Involving suppliers in collaborative new product development: comparing large and small firms

Luís Filipe Silva

ISCA-UA,
University of Aveiro,
R. Associação Humanitária dos Bombeiros Voluntários de Aveiro,
3810-500 Aveiro, Portugal
Fax: +351-234-380-111
Email: filipersilva@sapo.pt

António Carrizo Moreira*

DEGEIT, GOVCOPP,
University of Aveiro,
Campus Universitário de Santiago,
Aveiro, 3810-193, Portugal
Fax: +351-234-370-350
Email: amoreira@ua.pt
*Corresponding author

Abstract: The main purpose of this article is to investigate early supplier involvement (ESI) in collaborative new product development (CNPD). For that a comparative study between small and medium-sized enterprises (SMEs) and large firms was implemented according to the generated innovation. It is based on an exploratory approach, based on case studies involving four firms that involve their suppliers in CNPD. Results show that ESI in CNPD takes place when large firms seek to differentiate their products and SMEs aim to increase their efficiency. The paper further shows the radical innovation promotes ESI in CNPD, both regarding SMEs and large firms. This study contributes to the body knowledge regarding the influence of radical innovation in early supplier involvement in CNPD, by adding a comparative perspective between SMEs and large firms.

Keywords: collaborative new product development; CNPD; new product development; small and medium-sized enterprises; SMEs; large firms.

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Biographical notes: Luís Filipe Silva holds a PhD in Marketing and Strategy from Aveiro University, Portugal. He obtained his Master's degree in Management also from Aveiro University. He holds a Bachelor's degree in Management from the University of Beira Interior, Portugal. He is an active trainer and management consultant in management where he has been working with several firms and institutions in strategy, accountancy, and finance. He is Invited Lecturer at ISCA, Univerisity of Aveiro and Instituto Superior Miguel Torga, Coimbra, Portugal.

António Carrizo Moreira obtained his Bachelor's degree in Electrical Engineering and Master's degree in Management, both from the University of Porto, Portugal. He received his PhD in Management from UMIST – University of Manchester Institute of Science and Technology, England. He has a solid international background in industry leveraged by working for a multinational company in Germany as well as in Portugal. He has also been involved in consultancy projects and in research activities. He is an Associate Professor at the Department of Economics, Management, Industrial Engineering, and Tourism, University of Aveiro, Portugal, where he heads the Management group. He is member of GOVCOPP research unit.

1 Introduction

Researchers have been showing a strong interest in the study of interfirm collaboration, namely involving suppliers in collaborative new product development (CNPD) (Bidault et al., 1998; Wynstra et al., 2001; Petersen et al., 2005; Eisto et al., 2010; Sjoerdsma and van Weele, 2015; Melander and Lakemond, 2015; Jha et al., 2017), particularly in studies applied to the automobile, electronics, computer, semiconductor and chemical industries (Wynstra et al., 2001; Caputo and Zirpoli, 2002; Petersen et al., 2005) and to large firms (Caputo and Zirpoli, 2002; Schiele, 2010; Pero and Lamberti, 2013). In this paper, CNPD is understood as the way two or more firms work closely together to create a new product, which has implications on unitary costs, innovation generated and time to market of new products.

Early supplier involvement (ESI) in CNPD covers activities related to product conception and design (Dowlatshahi, 2000; Petersen et al., 2003; Eisto et al., 2010; Büyüközkan and Arsenyan, 2012; Menguc et al., 2014; Melander and Lakemond, 2015; Silva and Moreira, 2020). In this regard, most studies have been analysing ESI in CNPD according to its stages (Handfield et al., 1999; Petersen et al., 2003; Eisto et al., 2010) in order to ascertain ESI advantages and impact on CNPD performance (Handfield et al., 1999; Caputo and Zirpoli, 2002; Eisto et al., 2010; Brun et al., 2013; Jha et al., 2017). However, such studies do not address the way firms are involved in CNPD according to their size and purposes of such collaboration. In this paper, three stages of ESI are going to be analysed (idea/design, engineering/manufacturing process and physical development/prototype) as they involve different responsibilities and degrees of involvement (Handfield et al., 1999; Eisto et al., 2010).

Despite the emphasis of the literature on ESI in CNPD, on the type of innovation generated (Bidault et al., 1998; Handfield et al., 1999; Petersen et al., 2003; Menguc et al., 2014), on the type of intervening parties (Wognum et al., 2002; Nieto and Santamaria, 2010; Lai et al., 2012) and on the coordination of activities undertaken between suppliers and clients (Wynstra and ten Pierick, 2000; Le Dain et al., 2011; Pero and Lamberti, 2013; Tolmay and Badenhorst-Weiss, 2018; Zimmermann et al., 2019), there is no systematic approach regarding the influence of such topics on ESI in CNPD. Moreover, research has been favouring the analysis of ESI in CNPD in large firms (Caputo and Zirpoli, 2002; Sjoerdsma and van Weele, 2015), since they involve both developing highly innovative products and the need for specialisation in the early stages of CNPD (Wognum et al., 2002; McIvor and Humphreys, 2004; Eisto et al., 2010). However, research has overlooked the study of this topic in the reality of SMEs (Silva

and Moreira, 2017, 2018, 2020), which hinders the comparison between different realities and industries. As such, the purpose of this paper is to address this gap through a comparative analysis between small and large firms as research on CNPD has been done extensively involving large firms. Based on this gap, this paper aims to analyse how ESI differs between SMEs and large firms based on the objectives of the use of external technologies, the type of innovation generated and how ESI differs in the different phases of the CNPD (idea/design, engineering/manufacturing process and physical development/prototype).

This study is divided into seven sections: the following two sections provide the theoretical framework and research methodology. Section 4 features cases describing the reality of the interviewed firms. The subsequent section provides a discussion covering the studied cases. Section 6 sets out the main findings and implications of this study. Section seven lays down the limitations of this study.

2 Theoretical framework

2.1 Supplier involvement in CNPD

2.1.1 Objectives of supplier involvement

Supplier involvement in CNPD refers to the incorporation of technologies, technical information, ideas and the development of tasks in order to enhance the performance of new products (Johnsen, 2009; Büyüközkan and Arsenyan, 2012; Menguc et al., 2014; Yeniyurt et al., 2014). This topic has been addressing the way firms interact in CNPD (Wognum et al., 2002; Petersen et al., 2005; Brun et al., 2013). Various studies refer the objectives leading to supplier involvement in CNPD. Koberg et al. (2003) and Gassmann (2006) argue that large firms, especially those operating in high-tech industries, involve suppliers in CNPD in order to design differentiated products. Other studies indicate that both SMEs and large firms involve suppliers in CNPD in order to boost their business efficiency (van de Vrande et al., 2009; Lee et al., 2010; Park et al., 2010). According to van de Vrande et al. (2009) and Hossain (2015), SMEs involve suppliers in CNPD when aiming at diversifying their product portfolio. According to van de Vrande et al. (2009) and Bianchi et al. (2010), diversification broadens the base of suppliers involved in CNPD. On the other hand, product differentiation clearly encourages upstream involvement between large firms, while diversification and efficiency underpin upstream collaboration involving both large firms and SMEs.

