# SUPPORT OF PROCESS IMPROVEMENT ACTIVITIES TO PRODUCTS AND PROCESSES INNOVATION: CASES IN INNOVATIVE COMPANIES

FABIANE LETÍCIA LIZARELLI
Federal University of São Carlos / Department of Production Engineering, Brazil
fabiane@dep.ufscar.br (Corresponding)

JOSÉ CARLOS DE TOLEDO
Federal University of São Carlos/ Department of Production Engineering, Brazil
toledo@dep.ufscar.br

ARTUR YUITI ISHIZAKA
Federal University of São Carlos/ Department of Production Engineering, Brazil
arturyuiti@gmail.com

DÁRIO HENRIQUE ALLIPRADINI
FEI University / Department of Production Engineering, Brazil
dario.allip@gmail.com

## ABSTRACT

The Process Improvement (PI) is associated with the support of incremental innovations only, it is important to consider that PI can support radical process and product innovations. The aim of this paper is to verify whether and how PI can help product and process innovation and the main practices that allow this support. To verify how PI can help product and process innovation were used a Systematic Literature Review to identify which practices allow PI assists innovation and through multiple case studies were confirmed, detailed and identified new practices and the difficulties to PI assists innovation. The case studies were performed in four Brazilian companies, classified as the most innovative in their industry. Three of the analyzed companies indicated that the PI can assist in product innovation. The main practices identified are: sharing goals; stimulate the PI during product development; information sharing; participation of people from PI in product innovation team; and involvement of PI in product development activities. All the analyzed companies indicated that the PI can assist in process innovation. The practices identified are: encouraging the generation of innovative ideas of people from PI; free flow of ideas and information sharing and transformation of PI ideas into process innovation projects. Future research can explore in more depth how companies can foster the relationship between PI and innovation by identifying factors that may influence this relationship and performance outcomes, single-industry studies and a larger number of firms enable greater understanding of the theme. The paper allows a reflection on the role of PI in relation to radical innovation of products and processes. The managerial implications involve the promotion of interaction between PI and radical innovation projects. And the results show that the PI can foster and encourage radical innovations. The research contributes to the management and theoretical fields, discussing new advantages to the use of PI. Although it is a relevant topic with managerial implications, there are no

studies on what practices can be used to foster the contribution of PI to product and process innovation.

**Key words:** Process Improvement; Product Innovation; Process Innovation; Multiple Case Studies.

## INTRODUCTION

Process Improvement (PI) and Innovation of Products and Processes (IPP) are central to competitive advantage, differentiation against competitors and organizational management (Angelis and Fernandes, 2012; Benner and Tushman, 2002; 2003; Berente and Lee, 2013; Honarpour *et al*., 2012; Luzon and Pasola, 2011; Moreno-Luzon *et al*., 2014; McAdam *et al*., 1998; Perdomo-Ortiz *et al*., 2006).

The Process Improvement (PI) can be characterized by understanding the existing process, planning and deployment process improvement aimed at standardization, increasing efficiency and reducing variance (Benner and Tushman, 2002; Berente and Lee, 2013). The PI is also associated with other widespread terms, as management processes and continuous improvement, with similar activities and goals (Berente and Lee, 2013; Moreno-Luzon *et al*., 2014). The change created by the PI is traditionally seen as an improvement of efficiency within an existing technological trajectory, influencing incremental or exploitative innovation (Benner and Tushman, 2002; 2003; 2015; Moreno-Luzon *et al*., 2014). In the literature, the opinions are divided about the impact of PI on radical or explorative innovation (Benner and Tushman, 2002, 2003; Moreno-Luzon *et al*., 2014; Prajogo and Sohal, 2004). Often, PI is considered an obstacle to more radical innovation (Benner and Tushman, 2002; 2003; Berente and Lee, 2013; Moreno-Luzon *et al*., 2014). One argument is that the PI is related to standardization, rules, procedures and variability reduction and has traditionally been regarded as limiting experimentation and radical innovation (Benner and Tushman, 2015; Cole and Matsumiya, 2008; Moreno-Luzon *et al*., 2014; Prajogo and Sohal, 2001; Sadikoglu and Zahir, 2010).

Despite the presence in organizations of programs such as TQM (Total Quality Management), Lean and Six Sigma, which support the activities of PI, and the potential of improvement activities to support incremental and radical innovation, there is few research on how, with which practices, the PI can assist in the development of innovation (Benner and Tushman, 2002; Berente and Lee, 2013; Martínez-Costa and Martínez-Lorente, 2008; Moreno-Luzon *et al*., 2014; Perdomo-Ortiz *et al*., 2006). To avoid the view that the PI only supports incremental innovation, it is important to consider different ways of thinking about how the PI can support IPP (Berente and Lee, 2013; El-Ella *et al*., 2013; Moreno-Luzon *et al*., 2014).

The aim of this paper is to verify whether and how PI can help product and process innovation and the main practices that allow this support. To verify how PI can help product and process innovation were used a Systematic Literature

Review to identify which practices allow PI assists innovation and through multiple case studies were confirmed, detailed and identified new practices and the difficulties to PI assists innovation. The case studies were performed in four Brazilian companies, classified as the most innovative in their industry.

## LITERATURE REVIEW

### Process Improvement

The PI is intrinsically related to the concept of continuous improvement. It aims to map processes and document routines, continuously improve, seeking efficiency, effectiveness and to adopt standardized routines of best practice, focusing mostly on the production processes (Benner and Tushman, 2003; Garcia and Calantone, 2002; Moreno-Luzon *et al*., 2014).

The PI management and practices are supported by improvement programs such as TQM, and Six Sigma, and these initiatives spread the principles of process management as: efficiency, control, standardization and reduction of variability (Benner and Tushman, 2002; 2003).

However, improvement programs do not focus only on efficiency and control (Berente and Lee, 2013). TQM, for example, focuses on experimentation, continuous learning and customer satisfaction. Lean Manufacturing includes the elimination of waste and the involvement of people, whereas the key principle of Six Sigma is to reduce variation, defects and achieve process statistical control (Andersson *et al*., 2006; Berente and Lee, 2013; Bhuiyan and Baghel, 2005; Bhuiyan *et al*., 2006; Lopes *et al*., 2015; Salah *et al*., 2010). In Lean Sigma program waste and process variations can be eliminated quickly, seeking to provide value to the customer (Bhuiyan and Baghel, 2005; Bhuiyan *et al*., 2006; Drohomeretski *et al*., 2014; Kornfeld and Kara, 2011).

The simultaneous adoption of different PI programs allows projects of distinct types, levels of complexity and change (Andersson *et al*., 2006; Bhuiyan and Baghel, 2005; Bhuiyan *et al*., 2006; Nilsson-Wittel *et al*., 2005), including projects that can help radical innovation (Anand *et al*., 2009; Berente and Lee, 2013).

