

## **Innovation Networks: the Contribution of Partnerships to Innovative Performance of Firms in the Brazilian Electrical-Electronics Industry**

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### **ABSTRACT**

Innovation networks have been identified in the literature as a way to complement firms' innovative capabilities through collaboration with other partners. To provide empirical evidence for this assertion, this paper investigates the contribution of partners established in innovation networks for innovative performance of firms in the Brazilian electrical-electronics industry. For this purpose, we carried out an exploratory and descriptive survey among 185 companies. The data were analyzed using structural equation modeling (SEM). As the main findings, we observed that the establishment of collaborative relationships with customers, competitors and universities/research institutions can contribute to organizational and process innovation. However, despite obtaining some significant results concerning the contribution of different partners in the network, electrical-electronics industry companies also attach great importance to internal activities to develop their innovations.

**Keywords:** Innovation networks. Interorganizational collaboration. Innovative performance.

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## 1 INTRODUCTION

**C**ollaboration through the formation of networks is becoming increasingly relevant as a way to complement internal innovation activities of companies (HAGEDOORN, 2002; HILL; ROTHAERMEL, 2003). This phenomenon has attracted a good deal of interest by researchers and scholars, and has become an important line of research in the field of business administration. Clear examples of such networks can be found in organizations like Procter & Gamble, which successfully adopted a more open approach to the development of its innovations. The company perceived that it could expand its network of about 8,600 in-house scientists by collaboration with over 1.5 million external researchers and developers from other companies in the segment. From this initiative, P&G not only managed to meet its innovation objectives, but also to spread its ideas to other businesses, by allowing the ideas developed in its laboratories to be used, three years later, by other companies, including its direct competitors (CHESBROUGH, 2012).

Faems, Looy & Debackere (2005) point out that in the literature on innovation, interorganizational collaboration is referred to as an instrument to improve the innovative performance of firms. However, despite the interest in the theme, empirical evidence of this improvement is scarce. They also mention that not all innovation collaborations are successful. The lack of flexibility and adaptation, the unintentional diffusion of knowledge and misinterpretation of the intended benefits are commonly cited as reasons for poor performance of partnerships (FAEMS et al., 2005).

According to Tsai (2009), the lack of agreement among researchers on the possible innovation benefits from collaboration with different actors in the network can indicate the need for new studies. Therefore, to deepen academic knowledge of the theme, the general objective of this study is to verify the contribution of the partnerships established in innovation networks among companies, with focus on the Brazilian electrical-electronics industry (BEEI).

The choice of this industry is justified by its high dependence on innovative activity. Companies belonging to this technology-intensive sector rely on innovations to improve their competitiveness, and in the final analysis, to assure their survival (ABINEE, 2013).

The BEEI occupies a preeminent place in the nation's productive web, because the operations and efficiency of many other segments depend on electronic and electrical devices,

causing an intense multiplicative effect on the economy as a whole (MACEDO et al., 2009). This industry is one of the main priorities of official industrial development policies in Brazil, with the aim of modernizing companies and spurring innovation and improved competitiveness.

Our specific objectives for this study were: (1) to rank the main partnerships established in the innovation networks, according to their degree of importance; (2) to identify the main reasons why firms establish innovation networks; and (3) to measure the results in terms of product, process, marketing and organizational innovation.

The article is organized in five sections including this introduction. The second presents a brief review of the literature; the third describes the methodological procedures; the fourth presents the results; and the fifth presents our reflections on the theme and possible new avenues of research.

## **2 THEORETICAL FRAMEWORK**

### **2.1 INNOVATION NETWORKS**

Among the different types of networks discussed in the literature, innovation networks are defined as entities formed by various independent, heterogeneous and geographically distributed organizations that collaborate with each other to attain common objectives (PLISSON; LJUBIC; MOZETIC; LAVRAC, 2007). Likewise, the Oslo Manual (OECD, 2005) defines the concept of innovation network as a set of organizations that develop partnership ties for the purpose of overcoming the uncertainties of the innovation process.

Here we assume that an innovation network is any set of collaborative relations established between companies and other organizations, institutions and/or individuals in which all participants play an active role to realize innovations. This definition includes both formal and informal arrangements, over any time horizon, in any geographic location, except relations established by contracts for the acquisition of knowledge or technology (OECD, 2005; FORFÁS, 2004).

Regarding the factors behind the formation of these networks, Powell & Grodal (2006) indicate the possibility of information diffusion, sharing of resources, access to specific assets and learning by companies. In this sense, the establishment of networks is related to the need for inputs for the innovation process, based on the complexity of the base of knowledge necessary to innovate.

## 2.2 TYPES OF ACTORS IN INNOVATION NETWORKS AND THEIR CONTRIBUTIONS

Despite the diversity of the partnerships that firms can establish in the search for innovation, four types stand out in the literature: customers, universities/research institutions, suppliers and competitors (GEMÜDEN; RITTER; HEYDEBRECK, 1996; OECD, 2005; DOZ et al., 2006; TSAI, 2009; CARVALHO, 2010).

Collaboration with customers can be considered a relevant source of innovation by facilitating the identification of market opportunities for technological development and also to reduce the likelihood of poor conception in the initial phase of developing products (GUPTA; WILEMON; ATUAHENE-GIMA, 2000; FRITSCH; LUKAS, 2001; BROCKHOFF, 2003). Besides these aspects, understanding the needs of consumers through feedback from customers can help companies obtain new ideas (VON HIPPEL; THOMKE; SONNACK, 1999), favoring the rapid identification of market trends.

According to Gemüden et al. (1996), cooperation with suppliers can lead to innovations mainly regarding improvement of products. The reason is that suppliers tend to have more experience and better knowledge of the parts and components of products, which can be fundamental for development of new or improved products (EISENHARDT; TABRIZI, 1995). The development of a relationship involving sharing of innovative ideas with suppliers also helps companies to identify potential technical problems and opportunities to develop new products (KESSLER; CHAKRABATRI, 1996).