2.1.2 Generated innovation

The nature of the projects and the type of firms influence the innovation generated in CNPD (van de Vrande et al., 2009; Parida et al., 2012; Moreira and Karachun, 2014; Slater et al., 2014). The literature indicates that supplier involvement in CNPD depends on the aim of innovation regarding product design and manufacturing processes (Petersen et al., 2003; Lakemond et al., 2006; Van de Vrande et al., 2009; Inauen and Schenker-Wicki, 2012; Hofman et al., 2017). The outcomes of CNPD may be characterised as new – created from scratch – or improved – changed or redesigned in relation to the existing products (Laursen and Salter, 2006, Inauen and Schenker-Wicki,

2012; Parida et al., 2012; Moreira and Karachun, 2014). These concepts are used in this article to describe the innovation generated in CNPD. Other research works associate the innovation generated in CNPD with firm size, by stating that new products are developed by large firms since they have a high level of technological capacity (Gassmann, 2006; Parida et al., 2012), while SMEs often improve their products (van de Vrande et al., 2009; Silva and Moreira, 2018, 2020). It should be noted that some authors have different views on this topic. The study of Koberg et al. (2003) on the electronics and aerospace industry shows that collaboration between large firms results in the development of both new and improved products, in line with the collaborative environment of the industry in which they operate. Conversely, Lee et al. (2010) argue that SMEs also collaborate with clients when developing new products, because they are flexible and specialised enough to comply with CNPD requirements. From another point of view, Knudsen (2007), Parida et al. (2012), Slater et al. (2014) and Silva and Moreira (2018, 2020) argue that improved products arise from the collaboration between manufacturers, while the development of new products occurs upon the collaboration between manufacturers and service suppliers, due to the specialisation diversity required in CNPD. For Inauen and Schenker-Wicki (2012) and Hofman et al. (2017), highly radical CNPD is created by firms operating in high-tech industries. Although these points of view analyse the innovation generated in CNPD, they do not address its influence on the type of involvement between firms.

2.1.3 Type of suppliers involved

Supplier involvement mainly occurs in CNPD undertaken by large firms due to their experience in collaborative relationships and ability to develop and mass-produce highly differentiated products (Kessler and Chakrabarti, 1999; Wognum et al., 2002; Gassmann, 2006; Ribau et al., 2019). However, SMEs are also involved in CNPD with large firms (Johnsen and Ford, 2006; van de Vrande et al., 2009; Lee et al., 2010; Ribau et al., 2019; Silva and Moreira, 2017, 2018, 2020; Zimmermann et al., 2019), because the SMEs' specialisation and environmental adaptability facilitate the involvement with large firms in CNPD (Johnsen and Ford, 2006; Lee et al., 2010). However, the limited resources of SMEs may impair their collaboration in CNPD (Gassmann, 2006; Johnsen and Ford, 2006; Lee et al., 2010). Other studies indicate that collaboration is influenced by the nature of the business (Koberg et al., 2003; Roy et al., 2004; Gassmann, 2006; van de Vrande et al., 2009; Lee et al., 2010). According to Gassmann (2006), van de Vrande et al. (2009), Lee et al. (2010) and Menguc et al. (2014), industrial firms involve industrial suppliers in CNPD because they share similar technologies. For Roy et al. (2004) and Menguc et al. (2014), this interaction occurs when the products are disruptive. However, other researchers indicate that industrial firms also involve service suppliers in CNPD (Nieto and Santamaria, 2010; Hossain, 2015), particularly when SMEs need to diversify their product portfolio (Hossain, 2015). These points of view suggest that supplier involvement in CNPD occurs in line with their expertise and the type of specialisation required by clients (Johnsen and Ford, 2006; Slater et al., 2014; Ribau et al., 2019), but they do not associate the innovation generated in CNPD with the type of supplier involvement. From another point of view, van de Vrande et al. (2009) refer that involvement in CNPD occurs between firms operating in different industries. Conversely, Gassmann (2006) argues that firms involve suppliers operating within the same industry when CNPD requires a high degree of specialisation or the use of similar technologies.

2.1.4 Coordination of the undertaken activities

CNPD interaction occurs in accordance with the type of coordination of the undertaken activities – full interaction, functional interaction and independent interaction – the firm size and the generated innovation (Sobrero and Roberts, 2002; Lakemond et al., 2006). Full interaction is based on sharing the same workplace between firms and their suppliers during CNPD – co-location work (Sobrero and Roberts, 2002; Lakemond et al., 2006; Jiao et al., 2008) – occurring between large firms due to the high degree of dependency generated in CNPD (Kessler and Chakrabarti, 1999; Sobrero and Roberts, 2002; Lakemond et al., 2006; Ribau et al., 2019). From another point of view, Lakemond et al. (2006) argue that functional interaction – interdepartmental involvement between suppliers and clients – occurs upon the design concept or the development of manufacturing processes by sharing the same workplace. For Lakemond et al. (2006), independent interaction – separate undertaking of activities by the intervening parties in CNPD – occurs when the supplier simply follows the client's specifications, only intervening in the idea/design stage. Several authors (Sobrero and Roberts, 2002; Lakemond et al., 2006) compare the type of coordination of activities during CNPD and conclude that independent interaction occurs when there is a low degree of dependency between the intervening parties. From another standpoint, Kessler and Chakrabarti (1999) and Roy et al. (2004) conclude that full interaction occurs upon the development of new products. In this context, Kessler and Chakrabarti (1999) specify that the higher degree of interactivity in CNPD is reached between large firms. The aforementioned perspectives on the type of coordination of activities undertaken in CNPD are based on the reality of large firms. Nevertheless, the study of this topic in the reality of SMEs allows for the comparison of the influence of the size of the firm involved in CNPD on the coordination of their activities.

2.2 Early supplier involvement in CNPD

ESI in CNPD has been a contemporary subject of study (Petersen et al., 2005; Eisto et al., 2010; Schiele, 2010; Le Dain et al., 2011; Lai et al., 2012). According to Bidault et al. (1998), Dowlatshahi (2000), McIvor and Humphreys (2004), Eisto et al. (2010) and Menguc et al. (2014), ESI refers to the integration of suppliers in the early stages of CNPD, upon the product conception and design.

