Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8664
Doi: 10.4025/actascitechnol.v40i1.35242

MECHANICAL ENGINEERING

New product development in small and medium-sized technology based companies: a multiple case study

Eduardo Gomes Salgado*, Valério Antonio Pamplona Salomon, Carlos Henrique Pereira Mello and Carlos Eduardo Sanches da Silva

Instituto de Ciências Exatas, Universidade Federal de Alfenas, Rua Gabriel Monteiro da Silva, 700, 37130-000, Alfenas, Minas Gerais, Brazil.
**Author for correspondence. E-mail: egsalgado@yahoo.com.br*

ABSTRACT. The new product development (NPD) becomes more and more critical for the competitiveness, due to increasing internationalization of markets and diversification of products and decreasing life cycle of products. This paper addresses gaps in NPD literature, presenting a multiple case study involving small and medium-sized enterprises (SMEs), all of them are technology-based companies (TBC) manufacturers of electronics. A detailed investigation was conducted and three main sources of data were used for each case: documents from companies, in-depth interviews with NPD managers, and real-time observations. The different data sources enhanced reliability and validity to results. Our main finding is the identification of characteristics (e.g. Investment, establishing date, ISO 9001 certification) which influence these NPD in SMEs TBCs.

Keywords: electronics company; Product Management; company size.

Desenvolvimento de novos produtos em pequenas e médias empresas de base tecnológica: estudo de casos múltiplos

RESUMO. O processo de desenvolvimento de novos produtos (PDP) torna-se cada vez mais crítico para a competitividade das empresas, devido à crescente internacionalização dos mercados, à diversificação de produtos e à redução do ciclo de vida dos produtos. Esta pesquisa aborda lacunas na literatura de desenvolvimento de novos produtos, por meio da apresentação de um estudo de casos múltiplos envolvendo pequenas e médias empresas (PMEs) de base tecnológica (EBT), fabricantes de produtos eletrônicos. A pesquisa foi realizada, utilizando três fontes principais de dados: documentos das empresas, entrevistas em profundidade com os gerentes de PDP e observações em tempo real pelos pesquisadores. As diferentes fontes de dados melhoraram a confiabilidade e a validade dos resultados. A principal descoberta da pesquisa é a identificação de características que influenciam os PDPs das pequenas e médias empresas de base tecnológica (por exemplo: investimento, data de abertura da empresa, certificação ISO 9001).

Palavras-chave: empresas eletrônicas; gestão de produtos; tamanho das empresas.

Introduction

The quest for innovation and launching of new products to the market acceptance are main concerns of various economic sectors. New Product Development (NPD) is important to keep the company competitive in industrial branches as aerospace, automobile, electronics, food, furniture, and pharmaceutical, to name a few (Tyagi & Sawhney, 2010; Brentani, Kleinschmidt, & Salomo, 2010; Lee, Mackenzie, Fong, & Sherman, 2016; Vezzetti, Alemanni, & Morelli, 2017).

Continuously improve the performance of NPD has been the focus of several studies such as: Yeh, Pai, and Yang (2008); Rundquist and Halila (2010); Panizzolo, Biazzo, and Garengo (2010); Park (2010); Salgado, Salomon, Mello, and Silva (2014); Mendes, Salgado, and Ferrari (2016); Bashir, Papamichail, and Malik (2017); Krishnan and Scullion (2017). Then, new methods, tools, strategies, techniques, were successfully applied to NPD, reducing costs, shortening product development, improving quality, facilitating manufacture, and so on. NPD models supports the creation of strategies, reasoning, insights and communication. However, according to Scozzi, Garavelli, and Crowston (2005) NPD models alone do not ensure success in product development. This is because the successful product development depends on other factors as the ability of the project manager, the company's infrastructure and even the correct application of NPD models.

According to Millward and Lewis (2005), Koufteros, Vonderembse, and Jayaram (2005), Millward, Byrne, Walters, and Lewis (2006), Mu,

Peng, and Tan (2007), Love and Roper (2015), Acs, Audretsch, and Lehmann (2017) and Maksimov, Wang, and Luo (2017) small and medium-sized enterprises (SMEs) represent a key element in national economies all over the world. SMEs are a major driver of employment growth. Most of the NPD literature focuses on the activities of large well-known companies or within the context of well-developed economies, but the literature within SMEs located in developing countries is more limited (Toledo, Mendes, Jugend, & Silva, 2013; Mendes & Toledo, 2015). For Siu, Lin, Fang, and Liu (2006), various researches on NPD were conducted in large firms and the results do not necessarily apply in the context of SMEs. However, Bommer and Jalajas (2004) found that innovation in SMEs exceeds the rates of the largest companies, and some sources for innovation are different among them.

In agreement with Brunswicker and Vanhaverbeke (2015) and Grimpe, Sofka, Bhargava, and Chatterjee (2017), the introduction of a new product in the market by SMEs is risky and difficult. There is a growing need for a systematic or a method for evaluating new product opportunities in the early stages of development, but with fewer resources. For Toni and Nassimbeni (2003), the limited availability of financial resources is not a barrier for developing new products, since the lack of resources, firm size and shortened product cycles are characteristics of SMEs (Quian & Li, 2003).

O'Dwyer and Ledwith (2009) and Brunswicker and Vanhaverbeke (2015) indicated that SMEs should be aware of the strong relationship between the performance of NPD and organizational performance. Companies that are good at developing new products are those that have the best results. In addition, companies that are good at product launches are more likely to succeed in the new product, this is important for SMEs.