According to Tsai (2009), the least frequent agents in innovation networks are competitors. Nevertheless, this type of collaboration can allow companies to know their competitors better, which can favor their ability for differentiation (LINN, 1994). For Lawson & Samson (2001), the application of knowledge obtained from competitors, such as through benchmarking, permits internalization of the rivals' qualities by means of imitation or improvement.

On the matter of collaboration with universities and research institutions, Tsai (2009) indicated that this has been growing strongly, mainly due to government incentives. Universities and research institutions are important centers for the creation and dissemination of scientific knowledge (Hemmert, 2004). Therefore, firms can interact formally or informally with these institutions to acquire new knowledge that is useful for their innovation process (CALOGHIROU; KASTELLI; TSAKANIKAS, 2004).

### 2.3 KNOWLEDGE ABSORPTION CAPACITY

The capacity to absorb knowledge refers both to a firm's ability to use its own knowledge and to recognize, assimilate and use external knowledge for commercial purposes (COHEN; LEVINTHAL, 1990). According to Kim (2001), this capacity depends on the current level of technological knowledge, which in turn is derived from previous and current internal research and development (R&D) efforts. Complementing this thought, Schmidt (2005) proposed that the absorption of knowledge, besides depending on the intensity of R&D activities, is also related to the contracting of external professionals with different academic backgrounds or more schooling than the company's own technical staff.

According to Teece (2000) and Tsai (2009), a firm's ability to absorb knowledge can determine the extent to which it can use outside knowledge. Therefore, in an innovation network, the firm's capacity to absorb external knowledge can influence the types of relationships it develops and the results in terms of innovation.

### 2.4 KNOWLEDGE USE STRATEGIES

Another relevant variable for the study of innovation networks is the strategy of using the knowledge obtained by the company. The literature indicates the existence of two main strategies: exploration strategy and exploitation strategy (MARCH, 1991). The exploration strategy is related to research and experimentation with the aim of establishing new areas of knowledge and innovation. This strategy is generally established with partners that are not involved in the firm's activities (DITTRICH; DUYSTERS, 2003). In turn, the exploitation strategy is associated with the selection, refinement and execution of existing ideas and information in the company for production of products. For this reason, firms that adopt this strategy tend to strengthen their knowledge base by means of relations with organizations that have similar activities (DITTRICH; DUYSTERS, 2003).

## 3 RESEARCH METHOD

This study can be classified as exploratory and descriptive in nature. Exploratory research is the first step of the investigatory process, with the aim of becoming familiar with the phenomenon to be studied and to obtain a new perception of the topic under analysis (CERVO; BERVIAN; DA SILVA, 2007). In complementary form, descriptive research, as the name suggests, aims to describe the characteristics of a determined phenomenon, to enable establishment of relations between variables, besides helping to clarify the factors that contribute to its occurrence (GIL, 1996).

We first carried out a bibliographic review to delineate and define the concepts of interest, resulting in the proposal of two models to be tested. This was followed by empirical research, by applying a questionnaire with 25 questions, divided into four blocks, as indicated in Table 1.

1 – Data on the company	Refers to information about the firm studied, such as size, knowledge absorption capacity and economic sector, among other aspects.
2 – Innovation performance	Related to the firm's performance in terms of product, process, marketing and organizational innovation and the possible effects.
3 – Characteristics of the innovation network	Part composed of questions on the reasons for formation of networks, types of partnerships established and their relevance to the firm, and also the use of a strategy of exploitation or exploration of the knowledge developed.
4 – Profile of the respondent	Questions on the respondents' personal characteristics, such as level of schooling, position in the company hierarchy, age and gender.

Table 1 – Description of the blocks of the questionnaire

Source: Prepared by the authors.

With respect to the approach or focus applied, this study can be classified as quantitative. According to Sampieri, Collado & Lucio (2006), the quantitative focus is based on the use of data organized in structural (matrix) form and their statistical analysis, seeking to respond to the research questions and test previously established hypotheses.

### 3.1 CONCEPTUAL MODELS

Based on the proposed study objectives and the information obtained from the literature review, it was possible to establish two conceptual models, as depicted in Figure 1. These models consider four main types of partners, identified from the literature, with which companies establish relations for innovation: customers, universities/research institutions, suppliers and competitors. Operationally, the determination of the types of partnerships established by firms was based on two aspects: (1) the existence of relations seeing to develop at least one innovation in the past three years by means of collaboration with customers, universities/research institutions, suppliers or competitors, located in any geographic region (binary variable); and (2) the degree of importance of each of these actors in the firm's innovation process.