Studies carried out in the industry show that ESI in CNPD depends on their ability to collaborate in the design concept of complex and differentiated products (Wynstra and ten Pierick, 2000; Petersen et al., 2003; McIvor et al., 2006). In this regard, Le Dain et al. (2011) and Menguc et al. (2014) conclude that the higher the product complexity, the earlier the supplier involvement in CNPD occurs. Wognum et al. (2002) specify that this phenomenon takes place upon the collaboration between large firms operating in high-tech industries, such as the automobile and electronic industries, because suppliers interact in CNPD from its initial stage. For Caputo and Zirpoli (2002), Sobrero and Roberts (2002), McIvor and Humphreys (2004) and Eisto et al. (2010), ESI promotes unitary cost reduction in CNPD undertaken by large firms. Other studies applied to both SMEs and large firms conclude that ESI in CNPD increases the efficiency of the client's activity (Lai et al., 2012; Luzzini et al., 2015). Therefore, early sharing of resources between firms increases the performance of CNPD due to the greater combination of

activities carried out from their initial stage (Dowlatshahi, 2000; Moreira and Karachun, 2014; Menguc et al., 2014).

Other studies analyse ESI in CNPD according to the innovation generated, supplier contribution and the industrial context in which firms operate (Bidault et al., 1998; Wynstra and ten Pierick, 2000; Wognum et al., 2002; Eisto et al., 2010). For Bidault et al. (1998), ESI occurs when CNPD yields customised and differentiated products, while large-scale standardised products generated in CNPD do not require the incorporation of external technologies in the initial stage (Bidault et al., 1998). For Petersen et al. (2005) and Lau (2011), it is the high degree of technological intensity of the industry in which large firms operate and of the radicalness of product innovation that promotes ESI in CNPD, due to the need for specialisation regarding product design. As a result, supplier involvement in the early stages of CNPD depends on their ability to undertake intangible activities that satisfy the need for specialisation of clients (Petersen et al., 2003; Luzzini et al., 2015).

Innovation plays an important role in supplier involvement in CNPD as it influences the type of interfirm collaboration (Bidault et al., 1998, Petersen et al., 2003; Menguc et al., 2014). Research shows that the higher the degree of radicalness of the innovation generated in CNPD the higher the involvement of suppliers in the initial stage of CNPD in order to undertake activities associated with product design (Le Dain et al., 2011; Rosell and Lakemond, 2012; Luzzini et al., 2015). The development of improved manufacturing processes fosters supplier involvement in the later stages of CNPD (Rosell and Lakemond, 2012, Luzzini et al., 2015). However, Song and Di Benedetto (2008) and Menguc et al. (2014) argue that ESI depends on the need for specialisation of CNPD, whereas it can occur in the development of both new and improved products.

Another perspective shows that the need for specialisation on emerging technologies in the early stages of CNPD promotes the early involvement of service suppliers (Nieto and Santamaria, 2010; Un and Azakawa, 2015). In this context, the literature refers that service suppliers become involved in the early stages of CNPD undertaken by large firms (Laursen and Salter, 2006; Nieto and Santamaria, 2010; Un and Azakawa, 2015). In addition, the incorporation of technologies in the initial stage of CNPD may arise from the relationship with universities and consultants because they are at a favourable position for early involvement in CNPD undertaken by large firms for the design concept of new products (Laursen and Salter, 2006; Lai et al., 2012).

The type of supplier involvement is influenced by the coordination of the activities undertaken in CNPD. In this context, Bidault et al. (1998), Wynstra and ten Pierick (2000) and Petersen et al. (2003) argue that suppliers interact independently in CNPD in the idea/design stage, while suppliers involved in the later stages of CNPD may undertake activities in the clients' workplace (co-location work). Pero and Lamberti (2013) further concluded that there is a greater supplier interactivity in the later stages of CNPD undertaken by large firms due to the increasing dependency arising from the continuity of the undertaken activities. In contrast, Le Dain et al. (2011) and Brun et al. (2013) show that greater interactivity among suppliers and clients occurs in the initial stage of CNPD, because the product design concept and the definition of its specifications need a high degree of involvement between the intervening parties, for both SMEs and large firms, in order to consolidate the functional requirements accompanying the product development in the later stages. The different approaches on the coordination of activities undertaken in CNPD reveal that supplier involvement does

not occur in a similar way due to the different activities undertaken and the type of firms involved.

Generally speaking, research on ESI in CNPD has been analysed in large firms (Caputo and Zirpoli, 2002; Sobrero and Roberts, 2002; Petersen et al., 2005; Sjoerdsma and van Weele, 2015), due to its propensity to a highly radical CNPD (Song and Di Benedetto; Pero and Lamberti, 2013; Luzzini et al., 2015), thereby giving rise to the need of resorting to supplier specialisation in the early stages of CNPD (Lai et al., 2012; Brun et al., 2013; Menguc et al., 2014). Moreover, other studies show that SMEs have a greater interest in developing collaborative activities associated with the marketing of their products (van de Vrande et al., 2009; Hossain, 2015). Nevertheless, the comprehensive study of this topic enables one to analyse the type of supplier involvement in CNPD undertaken by SMEs, and to compare it to the reality of large firms.

Framework presented in Figure 1 was put forward to address ESI in CNPD through three linked steps – search of technologies, interfirm collaboration and early involvement. The first step describes the objective of firms for searching technologies upstream. The step that involves collaboration describe how firms interact in CNPD taking into account the type of innovation generated, the actors involved and the coordination of activities developed. The third step describes the supplier's involvement according to different stages of CNPD.

3 Methodology

This paper analyses the type of supplier involvement in CNPD undertaken by SMEs and large firms, according to a set of variables describing the interfirm collaboration. The unit of analysis is the involvement of industrial firms with suppliers in CNPD. For such purpose, the analysis focuses on the involvement of the client firm with its suppliers.

This research work is based on a qualitative study (Miles and Huberman, 1994; Yin, 2003; Baxter and Jack, 2008; Heath and Tynan, 2010) and relies on single and multiple case studies. This study involved three phases. The first phase involved the collection of primary data in industrial firms selected for this study. The second phase involved the analysis of the collected information for subsequent processing. The last phase encompassed the gathering of the collected information and its conversion into case studies (Miles and Huberman, 1994). The studied cases make it possible to characterise the individual reality of each firm and to simultaneously carry out a comparative approach (Yin, 2003; Baxter and Jack, 2008), according to the size of the firm and the type of innovation generated.

The analysis of the type of supplier involvement is based on the stages in which they intervene in CNPD. For this purpose, three stages illustrating supplier involvement were taken into account: idea/design, engineering/manufacturing process and physical development/prototype. The definition of the CNPD stages is substantiated by and adapted from the studies of Handfield et al. (1999) and Eisto et al. (2010).

The firms selected for this study, called focal firms (FF) are two SMEs (FFA and FFC) and two large firms (FFB and FFD) undertaking CNPD with suppliers. Theoretical sampling was used to select all four industrial firms known for their involvement in CNPD. The European Commission criterion (2003) on the number of employees was used to classify the SMEs. Thus, it is possible to compare the reality of study in SMEs

and in large firms. The selection of the firms, specified in Table 1, was made through a prior examination on the nature of their innovative activities. This purposive sampling is made up of firms of several industries in order to study their differences.

