis, leads the project, and has more comprehensive training in Six Sigma; while the Green Belt typically works on the project on a part-time basis and does not have as much training. The Master Black Belt has extensive training in Six Sigma and supports the Black Belts in project execution. The team typically consists of employees from different functional areas to address system wide problems. Using a cross-functional team increases the total pool of knowledge and skills available to the project and enhances learning within the project (Arumugam et al., 2013; Lloréns-Montes & Molina, 2006). Following the Six Sigma method, the project team members collaboratively draw on their skills and knowledge to achieve the project's goals (Anand et al., 2010; Arumugam et al., 2013). The Six Sigma method establishes a common problem-solving approach that helps bring employees together with diverse functional backgrounds to address system wide problems. Six Sigma projects have a definitive start and stop date and typically take 4 to 6 months to complete (Antony, 2004; Pande, Neuman, & Cavanagh, 2000).

The Method, a technical part of the Six Sigma project is considered the centerpiece to project execution and differentiates Six Sigma from other quality improvement initiatives (Antony et al., 2007; Linderman et al., 2003; Schroeder et al., 2008; Zu et al., 2008). This Method relies on gathering data, statistical analysis, and the scientific method to reduce variation in processes and makes dramatic reductions in defects as defined by the customer (Hoerl, 1998). It follows a sequence of steps – Define, Measure, Analyze, Improve, and Control – which maps onto the scientific method. The Method begins with the Define step that establishes the project objectives and determines what needs to be improved. This step involves setting challenging goals, which can be as high as a 10-fold improvement from the baseline performance (Linderman et al., 2003; Pande et al., 2000). This challenging goal goes far beyond normal quality levels and requires aggressive effort on the part of the project team to achieve the target goal (Linderman et al., 2003). Next, the Measure step involves collecting valid and reliable data to help problem diagnosis and learning. The Analyze step involves conducting data analysis to identify cause and effect relationship, which ultimately leads a diagnosis of the problem and the sources of unwanted variation. The Improve step identifies corrective actions that will improve the process. Finally, the Control step involves developing a control plan to ensure that the process improvements are sustained over time. At the end of the Control step the project team hands over the improved process to the process owner who maintains the process (Linderman, Schroeder, & Sanders, 2010; Pande et al., 2000; Schroeder et al., 2008). By carrying out a series of such projects, organizations systematically change their business processes to improve business performance. The projects engage not only the social aspects of Six Sigma but also employ the technical aspects (Linderman et al., 2006).

2.2 Goal theoretic perspective of Six Sigma

Goal theory, originated in the organizational behaviour and industrial psychology literature, states that individuals with specific challenging goals will have higher performance than those with nonspecific or “do your best” goals (Locke & Latham, 1990, 2002). Goals serve as a motivational mechanism that regulates human action (Locke, Saari, Shaw, & Latham, 1981). Challenging goals mobilize effort, direct attention, encourage persistence and influence strategy development (Locke & Latham, 1990; Seijts & Latham, 2005). More recently, scholars have started to apply goal theory to teams, not just individuals (Kleingeld, van Mierlo, & Arends, 2011; O’Leary-Kelly et al. 1994). Scholars have argued that group goals can also improve group performance (e.g. Locke & Latham, 2002; Weldon & Weingart, 1993), but empirical research in this area is just emerging and there is limited understanding of the precise mechanisms of how group goals lead to higher performance.

In the Six Sigma context, Pande et al. (2000) argued that six sigma establishes an extremely challenging but yet realistic goal. ‘‘Six Sigma is known for employing challenging process improvement goals’’ (Linderman et al. (2003, pp.196). Building on goal theory, Linderman et al. (2003) proposed a goal theoretic perspective to understand Six Sigma. They argued that a clear and challenging goal in Six Sigma projects results in more team member effort, persistence and focus which help the team achieve higher performance. Empirical research further shows that a challenging project goal influences Six Sigma project performance (Linderman et al. 2006). Linderman et al. (2006) also argue that the challenging goals are important to six sigma projects since they encourage intentional learning. However, they did not empirically consider knowledge and learning, and consequently did not offer a detailed understanding of the relationship between goals, knowledge and Six Sigma.

2.3 Learning and knowledge creation in teams

Scholars argue that making intentional improvements to processes and organizational routines creates organizational knowledge (Nelson & Winter, 1982; Argote et al., 2003). Six Sigma project teams engage in deliberate efforts to improve processes which improve the team members' use of knowledge (Anand et al., 2010; Arumugam et al., 2013; Lloréns-Montes & Molina, 2006; Wiklund & Wiklund, 2002; Linderman et al., 2010). The Six Sigma method encourages team members to engage in learning behaviours (Choo et al. 2007b), which benefit Six Sigma projects (McAdam & Hazlett, 2010). The use of the DMAIC method and tools in Six Sigma aids learning in project teams (Anand et al., 2010; Arumugam et al., 2014; Choo et al., 2007; Linderman et al., 2010; Lloréns-Montes & Molina, 2006; Savolainen & Haikonen, 2007; Wiklund & Wiklund, 2002). Prior research has established that learning ultimately leads to Six Sigma project success (Anand et al., 2010; Arumugam et al. , 2013; Choo et al., 2007b; Malik & Blummenfeld, 2012; Sony & Naik, 2012).

Goals can also influence the creation of knowledge and learning. Goal theory scholars argue that challenging goals motivate organizational members to engage in intentional learning activities that create knowledge and make improvements (Locke & Latham, 1990; Linderman et al., 2003, 2006). In a related study, Choo (2011) finds that the "sense of challenge" in six sigma project teams leads to knowledge creation. The present study investigates how the Six Sigma method moderates the effect of goals on knowledge and project performance. We use Sociotechnical Systems theory as an overarching theory to understand these relationships.

2.4 Sociotechnical systems (STS) theory

Sociotechnical Systems (STS) theory has emerged as a well-established strategy for work design. This perspective views organizations as composed of two independent but linked systems - a social system and a technical system. The technical system refers to the tools, techniques, artifacts, methods, configurations and procedures that an organization uses to acquire and transform input into output; while the social system consists of the people involved in the work and all that is human about their presence (Pasmore, 1988). STS theory provides a framework for understanding relationships between social and technical systems within organizations (Lawler, 1992; Pasmore, 1988; Trist & Bamforth, 1951). It predicts that the compatibility or joint optimization between the social and technical aspects of a work influences performance outcomes. That is, STS theory argues that the joint optimization of the social and technical components of a work system leads to higher performance than simple optimization of either system at the expense of others (Cherns, 1987; Cummings, 1978; Emery & Trist, 1969).

From an STS perspective, the method used by project teams belongs to the technical system, whereas the goals that motivate team members belongs to the social system.

STS argues that a change in the technical system affects the social system and vice versa (Pasmore, 1988). This theory explicitly recognizes the authority of teams to alter work methods to enhance performance (Emery & Thorsrud, 1976; Trist, 1978). This has potential implications for the degree to which teams use the Six Sigma method (technical system) and goals (social system), and the subsequent effect on performance. STS theory helps develop hypotheses to understand the underpinnings and contingencies of how challenging goals (social system) relate to the Six Sigma Method (technical system) which in-turn influences project performance.

3.0 Hypotheses

Figure 1 summarizes our hypothesized mediated-moderation model, which specifies how the social and technical elements of Six Sigma come together to affect performance. The model argues that knowledge mediates the effect of challenging goals on performance and the method moderates both the goal–performance (direct effect) and the knowledge–performance path (second stage indirect effect). Overall, the model signifies that the strength of the ‘‘goal–knowledge-performance’’ relationship depends on the degree of adherence to the Six Sigma method. The detailed arguments of the specific hypothesized links in the model follow.