Therefore, there are two main questions of research:

• What is the characterization of the NPD management in SMEs?

• What features are more relevant for SMEs to face market challenges?

To answer these questions, a multiple case study was conducted in an industrial cluster of electronics located in Southeast Brazil. Five different SMEs were studied. All of them were Technology-Based Companies (TBCs). This article has more four sections after this Introduction: the next section brings a literature review; the following explains the research method; section four presents data and results; and the last sections presents research conclusions.

Literature review

New product development

NPD refers to the steps, activities, tasks, stages and decisions that involve the project of developing a new product/service or improvement on an existing one, since the initial idea to discontinue the product, in order to systematize this process. NPD identifies customer's wishes translated into specifications to be developed in products. It is important to mention that the NPD covers the instructions elaboration for supply, production, assembly, distribution logistics, use and recycling, as presented in Figure 1. All of them are tied to the strategy, limitations and operational possibilities of the company and customer needs (Salgado, Salomon, & Mello, 2012). In the same line of thought, it is possible to define as a new product the creation of a very different product from those existing on the market or the improvement on an existing one.

Due to rapid technological changes, companies are operating in several markets that require more frequent innovation, increased diversity and variety of products, shorter life cycles of products and a product with high quality and reliability (Nijssen & Frambach, 2000; Koufteros et al., 2005; Xin, Yeung, & Cheng, 2008; Salgado, Salomon, Mello, Fass, & Xavier, 2010; Brunswicker & Vanhaverbeke, 2015; Tavares, Silva, & Souza, 2016).

According to Filippini, Salmaso, and Tessarolo (2004), developing new products quickly became a priority in many organizations, including manufacturers of electronic products. As Jun and Suh (2008), NPD is complex and unstructured compared to the manufacturing processes, because it has iterative, evolutionary, cooperative and uncertain characteristics. In order to effectively control NPD, it is required to describe the activities of the stages and process logic. Although many enterprises know the importance of NPD in the development of long-term business, even with efforts toward the improvement of NPD, the failure rate of new products is elevated. There are several reasons for such high failure rates, being one of the most substantial, the low use of models, tools and techniques to assist the NPD (Rundquist & Chibba 2004; Yeh et al., 2008; Chandra & Neelankavil, 2008; Graner & Mißler-behr, 2014). Discovering how to succeed in NPD or identify the causes of failure became a goal of many researchers in recent years. Many authors (e. g. Rozenfeld et al., 2006) seek to represent the reality of product development

by using reference models. The models assist in designing a unique view of NPD, by describing it and serving as a reference for businesses and their professionals to develop products in accordance with an established pattern. The reference models can be developed to meet a specific type of organization, an industry or a local productive arrangement based on the type of NPD. Schmidt, Sarangee, and Montoya (2009) confirm this, where different organizations have different numbers of stages (phases) of activity and points of decision making in their NPD.

Taking into account studies in NPD in SMEs, we can cite the work carried out in Australia by Huang, Soutar, and Brown (2002, p. 27), who reported that marketing-related activities were undertaken less frequently and were less well executed than technical activities in developing new products. In addition, it is important to mention the work done by Nicholas, Ledwith, and Perks (2011), which indicated differences between the specific practices that NPD practitioners from SMEs and large companies considered to be the best practices. Research carried out in Brazil focusing on NPD in SME mention the model for product development proposed by Salgado et al. (2014).

Technology-based company

Dahlstrand (2007) states it is common to define a TBC as a company that is dependent on technology for their development and survival. However, this does not mean that technology has to be new or innovative. Besides that, Storey and Tether (1998) surveying articles from different countries claimed that each country defines technological company differently.