Table 1 Profile of focal firms

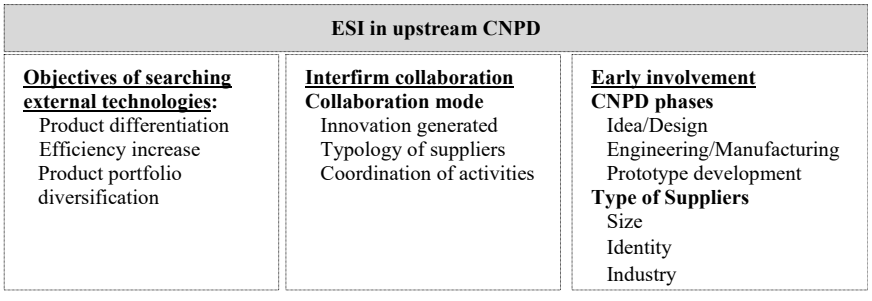
Description	*FFA*	*FFB*	*FFC*	*FFD*
Type of industry	Electronic products	Automotive fastening systems	Precision metallurgy	High-end appliances
Technological intensity	High	High	Moderate	Moderate
Main products	Electronic boards and circuits; miscellaneous electronic equipment	Fastening systems; shafts; by-products and other derived products	Metal boxes, racks, metallic computer accessories, other precision accessories	Microwave ovens; steam ovens; cooker hoods; hobs; stoves; dishwashers.
Sales volume (€)	€8,000,000	€22,000,000*	€750,000	€80,000,000*
Number of employees	200 SME	253* Large firm	18 SME	347* Large firm
Main markets	Electronics; Telecommunications; Automotive; Transportation; miscellaneous industry.	Automotive	Metal mechanics; Telecommunications; Electronics; miscellaneous industry.	Distributors; Appliance industry.
Interviewees	CEO; Technical director	Industrial manager; Head of design	Manager; Technical Director	R&D Manager; Marketing manager

Note: *Data from the division.

The information was collected through a two-round semi-structured interviews with the heads of the firms and departments in order to assess the type of involvement undertaken with suppliers upon CNPD, as well as the type of firms involved and the innovation generated. The interviews were conducted with an interview script composed of semi-open questions, with the purpose of guiding the study examination (Malhotra, 2007; Baxter and Jack, 2008). The duration of the interviews ranged from 1 hour and 25 minutes to 1 hour and 40 minutes. The information was ensured to be confidential and anonymous, in order to increase the quality of the obtained information and to safeguard the firms' identity. The interviews were recorded and subsequently transcribed. The interviews were performed within the firms' premises, thereby witnessing the undertaken innovative activities and obtaining information on the installed technology, developed processes, range of products, target market, among other information. Secondary information on the firms was also collected through e-mail and consultation of website and other public documents. The data was gathered through two rounds of interviews, analysis of written documents, and a feedback report on the results, which helped to triangulate all information. The analysis of results was supported on the framework shown in Figure 1. The framework was developed to assess ESI involving suppliers in upstream involvement in CNPD activities through three different aspects: objectives of

searching for external technologies in upstream activities, interfirm collaboration and early involvement.

Figure 1 Framework of analysis



The cases are analysed individually, according to the study topic, and aligned with the unit of analysis. The cases are also compared in order to assess their differences (Yin, 2003; Baxter and Jack, 2008), regarding the type of supplier involvement in CNPD, according to firm size and the type of innovation generated.

The data collection process was organised by two steps. In the first step, the objective was to obtain a clear overview about the involvement of suppliers in the different CNPD phases, taking into account the objectives of the internalisation of technologies by firms and the type of collaboration established upstream. In particular, we were looking for information regarding product differentiation, efficiency, product diversification, innovation generated, type of suppliers involved, and coordination of activities. The second step was prepared based on the preliminary conclusions derived from the first step. The second round of interviews was prepared with greater detail, based on the same open-ended questions as in the first step although seeking for enhancements of emerging ideas or concept reviews that were not completely clear after the first interview round. Clearly, in this second phase the major efforts were in understanding the whole process about involvement of suppliers in CNPD.

After the first step of the data collection process, the data was coded and analysed. The researchers coded the transcripts and compared the coding. During the data analysis phase the researchers aimed at identifying relevant issues, questions, and common factors, according to central topic under study, as recommend by Miles and Huberman (1994). The data was subsequently coded and organised in tables as presented in the following sections. The data from this phase – confirmed in the second round of interviews – was subsequently used to improve the construct validity. In order to strengthen the validity of the findings emphasis was on observation and discussing the type of supplier's involvement according to the types of firms. This was further validated by the interviewees. The secondary data obtained from the interviews was compared to build the multiple case study approach, which helped to mitigate the negative effects of observer bias (Eisenhardt and Graebner, 2007).

4 Case description

FFA is a 200-employee SME which manufactures electronics products for national and foreign clients operating in the automobile and telecommunications industries, with whom FFA has a close relationship. FFA is certified according to ISO 9001 (quality management standard) and ISO TS16796. Supplier involvement with FFA in CNPD takes place in the product design stage and in the engineering process development stage, due to the nature of the firm's activity and the way it relates with suppliers. Therefore, suppliers do not become involved in the product physical development stage, because the firm has its own expertise to put this stage into operation. FFA uses external technologies to increase its activity efficiency. Industrial suppliers become involved in the conception and design of the product's components and provide advice on the materials and components in order to improve performance and price. Service suppliers become involved in the engineering stage to develop programming modules and software adjustments. FFA involves suppliers in CNPD to design new and improved products, and the manufacturing processes materialising them. The development of new products integrating components, electronic boards, hardware and metal and plastic boxes is accompanied by the development of new software programming, and the contribution of service suppliers is essential for their design. The development of improved products and processes results in the increase of the strength of materials and software performance. Industrial suppliers become involved in the initial stage of CPD in order to design the format and sizing of the components and their functionality. Service suppliers become involved in the engineering stage, in order to develop manufacturing processes and specific programming. The size of the suppliers is diverse, which are large industrial firms and service providing SMEs. FFA collaborates with suppliers operating within the same industry, as well as with suppliers operating within different industries – metalworking, plastics and service suppliers. FFA involves suppliers operating in other industries due to the need to incorporate components having different manufacturing bases and specialised services. Interaction between FFA and suppliers in CNPD occurs functionally and independently – the service suppliers develop manufacturing processes in FFA's premises due to the sharing of similar technologies, while industrial suppliers interact independently from FFA and vice-versa.

