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A curvilinear assessment of innovation in Six Sigma project teams: the Influence of psychological safety and intrinsic motivation

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A curvilinear assessment of innovation in Six Sigma project teams: the influence of psychological safety and intrinsic motivation

Abstract

Purpose: To investigate the factors affecting innovation in Six Sigma improvement teams. Based on Activation Theory, this study explores the possibility of an inverted *U*-shaped association between psychological safety and innovation and examines how intrinsic motivation moderates this relationship.

Design/Method: Moderated regression analysis is carried out to test the curvilinear relationship, using data collected from 324 members of 102 Six Sigma improvement teams from two European manufacturing firms.

Findings: The findings demonstrate that the beneficial effect of psychological safety reaches an inflection point, after which its relations with innovation cease to be linear and positive; this gives the relationship a curvilinear pattern (inverted *U*-shaped). Further, intrinsic motivation has a supportive effect in enhancing the beneficial impact of psychological safety on innovation, and in shifting the inflection points to a higher level; this demonstrates their synergetic influence on innovation.

Originality/value: The impact of psychological safety on innovation is examined from the new perspective of a curvilinear relationship. This is one of the first studies to investigate the combined effects of individual (intrinsic motivation) and team-level antecedents (psychological safety) on innovation in Six Sigma teams. The study provides insights into how Six Sigma enhances innovation and offers some valid inputs to the current academic debate on this topic.

Keywords: Six Sigma projects, process innovation, psychological safety, intrinsic motivation

Paper type: Research paper

Quick value overview

Interesting because- As innovation drives profitability and growth, understanding the factors influencing it has become a hot topic among scholars. One major factor is psychological safety, with many studies showing a linear relationship between psychological safety and innovation. Our study is the first to establish a curvilinear relationship between these variables in Six Sigma process improvement teams. This new perspective on the impact of psychological safety is the paper's key novelty.

Theoretical value- Contrary to the prevailing view of a linear relationship between psychological safety and innovation, our study, grounded in Activation theory, establishes a curvilinear (inverted *U*) relationship. This suggests that moderate levels of psychological safety foster the most innovation in Six Sigma teams, aligning with the 'Too-Much-of-a-Good-Thing' (TMGT) effect, which posits that excess can be detrimental. Additionally, the study reveals that intrinsic motivation positively influences psychological safety, enhancing innovation and moderating the relationship beneficially.

Practical value- The study highlights that moderate level of psychological safety is crucial for fostering innovation in Six Sigma process improvement teams, challenging the previous belief that higher safety levels are always better. It also emphasises the importance of selecting intrinsically motivated individuals for teams, as intrinsic motivation can counterbalance the potential drawbacks of high psychological safety, thereby enhancing performance.

1. INTRODUCTION

Innovation is seen as a strategic weapon, and as a key to increasing profits and market share. It is frequently categorized as 'product innovation' (innovation in products or services that a firm provides) and 'process innovation', which involves innovation in processes that are used to produce products and services (Damanpour and Gopalakrishnan, 2001). Especially for manufacturing firms, process innovation is as important as product innovation (Kurkkio *et al.*, 2011).

Organizations increasingly use interventions that facilitate deliberate and new organizational attempts to gain process innovation (Baer and Frese, 2003). Typically, they achieve this outcome through teams, given that teams have access to diverse perspectives, diverse information, and a variety of skills that are conducive to creativity and innovation (Amabile, 1996; Gilson and Shalley, 2004; Kozlowski and Ilgen, 2006). Organizations that deploy business process improvement initiatives such as Six Sigma, which is the context of our study, engage their trained employees in various improvement teams, and task them to improve and innovate manufacturing and related processes (Schroeder *et al.*, 2008). The success of deploying Six Sigma initiatives depends on the success of these improvement teams (Arumugam *et al.*, 2016).

Some recent empirical studies find a positive association between Six Sigma and innovation, including in manufacturing industries (Antony *et al.*, 2016; Oprime *et al.*, 2021), the healthcare sector (Trakulsunti *et al.*, 2022), and SMEs (Antony *et al.*, 2016). From data collected from 83 Six Sigma project teams from a large automobile corporation (plants in North America, South America, and Europe), Oprime *et al.* (2021) found support for their hypotheses that Six Sigma influences and enhances process innovation. Zhen he *et al.* (2017) applied SEM analysis to data collected from 249 firms in China and found evidence of innovative outcomes from Six Sigma deployment.

A considerable number of firms, however, have adopted Six Sigma without much success. A few studies reveal that most of the Six Sigma implementations have consistently failed or not achieved their desired purpose (Chakravorty, 2010; McLean *et al.*, 2017). Chakravorty (2010), for example, in a study at an aerospace organization that had implemented more than 100 continuous process improvement projects, found that 50% of the improvement projects had failed to achieve the desired performance. One possible explanation for these findings is that despite a high level of implementation, critical contingencies that complement the process innovations are not in place (Baer and Frese, 2003). A host of studies in the organizational creativity literature find that employees' creative performance can be fostered by a supportive context (Amabile, 1988; Scott and Bruce, 1994), which can act as an activation agent for creative process engagement. Support for innovation, psychological safety, challenging work, workload pressure, organizational impediments, trust and openness, autonomy, supportive leadership, intellectual simulation, flexibility, and risk-taking are some of the activation agents that make team members engage in creative behaviour and deliver innovative outputs (West and Sacramento, 2012; Amabile *et al.*, 1996).