The impact of PI initiatives, even related to the same program, is not homogeneous within and between companies. The impact is subject to contingencies, such as project scope, the area to be held, organizational and market context and internal variables such as organizational structure, technological capacity and the type of management (Berente and Lee, 2013; Bhuiyan and Baghel, 2005; Bhuiyan *et al*., 2006; Torres Jr. and Gati, 2011).

Improvement programs are constantly evolving much more than the reduction of variation. The application and the focus of improvement projects change with the maturity of programs, including the possibility of innovations in products and processes (Berente and Lee, 2013; He and Goh, 2015). Empirical research can help in better understanding of the relationship between improvement and different kinds of product and processes innovations (Berente and Lee, 2013).

There is, therefore, an opportunity to investigate the possible ways that PI efforts can support or enable IPP (Berente and Lee, 2013; McAdam *et al*., 1998; Perdomo-Ortiz *et al*., 2006; Prajogo and Sohal, 2001, 2003; Santos-Vijande and Álvarez-González, 2007).

**Processes Improvement and support for innovation**

The PI features seen as radical innovation supporters include the creation of innovation culture (Abrunhosa and Sá, 2008), stimulate creativity and learning (Prajogo and Sohal, 2003; Zhang *et al*., 2012) and support to teamwork (Berente and Lee, 2013). Organizations that focus on continuous improvement are more likely to build a culture of innovation, with greater ability to adapt to change and lower risk aversion, since employees are not guilty for the mistakes in experimentation (Abrunhosa and Sá, 2008; Antony, 2015; McAdam *et al*., 1998; Sadikoglu and Zehir, 2010).

The PI can encourage members of the organization to assess creatively how tasks are done and carried out by promoting the possibility of experimentation, generation of ideas and learning that stimulate radical innovation (Prajogo and Sohal, 2003, 2004; Zhang *et al*., 2012). The improvement also enables increasing the autonomy and empowerment, allowing larger roles in the generation and selection of ideas, therefore, encouraging the ability to innovate (McAdam and Armstrong, 2001; Perdomo-Ortiz *et al*., 2006; Santos-Vijande and Álvarez-González, 2007) and creating knowledge (Asif *et al*., 2013).

Teamwork stimulated by improvement projects helps to increase the exchange of knowledge (result from the heterogeneous experience of members), the communication, the improvement of the information flow, the autonomy of those involved and the commitment to innovation, with the possibility of positive effects on radical innovation (Berente and Lee, 2013; McAdam *et al*., 1998; Perdomo-Ortiz *et al*., 2006; Prajogo and Sohal, 2001, 2003; Santos-Vijande and Álvarez-González, 2007).

But the technology and knowledge involved in PI are also seen as conservative, generating nothing more than incremental innovation or expertise in an existing knowledge (Benner and Tushman, 2003). The reduction of the variation, routines, stability, process control, and increased efficiency generate incremental results, since radical innovation is related to increase variation, uncertainty and abrupt changes (Benner and Tushman, 2002, 2003; Cole and Matsumiya, 2008; Prajogo and Sohal, 2001; Sadikoglu and Zahir, 2010).

The PI efforts tend to focus on existing activities, with a strong culture of quality and reliability of products and processes, to the detriment of activities that require more radical forms of innovation that generate high variability, uncertainty about quality and technology and market changes (Benner and Tushman, 2003; Cole and Matsumiya, 2008; Prajogo and Sohal, 2001; Santos-Vijande and Álvarez-González; 2007).

The teamwork promoted by the improvement may have negative aspects related to radical innovation, since it can limit creativity and individual innovative spirit

(Prajogo and Sohal, 2001; Santos-Vijande and Álvarez-González, 2007). However, even though the IP has a focus predominantly on incremental change, the results may be radicals (Berente and Lee, 2013; Moreno-Luzon *et al*., 2014; O'Reilly and Tushman, 2004; Tushman *et al*., 2010).

## Innovation of processes and products

The product innovations often require process innovations and improvements to be achieved (Utterback and Abernathy, 1975). After the development of the product, the focus begins to move to the process, to develop efficient processing technologies to leverage manufacturing advantages, and during the consolidation of the product on the market, focus is in process improvements and cost reduction (Utterback and Abernathy, 1975; Utterback, 1996).

The product innovations and process innovations or improvements may occur independently; however, they have the potential to benefit reciprocally triggering processes, products and technologies innovations (Bauer and Leker, 2013; Boland *et al*., 2007; Zairi, 1995).

There is close relationship between product development and process improvement. The development of a new product requires three stages: product development, process development and process improvement (Lu and Botha, 2006). Incremental processes improvements are required in both moments, before and after the product innovation. PI efforts allow the radical innovation products to be implemented (Berente and Lee, 2013).

The development of a new product may be the opportunity for PI to occur and increase the performance of the new product and of the existing ones, reaching common goals for both the PI and for product innovation (Chapman and Hyland, 2004; Corso and Pavesi, 2000). It is also important to have communication and knowledge management between the product development and process improvements areas, so that PI can know what is happening and improve critical processes (Bessant and Francis, 1999; Garcia-Sabáter *et al*., 2012; Kowang and Rasli, 2011).

The PI can generate inputs for processes innovation, as ideas and information (Anand *et al*., 2009; Irani and Sharp, 1997; Martínez-Costa and Martínez-Lorente, 2008; O'Brien and O'Reilly, 2010; Terziovski, 2002; Tidd *et al*., 2008). Even the design of new processes may have as source the ideas coming from PI (O'Brien and O'Reilly, 2010). Therefore, PI's efforts can support product innovation and can produce process innovations, not supporting the argument that the PI harms innovation (Berente and Lee, 2013).

## Method

A literature review and a field research on the support of PI for IPP were performed. The research steps can be observed in Figure 1.

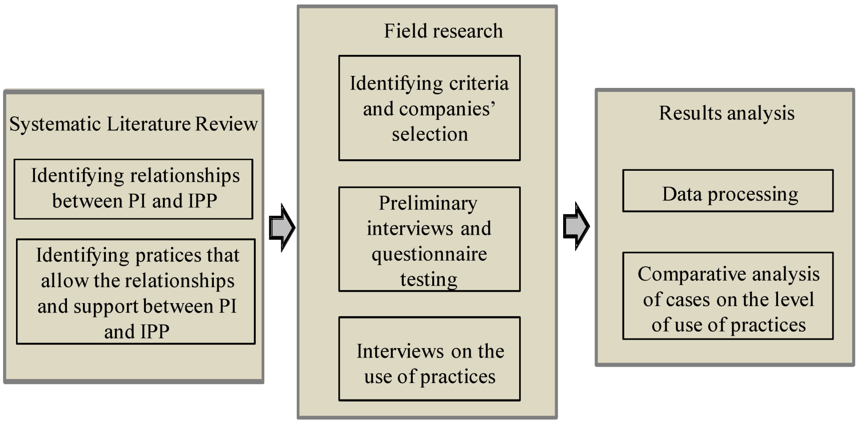


*Figure 1: Research Steps*

To identify papers relating PI and IPP, it was performed a Systematic Literature Review (SLR).  SLR uses defined procedures to identify, analyze and interpret the available evidence related to a research question or phenomenon of interest in an impartial way, which can be replicable and evidence-based (Brereton *et al*., 2007; Tranfield *et al*., 2003).