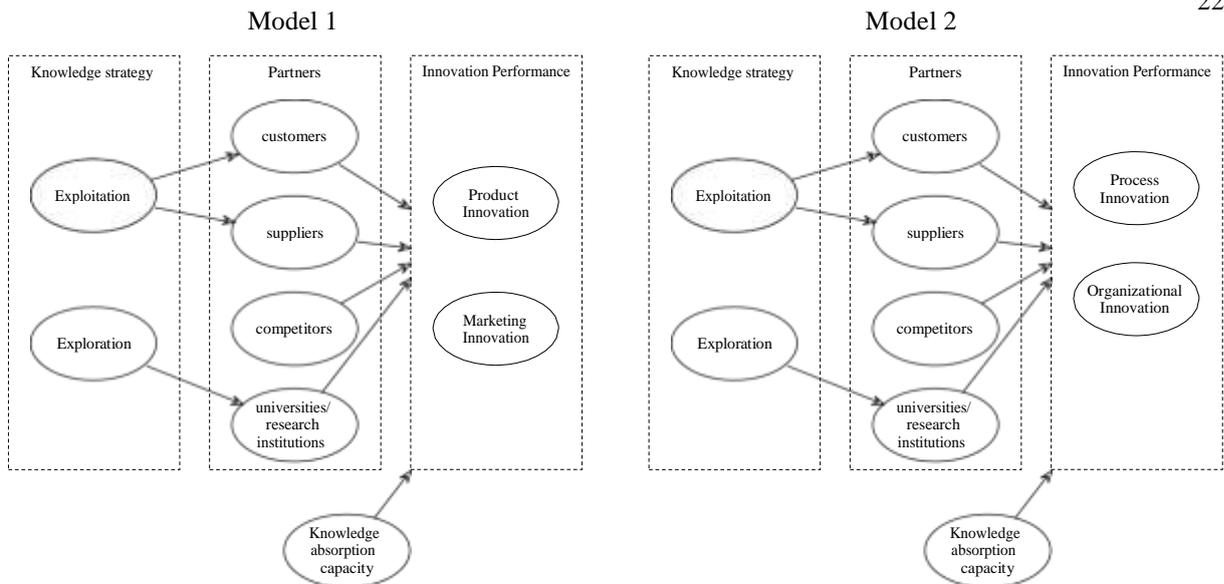


Figure 1 – Conceptual models  
 Source: Prepared by the authors.

We suggest in the models that the establishment of relations with the various actors can be related to the firm’s performance in terms of product and marketing innovation (model 1) and process and organizational innovation (model 2), from the standpoint of the respondent company. We then developed constructs to measure the results over the past three years of each firm related to each type of innovation. The respective variables are shown in Tables 2, 3, 4 and 5. The measurement of the variables occurred by means of the degree of agreement with the items on a scale of 1 to 10.

Code	Product Innovation	Adapted from:
PROD1	The company has introduced at least one new or significantly improved product (good or service) in the market.	Neely & Hill (1998) Faems et al. (2005) OECD (2005) Tsai (2009)
PROD2	A large part of the company’s sales revenue comes from new or significantly improved products (goods or services).	Neely & Hill (1998) Tsai (2009) Carvalho (2010)
PROD3	The company’s representatives frequently participate at congresses and trade fairs as exhibitor or speaker.	Oliva et al. (2011)
PROD4	The company has few competitors in its goods or services.	Oliva et al. (2011)
PROD5	There has been recent improvement in quality of the company’s goods or services.	OECD (2005) IBGE (2010)
PROD6	The company has recently expanded the range of goods or services offered.	OECD (2005) IBGE (2010)

Table 2 – Variables of the construct: product innovation  
 Source: Prepared by the authors.

Code	Process Innovation	Adapted from:
PROC1	The company has introduced at least one new method to manufacture goods or render services.	Neely & Hill (1998) OECD (2005) IBGE (2010)
PROC2	The company has introduced at least one logistical system or delivery method for its inputs, goods or services.	IBGE (2010)
PROC3	The company has introduced equipment, software and techniques in support of production.	IBGE (2010)
PROC4	There has been an increase in the capacity and flexibility of production or rendering of services.	OECD (2005) IBGE (2010)
PROC5	There has been a reduction in costs of production/services rendered.	OECD (2005) IBGE (2010)
PROC6	There has been a reduction in the consumption of raw materials and energy.	OECD (2005) IBGE (2010)

Table 3 – Variables of the construct: process innovation

Source: Prepared by the authors.

Code	Marketing Innovation	Adapted from:
MKT1	The company has implemented significant changes in its marketing concepts/strategies.	OECD (2005) IBGE (2010)
MKT2	The company has introduced important changes in the esthetics or design of at least one of its products.	IBGE (2010)
MKT3	The company has recently entered new markets.	OECD (2005) IBGE (2010)
MKT4	There has been an increase in the visibility or exposure of the company's products.	OECD (2005) IBGE (2010)
MKT5	The company has improved its ability to adapt to different demands from customers.	OECD (2005) IBGE (2010)

Table 4 – Variables of the construct: marketing innovation

Source: Prepared by the authors.

Code	Organizational Innovation	Adapted from:
ORG1	The company has introduced new management techniques to improve working routines and practices.	OECD (2005) IBGE (2010)
ORG2	The company has implemented new methods of organizing work to better distribute responsibilities and decision-making power.	IBGE (2010)
ORG3	The company has implemented changes in the relations with other firms or public institutions aiming to construct a new organizational reality.	IBGE (2010)
ORG4	There has been improvement in the communication and interaction between the different business areas.	OECD (2005) IBGE (2010)
ORG5	There has been improvement in the sharing and transfer of knowledge with other organizations.	OECD (2005) IBGE (2010)
ORG6	The company is subject to regulations and standards related to the internal or external market.	OECD (2005) IBGE (2010)

Table 5 – Variables of the construct: organizational innovation

Source: Prepared by the authors.

Another aspect analyzed was the strategy of using the knowledge obtained by the firm from its partners in the innovation network. Based on the theoretical study, we formulated two constructs to gauge the use of the exploration and exploitation strategies, as well as the possible associations with these partners (Table 6).

<b>Code</b>	<b>Exploration</b>	<b>Adapted from:</b>	
EXPR1	The company develops relations with partners that allow implementation of more radical innovations.	March (1991)  Dittrich & Duysters (2003)  Westerlund & Rajala (2010)	
EXPR2	The company seeks to develop relations that lead to the generation of new ideas and organizational knowledge.		
EXPR3	The development of weaker connections with the innovation partners is preferable, to enable the diffusion of new information.		
EXPR4	The company is focused on developing new products, processes and methods.		
<b>Code</b>	<b>Exploitation</b>		
EXPT1	The company develops relations with partners that allow realization of incremental innovations.		
EXPT2	The company seeks to develop relations that strengthen and improve the established organizational knowledge.		
EXPT3	The development of strong connections with innovation partners is preferable, based on regular interactions, which are fundamental to nurture trust between organizations.		
EXPT4	The company focuses on improvement of existing products, methods and processes.		