FFB is a division of a large conglomerate with eight divisions, in which five of them are localised in Portugal and the other three are in Spain, Brazil and China. FFB is a division with 253 employees that excels in manufacturing fastening systems for cars. The firm is certified according to ISO TS16949 (automobile industry) to operate in the global market. The type and complexity of the products developed by FFB determine that supplier involvement in CNPD occurs in the early stages – upon the product conception/design and the engineering stage. Suppliers collaborate in the product design concept, the materials and finishings proposal promoting the product's functionality and the operating range necessary to materialise the products. Suppliers do not become involved in the product physical development stage because the firm has the technology and technical expertise to put this stage into operation. FFB uses supplier specialisation in order to design differentiated products requiring specialised technologies to create 'special components'. In this context, industrial suppliers collaborate in the product conception, design and functionality, and provide advice on new materials to be used. Service suppliers become involved in the engineering stage for the development of tools, thermal and surface treatment processes and finishing of the products. FFB involves

suppliers to design new products and improved products, as well as new manufacturing processes. FFB develops improved manufacturing processes internally as a result of CNPD because it has the technology needed for such purpose. FFB involves suppliers in the early stages of CNPD differently. Therefore, industrial suppliers are liable for the product conception, design and functionality, and for the development of new materials in the initial stage of CNPD, and for the design of tools in the engineering stage. Service suppliers develop tools and manufacturing processes for the product's treatment and finishing. FFB collaborates with large suppliers because its activity is based on large-scale production. FFB collaborates in CNPD with suppliers operating in the same industry due to the specificity and differentiation of its products and the high specialisation degree required of the suppliers. Suppliers interact functionally and independently with FFB during CNPD. This way, the suppliers of materials and components that are involved in the initial stage of CNPD develop activities in FFB's premises contributing for a greater efficiency in CNPD. Service suppliers involved in the engineering stage and industrial suppliers involved in the design and engineering stages interact with FFB independently.

FFC is a family SME with 18 employees, operating in the precision metalworking subsector. FFC manufactures specific accessories complying with clients' specifications. FFC's main clients are firms operating in the electronics, telecommunications and metalworking industries. FFC has the expertise to design new products and to conceive the operating range furthering their physical development. However, the need for specialisation regarding some components justifies supplier involvement in CNPD upon the products' physical development stage. Therefore, industrial suppliers become involved in CNPD to develop new materials and specific components, and to provide advice on the methods for their processing and finishing. FFC involves suppliers in CNPD to develop new components, materials and manufacturing processes with the purpose of diversifying its product portfolio. Within this framework, industrial suppliers provide advice on the use of new manufacturing bases, regarding their application. FFC involves suppliers in CNPD in order to create new products and improved products, as well as improved manufacturing processes materialising them. Industrial suppliers collaborate in the design of new or modified components and materials, and of reprogrammed (changed) machining processes to operate with other manufacturing bases (metal alloys). FFC does not involve service suppliers in CNPD because the industrial suppliers ensure the need for specialisation in the product physical development stage. Moreover, supplier involvement in the product physical development stage is due to the fact that FFC has the technology to undertake the previous CNPD stages. The size of the suppliers varies from large industrial suppliers to SMEs, according to their specialisation and production capacity. CNPD undertaken by FFC fosters diverse inter-industry relations due to the relationship with industrial suppliers operating across several industries, the latter regarding the development of products not derived from metal, such as plastics, paints and cables. FFC collaborates with suppliers independently, because the non-similarity in respect of technologies between the firms involved in CNPD, along with its internal process management policy, contributes to the in-house development of the activities performed.

FFD is a division of a large industrial firm with 350 employees, which is part of an international group and manufactures sophisticated domestic electrical equipment for the Portuguese market. FFD has a standard product line and another product line which is

adapted to the requests from clients (OEM products). FFD is certified according to ISO 9001 and IQNet (international recognition of certified quality systems). The complexity of the products developed by FFC requires suppliers to be involved in several CNPD stages – from the product idea/design stage until its physical development. Supplier involvement in the initial stage of CNPD contributes for the product design concept and functionality, the materials to be used and the definition of its strategic and marketing component. In the engineering stage, suppliers develop manufacturing processes, tools and other activities materialising the products. Suppliers become involved in the product physical development stage in order to design specific components and to provide advice on material processing methods. FFD involves suppliers in CNPD when it aims at designing differentiated products. Within this framework, FFD turns to several suppliers involved in a different manner in the various CNPD stages, due to the requirement of specialised and simultaneously diversified technologies. FFD involves suppliers to design new and improved products. The design of new products fosters the development of new components, hardware, electronic boards, and metal and plastic boxes, as well as new manufacturing processes and software programming materialising the products. The development of improved products and processes translates into changes in components, design, materials and in a few software adjustments. The high degree of innovation of certain products facilitates service supplier involvement in order to develop new management methodologies linked to the strategic expansion to new markets. In this context, the contribution from consultants aims at adjusting the product to the market's features. The involvement of universities in the idea/design stage aims at developing unique technologies to be incorporated in the new products. The suppliers involved in CNPD are diverse because it requires specialisation in several areas. Thus, industrial suppliers collaborate in the development of new materials in the idea/design stage, and of the tools and finishing processes in the engineering stage, by also collaborating in the product physical development stage. Consultants become involved in the initial stage of CNPD in order to develop activities associated with product conception and design, and marketing strategy. The early involvement of universities in CNPD is due to the need for specialisation of FFD on new materials. Suppliers are SMEs with expertise on collaborative relationships. FFD collaborates with firms operating in different industries because the differentiation of its products requires the incorporation of new materials and components that are not processed by its technology. FFD interacts with suppliers in CNPD independently, because they do not share similar technologies and because supplier specialisation fosters in-house development of the activities allocated thereto.

5 Empirical findings and discussion

The information on the cases is presented in the tables. Table 2 summarises the type of supplier involvement with the focal firms, according to the CNPD stages. Tables 3, 4, 5 and 6 individually show the type of supplier involvement and the undertaken activities, according to:

- the purpose of firms using external technologies
- the innovation generated in CNPD

- the type of supplier involved in CNPD
- the coordination of the activities performed in CNPD.

Table 7 summarises CNPD between suppliers and focal firms, including the type of supplier involvement.

FFA's technology-intensive activity promotes collaboration with suppliers of different sizes, as their specialisation determines the type of involvement in CNPD. As per cases FFB and FFD, regarding large firms, the need for specialisation on design and the development of new manufacturing processes facilitate the design of new products, by involving suppliers in the initial stage of CNPD, thereby corroborating the studies of Petersen et al. (2003) and Lau (2011). Case FFA shows that the firm size does not prevent ESI from happening in CNPD undertaken by SMEs operating in high-tech industries, thereby complementing the literature on the collaboration between large firms (Wognum et al., 2002; Pero and Lamberti, 2013; Menguc et al., 2014). Cases FFA and FFB show that supplier involvement in the initial stage of CNPD derives from the functional interaction with suppliers operating in the same industry for the development of new products. Cases FFA and FFB further show that functional interaction takes place in the early stages of CNPD between firms operating in high-tech industries. These results contradict certain approaches (Bidault et al., 1998; Wynstra and ten Pierick, 2000; Pero and Lamberti, 2013) that do not take into account of the influence of the innovation created in CNPD on the coordination of activities between the intervening parties. From another point of view, the design of new products facilitates early service supplier involvement due to the need for specialisation of FFA on product design and the development of new manufacturing processes materialising them. Similarly to cases FFB and FFD, case FFA shows the importance of service supplier involvement in the early stages of CNPD because it increases the SMEs' expertise regarding the activities preceding prototype production, thereby complementing previous studies (Nieto and Santamaria, 2010; Un and Azakawa, 2015). In this respect, case FFA further shows that early service supplier involvement in CNPD occurs with SMEs and not exclusively with large firms, thereby complementing the abovementioned literature (Nieto and Santamaria, 2010; Lai et al., 2012).