Information on the way the research was conducted is detailed in Table 1. It is shown the question that drives the research and the search string, which included the concepts of PI and IPP. The databases were chosen because they are relevant to the research area and by have an international scope.

*Table 1: Directions of search*

| **Directions of Search** | |
|---|---|
| SLR question | The PI can assist in IPP and which practices can be used? |
| Bases | ISI Web of Science, Scopus e Engineering Village |
| Time | 1990-2015 |
| Search string | ("process improvement" or "continuous improvement" or "kaizen") and ("innovation" or "product development" or "process development") |
| Search items | Title, abstract and keywords |

The searches returned a significant number of papers (Table 1). All searches were made considering the title, abstract and keywords. For a first filtering of papers the following characteristics were established: knowledge areas of the paper related to (Engineering, Business, Management, Operations Research, Management Science e Decision Science); the selected languages were English, Spanish and Portuguese and only journal papers were selected.

The second filter involved the abstract reading and full paper availability checking (in databases, websites and direct contact with authors, considering that 15  papers were not found). The last filter involved the complete reading of the paper and the exclusion of items that were repeated in databases, remaining 26 articles on the subject.

*Table 2: SLR results (1990-2015)*

| Bases | | | | |
|---|---|---|---|---|
| Information | Engineering Village | Web of Science | Scopus * | Total |
| Number of items found | 1024 | 751 | 1763 | 3538 |
| Number of items after the first filtering | 322 | 264 | 341 | 927 |
| Number of papers after the second filtering | 60 | 58 | 69 | 187 |
| Number of papers after the third filtering | 3 | 8 | 15 | 26 |

* Search in Physical Sciences, and Social Sciences Humanities, which encompasses Business e Engineering

Table 3 shows the main authors who recognize the PI can assists the IPP. Out of the 26 selected papers, 8 mention the relationship between PI and product innovation, 8 mention the relationship between PI and process innovation, 10 indicate both relations.

*Table 3: Publications relating PI and IPP*

| **Theme** | **Number of publications** | **Authors** |
|---|---|---|
| PI supports product and process innovation | 10 | Bartezzaghi *et al*. (1997); Corso and Pavesi (2000); Boer *et al*. (2001); Prajogo and Sohal (2003); Matínez -Costa and Martínez-Lorente (2008); McAdam *et al*. (2010); Hung *et al*. (2011); Kim *et al*. (2012); Berente and Lee (2013); He and Goh (2015) |
| PI supports product innovation | 8 | Regan e Kleiner (1997); Chapman *et al*. (2001); Chapman and Hyland (2004); Hoang *et al*. (2006); Lu and Botha (2006); Salomo *et al*. (2007); Hoerl and Gardner (2010); Lee *et al*. (2010) |
| PI supports process innovation | 8 | Bessant and Francis (1999); Lee *et al*. (2000); Bessant *et al*. (2001); Nijhof *et al*. (2002); Yang *et al*. (2010); Suárez-Barraza *et al*. (2012); Martini *et al*. (2013); Suárez-Barraza and Smith (2014) |

The ways in which papers present relations are of very different nature, as it can be seen in Table 4.

*Table 4: Main statements about the relationship between PI and innovation*

| **Main statements** | **Authors** |
|---|---|
| Show continuous improvement or process management as part of a broader structure as TQM or quality management practices, and identify positive direct and indirect relationship between PI and processes innovation. | Prajogo and Sohal (2003); Martínez-Costa and Martínez-Lorente (2008);McAdam *et al*. (2010); Yang *et al*. (2010); Hung *et al*. (2011); Kim *et al*.(2012) |

| | |
|---|---|
| Show continuous improvement or processes management as part of a broader structure as TQM or quality management practices, and identify positive direct and indirect relationship between PI and product innovation. | Prajogo and Sohal (2003); Hoang *et al*. (2006); Martínez-Costa and Martínez-Lorente (2008); Lee *et al*. (2010); McAdam *et al*. (2010); Hung *et al*. (2011); Kim *et al*. (2012) |
| Descriptive models where PI can generate opportunities for product development projects or product development can generate needs to improve processes. | Bartezzaghi *et al*. (1997); Corso and Pavesi (2000); Boer *et al*. (2001); Chapman *et al*. (2001); Chapman and Hyland (2004); Hoerl and Gardner (2010); |
| Models indicate that the PI may generate opportunities for process development projects. | Bartezzaghi *et al*. (1997); Corso and Pavesi (2000); Boer *et al*. (2001); Martini *et al*. (2013); |
| The PI is positively related to process innovation. | Bessant and Francis (1999); Lee *et al*. (2000); Bessant *et al*. (2001);Nijhof, *et al*. (2002);Berente and Lee (2013); Suárez-Barraza and Smith (2014); He and Goh (2015) |
| The PI is positively related to product innovation | Lu and Botha (2006); Berente and Lee (2013); He and Goh (2015) |
| The improvement or processes management is related to the performance of new product development process | Regan and Kleiner (1997); Salomo *et al*. (2007) |

It was also identified papers that indicate that the PI does not have positive relationships with innovation (Benner and Tushman, 2002, 2003; Perdomo-Ortiz *et al*., 2006; Prajogo and Sohal, 2004) or that there is no statistically significant evidence of this relationship (Kohlbacher, 2013; Silva *et al*., 2014; Singh and Smith, 2004; Sun *et al*., 2009), or even that the PI is not a basis for more radical innovation (Hoerl and Gardner, 2010). Despite the identification of positive relationship between PI and IPP, there are few papers indicating practices to enable these relationships, which have been identified in papers that mentioned relationships, or other relevant content containing the subject (Table 5 and Table 6). These practices will be investigated in the case studies. In the papers, not always these actions were described with the term practices. In this research, the practices are considered usual behaviours that enable the PI's aid in innovation activities.