Table 6 – Variables of the construct: knowledge exploration and exploitation strategies  
Source: Prepared by the authors.

In the proposed models we also considered that the relation established between the variables is moderated by each firm’s ability to absorb knowledge. In other words, the performance with respect to product, process, marketing and organizational innovation can be influenced by the company’s knowledge absorption capacity. Therefore, we developed the construct specified in Table 7.

<b>Code</b>	<b>Knowledge Absorption Capacity</b>	<b>Adapted from:</b>
ABS1	Intensity in the R&D area (percentage of gross operating revenue spent on R&D and training in 2012 over the total number of employees)	Tsai (2009) Schmidt (2005)
ABS2	Number of employees in the R&D area in relation to the total headcount.	Faems et al. (2005)
ABS3	The R&D area is highly relevant to the development of innovations at the company (importance of the R&D area).	Faems et al. (2005) IBGE (2010)
ABS4	Percentage of employees that have completed specialization courses or hold master’s or doctorate degrees (weighted average: 1 – specialization; 2 – master’s; 3 – doctorate).	Schmidt (2005)
ABS5	Diversity of professional backgrounds of the employees (number of professional areas detected in the company over total number of employees).	Schmidt (2005)
ABS6	At least one innovation of the company was developed based on relations with customers, suppliers, competitors or universities/research institutions in the past 3 years.	Schmidt (2005)

Table 7 – Variables of the construct: knowledge absorption capacity  
Source: Prepared by the authors.

Based on the literature review and the conceptual models, we established the alternative hypotheses stated in Table 8, which were tested for the two models:

H1.1	Collaboration with customers is positively related to the company's innovation result.
H1.2	Collaboration with suppliers is positively related to the company's innovation result.
H1.3	Collaboration with competitors is positively related to the company's innovation result.
H1.4	Collaboration with universities/research institutions is positively related to the company's innovation result.
H1.5	The greater the company's knowledge absorption capacity is, the better will be its result in innovation.
H1.6	The use of knowledge exploitation strategies is positively related to the development of collaborations with customers.
H1.7	The use of knowledge exploitation strategies is positively related to the development of collaborations with suppliers.
H1.8	The use of knowledge exploration strategies is positively related to the development of collaborations universities/research institutions.

Table 8 – Research hypotheses  
Source: Prepared by the authors.

Note that we did not formulate a hypothesis for use of the exploration and exploitation strategies with respect to competitors, since besides not being a question addressed in the literature, we believe any relationship with these actors would be ad hoc, and thus without a defined strategy.

### 3.2 PROCEDURE FOR COLLECTING AND ANALYZING THE DATA

The reference universe was composed of all Brazilian companies in the electrical and electronics sector. The sample was chosen by the criterion of accessibility, so it is a non-probabilistic sample. We obtained 185 valid responses, collected in the period from February 18 to April 14, 2013, by means of the Gizmo on-line survey tool.

After gathering the data, we examined the resulting database for missing data and outliers and found no problems in these respects. Then we applied descriptive and multivariate statistical analysis by applying structural equation modeling (SEM), employing the AMOS version 21 software. In the SEM, the constructs were submitted to confirmatory factor analysis (CFA) and we calculated Cronbach's alpha to check the consistency of the data and satisfaction of the technical conditions. The Cronbach's alpha coefficients of some of the constructs were lower than 0.7, indicating the need to reassess them. Then the data were subjected to exploratory factor analysis (EFA) and, after the removal of some data and the union of others, it was possible to determine new constructs that satisfied the technical requirements. Table 9 presents the new constructs formed from the EFA and the abbreviations used.

New Constructs	Variables of the Construct
Exploration and exploitation strategy (EXPR_EXPT)	EXPR1, EXPR2, EXPT1, EXPT2 and EXPT3
Customers (CUST11)	CUST1*CUST2
Suppliers (SUPP11)	SUPP1*SUPP2
Competitors (COMP11)	COMPET1*COMPET2
Universities and research institutions (UNIVER11)	UNIVER1*UNIVER2
Product and marketing innovation (PROD_MKT)	PROD1, PROD2, PROD5, PROD6, MKT1, MKT3 and MKT5
Process and organizational innovation (PROC_ORG)	PROC1, PROC2, PROC3, PROC5, PROC6, ORG1, ORG2, ORG3, ORG4, ORG5 and ORG6
Knowledge absorption capacity (ABS)	ABS1, ABS2, ABS3, ABS4, ABS5 and ABS6

Table 9 – Formation of the new constructs  
Source: Prepared by the authors.

To check the goodness of fit of the models, we used various indexes:  $\chi^2/d.f.$  (Cmin/d.f.), GFI, CFI, IFI, RMSEA and SRMR, as shown in Table 10.

Measure	Acceptable Value
X <sup>2</sup> /d.f	Values less than or equal to 5.
Goodness of Fit Index (GFI)	Varies from zero (no fit) to 1 (perfect fit) > 0.8 marginal fit; > 0.9 good fit
Root Mean Square Error of Approximation (RMSEA)	Values lower than 0.08
Standardized Root Mean Residuals (SRMR)	Values lower than 0.10
Comparative Fit Index (CFI)	Varies from zero (no fit) to 1 (perfect fit) > 0.8 marginal fit; > 0.9 good fit
Incremental Fit Index (IFI)	Varies from zero (no fit) to 1 (perfect fit) > 0.8 marginal fit; > 0.9 good fit

Table 10 – Goodness-of-fit measures and recommended values  
Source: Hu & Bentler (1999); Hair Junior et al. (2009).