Of the various activating agents, psychological safety is found to be vital for employees' engagement in creativity and innovation. This is because psychological safety increases team learning and knowledge creation within the team (Edmondson, 1999; Edmondson and Lei, 2014), and team learning is considered essential for innovation, as it helps in creating and seizing opportunities to develop new products, services, or work practices (Van de Ven, 1986). Research has demonstrated that psychological safety allows employees "to feel safe at work in order to grow, learn, contribute, and perform effectively in a rapidly changing world" (Edmondson and Lei, 2014, p.23). Psychological safety encourages employees to take the initiative, make suggestions, and to facilitate the implementation of innovation (Burke *et al.*, 2006; Edmondson, 2004). Kark and Carmeli (2009) found that the positive impact of psychological safety on innovation can be related to the increased positive feelings of vitality, leading to a high level of activation. The positive feelings associated with high activation levels are in fact related to increased flexibility or divergent thinking, which facilitate innovative behaviour (Baas *et al.*, 2008). A host of individual, team-level, and organizational-level studies have found a positive association between psychological safety and innovative performance in a variety of industrial settings (e.g., Baer and Frese, 2003; Lee *et al.*, 2011).

While a series of previous studies have demonstrated the existence of a positive link between psychological safety and its potential impact on employees' ability to innovate, less is known regarding whether psychological safety influences distinct innovative capabilities in Six Sigma teams, which is the context of the present study. To the best of our knowledge, no prior studies have examined this relationship in Six Sigma teams.

Our first objective is to examine the relationship between psychological safety and innovation in the Six Sigma context. We propose, however, a curvilinear relationship between psychological safety and innovation, instead of a linear relationship, which has been studied in various innovation teams. The proposed curvilinear relationship gains support from the notion of the 'Too-Much-of-a-good-Thing' (TMGT) effect, whose underlying philosophical tenet is that an excess of any good thing is ultimately bad (Pierce and Aguinis, 2013). This suggests that the beneficial effects of psychological safety may reach an inflection point, after which its relations with innovation cease to be linear and positive; this gives the relationship a curvilinear pattern (inverted *U*-shape). Our arguments for the curvilinear relationship stem from Activation Theory (Scott, 1966; Gardner, 1986; Gardner and Cummings, 1988), which posits that moderate activation levels are most conducive to performance.

According to Activation Theory, individuals require a certain degree of mental arousal or activation to function effectively and achieve their goals. At a low activation level, it may be that the cognition level and other efforts are not sufficient to effectively process information. At a higher activation level, information processing is likely to be lowered due to impaired information processing (Scott, 1966; Gardner, 1986; Gardner and Cummings, 1988). Activation Theory is widely used in explaining a range of organizational behaviour phenomena (Gardner, 1986; Zhang and Bartol, 2010; Srikanth *et al.*, 2022).

In the present study, we propose that psychological safety serves as an activating agent in teams, directing members' attention towards performance. Based on Activation Theory, we suggest that a moderate level of psychological safety makes members deploy an optimal level of attention, leading to enhanced innovation outcomes; and beyond the moderate level, their innovative performance starts declining. This results in a curvilinear relationship between psychological safety and innovation in Six Sigma teams.

Creativity scholars maintain that some personal elements, such as intrinsic motivation, impact individual creativity (e.g., Amabile, 1996; Shalley *et al.*, 2004). Ryan and Deci (2000) describe intrinsic motivation as "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn"; it represents a "natural inclination toward assimilation, mastery, spontaneous interest, and exploration" (p.70). The influence of intrinsic motivation on the relationship between psychological safety and innovation has been rarely examined in the literature. Our second objective, therefore, is to investigate how intrinsic motivation amplifies the curvilinear relationship between psychological safety and innovation. Examining this aspect would advance our understanding of the combined influence of team-level (psychological safety) and individual-level (intrinsic motivation) factors on innovation in Six Sigma teams.

Consequently, we seek to address the following research questions: (1) Does the relationship between psychological safety and innovation in Six Sigma teams display a curvilinear relationship? (2) Does intrinsic motivation moderate the proposed curvilinear relationship between psychological safety and innovation?

The study uses data collected from 324 members (leaders and members) of 102 Six Sigma improvement teams from two European engineering organizations and employs regression analysis to test the relevant hypotheses.

Our study contributes to the literature in the following ways. First, to the best of our knowledge, the present study is the first of its kind in proposing and testing a curvilinear relationship between psychological safety and innovation. Investigating the influence of psychological safety through this new perspective in the context of Six Sigma team is the novelty of the paper. Second, by investigating the combined effects of team psychological safety and individual intrinsic motivation in a single study, the research addresses the calls by scholars (e.g., Shalley *et al.*, 2004) who advocate models that combine cognitions, personality traits, affect, and environmental factors to study innovation. In doing so, as a third contribution, our study addresses the recent research call by Edmondson and Lei (2014) who stated, "Work on the boundary conditions of psychological safety remains underdeveloped and a contingent model of psychological safety may be worth pursuing…" (p. 38). Thus, the current study contributes to a more contextualized understanding of psychological safety. Fourth, and more importantly, our study and its findings contribute to the growing but small stream of research investigating the innovative effects of Six Sigma.

The rest of the paper is structured as follows: Section 2 reviews the relevant literature and develops the relevant hypotheses; Section 3 explains the research methods used and the data collection, while Section 4 describes the data analysis and findings. In Section 5, we discuss the findings and present practical and research implications, followed by a conclusion.

2. THEORY AND HYPOTHESES

2.1 Psychological safety and innovation

Psychological safety is a shared belief amongst individuals as to whether it is safe to engage in interpersonal risk-taking in the workplace (Edmondson, 1999; Edmondson and Lei, 2014). As psychological safety lowers the perceived interpersonal risk and encourages risk-taking behaviour, it can enhance creative and innovative behaviours (West, 1990). Furthermore, psychological safety is an important psychological state vital for promoting employee engagement in cognitive processes, leading to creativity (West, 1990). Thus, many scholars have focused on the impact of psychological safety on innovation in various field settings, such as new product development (NPD), R&D, and manufacturing (e.g. Carmeli *et al*., 2015; Lee *et al*., 2011; West, 1990).