Table 2 Types of activities developed in the phases in CNPD

Description	*FFA*	*FFB*	*FFC*	*FFD*
Idea/design	Initial idea, design	Initial idea, design, materials	-	Initial idea, design, materials
Engineering/ manufacturing process	Components, manufacturing process, software programming	Materials, manufacturing process	-	Manufacturing process
Prototype development	-	-	Components, manufacturing process	Components, manufacturing process

Table 3 FFA's involvement with suppliers

Focal firm FFA description	*Suppliers involvement – CNDP phases*		
	Idea/design	*Engineering/ manufacturer process*	*Prototype development*
	(Early supplier involvement)		
Objectives for searching external technologies	Increase efficiency	Increase efficiency	-
Innovation generation			
• New product development	Initial idea, design and format of the components, functionality	Test of components, manufacturing base of the products (technical advice)	-
• Improved product development	Design of components, functionality	Test of components	-
• New production process	-	Software programming	-
• Improved production process	-	Software programming.	-
• Development of management methodologies	-	-	-
Typology of the suppliers involved			
• Suppliers size			
Large firms	Yes	-	-
SMEs	Yes	Yes	-
• Suppliers identity			
Industrial firms	Yes	-	-
Service firms	-	Yes	-
Universities	-	-	-
• Industry in which suppliers operate			
Same industry of the focal firm	electronics	-	-
Different industry of the focal firm	metallurgy, cables, plastics	software	-
Coordination of the activities developed			
• Functional interaction with industrial suppliers	-	-	-
• Functional interaction with service suppliers	-	Software programming	-
• Independent interaction with industrial suppliers	Format and functionality of components	-	-
• Independent interaction with service suppliers	-	Software programming	-

Table 4 FFB's involvement with suppliers

Focal firm FFB description	*Suppliers involvement – CNDP phases*		
	Idea/design	*Engineering/ manufacturer process*	*Prototype development*
	(Early supplier involvement)		
Objectives for searching external technologies	Product differentiation	Product differentiation	-
Innovation generation			
• New product development	Initial idea, design, performance and functionality of the product.	Type of materials, technical advice (manufacturing).	-
• Improved product development	Performance and functionality of the product.	Type of materials, technical advice (manufacturing).	-
• New production process	-	Operative production range, tools, surface treatment, finishing.	-
• Improved production process	-	-	-
• Development of management methodologies	-	-	-
Typology of the suppliers involved			
• Suppliers size			
Large firms	Yes	Yes	-
SMEs	-	-	-
• Suppliers identity			
Industrial firms	Yes	Yes	-
Service firms	-	Yes	-
Universities	-	-	-
• Industry in which suppliers operate			
Same industry of the focal firm	metallurgy	metallurgy	-
Different industry of the focal firm		Industrial services	-
Coordination of the activities developed			
• Functional interaction with industrial suppliers	Performance of materials and components – tests.	-	-
• Functional interaction with service suppliers	-	-	-
• Independent interaction with industrial suppliers	Format, finishing and functionality of the materials and components.	Operative production range	-
• Independent interaction with service suppliers	-	Tools, finishing processes.	-

Table 5 FFC's involvement with suppliers

Focal firm FFC description	*Suppliers involvement – CNDP phases*		
	Idea/design	*Engineering/ manufacturer process*	*Prototype development*
	(Early supplier involvement)		
Objectives for searching external technologies			Diversification of product portfolio
Innovation generation			
• New product development	-	-	Components, type of new materials, technical advice (manufacturing)
• Improved product development	-	-	Components, finishing process
• New production process	-	-	-
• Improved production process	-	-	Product transformation, finishing process
• Development of management methodologies	-	-	-
Typology of the suppliers involved			
• Suppliers size			
Large firms	-	-	Yes
SMEs	-	-	Yes
• Suppliers identity			
Industrial firms	-	-	Yes
Service firms	-	-	-
Universities	-	-	-
• Industry in which suppliers operate			
Same industry of the focal firm	-	-	Metallurgy
Different industry of the focal firm	-	-	Plastics, paints, cables
Coordination of the activities developed			
• Functional interaction with industrial suppliers	-	-	-
• Functional interaction with service suppliers	-	-	-
• Independent interaction with industrial suppliers	-	-	Transformation process advice, components and new materials, finishing.
• Independent interaction with service suppliers	-	-	-

Table 6 FFD's involvement with suppliers

Focal firm FFD description	*Suppliers involvement – CNDP phases*		
	Idea/design	*Engineering/ manufacturer process*	*Prototype development*
	(Early supplier involvement)		
Objectives for searching external technologies	Product differentiation	Product differentiation	Product differentiation
Innovation generation			
• New product development	Initial idea, design, type of materials, functionality.	Transformation process advice, performance of the product.	Components, transformation process advice.
• Improved product development	Design (restyle), type of materials, functionality.	Transformation process advice.	Components.
• New production process	-	Engineering process, software programming.	-
• Improved production process	-	Tools, software programming.	-
• Development of management methodologies	Product management, pricing strategy, technical design advice.	-	-
Typology of the suppliers involved			
• Suppliers size			
Large firms	-	-	-
SMEs	Yes	Yes	Yes
• Suppliers identity			
Industrial firms	Yes	Yes	Yes
Service firms	Yes	Yes	-
Universities	Yes	-	-
• Industry in which suppliers operate			
Same industry of the focal firm	-	-	-
Different industry of the focal firm	R&D consulting, electronics, cables.	Hardware, software, plastics.	Plastics, glass, paints, industrial services.

Table 6 FFD's involvement with suppliers (continued)

Focal firm FFD description	*Suppliers involvement – CNDP phases*		
	Idea/design	*Engineering/ manufacturer process*	*Prototype development*
	(Early supplier involvement)		
Coordination of the activities developed			
• Functional interaction with industrial suppliers	-	-	-
• Functional interaction with service suppliers	-	-	-
• Independent interaction with industrial suppliers	Materials, functionality.	Operative production range, finishing process.	Transformation of materials, development of components.
• Independent interaction with service suppliers	Design, marketing, materials (performance advice, functionality).	-	-

The nature of FFB's activity promotes ESI in the development of differentiated products in activities associated with the product idea/design, proposal of materials and operating range facilitating the physical development of new products, thereby complementing previous studies (Wynstra and ten Pierick, 2000; Petersen et al., 2003; McIvor et al., 2006; Luzzini et al., 2015). In addition, the high specialisation degree and production scale that characterise FFB promote early involvement in CNPD of large specialised suppliers operating in the same industry. In this case, the industry in which FFB operates determines that upstream CNPD is restricted to large specialised firms, as argued by Wognum et al. (2002) on the equivalence between the intervening parties in CNPD. As in case FFA, case FFB also shows that the sharing of similar technologies with suppliers in the early stages of CNPD involving disruptive innovation promote functional interaction, as mentioned by Le Dain et al. (2011) and Brun et al. (2013).