## 4 PRESENTATION AND ANALYSIS OF THE RESULTS

### 4.1 DESCRIPTION OF THE RESPONDENTS AND SAMPLE

Out of the total of 185 respondents (one from each company), the majority were men (74.05%), held positions as officers or managers (35.14% and 30.81% respectively) and had extensive schooling (50.27% held bachelor's or equivalent degrees and 36.22% had advanced graduate degrees).

With respect to the firms, most are located in the state of São Paulo (57.3%), followed by Rio Grande do Sul (9.2%) and Paraná (8.1%). Of the 185 companies, 85% are independent

and only 15% belong to a business group. The segment of activity that most stood out was informatics (28.11%), followed by industrial automation (12.43%) and telecommunications (9.73%). The firms ranged from micro-enterprises (44.86%), small businesses (24.32%), mid-sized firms (20.00%) and large companies (10.81%), according to the classification of SEBRAE (2012).

#### 4.2 DESCRIPTION OF THE INNOVATIVE ACTIVITY AND INNOVATION NETWORKS

The first question referred to the main party responsible for innovations, according to the company's perception, as expressed by the respondent. The great majority of respondents declared the company itself as being mainly responsible for innovations (76.22%), while another 15.68% stated their firms develop innovations in cooperation with other companies or institutions, 4.86% stated that another company of the groups was mainly responsible and 3.24% stated that innovations were developed by other organizations. These results are strongly convergent with the breakdown of the sources of innovation indicated by the National Innovation Survey (PINTEC) conducted by the Brazilian Institute of Geography and Statistics (IGBE, 2010) and the study conducted by Carvalho (2010), both of which demonstrate that the development of innovations is highly centralized in the company.

Despite this pattern, it can be noted in Figure 2 that the frequency of the actors with which the firms developed at least one innovation in the preceding three years was highly significant. The study revealed that 79.46% of the respondent companies developed at least one innovation in the previous three years with customers, 62.70% by collaboration with suppliers, 23.24% with competitors and 39.46% with universities or research institutions.

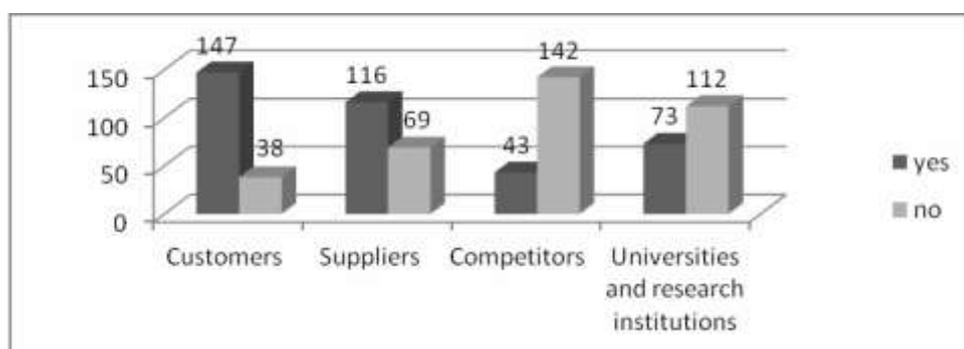


Figure 2 – Breakdown of collaboration for innovation  
Source: Prepared by the authors.

Customers and suppliers are the agents most often mentioned in the literature on innovation networks (GEMÜDEN et al., 1996; TETHER, 2002; OECD, 2005; CARVALHO, 2010; NDOU; DEL VECCHIO; SCHINA, 2011, CALDEIRA et al., 2012, FITJAR;

RODRÍGUEZ-POSE, 2013). This possibly can be explained by the need to create deeper and more longstanding collaborative efforts to enable companies to survive in a setting of rapid technological innovation (DOZ et al., 2006).

The data obtained show that most of the respondents had established various forms of partnership to develop innovations. Nevertheless, the participation of these partners in the innovative activity of the respondent companies as a whole is small, considering that the majority of firms stated that innovation was mainly in-house.

With respect to the degree of importance of each partner in the network (Objective 1), Table 11 shows that the least important are competitors. This pattern was also detected in the PINTEC (IBGE, 2010) and in the survey of Tsai (2009), both of which indicated that collaboration with competitors is the least common type of partnership for innovation.

**Table 11 – Degree of Importance of Partners for Innovation**

	Mean (1 – 10)	Standard Deviation	N
Customers	7.4	2.52	185
Suppliers	6.01	2.92	185
Universities and research institutions	3.76	3.12	185
Competitors	2.99	2.53	185

Source: Prepared by the authors.

Another question posed refers to the reasons for establishing innovation networks (Objective 2). Among the main responses, the standouts were access to new knowledge (51.89%), combination of competencies (48.68%) and enhancement of learning (37.29%). This result reveals the importance of transfer of knowledge and learning to the innovation process, findings also identified in other studies of the theme (POWELL; WHITE; KOPUT, 2005; DYER; NOBEOKA, 2000; CHESBROUGH, 2003; POWELL; GRODAL, 2006; CASSIMAN; VEUGELERS, 2006; NDOU et al., 2011). It should be noted, however, that the need to spread costs and reduction of risks, indicated as reasons to collaborate for innovation in the literature, were not among the motivating factors often cited for developing the networks in question.

Another objective of the study was to measure the performance of the companies in terms of product, process, marketing and organizational innovation (Objective 3), seeking to cross-reference these data with the information on the networks.