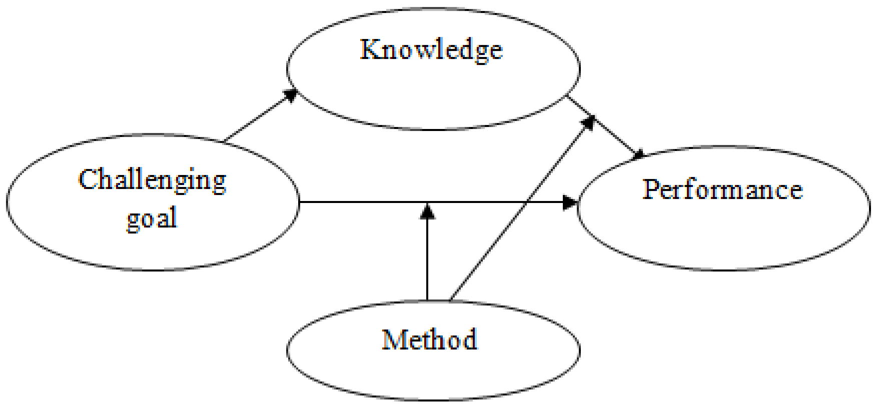


Figure 1: Mediated-moderation model

3.1. Goal and Performance

Research in goal theory has established a strong relationship between setting challenging goals and performance outcomes (Locke & Latham, 1990; Kleingeld et al., 2011). Emerging research also argues that goals apply to teams not only individuals. For instance, Gutiérrez, Lloréns-Montes, & Sanchez (2009) argue that challenging goals help orient team members towards a shared vision which in turn helps teams achieve project success. Past research has also found that social processes shape how quality management is practiced (Boiral, 2003; MacDuffie, 1997). In organizational research, Ghoshal & Bartlett (1994) argue that a challenging environment can make individuals voluntarily stretch their own standards and expectations. Overall, goals trigger motivational mechanisms, such as planning, cooperation, morale-building, communication, and collective efficacy (Weldon & Weingart, 1993). Linderman at al. (2006) argue that Six Sigma projects with a challenging goal will generate momentum within the team, motivate team member commitment, and encourage team members to develop strategies for success (Linderman et al., 2006). This suggests the first hypothesis.

> ***Hypothesis 1:*** *Challenging goals in Six Sigma projects lead to higher project performance*

3.2. Goal, knowledge, and performance

Locke et al. (1981) argue that challenging goals encourage people to develop effective strategies that improve performance. Strategy refers to action plans that involve skill development or creative problem solving (Argote et al., 2003). Challenging goals encourage experimentation, innovation and searching for new approaches to achieve target objectives (Sitkin, See, Miller, Lawless, & Carton, 2011), which benefits from knowledge. Lloréns-Montes & Molina (2006) state that Six Sigma projects provide a good setting for learning. Six Sigma engages the teams in problem diagnosis efforts to improve processes which facilitate learning in teams (McAdam & Hazlett, 2010). Through Six Sigma, teams engage in creative problem solving and experimentation to identify new strategies for improvement.

Locke & Latham (1990) assert that goals activate an individual’s knowledge and skills that are perceived relevant to the task. Goals further motivate team members to learn from each other and share knowledge. Schön (1978) suggests that problem solving is a learning process that integrates diverse knowledge types and becomes a basis for knowledge creation. The use of cross-functional teams in Six Sigma should enhance the diverse types of knowledge available to the project teams (Anand et al., 2010; Arumugam et al., 2013). A challenging goal can prompt learning as members seek new and varied approaches to reach the target (Sitkin et al. 2011). Furthermore, the creativity literature argues that stretch goals can influence creative behaviour and that in turn encourages learning and knowledge creation (Amabile, Conti, Coon, Lazenby, & Herron, 1996). Six Sigma teams when motivated by challenging goals, create knowledge about the process, discover cause and effect relationships, develop a collective understanding of the process and generate solutions to enhance performance (Arumugam et al., 2013).

Scholars have argued that knowledge creation has a positive relationship on performance and productivity (Davenport & Prusak, 2000). Knowledge creation enhances decision making (Mukherjee, Lapre, & Van Wassenhove, 1998), problem-solving capabilities (Kogut & Zander, 1992) and creativity (Davenport & Prusak, 2000; Nonaka & Takeuchi, 1995; Teece, Pisano, & Shuen, 1997). Empirical research indicates a positive relationship between knowledge creation and performance (e.g., Bontis et al., 2002; Tippins & Sohi, 2003). Soti, Ashish, Ravi Shankar, & Kaushal, (2010) found that employees' adaptability and flexibility toward learning enables successful deployment of Six Sigma. Other scholars have found that knowledge creation in Six Sigma projects increases performance (Anand et al., 2010; Arumugam et al., 2013; Sony &d Naik, 2012; Malik & Blumenfeld, 2012; Nair et al., 2011; Lee & Choi, 2006; Wiklund & Wiklund, 2002). Knowledge creation in Six Sigma project teams helps generate more informed solutions that in turn improve performance. Collectively the above arguments suggest,

> ***Hypothesis 2:*** *Challenging goal has a positive effect on project performance through knowledge in Six Sigma project team*

3.3. Goal, Knowledge, Method, and Performance

McAdam & Lafferty (2004) argued that successful implementation of Six Sigma requires attention to both process perspective (technical) and people perspective (social). The Method (DMAIC) in Six Sigma projects helps to identify the root causes of the problem, search for solutions, and improve the processes. The Method provides a systematic way to solve problems and promotes rational decision making (Cyert & March, 1963; Daft, 2000). A structured method that follows logical steps forces team members to search systematically for solutions (Choo et al., 2007a; Linderman et al., 2010). The Six Sigma Method links the tools and techniques in a sequential manner, which helps teams make better decisions. The Method through its logical steps and embedded tools provides a mechanism to guide projects to completion. Linderman et al. (2006) argued that the Method reduces the task complexity of projects and helps the team search for solutions to complicated problems, which in turn facilitates goal achievement. Therefore, the use of the Six Sigma method should alter a team's ability to achieve challenging goals, which leads to higher project performance. Choo et al. (2007a) argued that tools and techniques used by teams provide hard evidence for proposed process changes, which increases management buy-in leading to project success. Therefore, the effect of goal on performance depends on the level of adherence to the Six Sigma method.

Social-Technical systems theory argues that the social system and technical system should be compatible in work systems to optimize performance (Pasmore, 1988). More difficult goals create a demanding social system where project teams need to work hard to achieve their objectives. In such settings teams can benefit from a compatible technical systems. In the context of Six Sigma projects, this would relate to the teams adherence to the Six Sigma method. The Six Sigma method offers a guide or path that will help teams navigate the project (Choo et al., 2007a; Zu et al., 2008; Antony et al., 2007), as it offers a systematic approach and ensures multiple perspectives to identify a good solution (Gibbons, 2000; Simon, 1995). From a Social-Technical systems perspective, we argue that challenging goals should be compatible with the use of the Six Sigma methods. This suggests the following hypothesis.

Hypothesis 3a: *The adherence to the structured method followed in the Six Sigma project team positively moderates the effect of challenging goals on performance.*

We argue that the success in converting knowledge into a workable solution for implementation depends on the level of adherence to the Six Sigma method. While the project team internally identifies solutions to problems, the implementation of these solutions depends on factors external to the team such as management and operating personnel. These external factors influence the ultimate success of implementing improvements suggested by the project team. Implementation of any change requires user support, monitoring and continuous evaluation and acceptance from the users. Teams may often face difficulties in this since operating people may be comfortable with the status quo and question the merits of solutions that modify their work. This requires some amount of trial-and-error experimentation to change the process and requires coordination with personnel inside and outside the team (Cooke-Davis, 2002). The Method can facilitate coordination since the team members come from different functions that are affected by the proposed solution. Cross-functional cooperation also helps remove intra-organizational barriers to speed information flow and enhance productivity (Song, Montoya Weiss, & Schmidt, 1997). This coordinating capability can help teams achieve overall group performance (Sinha & Van de Ven, 2005; Van den Bosch, Volberda, & De Boer, 1999). Social-Technical System theory suggests that in more knowledgeintensive work settings, teams can benefit from a technical system that supports learning and knowledge creation (Pasmore, 1988). The above arguments suggest the following hypothesis.

Hypothesis 3b: *The adherence to the structured method in the Six Sigma project team positively moderates the effect of knowledge on performance.*

4. Research method

4.1 Data collection

The primary data for this study came from two manufacturing companies in Europe that used Six Sigma (called MFG1 and MFG2). MFG1 is a Fortune 500 company with over 40,000 employees worldwide they operate as an OEM in the automotive industry. They had deployed Six Sigma for a little more than six years at the time of data collection. MFG2 is a wind turbine manufacturer with over 16,000 employees worldwide. They had also deployed Six Sigma over six years ago. The unit of the analysis is the Six Sigma project. At both companies, Black Belts and senior Green Belts led the Six Sigma projects. They had expertise in the Six Sigma tools and problem-solving methods.