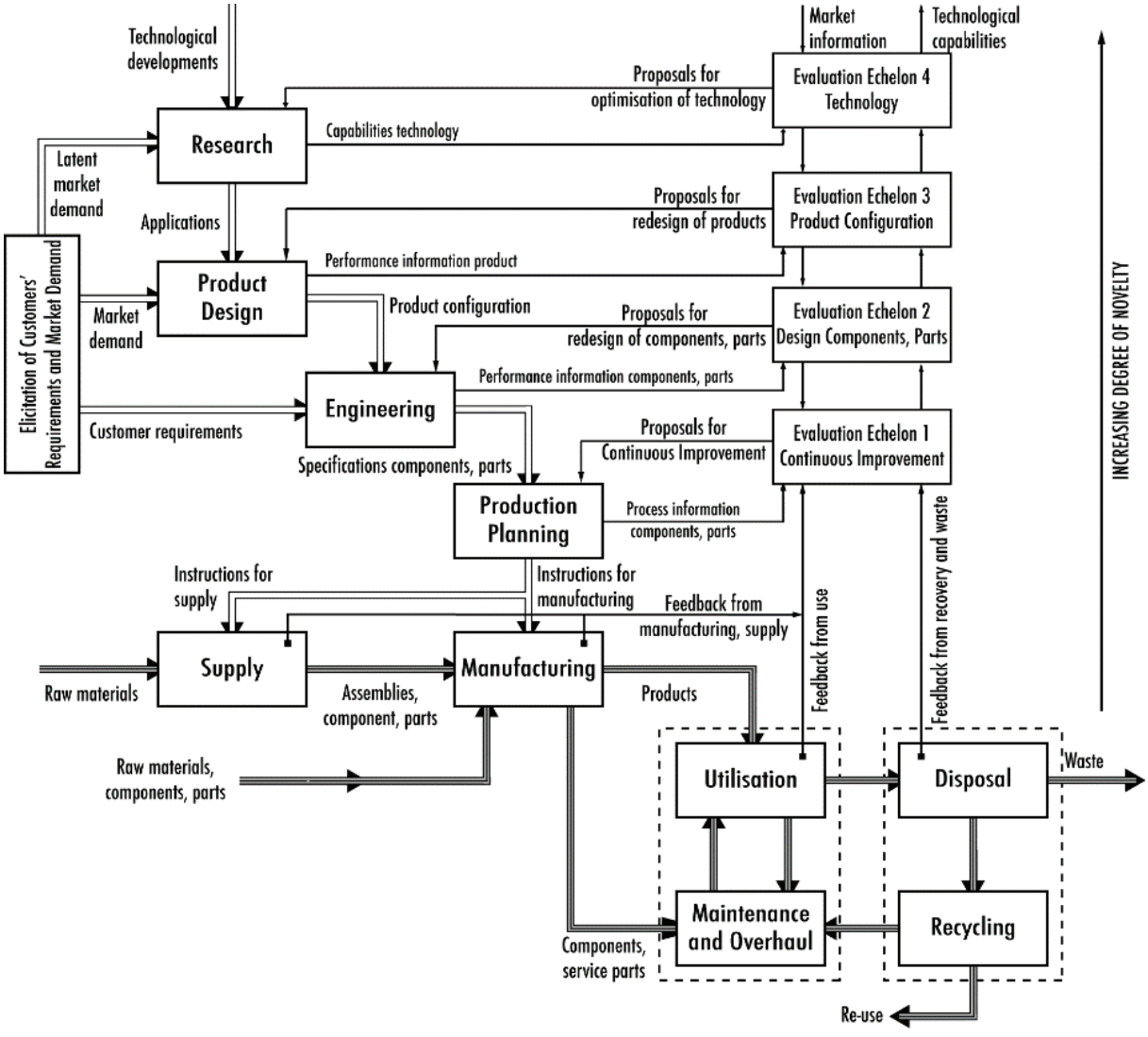

Figure 1. Generic reference model for engineering, manufacturing and deployment processes (Dekkers, Chang, & Kreutzfeldt, 2013).

Based on *Associação Nacional de Entidades Promotoras de Empreendimentos de Tecnologias Avançadas* (Anprotec, 2002), TBC is the one with a process or product result from scientific research and whose value arises from advanced technology fields such as: informatics, biotechnology, fine chemicals, precision engineering, new materials etc. and can further characterize the application of scientific knowledge, the field of complex techniques and toil of high technical qualification.

According to Ng (2006) and Silva and Santos (2017), TBCs have the characteristic of using emerging technologies to develop new products, services and solutions. In contrast to traditional industries, this type of technology company operates with an ongoing development to make gains for the delivery of new products, services and solutions with significant added value to the final customer. Then, since TBCs are generally intense in technology, they need well-structured product development processes to grow and achieve their goals.

We define technology as a specific type of knowledge (although this knowledge can be a material as well as a component, system or machine product). The key feature that distinguishes technology from other knowledge is that it is applied, focused on the know-how of the organization. Technology management involves identification, selection, acquisition, development, exploitation and protection of technology (Phaal, Farrukh, & Probert, 2004; Jarrín, Jaramillo, & Castorena, 2016).

Material and methods

Research method

For Martins (2010), the most appropriate methods for qualitative research are case study and action research. The case study was chosen because the objective of the research is to deepen the knowledge about a problem that is not sufficiently defined. Furthermore, the case study was selected because it is the appropriate research method to investigate the how and why of a set of contemporary events (Yin, 2005), as well as to describe the situation of the context in which it is being carried out research to identify the key features of technology-based small and medium-sized electronics sector companies. Additionally, the research aimed to stimulate understanding about the topic and to raise new hypotheses and questions, which justifies the use of this method. In addition, the main tendency in all types of case studies is that they attempt to clarify why a decision or set of decisions were made, how they were implemented, and with what results (Eisenhardt, 1989; Yin, 2005; Miguel, 2007). Based on Voss, Tsikriktsis, and Frohlich (2002), there are many challenges when conducting a case study: it is very time consuming, requires interviewers with skills and knowledge, care must be taken on the generalization of the findings from a limited number of cases and ensuring the rigor of the research. Nevertheless, the findings of case studies can have a powerful impact and lead to new and inventive insights and the development of new theories.

The steps proposed by Miguel (2007) were used to conduct this research, namely: define a theoretical conceptual framework plan cases, conduct pilot testing, collect data, analyze data and generate the report. It is also necessary a survey with regards to the characteristics of TBCs. For this, we used a research protocol. The use of the protocol allows the researcher to enhance the current knowledge about the subject and provides concepts for the construction of the adapted model. However, before performing the diagnosis in TBCs on SMEs manufacturers of electronics, a research protocol was tested in a technology-based incubator inside a university. Testing had as objective to diagnose doubt relevant to the questionnaire in both the interviewer and the interviewee, in order to improve it. Thus, it was included items appropriate to the research. Furthermore, the test was important to the analysis of the duration of the interview. The research protocol is applied to diagnose NPD in SMEs TBCs electronics manufacturers. This diagnosis is obtained through interviews, observations by the researcher and documentary analysis. During this stage, a multiple case study is developed. This multiplicity of sources of evidence is essential for reliability of the data collected, as well as increases the validity of the research, as affirmed by Martins (2010). The report generated in the multiple case studies are subjected to the interviewees for analysis and adjustments of the responses.