Case FFB particularly shows that the functional interaction in the initial stage of CNPD occurs when the firm differentiates its product. In addition, by comparing case FFB to case FFA, one can ascertain that differentiation promotes ESI and is a facilitator of functional interaction upon the design concept of the product. Therefore, case FFB shows that the co-location of the undertaken activities does not exclusively occur in the later stages of CNPD, as per the aforementioned literature (Bidault et al., 1998; Wynstra and ten Pierick, 2000; Petersen et al., 2003; Pero and Lamberti, 2013), but it also occurs upon the idea/design concept due to the high degree of interactivity generated between the intervening parties in CNPD. In contrast, case FFB differs from the other cases as to the size and specialisation of its suppliers, because FFB's size and the high degree of technological intensity of the industry in which it operates promote the collaboration between large 'specialised' firms operating in the same industry to create differentiated products. Nevertheless, FFA's use of external technologies leads to supplier involvement in the early stages of CNPD. Therefore, by comparing FFA to FFB, one can conclude that ESI is only influenced by the size of the firm when CNPD takes place between 'specialised' firms and creates a large production scale, which complements prior

literature assessing large firms (Wognum et al., 2002; Petersen et al., 2005; Luzzini et al., 2015).

FFC involves suppliers in order to design new and improved products with the purpose of diversifying its portfolio. In this context, supplier involvement only takes place in the final stage of CNPD because the need for external specialisation relates to improved manufacturing processes that facilitate the physical development of the products, as referred to by Rosell and Lakemond (2012). The comparison between case FFC and cases FFA, FFB and FFD allows us to ascertain that the aim of using external technologies and the innovation characterising manufacturing processes influence the type of supplier involvement. Thus, when the diversification of the product portfolio promotes the development of improved manufacturing processes, the upstream incorporation of external technologies occurs in the final stage of CNPD. FFC does not involve service suppliers in CNPD because the industrial suppliers have the required specialisation for the final stage of CNPD. Compared to cases FFA and FFB, FFC interacts with its suppliers independently in the final stage of CNPD as a result of the technological gap between them. Therefore, the type of coordination of the activities undertaken in CNPD is influenced by the (absence of) similarity of technologies and by the need for specialisation only in the product physical development stage. In addition, the lower degree of radical innovation in FFC's manufacturing processes creates a lower degree of interactivity between the intervening parties in CNPD, when compared to the other cases. These results differ from those of other studies on the type of coordination of activities in CNPD (Wynstra and ten Pierick, 2000; Petersen et al., 2003; Pero and Lamberti, 2013) because they reveal that the lowest degree of radicalness of manufacturing processes developed in the final stage of CNPD is achieved through the independent interaction between suppliers and clients.

FFD promotes the involvement of medium-sized industrial and service suppliers in all stages of CNPD. These results reveal that the development of new products does not limit interaction between large firms, as per previous studies (Johnsen and Ford, 2006; Lee et al., 2010), this interaction being determined by the need for specialisation in each stage of CNPD. Moreover, interaction differs from the perspective of certain authors (Kessler and Chakrabarti, 1999; Roy et al., 2004) and reveals that:

a CNPD occurs not only when there is full interaction between the intervening parties

b the coordination of activities in CNPD depends on the similarity of the technology used by the firms.

From another point of view, the comparison of case FFD with cases FFA and FFB shows that functional interaction in the initial stage of CNPD occurs when firms operate in high-tech industries due to the high degree of involvement between the intervening parties, as referred to by Le Dain et al. (2011) and Brun et al. (2013), and it further reveals that the firm size does not prevent such interaction from occurring, as shown by case FFA, which is an SME. As referred to in previous studies (Nieto and Santamaria, 2010; Lai et al., 2012), case FFD reveals that differentiation promotes service supplier involvement in the initial stage of CNPD undertaken by large firms. By confronting case FFD and FFB one can claim that differentiation also promotes medium-sized supplier involvement in the early stages of CNPD, thereby showing that firm size does not preclude early involvement of medium-sized suppliers in CNPD. Consequently, these results differ from the studies of Wognum et al. (2002) and reveal and ESI in CNPD

mainly depends on its ability to develop the design of complex and differentiated products, as referred to in other studies (Wynstra and ten Pierick, 2000; Petersen et al., 2005; McIvor et al., 2006), and on other intangible activities that eliminate the need for specialisation of clients in the early stages of CNPD (Petersen et al., 2005; Luzzini et al., 2015).

Table 7 Summary of involvement with suppliers

Description	*FFA*	*FFB*	*FFC*	*FFD*
Suppliers involvement – CNPD phases				
• Idea/design	Yes	Yes	-	Yes
• Engineering/manufacturing process	Yes	Yes	-	Yes
• Prototype development	-	-	Yes	Yes
Objectives for searching external technologies	Increase efficiency	Product differentiation	Diversification of product portfolio	Product differentiation
CNPD objective (innovation generated)				
• New product	Yes	Yes	Yes	Yes
• Improved product	Yes	Yes	Yes	Yes
• New production process	Yes	Yes	-	Yes
• Improved production process	Yes	-	Yes	Yes
• Management methodologies	-	-	-	Yes
Typology of the suppliers involved				
• Suppliers size:				
Large firms	Yes	Yes	Yes	-
SMEs	Yes	-	Yes	Yes
• Suppliers identity:				
Industrial firms	Yes	Yes	Yes	Yes
Service firms	Yes	Yes	-	Yes
Universities	-	-	-	Yes
• Industry in which suppliers operate				
Same industry of the focal firms	Yes	Yes	Yes	-
Different industry of the focal firms	Yes	-	Yes	Yes
Coordination of the activities developed				
• Functional interaction	Yes	Yes	-	-
• Independent interaction	Yes	Yes	Yes	Yes

The studied cases reveal different scenarios regarding supplier involvement in CNPD. The high degree of specialisation of both SMEs and large firms, and the radicalness of the products developed thereby, promote ESI in CNPD, as shown by cases FFA, FFB and FFD. Moreover, by comparing cases FFA, FFB and FFD to case FFC, one can claim that supplier involvement in the early stages of CNPD is mainly due to disruptive innovation (Le Dain et al., 2011; Rosell and Lakemond, 2012, Menguc et al., 2014; Luzzini et al., 2015), and not exactly because of the size of the firm, thereby differing from the perspective of a few authors on CNPD undertaken among large firms (Wognum et al., 2002; Gassmann, 2006). It should be noted that both SMEs operating in high-tech industries and large firms involve service suppliers in the initial stage of CNPD in order to develop activities associated with defining the initial project. From this point of view, cases FFA, FFB and FFD reveal that service suppliers become involved in the early stages of CNPD when the firms develop new manufacturing processes. Therefore, the results show the importance of service supplier collaboration in order to develop intangible activities that eliminate the need for specialisation of firms in the early stages of CNPD, as referred to in previous studies (Petersen et al., 2003; Luzzini et al., 2015).