A web-based survey was conducted to collect data. Personalized e-mails were sent by the Six Sigma deployment champions to Six Sigma project leaders and team members. Projects within the past two years were targeted to minimize the measurement error due to the recollection effect. Reminder and thank you e-mails were sent every week until we received a satisfactory response rate. Since the project leaders had a full-time commitment to the projects, they were excellent informants for all the variables in this research. The data for each project came from the project leader and at least two team members in the project. Having multiple respondents minimizes common method bias and improves instrument validity. The project leaders responded to questions about knowledge and performance while both the team members and project leaders responded to questions about the project teams goals and adherence to the Six Sigma method.

The data collection only included completed projects so that we could assess the project outcomes. We targeted 198 projects in total and obtained usable responses for 102 projects, which resulted in a 51.5% overall response rate. The responses came from 52 projects completed at MFG1 and 50 projects completed at MFG2, which represents a response rate of 47.3% and 56.8%, respectively. In total, 324 people participated in the survey (102 project leaders and the rest project team members). The team size varied from three to nine members. Although this is a good response rate, we also tested for a non-response bias by conducting a two-sample t-test between early and late responses, which showed no differences (Lambert & Harrington, 1990).

4.2 Measures

The items to measure the constructs were adapted from existing scales. Each item used a seven-point Likert scale and captured the extent to which respondents strongly disagreed or strongly agreed with statements. A pilot survey was conducted with the participation of five Six

Sigma organizations, which were different from our main survey organizations. Fifteen Six Sigma project leaders (Black Belts) and five team members took part in the pilot survey. These team members and project leaders had in-depth experience with Six Sigma projects in their respective organizations and hence were knowledgeable on the variables and concepts. Based on their feedback, the wording of some of the items was modified to improve clarity.

4.2.1 Main variables

Goal (Cronbach's α = 0.70) uses a two-item scale to evaluate how challenging the goals were in the Six Sigma project. These items came from Linderman et al. (2006). *Method* (Cronbach's α = 0.84) uses a three-item scale adapted from Linderman et al. (2006), and measures the extent that the team adhered to the Six Sigma methods and tools. *Knowledge* (Cronbach's α = 0.90) uses a three-item scale adapted from Choo et al. (2007b), which measures the degree of solution uniqueness, idea generation and improved understanding and capability of team members. Consistent with similar studies in Six Sigma, the scale items for *project performance* measured the extent to which the project customer satisfaction, cost benefits and strategic impacts were achieved in the project (Choo et al., 2007b; Linderman et al., 2006) (Cronbach's α = 0.93). Appendix gives the items for each scale.

4.2.2 Control variables

The analysis controls for project team size, project duration, the project leader's experience and project complexity, prior research shows that these variables affect project success. The team literature shows that team size affects team dynamics and performance (Polley & Dyne, 1994). For example, as team size increases, social loafing and responsibility diffusion can affect team learning and project performance. Recent research has also found that the leader's experience affects Six Sigma project success (Easton & Rosenzweig, 2012). Project duration can affect knowledge acquisition and performance. As project duration increases, the team may be affected by temporal variations, for example, they may place more importance on team relationships than task efficiency (Polley & Dyne, 1994). We include project complexity as a control factor in terms of team size (Easton & Rosenzweig, 2012). Projects with a broad scope tend to be complex involving multiple functions and hence have more team members.

4.2.3 Scale validity, reliability, and aggregation

We assessed the construct validity of our measures by examining dimensionality, criterion-related validity, and discriminant validity. We also checked the viability of the team level constructs by examining within-group agreement or inter-rater agreement r_{wg} (James, Demaree,

& Wolf, 1984). An r_{wg} value of 0 refers to the lack of agreement and 1 refers to complete agreement within a group. The analysis shows that different respondents for each project made similar responses to the constructs.

Responses to goal and Method were obtained from both project leaders and members of each project team. It is critical to demonstrate a high within-team agreement (r_{wg}) to justify using the team average as the score for the team-level variables. We computed r_{wg} values for multi-response variables (goal and method) and obtained median values of .75 for goal and .89 for Method. These values above 0.70 suggest high within-team agreement (James, Demaree, & Wolf, 1984; LeBreton & Senter, 2008). We measured the team-level variables by averaging the within-team member responses on the goal and Method measures.

We estimated a four-factor measurement model consisting of goal, knowledge, Method and performance, which consists of 12 items and found that the measurement model fits the data well. χ^2 (48) = 68.975, with a probability of 0.025, root mean square error of approximation (RMSEA) =. 06, goodness-of-fit index (GFI) = .90, TLI =.97, confirmatory fit index (CFI) = .98, with all values within the acceptable limits (Hu & Bentler, 1999). This analysis also showed that all items loaded significantly on their associated constructs (p <.001), which confirms the constructs' convergent validity (Bagozzi & Yi, 1991). We also compared the hypothesized four-factor model with a likely rival model to establish divergent validity. For example, because both the knowledge and the performance items are related to the outcome of the project, it is possible to combine them into a single factor. The alternative three-factor model yielded a very low fit (χ^2(51) =170.41, p<.001 RMSEA= .15, GFI =.79, TLI =0.83, CFI =.87) which indicates that the hypothesized model had a better fit than this alternative model. This further confirms our measurement approach.

The magnitudes of the average variance extracted (AVE) of all constructs (.53 to .78) had values greater than the minimum accepted value of .50, thus providing further evidence of the convergent validity of the scales. Discriminant validity was assessed by comparing the shared variance (squared correlation) between each pair of constructs against the average of the AVE for these two constructs. Within each of the six possible pairs of constructs, the shared variance estimated was found to be lower than the average of their AVEs, confirming discriminant validity (Fornell & Larker, 1981). The reliability of all measurement scales was equal to or exceeded the recommended Cronbach's alpha value of 0.7 (Nunnally & Bernstein, 1994). Overall, a series of statistical tests, including multiple tests of reliability, convergent and discriminant validity, and aggregation, further support the overall measurement quality (Gerbing & Anderson, 1988). Therefore, the measures were considered adequate for further analysis.

5. Analysis and results

The data of experience of the project leaders were found to be highly skewed, so we log transformed it for the analysis. Table 1 gives the descriptive statistics and correlations for all the variables. We use regression analysis to test the four hypotheses on mediation and moderation. Scholars have suggested a number of ways to test the mediated moderation model. Of these, path analytic methods have been shown to have the greatest statistical performance (Edwards & Lambert, 2007; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Incorporating both regression and path analysis overcomes the shortcomings of current approaches used to test for meditation-moderation effects. Also, we use bootstrapping methods to generate confidence intervals rather than using point estimates of the indirect effects. This helps avoid any potential power problems caused by asymmetric and other non-normal sampling distributions of conditional and indirect effects (MacKinnon et al., 2002).

Table 2 gives the results of the hierarchical regression analysis. The control variables were entered first, followed by the other study variables. All independent variables were mean-centered to reduce multicollinearity (Aiken & West 1991). Model M6 supports Hypothesis 1, which predicts that challenging goals lead to higher performance. Hypothesis 2 argues that knowledge mediates the effect of goals on project performance. This is tested using Baron & Kenny's (1986) three-step method: (1) the proposed mediator predicts the dependent variable,

Table 1
Descriptive Statistics of Variables

		Mean	Std Dev	1	2	3	4	5	6	7
1	Team size	5.402	1.678							
2	Project duration	6.888	2.109	.078						
3	Leader's experience (log)	0.225	0.281	.033	.025					
4	Company dummy	0.509	0.502	.224*	-.183	-.202*				
5	Goal	5.671	1.229	.012	-.071	-.071	.170			
6	Knowledge created	5.523	1.214	.082	-.008	-.020	.181	.530**		
7	Method	5.595	1.191	.082	.047	.074	.150	.338**	.296**	
8	Performance	5.404	1.359	.095	-.036	.037	.242*	.676**	.732**	.394**

*p<0.05. **p<0.01

(2) the independent variable predicts the mediator, and (3) the contribution of the independent variable drops substantially for partial mediation and becomes insignificant for full mediation when both independent and mediator variables are entered into the regression model. The analysis in M6 shows that goal has a significant positive relationship with project performance

(β =.660, *p* < .001). The analysis in M2 shows that goal has a positive significant relationship with knowledge (mediator) (β =.519, *p* < .001). The model M5 shows that knowledge has a significant positive relationship with project performance (β =.710, *p* < .001), and the contribution of goal to performance lessens (β = .400, *p* < .001) when entered into the regression model with knowledge, which remains significant (β =.502, *p*< .001) in M7. Collectively these results show partial mediation of goal through knowledge on performance – that is, the goal has both a direct and indirect effect on project performance. We also conducted tests for the significance of mediated effects (Frazier, Baron, & Tix, 2004; MacKinnon et al., 2002). A follow-up using the Sobel test (Baron & Kenny, 1986) provides further evidence of a significant mediating effect with a test statistic of 4.97 (*p*<.001). Furthermore, using a bootstrapping procedure for the indirect effect shows a confidence interval of [.161, .476] (*p*< .001), which gives even stronger support for mediation. Consequently, the analysis supports Hypothesis 2.