The *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES) is a Brazilian public company financing instrument for long-term investments in all segments of the economy, a policy which includes social, regional and environmental dimensions. BNDES considers as small-sized companies those with annual revenues between US$ 2.4 and US$ 16 million; midsized businesses

annual revenues vary from US$16 to US$ 90 million (BNDES, 2010). Moreover, researchers such as Hoffmann and Schlosser (2001) and Kaminski, Oliveira, and Lopes (2008) take into account the number of employees. Thus, the values vary, respectively, for small and midsized businesses, from one to 10 and 11–500.

The diagnosis of the NPD in TBEs Electronic manufacturers as proposed by this research has as its object of study an industrial cluster of electronics, located in the south of the State of Minas Gerais, Southeast Brazil. According to *Federação das Indústrias do Estado de Minas Gerais* (Fiemg, 2007), this cluster supplies 70% of Brazilian broadcasting market and is a pioneer in research as in the context of the Digital TV system. The cluster is made up of approximately 120 companies, where 40% are electronics manufacturers. Only 12% of companies use Project Management Body of knowledge (PMBOK), 57% developed their own system of management and 28% do not use any method. This indicates great potential for development of systematics, based on established or enhanced methods to enable the improvement of management in business practices. It is considered that the performance of NPD in these companies can be improved by adopting models and good practices of project management and product development.

The non-uniformity of the manufacturing company structures, with regards to the amount and types of equipment, was not taken into consideration. Therefore, this diagnosis does not cover the overall process of development in various sectors, but, the interviewed electronic companies.

Results and discussion

The NPD diagnosis of the companies was carried out based on information collected from interviews with those in charge from the areas of product development enterprises, by direct observation of the researcher and documents and records of the company, meeting the proposed by Yin (2005) and Miguel (2007). Consequently, five companies based on the criteria of the research method, i.e, company size and sector were selected. All companies met the defined requirements and have a NPD that has the role of accelerating technological diffusion and increasing the company's competitiveness in the same way as seen in Lindelöf and Löfsten (2003).

For the interview, a research protocol was used. For confidentiality reasons, the names of the companies were not revealed. Among those companies selected for the research, it can be considered that four companies are considered medium size and a small business. The company which has the features of a small company operates in the switching power supplies, chargers and nobreaks sector. Among the other four companies considered medium size, three operate in the telephony and telecommunications and the fourth in the alarm industry, building industry and home monitoring (Table 1). Table 2 lists the main features of each enterprise interviewed person.

It was evident that none of the interviewed companies went through a business incubator. This may have occurred because the foundation of the companies was before the opening of business incubators in the city, or the company was acquired or the lack of knowledge of the incubators. It cannot be affirmed that the time for the development of enterprises, the time for product development and form of managing the NPD would have been different if the companies had gone through incubator. Note that the company D was founded in the 70s, the E company in the 80s, the company A in the 90s and companies B and C, in 2005 and 2003.

Table 1. SMEs features.

	Company A	Company B	Company C	Company D	Company E
Business field	Alarms and building monitoring	Power sources, Nobreaks, Chargers	Transmitters, receptors and modulators	Transmitters and re-transmitters	PABX and telephony integrated solutions
Establishing date	1994	2005	2003	1977	1983
Staff number	180	20	70	350	160
Average annual profit Ref. (2009)	Not published	1.5 millions	12 millions	75 millions	38 millions
Number of projects	20	4	4	14	5
Number of sustainable projects	None	1	None	None	None
P&D investment	-	3% of profit	7% of profit	25% of profit	7% of profit
Product development structure	Matrix	Functional	Matrix	Matrix	Matrix
Project management training	PDP manager with post-graduation in project management	Projects Manager with 15 years of experience in other companies	Industrial manager with experience in other enterprises	P&D manager with Master's in Production Engineering	PDP manager with a training course in project management

Table 2. Features of interviewed staff.

Feature	Company A	Company B	Company C	Company D	Company E
Enterprise business time	5 years	6 years	7 years	10 years	13 years
Job post time	2 years	6 years	7 years	4 years	6 years
Academic graduation	– Electric engineer-telecommunications; – Project management expert	– Electric engineer-telecommunications; – Project management expert	– Electric engineer-telecommunications; – Project management expert	– Electric engineer; – MBA in Production engineering; – Master's in Production engineering	– Electric/Eletronic engineer; – Entrepreneurial MBA; Innovation Expertise
Job Post	Project Manager	Industrial Manager	Industrial Manager	P&D Manager	P&D Manager
Work field	PDP	Management	Management	PDP	PDP

Considering the characteristics of the products developed by companies A and D, both have the largest number of projects in development, 20 and 14, respectively. The company A designs and develops 5 projects. Companies B and C have 4 projects each. These same companies are those with the lowest number of employees and lower sales among the five observed. The results found attends that proposed by Toni and Nassimbeni (2003) and Quian and Li (2003), who affirmed that limited availability of financial resources, the lack of resources, firm size and shortened product cycles are not a barrier to developing new products.

Company A is a company that has the highest number of projects under development simultaneously, but this is justified primarily by the fact that the products developed by this company have a lower value and a lower selling price, because of the specific industry, in comparison to the products of other companies.

An important fact is that 50% of company C revenue comes from new products. The remaining companies did not report this information. Another characteristic of the interviewed companies is that investment in research and development reaches 25% of the revenues of the company (Company D), which enables the creation of new technologies and new products. All companies considered being of medium size have agreements with science and technology institutions. Company B has no partners for the development of technology or to collaborate in developing new products.