*Table 5: Practices for PI support to product innovation*

| **Practices** | **Authors** |
|---|---|
| Use the goals of the innovation / product development area to focus on the process improvement activities. | Corso and Pavesi (2000); Boer *et al*. (2001); Chapman *et al*. (2001); Corso (2002); Chapman and Hyland (2004) |
| Encourage improvements to the manufacturing process during the product development. | Regan and Kleiner (1997) |

| | |
|---|---|
| Incorporate knowledge of product development reports, database, process standards, among others, for later access and process improvements. | Bessant and Francis (1999); Corso and Pavesi (2000); Boer *et al*. (2001); Bessant *et al*. (2001); Chapman *et al*. (2001); Corso (2002); Chapman and Hyland (2004); Jager *et al*. (2004); Kowang and Rasli (2011); Garcia-Sabáter *et al*. (2012) |

*Table 6: Practices for PI support to process innovation*

| Practices | Authors |
|---|---|
| Encourage processes innovation ideas of the PI staff. | Regan and Kleiner (1997); Sohal *et al*. (2003); O'Brien and O'Reilly (2010) |
| Generate free flow of information from the PI area for processes innovation. | Irani and Sharp (1997); Irani *et al*. (2004); Jager *et al*. (2004) |
| Encourage the incorporation of PI ideas in process innovation projects. | Bessant *et al*. (2001); Nilsson-Witell *et al*. (2005); McAdam *et al*. (2010); O'Brien and O'Reilly (2010) |

To perform the field research was needed to identify companies where it would be possible to observe PI and IPP activities. For the selection, it was consulted information about product and processes innovation on patent reports and Exame magazine rank (similar to Forbes). It was selected four companies (with a higher number of patents and a better position in the rank) of four different industrial sectors considered the most innovative sectors in Brazil (PINTEC, 2016).

The selected companies belong to different industrial sectors, which allow a broader investigation into the use of practices in different contexts. The initial contact was made with IPP's area responsible that sent the search for specific persons related to both PI and innovative products and processes. To survey the perceptions of respondents, we developed a semi-structured questionnaire and a pilot test was conducted with preliminary interviews with three interviewed companies A, B and C, for analysis, questionnaire refinement and including practices that had not been found in literature. The questionnaire was applied to four employees in each company (A, B, C and D); the employees belonged to the areas of PI, Research and Development (R&D), Product Development and Process Development, to expand the scope of perceptions.

A comparative analysis of the cases was carried out, to this end, perception of respondents about the presence of relationships and use of practices was classified by levels (high, average, low and unused). As there was more than one respondent in each of the companies, the level presented was the most mentioned among respondents.

## FIELD RESEARCH

### Cases

The chosen companies are large and are considered in Brazil benchmarks in innovation, quality products and billing in their sectors (Table 7).

*Table 7: Overview of the companies studied*

| Company | Company A | Company B | Company C | Company D |
|---|---|---|---|---|
| Area | Consumer Goods | Appliances | Chemical | Cosmetics |
| Programs/ Process Improvement methodologies | Six Sigma (16 years) and Lean (12 years reshaped 5 years ago) | Six Sigma (18 years); Lean (12 years); Lean Sigma (1,5 years) | Improvement groups (over 30 years); and Six Sigma (8 years) | Lean and TPM (9 years); Six Sigma (5 years); Lean Sigma (2 years) |
| Product Development | Developed in Research and Development Center using Stage-Gate and Design For Six Sigma | Developed in the Product Development Board using Stage-Gate and Design For Six Sigma | Developed in Development Center - Division R&D with the use of Stage-Gate and Design For Six Sigma | Developed in the Center for Technology and Development of formulas, using the Stage-Gate |
| Process Development | Industrial area Responsibility | Industrial Engineering Responsibility | Responsibilities of Development Centers | Industrial Board Responsibility |

*Company A*

The innovation process is performed by the industrial area with matrix structure, with the presence of engineers and process managers, who often belong to the Belt structure of Six Sigma program and people from different functional units. The product innovation projects are developed in the Research and Development Center and are conducted using concepts of Simultaneous Engineering, the Stage-Gates model and DFSS - Design for Six Sigma; with cross-functional team composed by a technical specialist, product, quality and processes engineers. The projects are tracked by a Black Belt, who checks the phases of DFSS and connects it with the Six Sigma team to develop new processes and PI. The PI actions are under the responsibility of Lean Six Sigma area. Lean projects are focused in the operation, whereas Six Sigma projects are active in several areas of the organization, including manufacturing, logistics, R&D, among others. Currently, the Black and Green Belts receive basic training of Six Sigma and Lean concepts, an attempt to reconcile tools and methods of the two programs.

*Company B*

The process innovation projects are under the responsibility of industrial board and are related to the increase of the plant capacity and the implementation of new product lines, often the need of product development with new technology or a new product platform. For product innovation, projects use matrix structures, involving the product subsystems management, laboratorial approval (responsible for the technical release) and functional areas, such as: Quality, Marketing, Industrial Engineering and Customer Service. The implementation of new products and new technology projects is based on the Stage-Gates methodology, the DFSS and robust design. The PI is spread through the Six Sigma program and projects are related to the product improvement, reducing variability and costs. It uses also the Lean and Lean Sigma philosophy. Lean projects are more focused on productivity, setup time, process inventories, processes and security layout. The company conducts weekly forums for discussion and alignment of PI projects with new or ongoing products and processes development projects.

*Company C*

The company has a development center in the R&D division, where innovations are developed. The innovation process is led by process engineers allocated in R&D. They have a direct relationship with the industrial processes engineers, dedicated to security and PI projects. The development of new products and new technologies is performed with the use of matrix structure, led by R&D engineers. The projects follow the Stage-Gates methodology and are performed by cross-functional teams whose project director belongs to the industrial area, related to the PI. Participate, also, people from Quality, R&D, Supply Chain, Laboratorial Analysis, Marketing areas, among others. Regarding the PI, the company has an operational excellence area, which assists in managing and carrying out Six Sigma, Kaizen, Lean Sigma and TPM (Total Productive Maintenance) projects. The generation of ideas for the PI is from industrial engineers, production supervisors and even from operators. Projects are performed by a cross-functional team connected to the industrial area, with the participation of a laboratory chemist and an expert in processes from the R&D area.

*Company D*

Processes innovation, usually associated with the development of new products is linked to industrial board and it is led by industrial engineers, who, for this, use cross-functional teams. Regarding the product innovation, the company has an area of research, called Technology, responsible for the study of new active ingredients to be used in products. The development of a new product may or may not include a new active ingredient. The development of new products is the responsibility of Formula Development area, there is also participation of Marketing, Packaging Development and formulas, Manufacturing Engineering Technology Engineering, Supply and Supply Chain. The company uses the Stage-Gates for new product development. Concerning the PI, the company has Kaizen, TPM, Six Sigma and Lean Sigma projects. PI opportunities are deployed by improvement teams, these teams involve people of technical (development of formulas and packaging) and industrial areas.

## Result Analysis

The first analysis in the field research was on the presence of relationships identified in the literature (R1 and R2) (Table 8). The found level (zero, low, average or high) reflects the mode of the perceptions of respondents.