Hypothesis 3a predicts that Method positively interacts with goal on performance (direct path), and hypothesis 3b predicts that Method positively interacts with knowledge on performance (second stage indirect path). We add interaction terms to the regression on performance to test the moderation effects of Method on the impacts of goal on performance through knowledge. Model M9 has a significant, but negative interaction term between Method and goal (β =-.231, *p*< .01), which conflicts with H3a (we discuss later in this section, after explaining the path analysis results). The analysis shows a positive interaction between Method and knowledge (β =.260, *p*< .01), which supports H3b. These two variables account for 3.4% of variance in performance, which is significant and beyond the variance accounted for by the control variables and the independent variables (goal and knowledge), as reported in M7. The result in model M3 also shows no significant effect of Method on knowledge. This finding is consistent with the results of Choo et al. (2007b), where they found that method does not have any direct effect on knowledge but has an indirect impact on knowledge.

As we noted earlier, we followed Edwards & Lambert (2007) to test for the meditation-moderation effects. We ran the SPSS "constrained non-linear regression" syntax module as suggested by Edwards & Lambert (2007), which is based on the bootstrapping function. This allowed us to assess the direct, indirect and total effects of goals on performance at low (one standard deviation below the mean) and high (one standard deviation above the mean) levels of the moderator variable (Method). We estimated bias-corrected confidence intervals at the two selected levels of Method, with 1,000 random samples and with replacement from the full sample (Stine, 1989). Table 3 and Figure 3 give the results.

Table 3 shows significant path coefficients for the second stage at both low and high levels of Method (β =.34, $p< .01$ and β =.79, $p< .01$ respectively), which indicates the mediating effects of knowledge on the relationship between goal and performance. This further supports Hypothesis 2. The differences in the second stage (β=.45, $p< .05$), indirect effect (β=.23, $p< .05$) and direct effect (β=-.36, $p< .05$) are also significant, supporting moderation at the second stage and for the direct effect, which confirms Hypotheses 3b and 3a respectively. However, there is a negative moderation on the direct effect instead of a positive moderation as hypothesized (H3a). The results reveal that the indirect effect is stronger (β=.41, $p< .01$) when Method is high, whereas the direct effect is stronger (β=.59, $p< .01$) when Method is low, supporting the differential moderation effects of Method on direct and indirect paths. Overall, these results show the mediation of knowledge on the relationship between goal and project performance, as well as the moderation of Method on the link between goal and performance via knowledge.

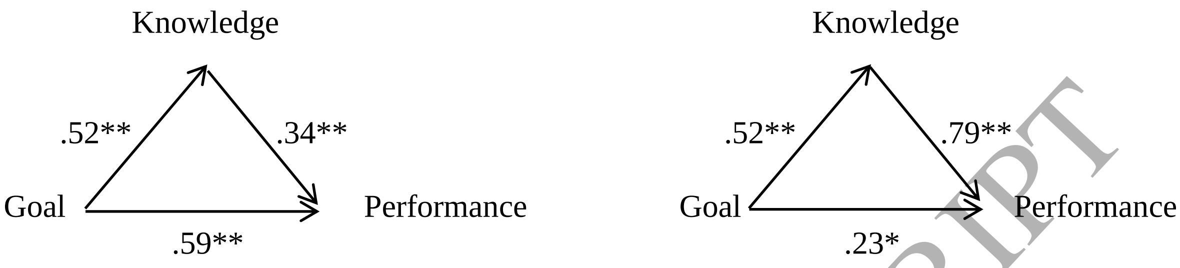
We now offer an explanation for the negative moderation of Method on the direct path of goal to performance. Very challenging goals require a significant departure from the current level of performance. This may require developing entirely new processes and benefits from a more innovative solution (Linderman et al., 2006). However, the DMAIC method gives teams a routine to improve existing processes. But for very challenging goals, the team needs to think and act "outside the box" and follow an unstructured approach to carrying out the project. That is, they may need to explore new ways of doing things that depart from existing

Table 2
Summary of the Regression Analyses Results

	Knowledge created			Performance					
	M1	M2	M3	M4	M5	M6	M7	M8	M9
Control variables									
Team size	.040	.050	.046	.035	.007	.048	.023	.020	.031
Project duration	.021	.041	.027	.005	-.010	.031	.010	.002	-.018
Leader's experience (log)	.015	.034	.020	.086	.076	.111	.094	.082	.100
Company	.179^	.096	.079	.253*	.126^	.148^	.099	.088	.095
Independent variables/indirect effects									
Goal		.519***	.479***			.660***	.400***	.374***	.373***
Knowledge created					.710***		.502***	.488***	.493***
Moderation									
Method			.113					.103	.097
Method * Goal			-.015						-.231**
Method * Knowledge									.260**
R^2	.035	.296	.307	.068	.554	.490	.667	.676	.708
Adj R^2	-.005	.259	.256	.029	.531	.463	.646	.652	.680
F	.833	8.059***	5.952***	1.758	23.848***	18.423***	31.722***	28.005***	24.816***

N= 102 project teams (222 members and 102 leaders). M = Model
^p<.1. *p<.05. **p<.01. ***p<.001
All coefficients are standardized

processes and products. The team should be open to new information from a variety of sources (Huber, 1991) and may require more flexible thinking about alternative strategies for goal attainment (March, 1991; March & Olsen, 1976). The Method, on the other hand, follows a systematic approach to solving problems (Cyert & March, 1963; Daft, 2000).



A. Simple effects for low Method

B. Simple effects for high Method

* $p < .05$ ** $p < .01$

Panels A and B show that method moderates the paths from knowledge to performance and more so for high Method than for low Method. The path from goal to performance is also moderated by Method, more strongly when Method is low. The indirect effect is stronger for high Method (.41**, $p < .01$) than for low Method (.18**, $p < .01$).

Figure 2: Mediated models showing the simple effects of low and high method/tools

A structured method with logical steps, forces team members to search for solutions that improve existing processes (Choo et al., 2007a; Linderman et al., 2010). According to the creativity literature, a structured approach can impede creativity (Amabile et al., 1996; Ekvall, 1997), which may be needed to achieve very challenging goals. It is likely therefore that strict adherence to the Method could adversely impact the effect of challenging goals on project performance. In contrast, if the degree of adherence to the Method is low, teams may engage in more creative "outside the box" problem solving and challenging goals will have more impact on performance. This explains the negative coefficient for the moderation term.

Sociotechnical system theory (STS) further supports this line of reasoning. STS theory argues that the social system and technical system benefit from joint optimization and that the social systems will influence technical systems in enhancing organizational outcomes (Fox, 1995). STS recognizes the importance of teams to alter their work methods to improve performance (Emery & Thorsrud, 1976; Trist, 1978). When teams have very challenging goals (social system) they may need to alter the use of the method (technical system) to achieve the best outcome. Consequently, the team will choose to deviate from the Method in order to achieve enhanced performance in the face of very challenging goals. This explains why the direct effect path coefficient for low adherence of Method (β=.59) is higher than that of higher adherence of Method (β=.23) as shown in Figure 2. Prior research has not examined this contingency.