With respect to product innovation, the results show that in general the firms introduced new goods or services in the market and/or received benefits resulting from this type of innovation in the organization (mean of the construct = 5.70). Very similar results were found regarding the performance in marketing innovation (mean of the construct =

5.66). The result was lower for process innovation (mean of the construct = 4.84) than for product and marketing innovations. The lowest score was obtained for organizational innovation (mean of the construct = 4.82). Therefore, it can be concluded that the companies surveyed in the BEEI have obtained better results in relation to innovations focused on the market (product and marketing) and slightly worse results regarding innovations focused on the company (process and organizational). However, this result has not yet been related to the effect of engaging in collaboration for innovation, a topic addressed in the next section.

#### 4.3 ANALYSIS OF THE PROPOSED MODELS

##### 4.3.1 Model 1

Model 1 was constructed to analyze the effect of collaboration on the performance in product and marketing innovation. The analysis to validate the constructs of Model 1 indicated the existence of a problem of convergent validity for PROD\_MKT ( $AVE < 0.50$ ), suggesting that the variables of this construct are not highly correlated with each other. Since Cronbach's alpha of this construct was 0.8442 and this problem might have occurred due to the joining of the variables 'product innovation' and 'marketing innovation' we decided to proceed with examination of the model. Besides this, the other conditions for validity and reliability were satisfied, indicating that this construct is adequate. Also, the construct ABS did not satisfy the conditions for reliability ( $CR < 0.70$ ) and converging validity ( $AVE < 0.50$ ). But since the other conditions were satisfied, we decided to continue the analysis. Table 12 reports the goodness-of-fit indexes of the first structural equations model, indicating a sufficiently good fit. With respect to the hypotheses tested, Table 3 shows that only hypotheses H1.6a (p-value = 0.005) and H1.7a (p-value < 0.001) were significant at the 5% level.

**Table 12 – Goodness-of-Fit Measures of Model 1**

Measure	Observed Value
X <sup>2</sup> /d.f	2.079
Goodness of Fit Index ( GFI)	0.825
Root Mean Square Error of Approximation (RMSEA)	0.077
Standardized Root Mean Residuals (SRMR)	0.079
Comparative Fit Index (CFI)	0.828
Incremental Fit Index (IFI)	0.832

Source: Prepared by the authors.



ideas. That fact implies that these partners can be relevant to the establishment of strong and weak relations seeking to develop radical and incremental innovations.

Observation of the standardized estimates of the parameters shows that an increase of one unit in both exploration strategy and exploitation strategy causes a rise of 0.833 in the suppliers metric and of 0.636 in the customer measure. Therefore, the greater the utilization of the exploration strategy or exploitation strategy, the greater the relative importance is of collaborating with customers and suppliers.

However, no significant relations were produced by Model 1 between the types of partnerships and performance in terms of product and marketing innovation. This result is in accordance with the findings reported by Monjon & Waelbroeck (2003) and Belderbos, Carree & Lokshin (2004) with respect to collaboration with customers. In relation to collaboration with suppliers, the results obtained are in line with those of Sánchez & Pérez (2003), Freel (2003), Belderbos *et al.* (2004) and Ledwith & Coughlan (2005). On the matter of collaboration with competitors, Monjon & Waelbroeck (2003), Miotti & Sachwald (2003) and Belderbos *et al.* (2004) also found that this type of collaboration does not have a significant effect on the performance in innovation, mainly related to products. Finally, with respect to collaboration with universities and research institutions, our results are congruent with those of Monjon & Waelbroeck (2003), Caloghirou *et al.* (2004) and Ledwith & Coughlan (2005). Besides this, the knowledge absorption variable also appears not to affect the results in relation to product and marketing innovation at 5% significance.

#### 4.3.2 Model 2

Model 2 was formulated to analyze whether collaboration with other actors can influence the performance in terms of process and organizational innovation. The model presented a problem of convergent validity for the construct PROC\_ORG (AVE < 0.50), suggesting that its variables are not strongly mutually correlated. As happened with PROD\_MKT, that fact is not worrying, since Cronbach's alpha for the construct PROD\_MKT was 0.8595, a result that might be related to the joining of the variables. Besides this, the other measures of validity and reliability indicate the adequacy of their use in the model. Furthermore, the construct ABS did not satisfy a condition for reliability (CR < 0.70) and convergent validity (AVE < 0.50). But since the other validation conditions were satisfied, we opted to proceed with the analysis.

Table 14 presents the goodness-of-fit measures of the second structural equation model. All the indexes are greater than or near to the minimum threshold necessary, indicating a relatively good fit.

**Table 14 – Goodness-of-Fit Measures of Model 2**

Measure	Observed Value
X <sup>2</sup> /d.f	2.327
Goodness of Fit Index (GFI)	0.785
Root Mean Square Error of Approximation (RMSEA)	0.085
Standardized Root Mean Residuals (SRMR)	0.128
Comparative Fit Index (CFI)	0.751
Incremental Fit Index (IFI)	0.756

Source: Prepared by the authors.

Table 15 shows that hypotheses H1.1b (p-value = 0.004), H1.3b (p-value = 0.011), H1.4b (p-value = 0.005), H1.7b (p-value < 0.001) and H1.5b (p-value = 0.045) were all significant at the 5% level.

**Table 15 – Hypothesis Tests of Model 2**

			Hypothesis	Estimate	T	P-Value
<b>PROC_ORG</b>	<---	<b>CUST11</b>	H1.1b	0.063	2.858	0.004
<b>PROC_ORG</b>	<---	<b>SUPP11</b>	H1.2b	0.022	1.136	0.256
<b>PROC_ORG</b>	<---	<b>COMPET11</b>	H1.3b	0.038	2.549	0.011
<b>PROC_ORG</b>	<---	<b>UNIVER11</b>	H1.4b	0.060	2.827	0.005
<b>PROC_ORG</b>	<---	<b>ABS</b>	H1.5b	-0.012	-2.008	0.045
<b>CUST11</b>	<---	<b>EXPR_EXPT</b>	H1.6b	0.595	1.337	0.181
<b>SUPP11</b>	<---	<b>EXPR_EXPT</b>	H1.7b	0.843	3.384	*
<b>UNIVER11</b>	<---	<b>EXPR_EXPT</b>	H1.8b	0.215	0.882	0.378

\* p-value < 0.001

Source: Prepared by the authors.