*Table 8: Summary of the view of respondents on the relationship between PI and IPP*

| Relation | Company | | | |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D** |
| R1: PI supports product innovation | Average presence The Stage-Gate and the existence of people of Six Sigma in the PDP promote collaboration between innovation needs and PI. | Average presence Communication in cross-functional teams and involvement of people of Six Sigma (PI) in PDP promote collaboration. | High presence Communication in committees and participation of people from the industrial area (PI) in product innovation projects promote collaboration. | Low presence The interaction occurs by the role of technology engineer, but it is sporadic and unstructured. |
| R2: PI supports processes innovation | High presence The aid occurs because people from PI area participate in processes innovation. | Average presence The aid occurs because people of the processes innovation also belong to PI area. | High presence The aid occurs by direct contact of the improvement teams with the R&D process engineers. | Low presence The aid occurs by the participation of the same people in PI and processes innovation. |

Regarding relationship 1 "PI supports product innovation", in company A, the new product development projects establish connection with the PI area through the Black Belts. The Black Belt is responsible for coordinating the process of new developments. This one will bring the PI’s requirements and ideas for Lean Sigma area, which will prioritize according to the goals of that year / semester / quarter. From the prioritization, specialist of the Lean Sigma area monitors the product project for changes in the process. There is a direct alignment between the goals of PI projects and new product performance goals, which is a request from the PDP to the improvement area. There is little incentive for experimentation and general ideas of PI area, aiming the development of new products.

In Company B, the process of product innovation has relations and integration with the areas of quality and industry through the participation of these areas in cross-functional teams to develop new products. As the Six Sigma training is widespread, many people from the product innovation team belong to Belt hierarchy. The driver and motivator element of innovation projects are the performance goals of the new product and the stimulus for the PI to occur simultaneously is most striking when the new product generates significant changes in the process.

In company C the product innovation is often dependent on the manufacturing process, and requires a greater relationship between the two areas, depending on the product / chemical process interdependence. The planning of activities to improve processes considers the needs and goals of product innovation. The work plans of improvement teams are aligned to the innovation goals and improvements are stimulated by it. The alignment of goals occurs, mainly, by the participation of the same people in the meetings of the innovation committee, where the innovative guidelines are presented, such as in the improvement groups, moreover, people in the industrial area participate in product development projects, enabling communication between projects. Therefore, the improvement teams' participants make such a connection by themselves. The process improvements projects can occur up to the pilot product implementation phase or after the product launch and PI projects can generate ideas for product innovation.

The company D performs process improvements, but these improvement initiatives are only reported to the product development area. Therefore, there is no alignment between the goals of development areas and PI. According to respondents, the lack of alignment also occurs because the teams are part of different boards. The PI projects can be displayed sporadically to occur with the product development. The responsible for bridging the gap between the improvement actions and projects is the technology engineer. There are no representatives nor involvement of the improvement area in product innovation projects teams.

The practices identified for the existence of relationship 1 "PI supports product innovation" can be seen in Table 9. The first three practices of Table 9 (P1, P2 and P3) were identified in the literature; P4 and P5 were identified in preliminary interviews in companies A, B and C.

*Table 9: Use level of each practice of relationship 1*

| **Practices (P)** | **Company** | | | |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D** |
| P1: Use the goals of the innovation / product development area to focus on the process improvement activities. | Low<br>No specific procedures for direct alignment. | Average<br>The product performance goals are the driver factor of PI teams. | High<br>Planning activities and work plan sets between PI and development of new products. | Null<br>There are no specific procedures. |
| P2: Encourage improvements to the manufacturing process during the product | Average<br>Lean Six Sigma teams prioritize participation | Average<br>The product performance goals are the motivating | High<br>All production processes have monthly meetings of | Low<br>PI projects can be indicated to occur with the |

| | | | | |
|---|---|---|---|---|
| development. | in development projects and participate in the development team. | factor of Six Sigma teams to improve processes for new products. | the PI group with goals and action plans set product development. | product development, by the technology engineers. |
| P3: Incorporate knowledge of product development in reports, database, process standards, among others, for later access and PI. | Null<br>The PI area does not have access to the database of product development data. | Null<br>There are no specific procedures. | Average<br>Database and meeting minutes, help to record and rescue for the PI. | Null<br>There is no communication between the development of database of new products and the PI area. |
| P4: Include the participation of a PI's person in innovation / product development teams. | High<br>The projects are coordinated and include the participation of a Black Belt. | Average<br>The quality of the area is responsible for bridging the gap between improvement and innovation, but there are Belts on the development team. | High<br>There is participation of people from improvement team in innovation committees. | Low<br>Connections between PI and product innovation are made by technology engineer participating in the projects. |
| P5: Involve the PI area in development / product innovation. | Low<br>Through the Black Belt, who participates in innovative projects, needs are disseminated to the PI area. | Low<br>Engagement is done through own matrix teams of project development of new products, involving Six Sigma members, who take information to the area for improvement. | High<br>The innovation committee directs and aligns the activities of PI groups, that the actions are involved with the projects. | Low<br>Communication between PI and product innovation occurs only through the technology engineer. |

Regarding relationship 2 "PI supports process innovation", company A is encouraged to generate ideas for processes innovation from the PI area, but for both Six Sigma and Lean projects, professionals follow deployment guidelines of the strategic goals to propose projects. Ideas encouraging occur through semiannual forums and the ideas can be improvements, radical changes and even new processes. The transfer of ideas from PI area to the process innovation is made possible by the participation of people from Lean Sigma in process innovation projects, through Black and Green Belts. There is also a global system of improvement projects and process innovation record, enabling the exchange of knowledge to be of free access for both areas. Ideas, suggestions and insights from the PI are raised, prioritized and enter as a possibility to be used in new development projects, but there is no structured procedure, so that this path to be faster and generate innovation projects.

In company B, the PI ideas are encouraged, especially for Six Sigma projects and should be aligned with program goals, but there is an explicit focus for innovation. Forums stimulate the generation and dissemination of ideas and they can transfer to process innovation projects, which are led by the representative of Quality area to the project team. What usually happens is the incorporation of ideas and improvement actions in projects for new processes to be a feasible achievement. The incorporation is facilitated by the proximity of the PI area and process engineers in the industrial area, responsible for processes innovation. Process engineers receive Black or Green Belt training, which helps to strengthen relations. However, there are no structured procedures for ideas from PI to become process innovation projects.

In company C the processes innovation ideas are encouraged in the areas of improvement through incentive programs, discussion forums and the ideas discussed in the forums are forwarded by the industrial manager to innovation committees that select projects and direct innovation goals processes. Such ideas become specific projects of innovation by direct contact of the improvement teams with process engineers of R&D, responsible for innovation. Yet, the procedures are still poorly structured. Practices are dependent on mechanisms such as the organizational culture, which allows direct contact and the structured teams formed for process improvement.

In company D, to encourage both incremental and more radical PI ideas, there are awards and forums in each area, there is communication and free flow ideas of the improvement teams for the processes innovation, mainly because there is participation of the same people in the improvement and innovation activities. The improvement ideas, that could be used for innovation processes can be presented in the forums in their areas, but there are no specific procedures for the transfer of ideas to innovation processes.