There is growing evidence of a link between psychological safety within the organization and individuals' creativity and innovation, from studies conducted at both organizational and team level. Andersson *et al.* (2020), for example, demonstrated that psychological safety is positively associated with SMEs' innovation performance, and positively related to product, process, service, and business model innovation capabilities. Carmeli *et al.* (2010) found a strong influence of psychological safety on innovation in R&D functions. Furthermore, Baer and Frese (2003), from data collected from 47 mid-sized German companies, established that at high levels of psychological safety, the relationship between process innovativeness (i.e., the use of advanced manufacturing techniques) and profitability was positive, whereas at low levels of psychological safety, the relationship was negative.

Numerous team-level studies have found increasing evidence of the influence of psychological safety on innovation in various settings. Nembhard and Edmondson (2006), using survey data from 23 healthcare teams, showed that psychological safety predicted high involvement in learning and quality improvement activities. Bressman and Zellmer-Bruhn (2012) collected data from 62 self-managed team members from 13 pharmaceutical R&D units, using interviews and surveys; they found that psychological safety enhanced internal and external learning behaviours, which are prerequisites for innovation. While exploring the impact of team psychological safety and team autonomy, Chandrasekaran and Mishra (2012) discovered that an increased psychological safety lowered team turnover and improved performance in R&D groups. Kostopoulos and Bozionelos (2011) studied survey data from 600 members of 142 innovation project teams in the IT and pharmaceutical sectors and showed that psychological safety promoted exploratory and exploitative learning and innovative team performance.

2.2 Six Sigma and psychological safety

In organizations that deploy Six Sigma, project teams headed by trained project leaders, and with members drawn from various functional departments, carry out process improvement projects. While carrying out such projects, teams typically engage in various interactive sessions, such as team meetings, discussion, brainstorming sessions, briefing, and debriefing sessions (Arumugam *et al.*, 2014; Anand *et al.*, 2010). Team members' interactions and collaborations help them to exchange ideas, discuss divergent viewpoints, and integrate and evaluate them to create innovative solutions.

Team-level studies investigating innovation in the context of Six Sigma are currently still evolving, with only limited studies examining the contributory factors. A few studies on Six Sigma teams show that psychological safety positively impacts learning behaviours, which help to improve team performance. From the data obtained from 951 members of 206 Six Sigma teams, Choo *et al.* (2007) found that psychological safety influences knowledge creation. In a related study, Arumugam *et al.* (2013) used data from members of 52 Six Sigma teams and revealed that psychological safety increased deliberate learning in teams, for improved performances. Our review reveals that we have only limited knowledge of the relationship between psychological safety and innovation in Six Sigma teams; whereas we have a relatively advanced understanding of the importance of psychological safety in other teams, such as product innovation teams.

2.3 Hypotheses development

H1: Psychological safety and innovation

Most authors in the field acknowledge that the core processes required for creative problem-solving are problem identification and construction, identification of relevant information, generation of new ideas, and the evaluation of these ideas (e.g., Mumford *et al*., 1991; Zhang and Bartol, 2010). As psychological safety levels increase in Six Sigma teams, team members are likely to expend more attention and effort to voice ideas, willingly seek feedback, provide honest feedback, collaborate, take risks, and experiment (Edmondson, 1999; Nembard and Edmondson, 2012). An increase in attention and effort helps team members understand the problem from multiple perspectives, search for information and knowledge from multiple sources, and generate alternatives that can connect diverse sources of information (Gilson and Shalley, 2004). As members in a psychologically safe environment feel safe in openly discussing things without any fear of being ridiculed (Edmondson, 1999), the exchange of tacit and explicit knowledge takes place in those interactions, as claimed by Anand *et al*. (2010). By promoting open discussion of the various aspects of the problem, psychological safety can make members understand different conceptualizations that arise from different experiences and backgrounds (as members of a Six Sigma team typically come from multiple functions); this can help to create a better understanding among members, leading to creative idea generation. The generation of new ideas is a cognitive process located within individuals and fostered by interaction processes (Mumford and Gustfson, 1988), and the increased level of interaction due to psychological safety can enhance the level of creative idea generation. Anderson and West (1998) argued that a nonthreatening group environment renders diverse ideas and competing viewpoints acceptable and enables explorations of alternative ideas and approaches without any threat of reprisal. As psychological safety encourages members to ask questions, they can think through the problem, and understand and make connections between their interpretations and understanding, thus leading to an appropriate evaluation of their usefulness. Furthermore, given that psychological safety enables team members to volunteer unique information or knowledge that is likely to be dissenting, a team with more psychological safety will be in a better position to draw on innovative ideas and solutions held by fellow members (Schulz-Hardt *et al*., 2006). This in turn can make team members engage with increased attentiveness in creative processes that produce novel and useful ideas for implementation. Thus, we expect psychological safety to increase members' activation level towards creative problem-solving and innovation implementation.

Activation Theory suggests that moderate levels of activation enhance behavioural and information-processing performance, as they are a function of central nervous system efficiency, and "high and low activation levels impair the ability to process information, by lowering information processing capacity" (Gardner and Cummings, 1988, p.89). Hence, we expect that a moderate level of psychological safety activates the optimal level of members' attention, leading to higher performance. In such a moderate level of psychological safety, members devote more attention and effort towards information processing, to solve problems and develop innovative solutions for implementation. As the level of psychological safety increases beyond moderate levels, there should be a decline in the team's performance level.

Thus, we expect that the beneficial effects of psychological safety may reach an inflection point, after which its relations with innovation cease to be linear and positive, thereby giving the relationship a curvilinear pattern (inverted *U*-shape). Accordingly, we present our first hypothesis:

Hypothesis 1 (H1): Psychological safety has a curvilinear relationship with innovative performance (inverted *U*-shape), with a moderate level of psychological safety being more conducive to high innovative performance in Six Sigma teams.