Table 3

Results of the moderated path analysis: Direct, indirect and total effects of goal on project performance at low and high levels of Method

Path	First Stage	Second Stage	Indirect effects	Direct effects	Total effects
Simple path for low Method	.52**	.34**	.18**	.59**	.76**
Simple path for high Method	.52**	.79**	.41**	.23*	.64**
Difference	0	.45*	.23*	-.36*	-.12
Mean	.52**	.57**	.29**	.41**	.70**

N = 102; Low Method refers to one standard deviation below the mean of Method and high Method to one standard deviation above the mean of Method. First Stage = Path from goal to knowledge; Second Stage = Path from knowledge to performance; Direct effects = Path from goal to performance.

* *p* <.05; ** *p*<.01.

The intercepts for both low and high levels of the moderator were then estimated for the second stage indirect effects, direct effects and total effects using the procedure given by Edwards & Lambert (2007). Using the slopes from Table 3 and the estimated intercepts, Figure 3 shows the simple slope curves. For display purposes, the axes of these figures have been converted back to their original scales (1 to 7 in our study) to facilitate interpretation as the plot does not alter the form of the plotted interaction (Aiken & West, 1991).

In Figure 3, Panel A shows that for the second stage (knowledge–performance) of the indirect effect, the relationship between knowledge and performance is steeper for the projects with a high level of adherence to the Method. This finding highlights that adherence to the Method enhances the benefits of knowledge gained by teams than when adherence to the Method is low (H3b). When the teams acquire a high level of knowledge, then adherence to the Method leads to higher performance. The slope lines in Panel A reveal projects with high knowledge benefit from the Method since it helps translate knowledge into solutions and consequently higher performance. This observation underscores the importance of adhering to the Method for projects that need to create knowledge to solve problems.

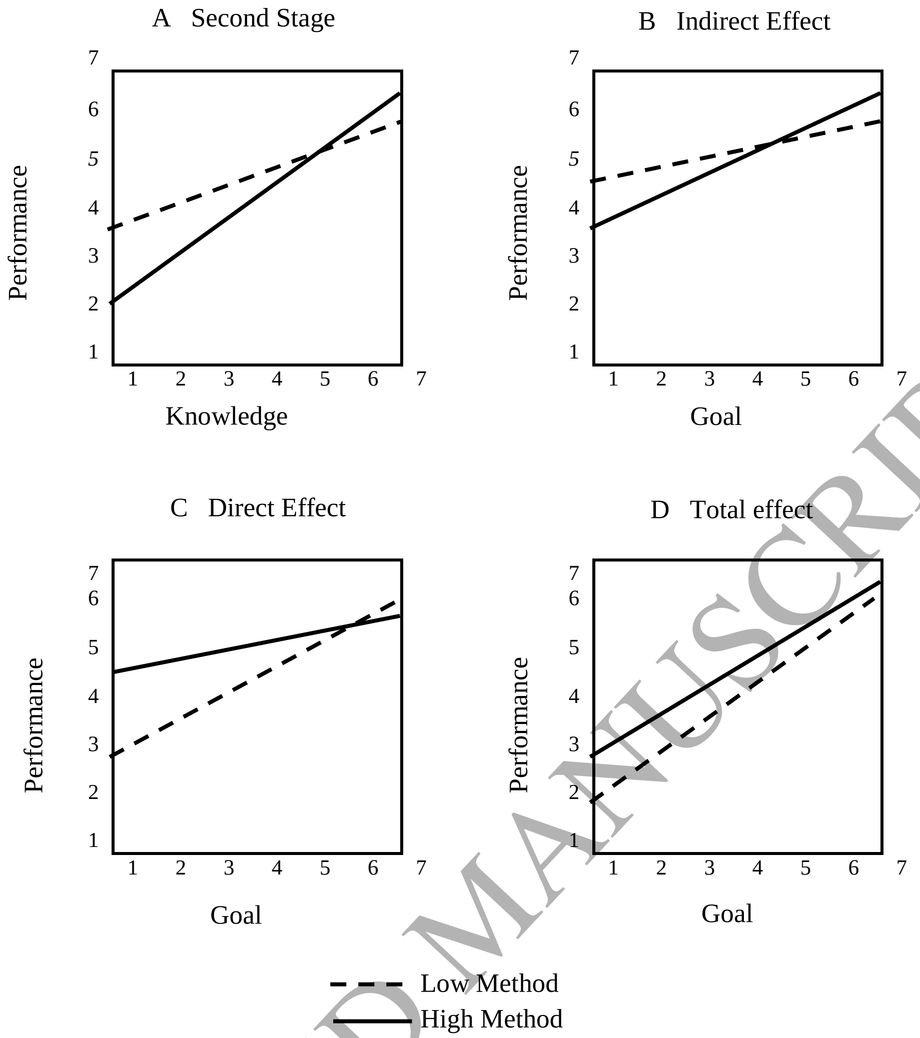


Figure 3 Plots of simple paths and effects with method as the moderator

Panel B in Figure 3 shows the indirect effect (knowledge route), which is similar to Panel A. The high Method path has higher performance as goal increases as expected. The graph further illustrates that projects with low (do your best) goals do not benefit from adhering to the Method. In fact, it may lower the performance as shown here. This provides an important lesson for Six Sigma practitioners and project team members. Projects that have a low goal should not be considered as Six Sigma projects since they do not require rigorous root cause analysis (Linderman et al., 2006).

It is interesting to observe the nature of the effects of goals on performance in Panels B and C (the indirect and direct effect respectively). The high method has a steeper slope in Panel B (indirect effect), while low Method has a steeper slope in Panel C (direct effect). This collectively indicates that the effect of goal on performance is stronger for the indirect path and weaker for the direct path when the Method is high. The low Method line in Panel C further reveals that low Method results in higher performance when a very high goal is set. Panel D gives the total effect, which indicates that high Method enhances performance, but the difference becomes muted as goals increase in challenge. Prior studies have not examined the precise mechanisms that underpin Six Sigma projects, which helps inform how organizations can better deploy Six Sigma.

6. Discussion and conclusion

6.1 Theoretical implications

Scholars have investigated the organizational benefits of implementing Six Sigma. Six Sigma takes a project-based approach to deployment that employs the Six Sigma method. Understanding how to deploy Six Sigma necessitates understanding how to manage successfully Six Sigma projects. However, researchers in the past have taken only a piecemeal approach to understanding the factors that lead to Six Sigma success. To fully understand Six Sigma projects we need to know the interrelationships among these factors. The main objective of the study is to examine the precise mechanisms that lead to project success and to better inform how to implement Six Sigma projects. With this aim, we investigate how the two important factors of Six Sigma deployment, Method (technical aspect of the project) and challenging goals (social aspect of the project) impact project performance. We draw on Sociotechnical system theory to understand the interrelationships of the factors that impact project performance. This helps identify boundary conditions and contingencies to Six Sigma project execution. The results show that the Six Sigma Method negatively moderates the relationship between goals and performance, but positively moderates the relationship between knowledge creation and performance. This has implications for how we understand and implement Six Sigma. The findings show that to understand fully what influences the performance of Six Sigma projects we need to understand the interrelationships between the social and technical factors in the projects. This also helps understand the boundary conditions to the utility of the Six Sigma method, which goes beyond prior studies.

This study also adds more generally to our understanding of goals and knowledge (Linderman et al., 2003; Kleingeld et al., 2011; Locke & Latham, 2007). Latham and Locke noted ‘‘Goal and knowledge connect goal setting to the entire field of cognitive psychology. Research so far has only scratched the surface of the issue of how goals and knowledge affect one another and work together to affect performance’’ (Latham & Locke, 2007: pp. 297). In

Six Sigma, Linderman et al., (2003) noted that "improvement goals motivate teams to engage in intentional learning activities that create knowledge and make improvements" (pp. 193–194), we included knowledge in the model and examined how goal and Method interact to impact performance through knowledge. Although some prior studies have considered knowledge while investigating six sigma projects (e.g., Choo et al., 2007b), research has not considered knowledge in the context of Six Sigma project goals. By incorporating knowledge as a mediator into the study, we develop a deeper understanding of the interaction between social and technical aspects of Six Sigma projects. Our study contributes to our understanding of how group goals relate to project team knowledge in the context of Six Sigma, to our knowledge prior research has not empirically examined these relationships.

The results more broadly contribute to goal theory. The majority of research in goal theory focuses on individual goals (Kleingeld et al., 2011; Locke & Latham, 1990) and only a few studies consider group goals but often in the context of stable work teams. Scholars note that field studies into group goal setting are rare in the applied psychology research (Kleingeld et al., 2011). Our study, with temporary problem-solving teams as a unit of analysis and incorporating knowledge in the model, advances the research into group goals and thus contributes to extending the goal theory literature.