The practices identified for the existence of relationship 2 "PI supports process innovation" can be seen in Table 10. The first three practices of Table 10 (P1, P2 and P3) were identified in the literature, P4 was identified in preliminary interviews in companies A, B and C.

*Table 10: Use level of each practice of relationship 2*

| **Practices (P)** | **Company** | | | |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D** |
| P1: Encourage processes | High<br>Forums and | Low<br>Incentive is | High<br>Incentive | Low<br>There are |

| | | | | |
|---|---|---|---|---|
| innovation ideas of the PI staff. | performance guidelines are used for the stimulation of ideas. | restricted to the Six Sigma system and goals, ideas are presented in the forums. | programs and forums are used for the generation of ideas. | awards for the ideas generated in the forums of the industrial area. |
| P2: Generate free flow of information from the PI area for processes innovation. | Average<br>The company culture and the generating ideas mechanisms allow the flow. | Average<br>The quality area takes the ideas of PI area, presented in the forums, to be incorporated. | Average<br>Innovation committee allows the free flow of ideas. | Null<br>There are no specific procedures. |
| P3: Encourage the incorporation of PI ideas in process innovation projects. | High<br>People of improvement area participate in the new process development teams. Committees and information systems assist the incorporation. | Average<br>Incorporation takes place through intermediarie s such as the Quality area representativ e. | High<br>Improvement ideas are presented in all forums. | Low<br>Improvement ideas can be presented in the forums of their areas. |
| P4: Transformation of ideas from improvement projects/area in projects of process innovation. | Average<br>The ideas come as a possibility to be used in new developments, but there is not a structured procedure. | Low<br>There are no specific procedures. | Average<br>Ideas are taken for committees to check for suitability to the strategy. | Null<br>There are no specific procedures. |

A summary of the use of practices encountered by the companies can be seen in Table 11.

*Table 1: Analysis of the use of practices*

| **Practices** | **Analysis of the use of practices** |
|---|---|
| **R1: PI supports product innovation** | |
| P1 | Companies use shared or product development goals to direct PI actions, however, there are still difficulties in alignment of product innovation and PI goals for being in different areas in organizations. |
| P2 | Companies encourage PI by prioritizing projects that are related to development / product innovation and sharing goals, but there is no proper procedures and behaviours structured for this purpose. |
| P3 | Knowledge management between improvement projects and product |

| | |
|---|---|
| | innovation is still a complex and unstructured point, only one company has database in which the PI can rescue knowledge to assist in product innovation. |
| P4 | The involvement of people from the improvement area in product innovation projects occurs in two of the companies by the spread of Six Sigma methodology and, in another, the participation of improvement persons in innovation committees where decisions are made. |
| P5 | In two companies the involvement link occurs by members of the Six Sigma program, indicating the needs of Six Sigma projects. The involvement occurs by a person who joins the areas. In another company the involvement is coordinated by the committee and later, the improvement and product innovation teams are align. |
| **R2: PI supports processes innovation** | |
| P1 | The main incentive is the participation in innovation forums that link the needs of process innovation and ask for assistance to the participating areas, including PI area. |
| P2 | The free flow of PI’s ideas for processes innovation occurs by own mechanisms of generating ideas, forums and committees. |
| P3 | The incorporation of ideas takes place through mechanisms such as forums and committees and the participation of people from the improvement area in process innovation projects. |
| P4 | Ideas are generally incorporated in project development of new processes, but there is no creation of innovation projects as a result of ideas. |

## CONCLUSIONS

The research identified practices that allow PI to support IPP. Practices were raised both by the literature review as by the respondents in the studied companies. It was observed that different practices are important to foster the support.

The relation "PI supports product innovation" has average and high presence in three of the analyzed companies indicating that the PI can assist in product innovation. The company with high presence (company C) operates in the chemical sector and has product / process dependency, this may be the reason for the high presence.

It was identified five practices for “PI supports product innovation”: sharing goals; stimulate the PI during development; information sharing; participation of people from PI in innovation team; and involvement of improvement area in development activities. However, there is still difficulty for companies to share information between innovation and PI areas and involve improvement area in product development projects. This involvement occurs when there is participation of people from improvement area in product development projects, especially the participation of members of the Belt hierarchy in the projects, necessary due to the use of DFSS in projects. There is an increased use of practices such as PI stimulus during development, emphasizing the dependence between the process of development of new products and PI, furthermore, there is an alignment of the goals of these two areas, so that the benefits are mutual and generate greater impact and alignment of efforts.

All the analyzed companies indicated that the PI can assist in process innovation. The practices identified to enable this relationship are: encouraging the generation of innovative ideas of people from PI area; free flow of ideas and information sharing; transfer of ideas from improvement to innovation and transformation of PI ideas into innovation projects. The high connection between people and actions from the improvement and innovation processes enables practices to be implemented, generating an encouragement of ideas and PI projects that have potential for innovation, provided that they are aligned with the organization's goals. The information sharing and the use of ideas are mainly linked to the connection between the areas, often occurring through forums and people that connect the areas. It is also difficult for the companies to create specific procedures for these practices to occur.

The paper allows a reflection on the role of PI in relation to innovation of products and processes. The managerial implications are related to the vision of PI over innovation, if there is an understanding that PI can support innovation resources and actions can be directed to foster such support. A research effort is needed to clarify other questions such as the impact of PI in the performance of innovation and identification of intra-company factors that influence this relationship. A greater number of companies' investigations is necessary or even of companies from a specific sector, as there may be significant differences in practices for companies from different industries and technologies.

## ACKNOWLEDGEMENTS

The authors would like to thank the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq, Brazil) - grant #45994220140.

## REFERENCES

Abrunhosa, A., and Sa, P. M. E., (2008), Are TQM principles supporting innovation in the Portuguese footwear industry?. Technovation, 28(4), 208-221.

Anand, G., Ward, P. T., Tatikonda, M. V., and Schilling, D.A., (2009), Dynamic capabilities through continuous improvement infrastructure. Journal of Operations Management, 27, 444-461. Andersson, R., Eriksson, H., and Torstensson, H., (2006), Similarities and differences between TQM, six sigma and lean. The TQM Magazine, 18(3), 282-296.

Angelis, J., and Fernandes, B., (2012), Innovative lean: work practices and product and process improvements. International Journal of Lean Six Sigma, 3(1), 74 – 84.

Antony, J., (2015), The ten commandments of quality: a performance perspective. International Journal of Productivity and Performance Management, 64(5), 723 – 735.

Asif, M., de Vries, H. J., and Ahmad, N., (2013), Knowledge creation through quality management. Total Quality Management & Business Excellence,24(5-6), 664-677.

Bartezzaghi, E., Corso, M., and Verganti, R., (1997), Continuous improvement and inter-project learning in new product development. Technology Management, 14(1), 116-138.