Company D is the one which most invests in development research and the company that has the highest sales and highest number of products developed, pointing to the sense that a relationship exists between investment in R&D versus revenues versus number of products developed however as this research is limited to the NPD it will not address the issue of R&D.

Companies said that the tendency for the new products and the new technologies have originated in partnerships (both with research centers, educational institutions and suppliers), trade fairs, conferences, stock of patents and scientific articles.

Company D is the company that most launched new products, but remember that it is the company with the oldest foundation. However, the only company that reported that 100% of the developed products hit the market was the company E also showing a rate of 95% of products deemed to be successful. The worst product success rate was indicated by company B, with a success rate of 15% of the products. Companies A and D consider 70% of products successful.

Companies A, D and E hold an annual strategic planning and Companies B and C do not formalize such discussions. Thus, the outputs of this process for companies A, D and E are structured in a list with ongoing projects to be developed and potential projects for the company. Therefore, for the selection and defining which product designs will be developed brainstorming is mainly used. However, they take into account the return on investment, the amount of human resources required, the time and cost for developing and market analysis

Among the criteria for selecting projects to be developed, companies basically use financial analysis. All five companies stated that the use as a methodology to manage their projects the requisites defined by ISO 9001 and Companies A, C, D and E said they use the PMBOK. The company E stated that uses the stage-gates method as an aid in the project management. All companies have a formal plan for each project, with the exception of company B. This is because company B did not use the PMBOK methodology.

It was found that tools for the development of products such as Technology Roadmapping (TRM), Quality Function Deployment (QFD), Failure Mode and Effect Analyses (FMEA), Design for X (DFX), life cycle analyses and others are not being fully disseminated and used by all organizations. In company E, the TRM was being implemented because of expertise in innovation of project management. In other companies, this tool was not used. Meanwhile, tools like physical prototype, CAD, CAE and financial analysis were observed in all companies, regardless of their size. Thus, it can

be seen that the NPD could perform better because Yeh et al. (2008) assert that the tools and techniques of NPD can be used by companies to improve their performance in development of new products. The companies analyzed do not use tools and techniques of NPD.

During interviews in companies A, D and E, it was found that measuring the performance of NPD is done by means of performance indicators. Taking into account the project budgets that were exceeded, only company D presented that in none of its projects this problem had occurred.

Each company sets their needs to manage their processes. In this way, the company's Manager in NPD holds a postgraduate degree in project management, in company B, the Project Manager has 15 years of experience in managing projects in other companies, in the industrial company C, the director has experience in other companies, in Company D, the R&D manager holds a Master's degree in Production Engineering and the manager of NPD of company E has a basic training course in project management. In these cases, it is not possible to correlate the ability of the manager of the R&D area with the capacity of the undertaking in launching products. However, these data are similar to the research conducted by Oliver, Dostaler, and Dewberry (2004) as relate to time of experience and knowledge of each manager.

For each specific project development, the companies A and C claimed that the project manager is assigned by area of expertise, skills and availability. For company D, the project manager is chosen by technical knowledge. Company E said that the project manager defines the functional manager of the area involved and company B is the partner/director of the company, primarily by size.

The greatest difficulty for development of new products by Company A is the study the competitors and access to market information. For Company B, due to its size, the biggest difficulty is financial resources. Unlike the difficulty pointed out by C, it defined the qualified labor. Company D indicated as the main difficulty identifying the priorities projects and remain focused on the project. As for company E, in the same line of company B, the main difficulty is in resources. The only company which made a strategy for the development of new products was Company D, and the return of projects in the development shall finance upcoming projects. Company D and Company E have a formal record of lessons learned.

Analyzing trends that companies expect to adopt on NPD, the tendency is to develop sustainable products (Company B) and improving the reliability of the products (Company D). Two companies have shown a trend based on innovation, with the company and with open innovation and company C with simple solutions based on innovation.

It is noteworthy that all companies understand and practice the post-development in the NPD, with the exception of Company C. However, during the interview it was revealed that the companies practice post development stages, such as technical assistance. In this case it is noticed that the company understands post-development as the end of product life.

Companies A, C, D and E are certified by the ISO 9001:2008 and all possess their scope of certification in the procedure for product development. Company B, during the diagnosis, was in the QMS (Quality Management System) implementation process based on the ISO 9001:2008. So, it was possible to verify that the ISO 9001 helps structuring the NPD enterprises, mainly because the certification of the quality system is based on the processes. All companies described and evidenced that their activities are based on the requirements of ISO 9001.

By the end of the interviews, it was possible to identify the key phases and activities in the product development process of the analyzed companies. Therefore, comparing the activities performed by these companies making use of generic models were possible to verify that some activities such as planning activities for strategic planning review, defining the communications plan, reviewing and updating the product scope, monitoring and updating the economic and financial viability of the product, designing and manufacturing resources, detailing the life cycle of the product, plan the end of life of the product, plan the discontinuation of the product, preparing the receiving of the product and finalizing the product support were not identified in the product development process of the companies interviewed.

Nevertheless, for other activities, it was observed and provided that the firms performed in a partial manner or informally, such as analyzing product portfolio, proposing changes, evaluating risks, reviewing and updating the product scope, identifying customer requirements, defining ergonomics and aesthetics, selecting the design of the product, optimizing the process and product, optimizing the production, planning the launch, developing the production process and promoting marketing for the release.