Our mediated moderation model also provides a new way of investigating the effects of goals on the performance of Six Sigma improvement projects. This study provides interesting insights into the interplay of the structured method (technical), challenging goals (social aspects), and knowledge in Six Sigma projects. The empirical results show a complex moderating effect of Method on the ''goal-knowledge-performance'' relationship. The overall moderating effect shows that high adherence to the Method has higher performance across all levels of goal, which is consistent with prior research (Linderman et al., 2006). However, this relationship becomes more complicated when considering the direct and indirect (via knowledge) effects of goals on performance. The results of this study provide a more comprehensive understanding of the antecedents, contingencies, and performance implications of Six Sigma projects, and thus aid theory building.

Panel D in Figure 3 shows that when teams have high goals, the performance of teams with low Method is almost the same as those with high Method. This finding suggests that Six Sigma teams with low Method can approximate the performance of teams with high Method through the use of challenging goals. This signifies that to achieve high performance, we need to have either high degree of Method adherence or a very challenging goal. Thus, it seems that goal and the level of adherence to the Method can compensate for one another to some degree. This is an interesting and somewhat surprising finding for both theory and practice. The following explanation can be given. A team that adheres to the Method apply various tools and techniques throughout the DMAIC phases, creates knowledge, solves problems and identifies the optimal solution. On the other hand, a team that follows the Method more loosely may have to take additional precautions to avoid any mistakes in their approach to be successful. A challenging goal may cause this team to reflect on aspects of activities or tasks that go wrong during the project. It may also keep the team from rushing into any quick judgments and thereby omitting any relevant tasks, which helps avoid making mistakes. That is challenging goals encourage teams to develop their problem-solving strategies. All these additional actions by the team contribute toward learning and hence knowledge creation in the team. In an extreme case, as Latham, Seijts, & Crim, (2008) argues, a highly challenging goal may even prompt the team to conduct an additional search for alternative solutions, leading to further learning. The goal, in this case, seems to cue the team to take a more cautious approach, leading to enhanced performance (Latham et al., 2008). The study thus points out the importance of Method adherence and challenging goal and their complementary relationship in impacting knowledge creation and performance in process improvement teams. Prior research has not examined this relationship, which helps better understand the technical and social dimensions of Six Sigma project execution.

Our findings also suggest that the project team can alter their choices on the level of adherence to gain a higher level of performance. Through a higher level of adherence to the Method during the implementation phase, teams seek involvement, cooperation, and coordination from the stakeholders and the process people. The results imply that Six Sigma provides a technical means to break down existing structural barriers between teams and different functions to enhance project effectiveness. In contrast, by not adhering strictly to the Method (direct effect), teams cease to engage with the stakeholders, thus adding structural barriers. This is consistent with the STS perspective, which explicitly recognizes the authority of teams to alter work methods to improve effectiveness (Emery & Thorsrud, 1976; Trist, 1978). Although Six Sigma is a new quality management paradigm, existing theories from relevant fields can be applied to understand this phenomenon. Relevant theories can provide new perspectives and insights into Six Sigma and enhance our understanding.

This study offers a deeper understanding of the relationship between the Six Sigma Method with knowledge and learning. Exploratory learning is the search for new possibilities, discovery, novelty and innovation, whereas exploitative learning concerns refinement, reutilization, production and implementation of knowledge (March, 1991). Our results suggest that the Method helps translate new-found knowledge in teams into workable and implementable solutions, thus exploiting this knowledge; hence, it is found to have a strong orientation towards exploitative learning. Our study has shown that challenging goals encourage novel ideas and innovative solutions and knowledge creation, relating to exploratory learning (McGrath, 2001). Thus, goals (social) and Method (technical) promote exploratory and exploitative learning respectively, showing that Six Sigma projects help manage a balance between explorative and exploitative learning (Levinthal & March, 1993) and contribute to internal innovation (Tushman & O'Reilly, 1996).

The analytical approach used in this study to investigate the moderating effect also helped provide a deeper understanding of Six Sigma project execution. This approach integrates both the moderated regression analysis and path analysis, which yields detailed results along with the statistical tests of moderation for each path of our research model. By doing so, it helps reveal how the direct, indirect, and total effects of the challenging goal vary across levels of the moderator variable Method (low and high Method) to get a deeper understanding of project execution.

Future research can consider other mediators that may advance our understanding of the mechanisms that explain the goal–performance relationship. For example, participation in setting goals and satisfaction may mediate this relationship (Latham & Locke, 2007). Concerning moderators, future research should aim to focus on team climate constructs, such as the team's ability, goal commitment, performance feedback, incentives and rewards, leadership styles, self-efficacy and cognitive ability, as these moderators are found to affect the goal–performance relationship in the literature. The goal-setting literature also shows that task complexity affects learning in teams and hence future research might focus on this factor.

6.2 Managerial implications

This research has some important implications for managers. First, the findings suggest that adherence to the method in projects has a positive overall reinforcement effect on goals. This signifies the need to provide proper training for project team members on Method and tools. Second, the finding that the challenging goal impacts performance through knowledge creation (mediation effects) suggests that managers should provide an environment conducive to learning, which will enhance project performance. Third, our findings suggest that Six Sigma goals can offer a powerful alternative to strictly adhere to the Six Sigma Method. If

Six Sigma projects don't require a lot of knowledge creation, then the relative benefit of adhering to the method declines (technical) – suggesting teams should focus more on goals (social). A recent literature review found that out of 417 research papers published from 1992 to 2008, 256 papers (more than 51%) focused on methods and tools (Aboelmaged, 2010). Although much consulting in Six Sigma has been on the use of the tools and method, not enough consideration has been given to the social benefits of setting challenging goals. As Ghoshal & Bartlett (1994) put it, "By developing stretch as a key element of the internal environment, managers can influence the aspiration levels of individuals engaged in all kinds of activities – from the ongoing improvement of existing and relatively standardized tasks to the creation of new products and businesses" (p. 100). Our findings point out the importance of setting challenging goals in Six Sigma projects or, more generally, managing the social setting in project teams. Finally, if managers have a team that is not well trained in the use of the method, they can set challenging goals and still achieve significant improvements. Organizations that are in the initial stages of Six Sigma deployment can enhance new teams' capabilities in carrying out projects and the success of Six Sigma deployment by setting highly challenging goals. This finding should be welcomed by firms that are interested in Six Sigma deployment.

6.3 Limitation

The study has some limitations. First, the sample consists of only 102 project teams from only two organizations. Although all the statistical power analysis indicated no problems with the statistical tests, future research with more sample organizations may help generalize the findings. Second, the sample organizations have been employing the Six Sigma approach for more than six years and hence the degree of adoption of the Method may be at an advanced level compared to that of other organizations. It may be that in less matured organizations the relative benefits of goals and the use of the method differ. Further research can investigate this issue across organizations that have varying levels of maturity in their deployment. In spite of these limitations, this study advances our understanding of Six Sigma and contributes to extant theory and research in several areas of inquiry, highlighting implications for management practices.

Appendix: Measurement scales

All responses range from 1 (strongly disagree) to 7 (strongly agree)
Goal (α = 0.70) *from Linderman et al. (2006)*

1. We found it difficult to achieve the project goals
2. The project goals were challenging to us

Method (α = 0.84) *from Linderman et al. (2006)*

1. We followed strictly the sequence of DMAIC or a similar methodology
2. Each step in DMAIC (or similar methodology) was faithfully completed
3. Team frequently used Six Sigma tools to analyze data and information

Knowledge (α = 0.90) *adapted from Choo et al. (2007)*

1. The team generated many ideas while doing the projects
2. Doing this project enhanced the team's abilities and knowledge of the project team
3. The solutions found in this project were clearly unique and innovative to the company

Performance (α = 0.93) *from Linderman et al. (2006)*

1. We met or exceeded customers' expectations in this project
2. The cost savings or the strategic impact of the project were significant
3. The team had superb results on the project
4. The project was effective at improving the process or product

References

Aboelmaged. M. G. (2010). Sigma quality: a structured review and implications for future research. *The International Journal of Quality & Reliability Management*, 27(3), 269–318.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.