H2: Intrinsic motivation and innovation

Scholars argue that individuals are likely to be most creative when they experience high levels of intrinsic motivation (Amabile, 1996). For instance, Amabile (1988) observed that intrinsic motivation could result in enthusiasm for creative activity; it also involves feelings of personal control and feelings of competence (Ryan and Deci, 2000). Simon (1967) noted that the primary function of intrinsic motivation is the control of attention. When people are more intrinsically motivated, they may feel a much stronger sense of personal control and competence (Fischer, 1978). Furthermore, intrinsic motivation increases individuals' tendency to be curious, cognitively flexible, risk-taking, and persistent in the face of barriers (Zhou and Shalley, 2003). Intrinsically motivated individuals often report interest, curiosity, enjoyment, and positive feelings (Amabile *et al.*, 1994). These factors should facilitate the development of creative ideas (Shalley *et al.*, 2004).

Previous studies suggest that individuals who possess higher intrinsic motivation are more likely to use their increased activation and efforts to achieve success in the task, and persistence with it after achieving initial success (Cerasoli *et al.*, 2014). Individuals with higher intrinsic motivation should be more sensitive to their situation and may adjust their task-based behaviours to align and cope with the expectations of the team's objectives. We expect, therefore, that highly intrinsically motivated individuals will align their attentive actions with their work, leading to improved team performance.

Moreover, scholars note that other motivational support is also needed to keep members engaged in creative processes, in addition to a safe psychological environment (Paulus and Dzindolet, 1993; Paulus *et al.*, 2012). Hence, we propose that intrinsic motivation may provide a social context that motivates and increases members' creative behaviours that are associated with psychological safety. We expect that intrinsic motivation, as behaviours related to the amount and persistence of effort, can amplify the effects of psychological safety.

On seeing the team's overall performance levels, it is possible that members' intrinsic motivation will make them engage with more enthusiasm, and thereby make the efforts necessary to achieve their team goal, when psychological safety is low to medium. Likewise, with higher psychological safety, intrinsic motivation can enhance the levels of involvement, minimize distractions, and increase absorption in work, by acting as a buffer; this should minimize the negative effects of high psychological safety on performance.

Based on the above arguments, we propose that the impact of psychological safety on innovation will be amplified if the team members have a higher level of intrinsic motivation:

H2: Team members' intrinsic motivation moderates the relationship between psychological safety and innovative performance positively, such that the higher the level of intrinsic motivation in the team, the greater the impact of psychological safety on innovation in Six Sigma teams.

3. METHODS

3.1. Research setting and data collection

Data for the current study were obtained from a web-based survey carried out in two European large manufacturing organizations that deploy Six Sigma (company A, automobile manufacturing; and company B, a wind turbine manufacturing company). These two organizations agreed to participate in our survey and were promised a copy of the summarized results upon its completion. Six Sigma deployment champions of these organizations were our contacts for the survey, including for post-survey activities. The survey targeted only the recent Six Sigma projects, to avoid any non-responses due to recollection effects. As agreed by the respective organizations, we targeted 110 Six Sigma projects from Company A, and 88 from Company B, which had been completed during the previous two years. In both organizations, each of these projects was led by a full-time trained Six Sigma specialist, and team members from multiple functions worked part-time in the projects. The selected projects focused on improving manufacturing and manufacturing-related processes.

The survey employed two separate questionnaires, for team leaders and team members. The questionnaires asked the respondents to provide the project title, and to refer to that specific project in their responses. The precautionary measures taken during our data collection stage helped to code the responses from leaders and members to their specific projects and ensured that the responses were matched to represent the specific project. Multiple questionnaires also helped to reduce the number of questions required per survey, and to increase the response rate.

Two weeks before the start of the survey, our contacts sent emails to the target respondents, with information about the research. After two weeks, the survey links were sent to the target members and leaders to commence the survey. After three weeks, non-respondents were contacted via email for a reminder. Responses for each project were considered full if the respondents included at least two members, and the project leader (Choo *et al.*, 2007). Our final usable responses were obtained from 102 projects of the 198 projects targeted, representing a response rate of 51.5%, with participation from 324 members (leaders and team members). Among the final data sample, project duration ranged from 3 to 8 months, and the average firm tenure was 8.5 years. Out of the total number of participants, 72% were male.

3.2 Measures

All our measures were either obtained from existing studies or adapted to suit the research context; they were measured on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). For this study, responses for innovation came from leaders, and responses for all the other study variables came from both leaders and members. Scores for the multi-response measures were aggregated to the team level. As reported below, we estimated the interrater agreement index r_{wg} for multi-response items, to justify the team-level aggregation (James *et al.*, 1984).

Innovation was measured on a three-item scale adapted from the innovation literature (Hülsheger *et al.*, 2009; West and Farr, 1990), capturing novelty, innovation, and usefulness of the implemented solutions. Cronbach's α for the scale was 0.89. *Psychological safety* was measured on a four-item scale taken from Edmondson (1999) and used in Choo *et al.* (2007). The value of the median r_{wg} was .84, which is within the acceptable limit for team-level aggregation; Cronbach's α for the scale was 0.86. *Intrinsic motivation* at work was measured with three items adapted from Zhang and Bartol (2010). The value of the median r_{wg} was .78, which is within the acceptable limit for team level aggregation, and Cronbach's α for the scale was 0.71.