Conclusion

Through the diagnosis, it was possible to see that the business of this branch permitted the acknowledgment that the generic NPD models are

not used in full as a reference by any of companies surveyed. Most of the companies surveyed takes its own model for developing products, but it can be seen that in some phases and activities observed in the models of companies surveyed are similar to the models found in the literature.

In companies that have a certified quality management system and which include the requirement for designing and developing the ISO 9001 standard, the field research appears to indicate greater ease of developing new products, both for the complete accomplishment of the steps as in evidence generation (records and controls) necessary to support the process.

The existence or the lack of a system of certified quality management that includes the requirement for design and product development was not a condition for the choice of the companies, but proved to be a facilitator noticed during diagnosis to model proposition of this research.

It is necessary to point out the difficulties and limitations of this work. Attempting to obtain primary data required a great research effort in order to select only those companies that could be considered as small and medium-sized technology-based manufacturers of electronic products. As this concept lacks more objective definitions, the difficulty of selecting units of analyses and accessing sources of evidence were aspects that generated part of the methodological limitations. In addition, methodological limitation comes from the case study since this method does not allow generalization of results.

Managerial implications

Notwithstanding, this study is an empirical research, whose results have several managerial implications for improving the NPD for SMEs. The authors expect that this work may contribute to improve the NPD practice in small and medium-sized electronics TBE. This is due to the availability of relevant information from companies that have similar characteristics and, consequently, to allow improvements in the process. Therefore, it can stimulate the development of new research in the field and provide information to allow companies to organize their NPD in order to increase competitiveness and technological competence. In addition, new product managers in SMEs need to be aware of how each attribute related to NPD activities affects performance metrics so that they can reach the best results in the NPD, taking into account the company size.

Further research

Evidently, many studies have already been developed with a focus on the NPD process. However, we also identified gaps in the literature from a theoretical and a practical perspective. Hence, suggestions for future research emerge from this work:

- First, there is a lack of empirical evidence about surveyed NPD with a focus on SMEs. For large companies, this has been well-researched, but there are differences between large companies and SMEs.
- Also, more research is necessary to compare the results with the NPD of SMEs in companies graduated in incubator centers.
- Finally, further attention by the academia seems to justify research on the relationship between ISO 9001 and innovation.

References

Acs, Z. J., Audretsch, D. B., & Lehmann, E. E. (2017). National systems of innovation. *The Journal of Technology Transfer, 42*(140), 1-12.

Associação Nacional de Entidades Promotoras de Empreendimentos de Tecnologias Avançadas. (2002). *Glossário dinâmico de termos na área de Tecnópolis, Parques Tecnológicos e Incubadoras de Empresas*. Brasília, DF: Editado Anprotec & Sebrae.

Banco Nacional de Desenvolvimento Econômico e Social. (2010). *Circular No 11/2010*. Recuperado de http://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/produtos/download/Circ011_10.pdf

Bashir, N., Papamichail, K. N., & Malik, K. (2017). Use of social media applications for supporting new product development processes in multinational corporations. *Technological Forecasting and Social Change, 120*, 176-183. doi: 10.1016/j.techfore.2017.02.028

Bommer, M., & Jalajas, D. S. (2004). Innovation sources of large and small technology-based firms. *Transactions on Engineering Management, 51*(1), 13-18. doi: 10.1109/TEM.2003.822462

Brentani, U., Kleinschmidt, E. J., & Salomo, S. (2010). Success in global new product development: impact of strategy and the behavioral environment of the firm. *Journal of Product Innovation Management, 27*(2), 143-160. doi: 10.1111/j.1540-5885.2010.00707.x

Brunswicker, S., & Vanhaverbeke, W. (2015). Open innovation in small and medium-sized enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management, 53*(4), 1241-1263. doi: 10.1111/jsbm.12120

Chandra, M., & Neelankavil, J. (2008). Product development and innovation for developing countries: Potential and challenges. *Journal of Management Development, 27*(10), 1017-1025. doi: 10.1108/02621710810916277

Dahlstrand, A. L. (2007). Technology-based entrepreneurship and regional development: the case of Sweden. *European Business Review, 19*(5), 373-386. doi: 10.1108/09555340710818969

Dekkers, R., Chang, C. M., & Kreutzfeldt, J. (2013). The interface between "product Design and Engineering" and manufacturing: A review of the literature and empirical evidence. *International Journal of Production Economics, 144*(1), 316-333. doi: 10.1016/j.ijpe.2013.02.020

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review, 14*(4), 532-550. doi: 10.2307/258557

Federação das Indústrias do Estado de Minas Gerais. (2007). Diagnóstico do arranjo produtivo da indústria do vale da eletrônica: mercado, tecnologia e inovação. Belo Horizonte, MG: Feimg/IEL Minas/Sindvel.

Filippini, R., Salmaso, L., & Tessarolo, P. (2004). Product development time performance: Investigating the effect of interactions between drivers. *Journal of Product Innovation Management, 21*(3), 199-214. doi: 10.1111/j.0737-6782.2004.00070.x

Graner, M., & Mißler-behr, M. (2014). Method application in new product development and the impact on cross-functional collaboration and new product success. *International Journal of Innovation Management, 18*(1) 1-25. doi: 10.1142/S0219877015500194

Grimpe, C., Sofka, W., Bhargava, M., & Chatterjee, R. (2017). R&D, marketing innovation, and new product performance: a mixed methods study. *Journal of Product Innovation Management, 34*(3), 360-383. doi: 10.1111/jpim.12366

Hoffmann, W. H., & Schlosser, R. (2001). Success factors of strategic alliances in small and medium-sized enterprises – an empirical survey. *Long Range Planning, 34*(3), 357-381. doi: 10.1016/S0024-6301(01)00041-3