Bauer, M., and Leker, J. (2013). Exploration and exploitation in product and process innovation in the chemical industry. R&D Management, 43(3), 196-212.

Benner, M.J., and Tushman, M.L., (2002), Process management and technological innovation: A longitudinal study of the photography and paint industries. Administrative Science Quarterly, 47, 676–707.

Benner, M.J., and Tushman, M.L., (2003), Exploitation, exploration, and process management: The productivity dilemma revisited. Academy of Management Review, (28), 238–56.

Benner, M. J., and Tushman, M. L., (2015), Reflections on the 2013 Decade Award —“Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited” Ten Years Later. Academy of Management Review, 40(4), 497-514.

Berente, N., and Lee, J., (2013)., How process improvement efforts can drive organisational innovativeness. Technology Analysis & Strategic Management, 26(4), 1-17.

Bessant, J., Caffyn, S., and Gallagher, M., (2001), An evolutionary model of continuous improvement behavior. Technovation, 21(2), 67-77.

Bessant, J., and Francis, D., (1999), Developing Strategic Continuous Improvement Capability. International Journal of Operations & Production Management, 19(11), 1106-1119.

Bhuiyan, N., and Baghel, A., (2005), An overview of continuous improvement: from the past to the present. Management Decision, 43(5), 761-771.

Bhuiyan, N., Baghel, A., and Wilson, J., (2006), A sustainable continuous improvement methodology at an aerospace company. International Journal of Productivity and Performance Management, 55(8), 671-687.

Boer, H., Caffyn, S., Corso, M., Coughlan, P., Gieskes, J., Magnusson, M., Pavesi, S., and Ronchi, S., (2001), Knowledge and continuous innovation: the CIMA methodology. International Journal of Operations & Production Management,21(4), 490-504.

Boland, R. J., Lyytinen, K., and Yoo, Y., (2007), Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. Organization science, 18(4), 631-647.

BRASIL. Ministério do Planejamento, Desenvolvimento e Gestão (MP). Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa de Inovação (PINTEC). Rio de Janeiro: 2016.

Brereton, P., Kitchenham, B. A., Budgen, D., Turner, M., & Khalil, M. (2007). Lessons from applying the systematic literature review process within the software engineering domain. Journal of systems and software, 80(4), 571-583. http://dx.doi.org/10.1016/j.jss.2006.07.009

Chapman, R., and Hyland, P. (2004). Complexity and learning behaviors in product innovation. Technovation, 24(7), 553-561.

Chapman, R., O'Mara, C. E., Ronchi, S., and Corso, M. (2001). Continuous product innovation: A comparison of key elements across different contingency sets. Measuring Business Excellence, 5(3), 16-23.

Cole, R.E., and Matsumiya, T. (2008). When the pursuit of quality risks innovation. The TQM Journal, 20(2),130-142, 2008.

Corso, M. (2002). From product development to Continuous Product Innovation: mapping the routes of corporate knowledge. Int. J. Technology Management, 23(4), 322.

Corso, M., and Pavesi, S. (2000) How management can foster continuous product innovation. Integrated Manufacturing Systems, 11(3), 199-211.

Damanpour, F. (1987). The Adoption of Technological, Administrative, and Ancillar. Journal of Management, 13(4), 675-688.

Drohomeretski, E., Costa, S.E.G., Lima, E., and Garbuio, P.A.D.R. (2014). Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy. International Journal of Production Research, 52(3), 804-824.

El-Ella, N. A., Stoetzel, M., Bessant, J., and Pinkwart, A. (2013). Accelerating high involvement: The role of new technologies in enabling employee participation in innovation. International Journal of Innovation Management, 17(06), pp. 1340020 – 1340020-22.

Garcia, R., and Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. The Journal of Product Management, 19, 110-132.

Garcia-Sabater, J. J., Marin-Garcia, J. A., & Perello-Marin, M. R. (2012). Is implementation of continuous improvement possible? An evolutionary model of enablers and inhibitors. Human Factors and Ergonomics in Manufacturing & Service Industries, 22(2), 99-112.

He, Z., and Goh, Z. T., (2015), Enhancing the Future Impact of Six Sigma Management. Quality Technology & Quantitative Management, 12(1), 83-92.

Hoang, D. T., Igel, B., and Laosirihongthong, T., (2006), The impact of total quality management on innovation: Findings from a developing country. International Journal of Quality & Reliability Management, 23(9), 1092-1117.

Hoerl, R. W., and Gardner, M. M., (2010), Lean Six Sigma, creativity, and innovation. International Journal of Lean Six Sigma, 1(1), 30-38.

Honarpour, A., Jusoh, A., and Md Nor, K., (2012), Knowledge management, total quality management and innovation: A new look. Journal of Technology Management & Innovation, 7(3), 22-31.

Hung, R. Y. Y., Lien, B. Y. H., Yang, B., Wu, C. M., & Kuo, Y. M., (2011), Impact of TQM and organizational learning on innovation performance in the high-tech industry. International Business Review, 20(2), 213-225.

Irani, Z., Beskese, A., Love, P.E.D., (2004), Total quality management and corporate culture: constructs of organizational excellence. Technovation, 24(8), 643-650.

Irani, Z., and Sharp, J.M., (1997), Integrating continuous improvement and innovation into a corporate culture: a case study. Technovation, 17(4), 199-206.

Jager, B., Minnie, C., Jager, J., Welgemoed, M., Bessant, J., and Francis, D., (2004), Enabling continuous improvement: a case study of implementation. Journal of Manufacturing Technology Management, 15(4), p. 315-324.

Kim, D., Kumar, V., and Kumar, U., (2012), Relationship between quality management practices and innovation. Journal of Operations Management, 30( 4), 295-315.

Kornfeld, B. J., and Kara, S., (2011)., Project portfolio selection in continuous improvement. International Journal of Operations & Production Management,31(10), 1071-1088.

Kohlbacher, M., (2013), The impact of dynamic capabilities through continuous improvement on innovation: the role of business process orientation. Knowledge and Process Management, 20(2), 71-76.

Kowang, T. O., and Rasli, A., (2011), New product development in multi-location R&D organization: A concurrent engineering approach. African Journal of Business Management, 5(6), 2264-2275, 2011.

Lee, G., Bennett, D., and Oakes, I., (2000), Technological and organisational change in small- to medium-sized manufacturing companies: A learning organisation perspective. International Journal of Operations & Production Management, 20(5), 549-572.

Lee, V. H., Ooi, K. B., Tan, B. I., and Chong, A. Y. L., (2010), A structural analysis of the relationship between TQM practices and product innovation. Asian Journal of Technology Innovation, 18(1), 73-96.

Lin, H. E., and McDonough, E. F., (2011), Investigating the role of leadership and organizational culture in fostering innovation ambidexterity. IEEE Transactions on engineering management, 58(3), 497-509.