*Control variables***.** We included team size, project duration, and members' demographic information such as gender (Blau's diversity index) and tenure as control variables, as these variables are found to influence creativity in teams (Hülsheger *et al.*, 2009; Shalley *et al.*, 2004). In addition, we have included 'adherence to structured method' in the project, and a 'challenging goal' set for the project, as these two are also likely to influence creativity and innovation (Arumugam *et al.*, 2014; Montgomery and Woodall, 2008; Gilson and Shalley, 2004). 'Adherence to structured method' was captured using a three-item scale from Linderman *et al.* (2006); responses were obtained from both team leaders and members. The median value r_{wg} = .89 was found to be within the acceptable limit, providing support for team-level aggregation; Cronbach's α for the scale was 0.84. The 'challenging goal' measure was captured using a two-item scale (from Linderman *et al*., 2006), with responses from both leaders and members. The median value of r_{wg} = .75 supported the aggregation of scores to the team level, and Cronbach's α for the scale was 0.70. In addition, we included a dummy variable to control for company differences. Appendix I displays all our measures.

3.3 Non-response bias and common method bias

We applied a series of procedural remedies to overcome any potential non-response bias. Our follow-up emails and telephone calls to a few non-responding project team members indicated that they did not participate due to a lack of time, or reluctance to reveal confidential information. We followed the recommended procedures (Armstrong and Overton, 1977) to estimate the non-response bias. We tested for non-response bias by conducting a two-sample t-test between early and late responses (responses after our email follow-up emails) on all the study variables from team leaders and members. The results indicated no significant differences between the early and late responses in each case; this suggests that there was no non-response bias in our data (Armstrong and Overton, 1977).

Responses from multiple respondents helped to mitigate the effects of common method bias. We also distributed predictor and dependent variables throughout the main survey questionnaires and placed other items in between to avoid any common method bias (Podsakoff *et al*., 2003). We assured participants that their individual responses would be kept anonymous (Podsakoff *et al*., 2003). The survey responses were received only by the researchers, and the respondents were made aware of this; these procedures also helped to reduce common method bias. We also conducted appropriate statistical tests to assess the level of common method bias. Responses for the independent variable, psychological safety, were obtained from both leaders and members, whereas those for the dependent variable were collected from team leaders. This reduced the possibility of any common method bias. However, to rule out any adverse effects, we conducted Harman's one-factor test to detect the presence of any common method bias. All scale items of psychological safety and innovation were loaded into a single factor with no rotation; the common method variance extracted was found to be 41.04%, which was well within the commonly accepted threshold of 50%, indicating that any common bias that existed might not pose a severe threat to the validity of the study.

4. STATISTICAL ANALYSIS AND RESULTS

4.1 Data normality and reliability analysis

We evaluated the normality and reliability of our data set prior to data analysis. Our analysis showed that the data were normally distributed, with skewness and kurtosis values within the limits of (± 2), except company tenure data, which were then converted into their logarithmic values for further analysis. Reliability was tested using Cronbach's alpha. All constructs showed reliability, with their respective values over 0.70. The average variance extracted for psychological safety (0.72), intrinsic motivation (0.63), and innovation (0.81) were well above the recommended cut-off of 0.5). Composite reliability (CR) of each construct was also at an acceptable level (all were above 0.50). We also carried out a confirmatory factor analysis (CFA) for the items of psychological safety and innovation. A two-factor model showed a better fit than a single-factor model, with fit indices all within the acceptable limits. (χ^2 (7) = 11.84, $p < .11$, RMSEA = .08, GFI = .97, TLI = .97, CFI = .99); this suggests that these two constructs are distinctly different.

4.2 Hypotheses testing

Table 1 shows descriptive statistics and the correlation of the study variables. We tested all our hypotheses using moderated hierarchical regression analysis in SPSS. Following Aiken and West (1991), we mean-centred our independent and moderating variables, to reduce multicollinearity. We also calculated variance inflation factor (VIF) scores to assess the extent to which multicollinearity may affect the results. All VIF values were less than 2.00, suggesting that multicollinearity did not appear to threaten the validity of the study. To assess model significance, we tested differences in *F*-statistic and R^2 values.

……Table 1 here …..

4.2.1 Hypothesis 1 results: Curvilinear effect of psychological safety

The regression results are shown in Table 2. We entered the control variables first, followed by our study variables. The quadratic term of psychological safety was used in the analysis to assess the curvilinear effect.

Hypothesis 1 predicted an inverted U-shaped relationship between psychological safety and innovation. The results in M2 and M3 support this relationship. In the final model M2, the coefficient for the quadratic term is significant ($\beta = -0.229$; $p < 0.01$), and the *F* statistic is also found to be highly significant ($F = 18.865$, $p < 0.001$). These results support H1.

4.2.2. Hypothesis 2 results: Moderation effect of intrinsic motivation

To test the moderation effect, we introduced the interaction term (psychological safety x intrinsic motivation) into the regression. In M3, coefficients for both intrinsic motivation and interaction terms are highly significant – ($\beta = 0.518$; $p < 0.001$) and ($\beta = 0.125$; $p < 0.05$) respectively – with a highly significant *F* statistic (18.865, $p = 0.001$), and change in *R*-squared is also significant ($\Delta R^2 = 0.148$, $p < 0.05$). This fully supports H3, which posited that intrinsic motivation positively moderates the impact of psychological safety on innovation.

Simple slope curves were plotted, as suggested by Aiken and West (1991); Figure 1 shows how low, mean, and high levels of the moderating variable 'intrinsic motivation' (one standard deviation below the mean, mean, and one standard deviation above the mean) affect the impact of psychological safety on innovation. The slope curves for three intrinsic motivation levels at different values of psychological safety are shown in Figure 1. The plot shows that the graphs are shifted upwards as the level of intrinsic motivation increases, suggesting a positive moderating effect on the curvilinear relationship between psychological safety and innovation. Slopes also reveal that the innovation outcome becomes higher as we move from low to high intrinsic motivation across all values of psychological safety; this points to a positive synergy between psychological safety and intrinsic motivation. Overall, the slope analysis shows that our data support H2, as expected.