Huang, X., Soutar, G. N., & Brown, A. (2002). New product development processes in small and medium□sized enterprises: some Australian evidence. *Journal of Small Business Management, 40*(1), 27-42. doi: 10.1111/1540-627X.00036

Jarrín, M. A. T., Jaramillo, I. E. P., & Castorena, D. G. (2016). Methodology for the of building process integration of Business Model Canvas and Technological Roadmap. *Technological Forecasting and Social Change, 110*(1), 213-225. doi: 10.1016/j.techfore.2016.01.009

Jun, H.-B., & Suh, H.-W. (2008). A modeling framework for product development process considering its characteristics. *IEEE Transactions on Engineering Management, 55*(1), 103-119. doi: 10.1109/TEM.2007.912808

Kaminski, P. C., Oliveira, A. C., & Lopes, T. M. (2008). Knowledge transfer in product development processes: a case study in small and medium enterprises (SMESs) of the metal-mechanic sector form São Paulo, Brazil. *Technovation, 28*(1-2), 29-36. doi:10.1016/j.technovation.2007.07.001

Koufteros, X., Vonderembse, M., & Jayaram, J. (2005). Internal and external integration for product development: the contingency effects of uncertainty, equivocality, and platform strategy. *Decision Sciences, 36*(1), 97-133. doi: 10.1111/j.1540-5915.2005.00067.x

Krishnan, T. N., & Scullion, H. (2017). Talent management and dynamic view of talent in small and medium enterprises. *Human Resource Management Review, 27*(3), 431-441. doi: 10.1016/j.hrmr.2016.10.003

Lee, Y., Mackenzie, W. I., Fong, E. A., & Sherman, J. D. (2016). The importance of inter-temporal integration in new product development. *International Journal of Fashion Design, Technology and Education, 20*(3), 110-123. doi: 10.1142/S1363919616500213

Lindelöf, P., & Löfsten, H. (2003). Science park location and new technology-based firms in sweden – implications for strategy and performance. *Small Business Economics, 20*(3), 245-258.

Love, J. H., & Roper, S. (2015). SME innovation, exporting and growth: A review of existing evidence. *International Small Business Journal: Researching Entrepreneurship, 33*(1), 28-48.

Maksimov, V., Wang, S. L., & Luo, Y. (2017). Reducing poverty in the least developed countries: The role of small and medium enterprises. *Journal of World Business, 52*(2), 244-257. doi: 10.1016/j.jwb.2016.12.007

Martins, R. A. (2010). Princípios da pesquisa científica. In P. A. C. Miguel (Org.), *Metodologia de pesquisa em Engenharia de Produção e Gestão de Operações* (p. 5-29). Rio de Janeiro, RJ: Campus/Elsevier.

Mendes, G. H. S., & Toledo, J. C. (2015). Organizational characteristics in concurrent engineering: Evidence from Brazilian small and medium enterprises in the medical device industry. *Concurrent Engineering, 23*(2), 135-144.

Mendes, G. H. S., Salgado, E. G., & Ferrari, B. E. M. (2016). Prioritization of TQM practices in Brazilian medical device SMEs using Analytical Hierarchy Process (AHP). *Dyna, 83*(197), 194-202. doi: 10.15446/dyna.v83n197.52205

Miguel, P. A. C. (2007). Estudo de caso na engenharia de produção: estruturação e recomendações para sua condução. *Revista Produção, 17*(1), 216-229. doi: 10.1590/S0103-65132007000100015

Millward, H., & Lewis, A. (2005). Barriers to successful new product development within small manufacturing companies. *Journal of Small Business and Enterprise Development, 12*(3), 379-394. doi: 10.1108/14626000510612295

Millward, H., Byrne, C., Walters, A., & Lewis, A. (2006). New product development within small and medium-sized enterprises: analysis through technology management maps. *International Journal of Innovation and Technology Management, 3*(3), 283-302.

Mu, J., Peng, G., & Tan, Y. (2007). New product development in Chinese SMEs: Key success factors from a managerial perspective. *International Journal of Emerging Markets, 2*(2), 123-143. doi: 10.1108/17468800710739216

Ng, A. W. (2006). Reporting intellectual capital flow in technology-based companies: Case studies of

Canadian wireless technology companies. *Journal of Intellectual Capital,* 7(4), 492-510. doi: 10.1108/14691930610709130

Nicholas, J., Ledwith, A., & Perks, H. (2011). New product development best practice in SME and large organisations: theory vs practice. *European Journal of Innovation Management, 14*(2), 227-251. doi: 10.1108/14601061111124902

Nijssen, E. J., & Frambach, R. T. (2000). Determinants of the adoption of new product development tools by industrial firms. *Industrial Marketing Management, 29*(2), 121-131. doi: 10.1016/S0019-8501(98)00043-1

O'Dwyer, M., & Ann, L. (2009). Determinants of new product performance in small firms. *International Journal of Entrepreneurial Behavior & Research, 15*(2), 124-136. doi: 10.1108/13552550910944548

Oliver, N., Dostaler, I., & Dewberry, E. (2004). New product development benchmarks: The Japanese, North American, and UK consumer electronics industries. *The Journal of High Technology Management Research, 15*(2), 249-265. doi: 10.1016/j.hitech.2004.03.006

Panizzolo, R., Biazzo, S., & Garengo, P. (2010). New product development assessment: towards a normative-contingent audit. *Benchmarking: An International Journal, 17*(2), 173-194. doi: 10.1108/14635771011036294

Park, Y. H. (2010). A study of risk management and performance measures on new product development. *Asian Journal on Quality, 11*(1), 39-48. doi: 10.1108/15982681011051813

Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). Technology roadmapping-a planning framework for evolution and revolution. *Technological forecasting and social change, 71*(1), 5-26. doi: 10.1016/S0040-1625(03)00072-6

Quian, G., & Li, L. (2003). Technology industry success: Strategic options for small and medium firms. *Business Horizons, 46*(5), 41-46.