Lopes, R. B., Freitas, F., and Sousa, I., (2015), Application of Lean Manufacturing Tools in the Food and Beverage Industries. Journal of Technology Management & Innovation, 10(3), 120-130.

Lu, Q., and Botha, B., (2006), Process development: a theoretical framework.International Journal of Production Research, 44(15), 2977-2996.

Luzon, M.D.M, and Pasola, J.V., (2011), Ambidexterity and total quality management: towards a research agenda, Management Decision, 49(6), 927 – 947.

Martini, A., Laugen, B. T., Gastaldi, L., and Corso, M., (2013), Continuous innovation: towards a paradoxical, ambidextrous combination of exploration and exploitation. International Journal of Technology Management, 61(1), 1-22.

Martínez-Costa, M., and Martínez-Lorente, A. R., (2008), Does quality management foster or hinder innovation? An empirical study of Spanish companies. Total Quality Management, 19(3), 209–221.

McAdam, R., and Armstrong, G. (2001). A symbiosis of quality and innovation in SMEs: a multiple case study analysis. Managerial Auditing Journal, 16(7), 394-399.

McAdam, R., Armstrong, G., and Kellly, B., (1998), Investigation of the relationship between total quality and innovation: a research study involving small organizations. European Journal of Innovation Management, 1(3),139-147.

McAdam, R., Moffett, S., Hazlett, S. A., and Shevlin, M., (2010), Developing a model of innovation implementation for UK SMEs: A path analysis and explanatory case analysis. International Small Business Journal, 28(3), 195-214.

Moreno-Luzon, M. D., Gil-Marques, M., and Arteaga, F., (2014), Driving organisational ambidexterity through process management. The key role of cultural change. Total Quality Management & Business Excellence, 25(9-10), 1026-1038.

Nijhof, A., Krabbendam, K., and Looise, J. C., (2002), Innovation through exemptions: building upon the existing creativity of employees. Technovation, 22(11), 675-683.

Nilsson-Witell, L., Antoni, M., and Dahlgaard, J.J., (2005), Continuous improvement in product development: Improvement programs and quality principles. Internationa lJournal of Quality & Reliability Management, 22(8), 754-776.

O'Brien, L., and O'Reilly, P., (2010), An Investigation of Process Innovation Activity Levels and their Influencing Factors in Two Irish Manufacturing Facilities. In Proc. 2010 IEEE- International Conference on Management of Innovation & Technology, pp. 863-868. Singapore: Furama Riverfront.

O’Reilly, C. A., and Tushman, M. L., (2004), The ambidextrous organization. Harvard business review, 82(4), 74-83.

Perdomo-Ortiz, J., González-Benito, J., and Galende, J., (2006), Total quality management as a forerunner of business innovation capability. Technovation, 26(10), 1170-1185.

Prajogo, D. I., and Sohal, A. S., (2004), The multidimensionality of TQM practices in determining quality and innovation performance—an empirical examination. Technovation, 24(6), 443-453.

Prajogo, D. I., and Sohal, A. S., (2003), The relationship between TQM practices, quality performance, and innovation performance: An empirical examination. International journal of quality & reliability management, 20(8), 901-918.

Prajogo, D. I., and Sohal, A. S., (2001), TQM and innovation: a literature review and research framework, Technovation, 21( 9), 539-558.

Regan, P., and Kleiner, B. H., (1997), New developments in improving quality management in research and development. Aircraft Engineering and Aerospace Technology, 69(1), 26-30.

Sadikoglu, E., and Zehir, C., (2010), Investigating the effects of innovation and employee performance on the relationship between total quality management practices and firm performance: An empirical study of Turkish firms. International Journal of Production Economics, 127(1), 13-26.

Salah, S., Rahim, A., and Carretero, J. A., (2010), The integration of Six Sigma and lean management. International Journal of Lean Six Sigma, 1(3), 249-274.

Salomo, S., Weise, J., and Gemünden, H. G., (2007), NPD planning activities and innovation performance: the mediating role of process management and the moderating effect of product innovativeness. Journal of Product Innovation Management, 24(4), 285-302.

Santos-Vijande, M. L., and Álvarez-González, L. I., (2007), Innovativeness and organizational innovation in total quality oriented firms: The moderating role of market turbulence. Technovation, 27(9), 514-532.

Silva, G. M., Gomes, P. J., Lages, L. F., and Pereira, Z. L., (2014), The role of TQM in strategic product innovation: an empirical assessment. International Journal of Operations & Production Management, 34(10), 1307 – 1337.

Singh, P. J., and Smith, A. J., (2004), Relationship between TQM and innovation: an empirical study. Journal of Manufacturing Technology Management, 15(5), 394-401.

Sohal, A. S., Terziovski, M., and Zutshi, A., (2003), Team-based strategy at Varian Australia: a case study. Technovation, 23(4), 349-357.

Suárez-Barraza, M. F., and Smith, T., (2014), The Kaizen approach within process innovation: findings from a multiple case study in Ibero-American countries. Total Quality Management & Business Excellence, 25(9-10), 1002-1025.

Suárez-Barraza, M. F., Smith, T., and Dahlgaard-Park, S. M., (2012), Lean Service: A literature analysis and classification. Total Quality Management & Business Excellence, 23(3-4), 359-380.

Sun, H.; Zhao, Y.; and Yau, H. K., (2009), The relationship between quality management and the speed of new product development. The TQM Journal, 21(6), 576-588.

Terziovski, M., (2002), Achieving performance excellence through an integrated strategy of radical innovation and continuous improvement. Measuring Business Excellence, 6(2), 5-14.

Tidd, J., Bessant, J., and Pavitt, K., (2008), Gestão da inovação. Porto Alegre: Bookman.

Torres Jr., A., and Gati, A. M., (2011), Identification of barriers towards change and proposal to institutionalize continuous improvement programs in manufacturing operations. Journal of Technology Management & Innovation, 6(2), 94-109.

Tranfield, D., Denyer, D., and Smart, P., (2003), Towards a methodology for developing evidence-informed management knowledge by means of systematic review. British Journal of Management, 14, 207–222.

Utterback, J. M., (1996), Mastering the dynamics of innovation. Boston: Harvard Business School Press.

Utterback, J. M., and Abernathy, W. J., (1975), A dynamic model of process and product innovation. Omega, 3(6), 639-656.

Yang, C. L., Lin, S. P., Chan, Y. H., and Sheu, C., (2010), Mediated effect of environmental management on manufacturing competitiveness: an empirical study. International Journal of Production Economics, 123(1), 210-220.

Zairi, M., (1995), Moving from continuous to discontinuous innovation in FMCG: a re-engineering perspective. World Class Design to Manufacture, 2(5), 32-37.

Zhang, D., Linderman, K., and Schroeder, R. G., (2012), The moderating role of contextual factors on quality management practices. Journal of Operations Management, 30(1), 12-23.