Figure 4 depicts the second model obtained from applying the structural equation modeling technique. The estimates of the parameters show that the stronger the exploration strategy and exploitation strategy, the higher the relative importance of collaboration with suppliers, and the stronger the collaboration with universities and research institutions, customers and competitors, the higher the importance of process and organizational innovation. Finally, the greater the absorptive capacity, the lower the process and organizational innovation will tend to be.

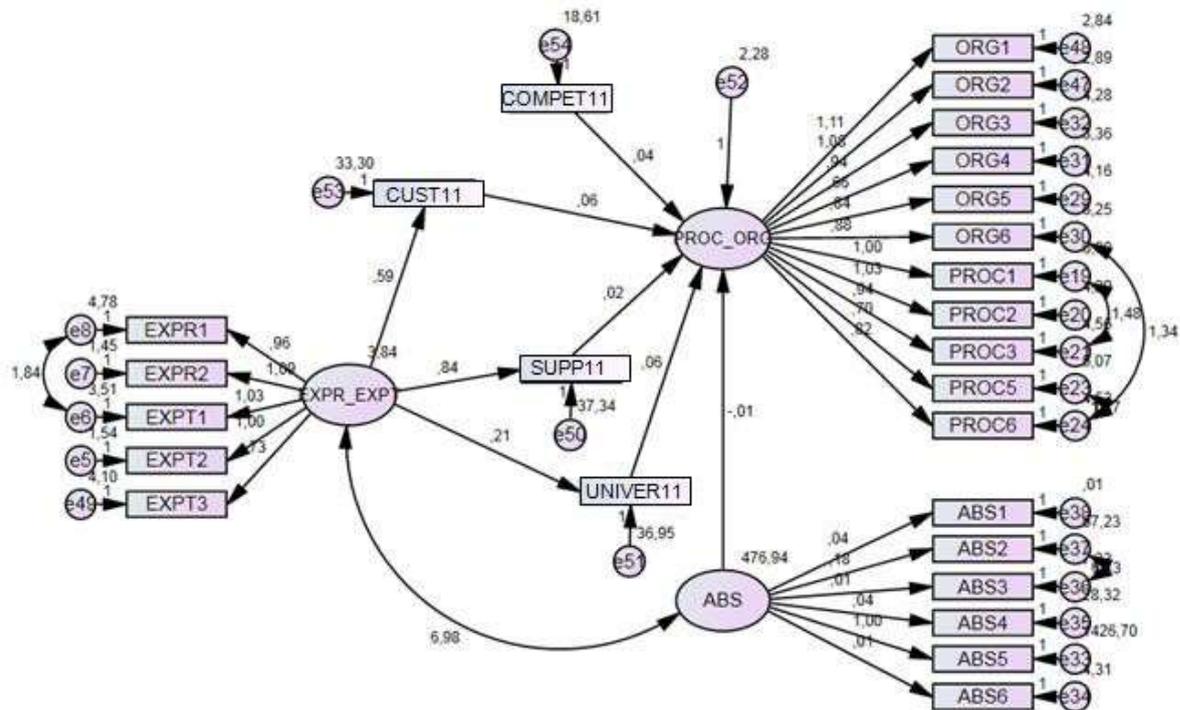


Figure 4 - Structural equation model for process and organizational innovation  
Source: Prepared by the authors.

Despite the scarcity of studies specifically examining the type of partner in the network with the performance in process innovation, and mainly in organizational innovation, the results of Model 2 appear coherent with those reported by some authors.

According to Gemüden et al. (1996), for example, obtaining success in terms of process innovation depends on the development of cooperation in networks with multiple actors, be it by means of strong interactions with universities and consultants or by more modest interactions with other agents.

The same result was also reported by Varis & Littunen (2010), who conducted one of the few studies dedicated to evaluating the influence of the sources of information on organizational innovations. According to the authors, the different network relations established by a firm tend to have a significant effect on the performance in terms of organizational innovation. Their results indicated that firms classified as innovators are more likely to establish relations with different partners in networks, and research and teaching institutions are a valuable source of information.

In this sense, customers can be considered an important source of innovation, as found by Gupta et al. (2000), Fritsch & Lukas (2001), Brockhoff (2003) and Prahalad & Ramaswamy (2004). The reason is that customers can supply valuable insights into their needs and those of the market in general. This information, if internalized, can prompt

significant changes in the firm's *modus operandi*, both in terms of processes and in terms of management.

With respect to competitors, the study of Lawson & Samson (2001) indicated that the application of knowledge obtained from rivals allows benchmarking and internalization of other firms' qualities, by means of imitation and/or improvement. Inkpen & Pien (2006) also suggested that companies that collaborate with competitors can obtain better performance in innovation compared to the use of other forms of collaboration.

On the subject of collaboration with universities and research institutions, Hemmert (2004), Caloghirou et al. (2004) and Clifton et al. (2010) reported its importance with respect to the creation, dissemination and acquisition of new scientific knowledge that can be applied in the innovation process. According to Ruef (2002), by enabling access to non-redundant information, universities and research institutions can contribute to organizational innovation.

Just as in Model 1, the results of the second model show that the use of knowledge exploration and exploitation strategies is positively related with the development of collaboration with suppliers, indicating that they can be relevant partners for exchange of new knowledge and refinement and selection of existing knowledge held by the company. However, in contrast to the findings of Fitjar & Rodríguez-Pose (2013), the relation between collaboration with suppliers and performance in process and organizational innovation was not significant in this study at the 5% level.