In addition, the differentiation of products developed by large firms, created in large production scales, affects supplier involvement in CNPD, as case FFB demonstrates. This phenomenon is also due to the high degree of specialisation of the activity of large firms. In this case, CNPD occurs between large 'specialised' firms with technological capacity to collaborate in the initial stage of CNPD. Unlike the other cases, case FFC reveals that CNPD undertaken by SMEs in order to diversify their product portfolio promotes supplier involvement only in the product physical development stage (late involvement), when it is materialised by improved manufacturing processes. Therefore, one can conclude that the exclusion of radical innovation in CNPD does not promote ESI.

Another perspective reveals that the coordination of activities undertaken between industrial firms and suppliers in CNPD is made separately. In this regard, by comparing cases FFA and FFB with cases FFC and FFD, it is revealed that functional interaction occurs in high-tech industries, and when suppliers involved in the early stages of CNPD operate in the same industries as their clients. In this context, case FFA shows that firm size does not influence the type of coordination of the activities undertaken in CNPD, namely functional interaction. These results differ from other studies on the coordination of activities in CNPD (Kessler and Chakrabarti, 1999; Wynstra and ten Pierick, 2000; Pero and Lamberti, 2013) because they demonstrate that a higher degree of interactivity does not occur exclusively between large firms and in the later stages of CNPD. This difference in the results obtained is due to the fact that the previous studies did not take account of the analysis of the technological intensity of the industry in which the firms operate, as well as their specialisation. The analysed cases show that ESI occurs when CNPD undertaken both by large firms and SMEs operating in high-tech industries creates differentiated products or increases the efficiency of their activity. Specifically speaking, case FFD demonstrates that the involvement of service suppliers with large firms in order to develop new management methodologies occurs in the initial stage of CNPD due to the need for specialisation on strategic activities upon the conception of differentiated products. Case FFD further demonstrates that large firms involve medium-sized suppliers in CNPD. These results show, firstly, that the size of suppliers does not preclude their involvement in the early stages of CNPD, if they have the specialisation and adaptability

to collaborate with large firms, and, secondly, that ESI in CNPD occurs when firms aim at differentiating the product or increasing the efficiency of their activity.

6 Conclusions and implications

This study analysed supplier involvement in CNPD undertaken by SMEs and large industrial firms. In accordance with the literature on this topic, this study shows that the type of supplier involvement in CNPD differs according to:

- the objectives of the use of external technologies by firms – differentiation, enhancing firm efficiency or diversification of the product portfolio
- the innovation generated in CNPD regarding products and processes
- the type of intervening parties in CNPD, according to firm size
- the technological intensity and specialisation of the industry in which the firm operates.

According to the facts set out above, ESI in CNPD occurs when the clients intend to differentiate the product or enhance their efficiency. This phenomenon takes place when large firms and SMEs design new products and new manufacturing processes. Moreover, this paper shows that CNPD undertaken by SMEs in order to diversify their product portfolio promotes supplier involvement only in the prototype development stage, and when they design improved manufacturing processes. Therefore, the higher the degree of radicalness of the innovation generated in CNPD, the earlier the supplier involvement occurs.

From another perspective, this paper emphasises the importance of the early involvement of service suppliers in CNPD. The cases analysed show that the involvement of service suppliers occurs in the early stages of CNPD, and not only in the latest stages, when firms require specialisation in order to develop new products that are materialised by new manufacturing processes. Therefore, the need for specialisation of large firms – to differentiate the product – and SMEs – to enhance efficiency – is what fosters ESI. Moreover, case FFC shows that SMEs involve industrial suppliers only in the final stage of CNPD, because the radicalness of the innovation generated in diversified products is comparatively lower than that of the other studied cases. Therefore, ESI is not influenced by the size of the firm, but rather by the high degree of radicalness of the innovation generated in CNPD.

The results of this study further show that ESI in CNPD occurs due to the functional interaction between firms sharing similar technologies and operating in high-tech industries. These results contradict the theories on independent interaction of suppliers in the early stages of CNPD, and suggest that supplier involvement in CNPD does not occur in a similar way due to the difference in firms' specialisation and in the technological intensity of the industry in which they operate. As a result, the co-location of activities undertaken between the intervening parties in CNPD fosters ESI in CNPD in large firms and SMEs.

The main differences between FFC and the other cases are linked to the less active involvement in CNPD. In this framework, supplier involvement in CNPD undertaken by FFC with the purpose of diversifying its portfolio only occurs upon the product physical

development stage, because, in this case, CNPD does not require supplier specialisation for product design. Conversely, cases FFA and FFB show that SMEs and large firms are the ones operating in high-tech industries involving suppliers in the early stages of CNPD, because their need for specialisation is limited to product design, as well as to the processes materialising them. The results of this study further show that the size of suppliers does not influence their involvement in the early stages of CNPD, when such collaboration does not occur between large 'specialised firms' with a large production scale, as exemplified by cases FFD and FFB, respectively.

The results of this research work show that the need for specialisation of firms in the early stages of CNPD fosters not only the early involvement of industrial suppliers, but also service suppliers. This phenomenon shows the importance of the intervention of service suppliers in CNPD.

This paper contributes with a comparative approach on interfirm collaboration according to their size. This approach shows that ESI occurs in CNPD undertaken by large firms when they strive for product differentiation, while SMEs seek to enhance their activity efficiency, in both cases through the development of new products and manufacturing processes. As a result, radical innovation fosters ESI in CNPD.

This study has implications regarding CNPD management according to the size of the firm involved and the generated innovation. By means of the developed framework, managers can analyse and compare the interactions developed between large firms and SMEs in CNPD, and assess on the proper allocation of innovative activities. These facts have a practical implication on the decisions for defining the activities undertaken in CNPD, in accordance with the innovation generated. Moreover, this study shows that there are industries where ESI is more likely to occur, due to the high degree of technological intensity of their business environment.

7 Limitations and future research

This study has limitations that may be analysed in future research. Since it is a qualitative study, its main limitation is the non-generalisability of its results. Furthermore, this study is limited to the analysis of the perspective of the client (focal firm) in its upstream relationship. Hence, future studies may analyse the supplier's perspective, thereby contributing for the understanding of both perspectives: of the supplier regarding the client and of the client regarding the supplier. Another limitation of this study is the unit of analysis, which is limited to upstream relationship, and so future studies may cover the downstream relationship. In turn, future studies may analyse supplier involvement in CNPD according to the type of projects developed, regarding R&D, type of intervening parties (industry, services, type of business) and the generated innovation (radical, incremental), as well as take account of the relationship with other partners (competing firms, public firms). Lastly, future research may more systematically explore the study of supplier involvement in CNPD according to the technological intensity of the industry, by comparing the reality of high-tech industries with low-tech industries.

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