Amabile, T., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal*, 39(5), 1154–1184.

Anand, G., Ward, P.T., & Tatikonda, M. V. (2010). Role of explicit and tacit knowledge in Six Sigma projects: An empirical examination of differential project success. *Journal of Operations Management*, 28, 303–315.

Antony, J. (2004). Some pros and cons of Six Sigma: an academic perspective. *The TQM Magazine*, 16(4), 303–306.

Antony, J. (2008). What is the role of academic institutions for the future development of Six Sigma? International journal of productivity and performance management 57 (1), 107- 110.

Antony, J, Frenie, J.A, Kumar, M., & Cho, B.R. (2007). Six sigma in service organizations: Benefits, challenges and difficulties, common myths, empirical observations and success factors. *International journal of quality & reliability management*, 24 (3), 294-311.

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: an integrative framework and review of emerging themes. *Management Science*,49(4),571-82.

Arumugam, V., Antony, J., & Kumar, M. (2013). Linking learning and knowledge creation to project success in six sigma projects: An empirical investigation. *International Journal of Production Economics*, 141(1), 388–402.

Arumugam, V., Antony, J., & Linderman, K. (2014). Multi-level framework of Six Sigma: Systematic review, possible extension and future research. *Quality Management Journal*, 21 (4), 36-61.

Bagozzi, R. P., & Yi. Y. (1991). Multitrait-multimethod matrices in consumer research. *Journal of Consumer Research*, 17(4), 426–439.

Banuelas, R., Tennant, C., Tuersley, I., & Tang, S. (2006). Selection of Six Sigma projects in the UK. *The TQM Magazine*, 18(5), 514-527.

Baron, R. M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, 51, 1173–1182.

Biedry, J. (2001). Linking Six Sigma analysis with human creativity. *Journal of Quality and Participation*, 24 (4), 36-38.

Bontis, N., Crossan, M., & Hulland, J. (2002). Managing an organizational learning system by aligning stocks and flows. Journal of Management Studies 39(4), 437-469.

Braunscheidel, M. J., Hamister, J. W., Suresh, N.C., & Star, H. (2011). An institutional Theory perspective on Six Sigma adoption. *International Journal of Operations & Production Management*, 31(4), 423–451.

Buch, K. and A. Tolentino. 2006. Employee expectancies for Six Sigma success. *Leadership & Organization Development Journal* 27 (1), 28-37.

Byrne, George, Dave Lubowe., & Amy Blitz. (2007). Using a Lean Six Sigma approach to drive innovation. *Strategy & Leadership*, 35(2), 5-10.

Cherns, A. (1987). Principles of sociotechnical design re-visited. *Human Relations*, 40(3), 153-162.

Choo, A.S., Linderman, K., & Schroeder, R.G. (2007a). Method and context perspectives on learning and knowledge creation in quality management. *Journal of Operations Management*, 25, 918-931.

Choo, A.S., Linderman, K., & Schroeder, R.G. (2007b). Method and Psychological Effects on Learning Behaviors and Knowledge Creation in Quality Improvement Projects. *Management Science*, 53(3), 437–450.

Choo, A.S. (2011). Impact of stretch strategy on knowledge creation in quality improvement Projects. *IEEE Transactions on Engineering Management*, 58(1), 87-96.

Cooke-Davis, T. (2002). The "real" success factors on projects, *International Journal of Project Management*, 20, 185-190.

Cummings, T. (1978). Self-regulated Work Groups: A Socio-technical Synthesis. *Academy of Management Review*, 3, 625-634.

Cyert, R.M. & March, J.C. (1963). *A behavioural theory of the firm*. Englewood Cliffs, NJ: Prentice Hall.

Daft, R.L. (2000). *Management* (5th Ed.). Orlando, FL: The Dryden Press.

Davenport, T.K., & Prusak, L. (2000). *Working Knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Easton, G.S., & Rosenzweig, E.D. (2012). The Role of Experience in Six Sigma Project Success: An Empirical Analysis of Improvement Projects. *Journal of Operations Management*, 30, 481–493.

Edmondson, A. C. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, 44(2), 350–383.

Edwards, J. R., & Lambert, L. S. (2007). Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. *Psychological Methods*, 12, 1–22.

Ekvall, G. (1997). Organizational Conditions and Levels of Creativity. *Creativity and Innovation Management*, 6, 195–205.

Emery, F. E. and E. Thorsrud. (1976). *Democracy at Work: The Report of the Norwegian Industrial Democracy Program*, Leiden, The Netherlands: Martinus Nijhoff.

Emery, F. E., & E. L. Trist (1969). Socio-technical Systems. In F. E. Emery (Ed.), *Systems*

Thinking, London: Penguin Books, 281-296.
Fornell, C., & Larcker, D.F. (1981). Evaluating Structural Equation Models with unobservable variables and measurement error. *Journal of Marketing Research*, 18, 39– 50.
Fox, W. M. (1995). Sociotechnical system principles and guidelines: Past and present. *Journal of Applied Behavioral Science*, 31(1), 95–105.
Gerbing, D.W., & Anderson, J.C. (1988). An updated paradigm for scale development incorporating unidimensionality and its assessment. *Journal of Marketing Research*, 25(2), 186-192.
Ghoshal, S., Bartlett, C.A. (1994). Linking organizational context and managerial action: the dimensions of quality of management. *Strategic Management Journal*, 15, 91-112.
Goh, T.N. (2002). A strategic assessment of Six Sigma. *Quality and Reliability Engineering International*, 18, 403-410.
Gutiérrez, L.J., Lloréns-Montes, F.J., & Sanchez, O.F. (2009). Six Sigma: from a goal-theoretic perspective to shared-vision development. *International Journal of Production and Operations Management*, 29(2), 151–169.
Hoerl, R.W. (1998). Six Sigma and the future of the quality profession. *Quality Progress*, 31(6), 35-42.
Hu, L., & Bentler, P.M. (1999). Cut off criteria for fit indexes in covariance structure anlysis: conventional criteria versus new alternatives. *Structural Equation Modelling*, 6 (1), 1-55.
Huber, G.P. (1991). Organizational learning: The contributing processes and the literatures. *Organizational Science*, 2, 88-115.
Jacobs, B.W., Swink, M., Linderman, K., (2015). Performance effects of early and late Six Sigma adoptions. *Journal of Operations Management*, 36, 244-257.
James, L.R., Demaree, R.G., & Wolf, G. (1984). Estimating within-group interrater Reliability with and without response bias. *Journal of Applied Psychology*, 69(1), 85-98.
Kleingeld, A., van Mierlo, H., & Arends, L. (2011). The effect of Goal Setting on Group Performance: A Meta- Analysis. *Journal of Applied Psychology*, 96(6), 1289–1304.
Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3(3), 383–397.
Kumar, M., Antony, J., & Cho, B.R. (2009). Project selection and its impact on the successful deployment of Six Sigma. *Business Process Management Journal* 15(3), 669-686.
Kwak, Y. H., & Anbari, F.T. (2006). Benefits, obstacles and future of Six Sigma approach. *Technovation*, 26, 708-715.
Lambert, D.M., & Harrington, T.C. (1990). Measuring non responses bias in customer service mail Surveys. *Journal of Business Logistics* 11(2), 5–25.
Latham, G.P., & Locke, E.A. (2007). New Developments in and Directions for Goal-Setting Research, *European Psychologist*, 12(4), 290–300
Latham, G.P., Seijts, G., & Crim, D. (2008). The Effects of Learning Goal Difficulty Level and Cognitive Ability on Performance. *Canadian Journal of Behavioral Science*, 40 (4), 220–229.
Lawler, E.E. (1992). *From the ground up: Six principles for building the new logic corporation.* San Francisco: Jessey-Bass.
LeBreton, J. K., & Senter, J. L. (2008). Answers to 20 Questions about interrater reliability and interrater agreement. *Organizational Research Methods*, 11(4), 815-852.
Lee, K. and Choi, B.(2006).Six Sigma management activities and their influence on corporate competitiveness. *Total Quality Management & Business Excellence*, 17 (7), 893-911.
Lee-Mortimer, A. (2007). Leading UK manufacturer probes the potential of Six Sigma. *Assembly Automation*, 27 (4), 302-308.
Levinthal, D.A., & March, J.G. (1993). The myopia of learning. *Strategic Management Journal*, 14, 95–112.