…..Figure 1…

4.2.3. Control variables

Although they are not central to this research, the effects of some control variables are quite interesting. The coefficients for the control variables 'challenging goal' and 'structured method' are found to be positive and significant ($\beta = 0.218$, $p < 0.01$ and $\beta = 0.109$; $p < 0.1$, respectively). Our regression analysis results suggest that the structured method used by Six Sigma teams can impact innovation; this supports the views expressed by some scholars (Arumugam *et al.*, 2014; Montgomery and Woodall, 2008; Schroeder *et al.*, 2008), and indicates that a challenging goal enhances innovation in Six Sigma teams. Although not hypothesized in the study, the results provide some evidence of the impact of goals on innovation in Six Sigma. Only a few studies in the creativity literature have found that a high-level shared goal is a predictor of creativity (e.g., Gilson and Shalley, 2004). Thus, our findings provide the first piece of empirical evidence of the impacts of both structured method and challenging goals on creativity and innovation in the Six Sigma context.

4.3 Inflection analysis

To explore the TMGT effects, we conducted inflection analysis, as suggested by Pierce and Aguinis (2013). TMGT effects are explained in terms of how (1) the positions of the inflection points and (2) the shape of the slopes change as the intrinsic motivation level changes. We estimated the inflection points (the points at which the effect of psychological safety declines) for the three slope lines and the corresponding innovation levels.

4.3.1 Positions of the inflection points

The slopes reveal that the inflection points (beyond which increasing psychological safety leads to an undesired effect on innovation) become more positive as the level of intrinsic motivation increases from low to mean, and to high: (positions P_1, P_2, and P_3 in the psychological safety axis in Figure 1); this indicates that the inflection point is lower for low intrinsic motivation than for medium and high intrinsic motivation. The results thus reveal that the positions of the inflection point change depending on the context. The plots also reveal the innovation levels associated with the corresponding inflection points for the three levels of intrinsic motivation. The slopes show that the level of innovation at each inflection point rises as we move from low to higher intrinsic motivation (I_1, I_2, I_3 respectively in the innovation axis); this suggests that the presence of intrinsic motivation changes the 'psychological safety–innovation' path to a more positive upward trajectory. These results together support H2, by showing a highly positive moderating role of intrinsic motivation on the relationship between psychological safety and innovation.

4.3.2 Shapes of the slopes

The plots reveal some interesting findings about the rate of change of the impact of psychological safety at different levels of intrinsic motivation. Referring to the three plots in Figure 1, as the level of psychological safety moves from low to mean, the impact of psychological safety on innovation is steeper for mean intrinsic motivation than for low intrinsic motivation; and steeper for high intrinsic motivation than for mean intrinsic motivation.

However, beyond the inflection points, the plots show different effects. The drop in innovation beyond the inflection point is much steeper for low intrinsic motivation than for mean intrinsic motivation; and the drop in innovation is steeper for mean intrinsic motivation than for high intrinsic motivation. These observations suggest that the detrimental effect of the higher level of psychological safety is relatively low in the presence of higher intrinsic motivation. Furthermore, the plot for high intrinsic motivation beyond the point of inflection becomes almost asymptotic, with a very low rate of change (topmost plot). This shows that highly intrinsic motivation is likely to reduce the negative effect of psychological safety to a negligible level beyond the point of inflection, as the inverted *U* shape becomes almost asymptotic in shape at high intrinsic motivation. Overall, these observations reveal the positive moderating effects of intrinsic motivation.

5. DISCUSSION

Our findings, from the data collected from 102 process improvement teams, illustrate that team psychological safety has a curvilinear impact on process innovation in Six Sigma teams, as we had proposed (H1). Furthermore, when we incorporate intrinsic motivation as a moderator in the analysis (H2), several interesting findings emerge. First, the results suggest that intrinsic motivation has a synergistic influence on psychological and innovation. Second, the position of inflection points (where the impact of psychological safety starts declining) is shifted positively by the presence of employees' intrinsic motivation, suggesting that intrinsic motivation has a positive moderating influence on the curvilinear relationship. Third, the detrimental effect of higher psychological safety on process innovation is relatively low in the presence of intrinsic motivation. Stated differently, at a higher psychological safety level, its negative influence on innovation is reduced by the presence of intrinsic motivation. This finding is logical and consistent with our theoretical argument that employees with higher intrinsic motivation find it easier to regulate their attention, to mitigate the negative impact of psychological safety; they can focus their motivation on attention and engagement in creative and innovation tasks, which are otherwise reduced with a higher level of psychological safety.

5.1 Theoretical implications

Although some previous studies on Six Sigma have shown that psychological safety improves team performance (Choo *et al.*, 2007; Arumugam *et al.*, 2013), for the first time, the present study establishes that psychological safety can enhance innovative behaviours in Six Sigma teams. The findings of this study shed light on the role of psychological safety in work teams, and they extend prior research on the impact of psychological safety on innovation, in line with similar findings in other field settings (Carmeli *et al*., 2010; Liu and Keller, 2021; Lee *et al*., 2011).

Additionally, our findings advance the field of psychological safety research by demonstrating the non-linear influence of psychological safety on innovation in work teams. Most studies investigating the impact of psychological safety in innovation teams propose and establish only a linear relationship (e.g., Edmondson, 1999; Carmeli *et al*., 2010; Liu and Keller, 2021). Furthermore, few studies find a weak relationship between psychological safety and innovation (meta-analysis: Hülsheger *et al*., 2009). Based on Activation Theory (Scott, 1966; Gardner, 1986; Gardner and Cummings, 1988), we proposed and investigated a curvilinear relationship between psychological safety and innovation. As expected, our findings support this new perspective, showing that the beneficial effect of psychological safety reaches an inflection point, after which its relations with innovative outcomes cease to be linear and positive, shaping the relationship into an inverted *U*-shape pattern. This new perspective on psychological safety, regarding its impact on innovation, also supports the view expressed by some innovation literature scholars (Paulus *et al.*, 2012), who observed that a highly safe psychological environment may reduce the overall extrinsic motivation, leading to a reduced innovation effort. Prior research has overlooked this non-linear nature of the psychological safety impact on innovation. The finding supports the notion of the TMGT effect (Pierce and Aguinis, 2013), and is in line with similar findings in other research disciplines (Gardner, 1986, 1990; Zhang and Bartol, 2010; Srikanth *et al*., 2022).