Rozenfeld, H., Forcellini, F. A., Amaral, D. C., Toledo, J. C., Silva, S. L., Alliprandini, D. H., & Scalice, R. K. (2006). *Gestão de desenvolvimento de produtos. Uma referência para a melhoria do processo*. São Paulo, SP: Saraiva.

Rundquist, J., & Chibba, A. (2004). The use of processes and methods in NPD: a survey of Swedish industry. *International Journal of Innovation and Technology Management, 1*(1), 37-54. doi: 10.1142/S0219877004000076

Rundquist, J., & Halila, F. (2010). Outsourcing of NPD activities: a best practice approach. *European Journal of Innovation Management, 13*(1), 5-23. doi: 10.1108/14601061011013203

Salgado, E. G., Salomon, V. A. P., & Mello, C. H. P. (2012). Analytic hierarchy prioritisation of new product development activities for electronics manufacturing. *International Journal of Production Research, 50*(17), 4860-4866. doi: 10.1080/00207543.2012.657972

Salgado, E. G., Salomon, V. A. P., Mello, C. H. P., & Silva, C. E. S. (2014). A reference model for the new product development in medium-sized technology-based electronics enterprises. *IEEE Latin America Transactions, 12*(8), 1341-1348. doi: 10.1109/TLA.2014.7014499

Salgado, E. G., Salomon, V. A. P., Mello, C. H. P., Fass, F. D. M., & Xavier, A. F. (2010). Modelos de referência para desenvolvimento de produtos: classificação, análise e sugestões para pesquisas futuras. *Produção Online, 10*(4), 1-14. doi.org/10.14488/1676-1901.v10i4.520

Schmidt, J. B., Sarangee, K. R., & Montoya, M. M. (2009). Exploring new product development project review practices. *Journal of Product Innovation Management, 26*(5), 520-535. doi: 10.1111/j.1540-5885.2009.00678.x

Scozzi, B., Garavelli, C., & Crowston, K. (2005). Methods for modeling and supporting innovation processes in SMEs. *European Journal of Innovation Management, 8*(1), 120-137. doi: 10.1108/14601060510578619

Silva, A. S. R., & Santos, E. M. (2017). Social media in technology-based companies: a study on the use of facebook in áity incubator. *Gestão, Org-Revista Eletrônica de Gestão Organizacional, 14*(esp.), 213-223. doi: 10.21714/1679-18272016v14Esp2.p213-223

Siu, W. S., Lin, T., Fang, W., & Liu, Z. C. (2006). An institutional analysis of the new product development process of small and medium enterprises (SMEs) in China, Hong Kong and Taiwan. *Industrial Marketing Management, 35*(3), 323-335. doi: 10.1016/j.indmarman.2005.04.008

Storey, D. J., & Tether, B. S. (1998). New technology-based firms in the European union: an introduction. *Research Policy, 26*(9), 933-946. doi: 10.1016/S0048-7333(97)00052-8

Tavares, B. G., Silva, C. E. S., & Souza, A. D. (2016). Analysis of Scrum practices for risk treatment. *Product: Management & Develop-ment, 14*(1), 38-46. doi: 10.4322/pmd.2016.006

Toledo, J. C. D., Mendes, G. H. D. S., Jugend, D., & Silva, S. L. D. (2013). New product development in brazilian technology-based small and medium enterprises. *Product, 11*(1), 56-64. doi: 10.4322/pmd.2013.014

Toni, A., & Nassimbeni, G. (2003). Small and medium district enterprises and the new product development challenge: Evidence from Italian eyewear district. *International Journal of Operations & Production Management, 23*(6), 678-697. doi: 10.1108/01443570310476672

Tyagi, R. K., & Sawhney, M. S. (2010). High-performance product management: the impact of structure, process, competencies, and role definition. *Journal of Product Innovation* Management, 27(4), 83-96. doi: 10.1111/j.1540-5885.2009.00701.x

Vezzetti, E., Alemanni, M., & Morelli, B. (2017). New product development (NPD) of 'family business' dealing in the luxury industry: evaluating maturity stage for implementing a PLM solution. *International Journal of Fashion Design, Technology and Education, 10*(2), 219-229. doi: 10.1080/17543266.2016.1250286

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management, 22*(2), 195-219. doi: 10.1108/01443570210414329

Xin, J. Y., Yeung, A. C. L. E., & Cheng, T. C. E. (2008). Radical innovations in new product development and their financial performance implications: An event study of US manufacturing firms. *Operations Management Research, 1*(2), 119-128. doi.org/10.1007/s12063-009-0017-3

Yeh, T. M., Pai, F. Y., & Yang, C. C. (2008). Performance improvement in new product development with effective tools and techniques adoption for high-tech industries. *Quality and Quantity, 44*(1), 131-152.

Yin, R. (2005). *Estudo de caso. Planejamento e métodos* (3 ed.). Porto Alegre, RS: Bookman.

Received on February 6, 2017.
Accepted on July 28, 2017.