Finally, the result regarding knowledge absorption capacity also deserves mention. The study showed that this ability has a weak, but negative, influence on process and organizational innovation. Since this result could have been influenced by problems of reliability and convergent validity of the construct, its interpretation suggests that the variables related to the intensity of R&D activities in the company and the level of employee training negatively influence process and organizational innovations. Although they appear contradictory, similar results were found by Tsai (2009) regarding the relation between absorptive capacity and performance in marginal product innovation, based on relations established with customers.

#### 4.4 ANALYSIS OF THE HYPOTHESES

Based on the results presented in the previous subsections, Table 16 summarizes the considerations on each hypothesis formulated.

Hyp.	Result	Justification
H1.1	Partly confirmed	Considering that the collaboration with customers was only significant in Model 2, this hypothesis was confirmed partially. Therefore, it can be stated that collaboration with customers is positively related to the results from process and organizational innovation, but no associations were identified between these partners in the network and the performance in product and marketing innovation.
H1.2	Rejected	This hypothesis was rejected in both models. Therefore, the analysis of collaborative relations with suppliers and their level of importance, there was no association of this type of partner with the firm's innovative performance, at 5% significance.
H1.3	Partly confirmed	Collaboration with competitors was only significant in Model 2. Therefore, it can be said that competitors can contribute to the results in process and organizational innovation. Since no associations were identified between these partners and the performance in product and marketing innovation, this hypothesis was partially confirmed.
H1.4	Partly confirmed	Since collaboration with universities and research institutions was only significant in Model 2, this hypothesis was only partially confirmed. Hence, it can be stated that universities and research institutions make a positive contribution to the results of process and organizational innovation. Not associations were identified between these partners and the performance in product and marketing innovation at the 5% significance level.
H1.5	Rejected	This hypothesis was not significant in Model 1 and in Model 2 the knowledge absorption capacity was negatively associated, albeit weakly, with process and organizational marketing. Therefore, this hypothesis was rejected.
H1.6	Partly confirmed	This hypothesis was partly confirmed, because it was only significant in Model 1. This confirmation was valid for both the exploitation strategy and exploration strategy, since the variables of the constructs were highly correlated. Therefore, the greater the use of both exploration strategy and exploitation strategy, the greater the collaboration/relative importance of customers, considering the development of product and marketing innovations.
H1.7	Confirmed	This hypothesis was confirmed in both models. Once again, this confirmation was valid for both exploitation strategy and exploration strategy, since the variables of the constructs were highly correlated. Therefore, the greater the use of both exploration strategy and exploitation strategy, the greater the collaboration/relative importance of suppliers, considering the development of product, process, marketing and organizational innovations.
H1.8	Rejected	This hypothesis was rejected in both models. Hence, the use of exploration and exploitation strategies is not related to the establishment of collaboration with universities and research institutions.

Table 16 – Summary of the hypotheses and results

Source: Prepared by the authors.

## 5 FINAL CONSIDERATIONS

The results of this study show that the establishment of collaboration with customers, competitors and universities/research institutions can contribute to the results of process and organizational innovation.

Although some authors have stated that suppliers can be considered an important source of information for innovative activity, we did not observe an association between this partner type and innovative performance. Furthermore, we also did not observe significant relations between collaboration with customers, suppliers, competitors and universities/research institutions with firms' performance in terms of product and marketing innovation. This result allows assuming that despite the relations established, the innovations directed to the market are still under the internal control of the company, so that external collaboration has little importance for this activity.

In other words, even though this study detected a strong association between collaborative relations with customers and suppliers and innovation, there is still centralization of the innovation development process. This centralization can arise from the existence of barriers that affect the formation and development of networks, such as: (i) the lack of awareness of managers regarding the benefits provided by innovation networks; (ii) the reluctance, especially by small and medium-sized enterprises, to dedicate time and resources to a process that is not well understood or whose results are not clear; (iii) the reluctance of companies to share information and knowledge with other organizations, especially competitors; (iv) the difficulty of firms to identify the partners and opportunities to form networks, since their base of knowledge and information can be limited to their own contacts; and (v) the lack of abilities and resources to facilitate or coordinate implementation of a network, preventing the formation of cooperative relations.

Further regarding the barriers to the development of collaboration aimed at innovation, it is possible to propose some measures to overcome them, such as clear definition of the objectives and needs of the actors in the network, the establishment of coordination mechanisms to achieve mutual trust between partners and the support and intermediation of the government.

In general, this study permitted identifying the importance of external sources of knowledge for the innovation process. Another contribution is the measurement of the results of companies in terms of marketing and organizational innovation, topics that are still incipient in the majority of studies on the theme.

The results of this study have important implications for managers of companies in the electrical-electronic sector. Considering the intense competition in this market and the need for constant innovations, this survey is relevant by showing that different types of collaborative partnerships can help attain different types of performance in innovation, and that managers should be aware of the importance of choosing the right type of partners to complement and leverage their firms' innovative capabilities.

With respect to the limitations of this study, it only examined innovation networks from the perspective of the main actor (micro level), based on the perception of the respondents. For a more comprehensive understanding of the theme, we suggest new qualitative and longitudinal studies to investigate broader questions, from the point of view of all the actors of innovation networks. We can also suggest the introduction of new variables that represent the characteristics of the relations established and their objectives, the dynamics of networks,

mechanisms for coordination, structure of networks and division of powers among the actors. Finally, we suggest the establishment of new constructs to measure the capacity to absorb knowledge by companies. The expansion of research into innovation networks will provide a more solid foundation to deal with equally pertinent questions, such as governance of networks.

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