The finding also resonates with the view expressed by Hülsheger *et al*. (2009), who noted that to maintain a positive group environment ('*groupthink*': Janis, 1972), team members may avoid conflict. Hence, they are likely to avoid sharing ideas that might produce conflict within the group, leading to reduced innovative outcomes from the team.

In the team effectiveness literature, it is argued that psychological safety, being an inherently interpersonal construct built through workplace interactions, can be breached or violated (Frazier *et al*., 2017). In fact, recent research by Pearsall and Ellis (2011) has found that high psychological safety has created a context in which teams are more likely to engage in cheating behaviour, as the perception of interpersonal risk is low at a high safety level. Although we have not postulated any hypothesis on this line of argument, our results do indeed support the view that a high level of psychological safety leads to detrimental effects on innovation, especially when motivation is very low.

The results show that psychological safety and intrinsic motivation both have direct as well as a positive synergetic influence on innovation. Thus, the present study sheds light on their complex role as enablers of innovation in Six Sigma teams; it provides the first piece of empirical evidence of the combined roles of psychological safety (a team-level factor) and intrinsic motivation (individual-level factor) and their interactions in a single study. Furthermore, the research addresses the recent calls by scholars who advocate models that combine cognitions, personality traits, affect, and environmental factors to study innovation (e.g., Shalley *et al.*, 2004).

Our results indicate that intrinsic motivation seems to provide a motivational gain to teams that are otherwise affected by process coordination and motivational losses, and the resulting reduced performance due to the high level of psychological safety. Intrinsic motivation helps to repair this undesired result, to reap the benefits of high psychological safety.

The results suggest that intrinsic motivation plays a role in changing employees' attention levels. The finding is consistent with the outcome we had proposed; it is also more logical, given that intrinsic motivation is associated with focused and persistent task engagement, and employees are likely to explore new cognitive pathways (Amabile, 1996, Ryan and Deci, 2000).

The study also contributes toward a more fine-grained understanding of the impact of psychological safety in teams, especially its impact on innovation and its boundary condition. Thus, it addresses the recent call by Edmondson and Lei (2014), who stated, "We suggest that work on the boundary conditions of psychological safety remains underdeveloped and that a contingent model of psychological safety may be worth pursuing for understanding the essential collaborative and innovative activities that fuel today's fast-paced organizations" (p. 38).

Third, and more importantly, our study and its findings contribute to the growing but small stream of research investigating the innovative effects of Six Sigma. Studies on innovation in Six Sigma are still evolving; we have only a limited number of studies that examine innovation, and even fewer that focus on teams. Team-level studies are especially important, as creativity and innovations are often enacted in teams.

Finally, our study contributes to creativity literature in many ways. The study adds to the emerging literature on team-level creativity and innovation in the workplace (Gilson and Shalley, 2004). This is increasingly important as more and more organizations are using teams to improve innovation and organizational performance (Kozlowski and Ilgen, 2006), Moreover, most of the empirical studies in group creativity and innovation have been carried out in laboratory settings, and hence have limited implications for real-world teams (Kozlowski and Ilgen, 2006; Sutton and Hargadon, 1996). By gathering data from a field setting, this study contributes and offers valid inputs to innovation research and practice.

5.2 Practical implications

Our study highlights the practical implications of team psychological safety and individual intrinsic motivation on innovation in Six Sigma teams. Maintaining a moderate level of psychological safety is crucial for fostering innovation effectively, as our empirical findings suggest. Drawing from existing literature on psychological safety and team dynamics (Edmondson, 1999), we emphasize the need for managerial and HR interventions. Training high-performing team leaders to cultivate optimal psychological safety levels within teams can enhance innovation in process improvement initiatives. Furthermore, prioritising intrinsically motivated individuals in team formation can further boost performance levels. These insights offer actionable strategies for organisations seeking to maximise innovation outcomes in operational teams.

6. CONCLUSION

In summary, this study has explored the connection between Six Sigma and innovation through a team-level study, and thus contributes to the evolving literature on Six Sigma and innovation. Our main objective was to investigate the proposed relationship between psychological safety and innovation in Six Sigma process improvement teams, which no prior study has examined, although these factors are conceptually linked in Six Sigma teams (e.g., Arumugam *et al.*, 2016). We proposed a new perspective of a non-linear relationship, rather than the usual linear relationship that has been the focus in all previous studies on the topic. Our study suggests that psychological safety can increase employees' innovative performance through increased engagement and activation, when moving from low to moderate levels of psychological safety; innovation then starts declining beyond moderate psychological safety. Thes findings are aligned with Activation Theory (Scott, 1966; Gardner, 1986; Gardner and Cummings, 1988), which posits that moderate levels of activation are most conducive to performance. The study further suggests that intrinsic motivation can provide a remedy for teams that are otherwise affected by process coordination, motivational losses, and the resulting reduced performance, due to the high level of psychological safety.