Linderman, K., Schroeder, R.G., Zaheer, S., & Choo, A.S. (2003). Six Sigma: a goal theoretic perspective. *Journal of Operations Management*, 21, 193–203.
Linderman, K., Schroeder, R.G., Zaheer, S., & Choo, A.S. (2006). The role of goals in improvement teams. *Journal of Operations Management*, 24(2), 779–790.
Linderman, K., Schroeder, R.G., & Sanders, J. (2010). A Knowledge Framework Underlying Process Management. *Decision Sciences*, 41(4), 689–719.
Lloréns-Montes, F.J., & Molina, L.M. (2006). Six Sigma and Management Theory: Processes, Content and Effectiveness. *Total Quality Management & Business Excellence*, 17(4), 485-506.
Locke, E.A., & Latham, G.P. (1990). *A Theory of Goal Setting and Task Performance*. Englewood Cliffs, NJ: Prentice Hall.
Locke, E.A., & Latham, G.P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, 57, 705–717.
Locke, E.A., Saari, L.M., Shaw, K.N., & Latham, G.P. (1981). Goal Setting and Task Performance: 1969-1980. *Psychological Bulletin*, 90(1), 125–152.
MacDuffie, J.P. (1997). The road to "root cause": Shop-floor problem-solving at three auto assembly plants. *Management Science*, 43(4), 479-502.
MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological Methods*, 7, 83–104.
Malik, A., and S. Blumenfeld. (2012). Six Sigma, quality management systems and the development of organizational learning capability. *The International Journal of Quality & Reliability Management* 29 (1),71-91.
March, J.G. (1991). Exploration and Exploitation in organizational learning. *Organization Science*, 2(1), 71-87.
March, J.G., & Olsen, J.P. (1976). Organizational learning and the ambiguity of the past. In J.G. March & J.P. Olsen (Eds.), *Ambiguity and choice in organizations*, 54-68. Bergen: Universitetsforlaget.
McAdam, R., Hazlett, S, & Henderson, J. (2005). A critical Review of Six Sigma: Exploring the dichotomies. *The International Journal of Organizational Analysis*, 13(2), 151-174.
McAdam, R & Hazlett, S. (2010). An absorptive capacity interpretation of Six Sigma. *Journal of Manufacturing Technology Management*, 21(5), 624-645.
McAdam, R., & Lafferty, B. (2004). A multilevel case study critique of Six Sigma: Statistical control or strategic change? *International Journal of Operations & Production Management*, 24(5), 530-49.
McAdam, R., & Hazlett, S. (2010). An absorptive capacity interpretation of Six Sigma. *Journal of Manufacturing Technology Management*, 21(5), 624-645.
Montgomery, D.C. and Woodall, W.H. (2008). An overview of Six Sigma, *International Statistical Review*, 76(3), 329-46.
McGrath, R.G. (2001). Exploratory learning, innovative capacity, and managerial oversight. *Academy of Management Journal* 44(1), 118-131.
Mukherjee, A.S., Lapre, M.A., & Van Wassenhove, L.N. (1998). Knowledge Driven Quality Improvement. *Management Science*, 44(11) Part 2 of 2, S35–S49
Nair, A.M., Malhotra, S., & Ahire, S. (2011). Toward a theory of managing context in Six Sigma process improvement projects: An action research investigation. *Journal of Operations Management*, 29(5), 529–548.
Nelson, R. R., & S. G. Winter. (1982) . *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.
Nonaka, I., & Takeuchi, H. (1995). *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*? NY: Oxford University Press.

Nonthaleerak, P., & Hendry, L. (2008). Exploring the Six Sigma phenomenon using multiple case study evidence. *International Journal of Operations and Production Management*, 28 (3), 279-303.
Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric Theory*, (3rd Ed.). NY: McGraw-Hill.
O'Leary-Kelly, A.M., Martocchio, W., & Frink, D.D. (1994). A review of the influence of Group goals on group performance. *Academy of Management Journal*, 37(5), 1258-1301.
Pande, P.S., Neuman, R.P., & Cavanagh, R.R. (2000). *The Six Sigma Way: How GE Motorola and Other Top Companies are Honing Their Performance*, NY: McGraw-Hill.
Parast, M. M. (2011). The effect of Six Sigma projects on innovation and firm performance. *International Journal of Project Management* 29 (1), 45-55.
Pasmore, W. A. (1988). *Designing effective organizations: The Sociotechnical Systems Perspective.* New York: Wiley.
Polley, D., & Dyne, L.V. (1994). The limits and liabilities of self-managing work teams. In: Beyerlein, M.M., Johnson, D.A. (Eds.), *Advances in interdisciplinary studies of work teams* 1. London: Jai Press Inc., 1–38.
Ray, Sanjit, and Prasun Das. (2010). Six Sigma project selection methodology. *International Journal of Lean Six Sigma*, 1(4), 293-309.
Savolainen, T., and A. Haikonen. (2007). Dynamics of organizational learning and continuous improvement in six sigma implementation. *The TQM Magazine* 19(1) 1:6-17.
Schroeder, R.G., Linderman, K., Liedtke, C. & Choo, A.S. (2008). Six Sigma: definition and underlying Theory. *Journal of Operations Management*, 26(4), 536–554.
Schön, D. (1975). Deutero –learning in organizations: learning for increased effectiveness. *Organizational Dynamics*, 4(1), 2-16.
Sinha, K.K. & Van de Ven, A.H. (2005). Designing work within and between organizations, *Organization Science*, 16(4), 389-408.
Sitkin, S.B., See, K.E., Miller, C.C., Lawless, M.W., & Carton, A.M. (2011). The paradox of stretch goals: organizations in pursuit of the seemingly impossible. *Academy of Management Review*, 36(3), 544-566.
Shafer, S. M., and S. B. Moeller. (2012). The effects of Six Sigma on corporate performance: An empirical investigation. *Journal of Operations Management* 30 (7&8), 521-532.
Stine, R. (1989). An Introduction to Bootstrap Methods: Examples and Ideas. *Sociological Methods & Research*, 18(2&3), 243–291.
Song, X.M., Weiss, M., & Schmidt, J.B. (1997). Antecedents and consequences of cross-functional cooperation: A comparison of R&D, manufacturing, and marketing perspectives. *Journal of Product Innovation Management*, 14(1), 35-47.
Sony, M., & Naik, S. (2012). Six Sigma, Organizational Learning and Innovation: An Integration and Empirical Examination. *International Journal of Quality & Reliability Management*, 29(8), 915-936.
Soti, A., Ravi Shankar, & Kaushal, O.P. (2010). Modeling the enablers of Six Sigma using interpreting structural modeling. *Journal of Modelling in Management* 5(2), 124-141.
Swink, M., & B. W. Jacobs. (2012). Six Sigma adoption: Operating performance impacts and contextual drivers of success. *Journal of Operations Management* 30 (6), 437-453.
Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509–533.
Tippins, M.J., & Sohi, R.S. (2003). IT competency and firm performance: is organizational learning a missing link? *Strategic Management Journal*, 24(8), 745-61.
Trist, E. (1978). On sociotechnical systems. In W. Pasmore & J. Sherwood (Eds.), *Sociotechnical Systems: A sourcebook.* San Diego: University Associates, 43-57.
Trist, E., & Bamforth, K. (1951). Some social and psychological consequences of the long wall method of coal-getting. *Human Relations*, 1, 3-38.

Tushman, M.L., & O' Reilly III, C.A. (1996). Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change. *California Management Review*, 38 (4), 8-30.
Van den Bosch, F.A., Volberda, H.W., & De Boer, M. (1999). Coevolution of firm's absorptive capabilities. *Organization Science*, 10, 551-568.
Weldon, E., & Weingart, L.R. (1993).Group goals and group performance. *British Journal of Social Psychology*, 32(4), 307–334.
Wiklund, H., and P. Wiklund. (2002). Widening the Six Sigma concept: an approach to improve organizational learning. *Total Quality Management and Business Excellence* 13(2), 233-239.
Zairi, M. (2002). Six Sigma: Another imitation or a blessed addition for better management. *TQM Magazine*, 14, 273-275.
Zu, X., Fredendall, L.D., & Douglas, T. J. (2008). The evolving theory of quality management: The role of Six Sigma. *Journal of Operations Management*, 26, 630-650.