6.1 Limitations and future research

Despite making valid contributions, the study has some limitations. Our sample data were obtained from only two organizations, and hence generalizability is restricted. This can be overcome in future studies with data from multiple organizations. Second, our data are cross-sectional, and although we provided sound theoretical reasoning for our model, future research should make use of a longitudinal design to allow for causal interpretations. Furthermore, although our approach using regression analysis helped to logically interpret the findings, a more robust method such as structural equation modelling (SEM), which can assess simultaneous effects of all variables, would be appropriate in future research.

The research could be expanded in several directions. While the focus of our study was to examine how psychological safety as an activating agent influences innovation in Six Sigma teams, the impact of other activation agents – such as workload pressure, trust and openness, autonomy, supportive leadership, and intellectual simulation, to name a few – could be investigated in more detail. Additionally, cross-cultural studies might offer insights regarding the relationship between psychological safety and innovative performance, which might illustrate how performance starts to decline in different cultures. It would be interesting to carry out a comparative study, for example, between countries with different hierarchical cultures, to assess how the inflection points' position varies depending on these organizational cultures. ``

Despite these limitations, the study provides an important step towards understanding the influence of psychological safety and intrinsic motivation on innovation in Six Sigma process improvement teams and contributes to both the innovation and team effectiveness literature.

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Appendix: Measures

Method (Cronbach's α =0.84; 3 item scale 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

Challenging Goal (α=.70; from Linderman *et al*. (2006)

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

Innovation (α = 0.89; adapted from Hülsheger *et al*. (2009) and West and Farr (1990).

1. The solutions implemented were clearly unique and innovative to the company (unique)
2. We met or exceeded customers' expectations in this project (useful)

3. Our implemented solution was clearly new to the organization (newness)

Psychological safety (α = 0.87; from Edmondson (1999)

1. Members of the team were able to discuss problems and tough issues openly

2. Members of the team accepted each other’s differences

3. No one in this team deliberately acted in a way that undermines my efforts

4. Working with members of this team, my unique skills and talents were valued and utilized

Intrinsic motivation (α = 0.71 adapted from Zhang and Bartol, 2010)

1. I enjoyed finding solutions to the problems we tried to solve

2. I enjoyed creating new procedures for the tasks related to the problems we solved

3. I enjoyed improving existing processes.

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Table1. Descriptive statistics and correlation

		Mean	Std dev.	1	2	3	4	5	6	7	8	9
1	Team Size	5.402	1.678									
2	Project duration	6.887	2.109	0.078								
3	Gender	0.404	0.072	0.109	-0.012							
4	Tenure (log)	1.021	0.157	0.147	0.198*	-0.059						
5	Company dummy	0.509	0.502	0.224*	-0.183	-0.023	0.086					
6	Structured method	5.595	1.191	0.091	0.048	0.029	0.087	0.147				
7	Challenging goal	5.671	1.229	0.012	-0.071	-0.048	-0.020	0.170	0.337**			
8	Psychological safety	5.539	1.143	-0.166	0.050	-0.125	0.147	0.098	0.210*	0.272**		
9	Intrinsic motivation	5.725	1.081	0.056	-0.046	-0.019	-0.057	0.291**	0.316**	0.646**	0.305**	
10	Innovation	5.377	1.233	0.077	-0.069	-0.072	0.003	0.233*	0.363**	0.624**	0.463**	0.738**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 2. Regression analysis results

	M1	M2	M3
Team Size	0.042	0.072	0.035
Project duration	-0.020	-0.015	-0.002
Gender	-0.054	-0.031	-0.027
Tenure (log)	-0.014	-0.088	-0.031
Company dummy	0.103	0.064	-0.039
Structured method	0.163+	0.129+	0.109+
Challenging goal	0.545***	0.493***	0.218**
Psychological safety		0.204*	0.129+
Psychological safety²		-0.226*	-0.229**
Intrinsic motivation			0.518***
Psychological safety X Intrinsic motivation			0.125*
R^2	0.433	0.549	0.697
ΔR^2		0.116***	0.148**
F	10.259***	12.426***	18.865***

*** $p < .001$. ** $p < .01$. * $p < .05$. + $p < .10$

[a]. Blau's index.

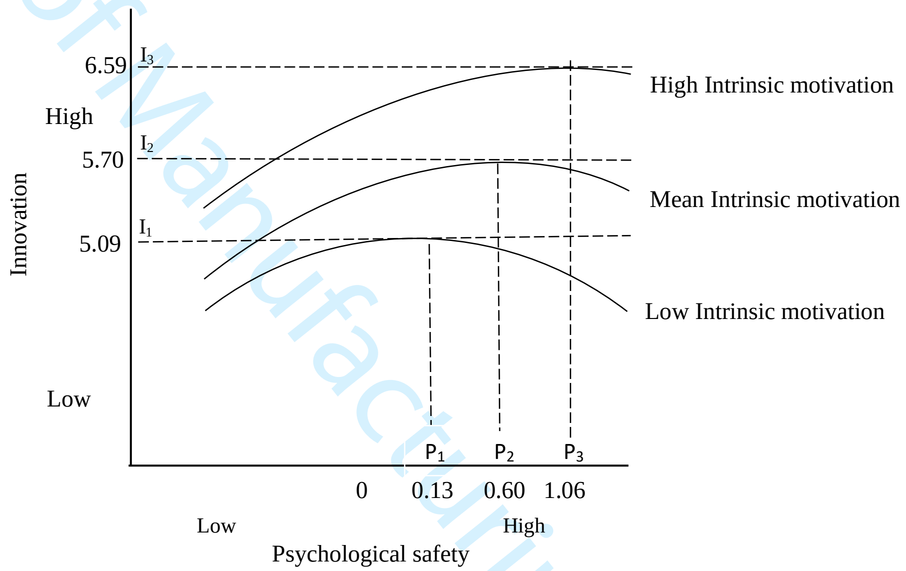

Figure 1. Moderation of the innovation-psychological safety relationship by intrinsic motivation (shape and inflection points)