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INFLUENCE OF INTERORGANIZATIONAL COLLABORATION ON THE IMPLEMENTATION OF INNOVATIONS

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ABSTRACT

Collaboration for innovation is addressed in several texts, but few bring empirical evidence of the influence of collaboration on innovation. Thus, the aim of this research is to identify and analyze the degree of the influence of collaboration on the implementation of innovations in Brazilian industries. The theoretical basis used consisted of texts that approach with innovation in a more consistent way and that specifically address collaboration for innovation. For data collection, a structured questionnaire applied to the Brazilian extractive and processing industries was used. This resulted a sample of 254 valid questionnaires. The questionnaire measured the innovation (5 variables), the sources of collaboration (9 variables) and the motives for collaborating (9 variables). The analyzes were based on the Exploratory Factor Analysis for the Motives and Sources constructs and the Multiple Linear Regression Analysis to verify the influence of Motives and Sources on Innovation. The results indicate that collaboration with subsidiaries or group companies, suppliers, customers and competitors has a significant and higher impact in relation to the five types of innovation evaluated. In the cases of radical and incremental innovation in process and Organizational Innovation, besides the sources already mentioned, one of the motives factors (access to resources) was also significant, indicating their influence on the implementation of innovations. As a theoretical contribution, this study seeks empirical evidence on the impact of collaboration on innovation, which is still in its infancy. As a practical contribution, it provides subsidies for companies and for the definition of public policies.

Keywords: Innovation; Collaboration; Universities; Research Institutions.

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INFLUÊNCIA DA COLABORAÇÃO INTERORGANIZACIONAL NA IMPLEMENTAÇÃO DE INOVAÇÕES

RESUMO

A colaboração para inovação é abordada em diversos textos, mas poucos trazem evidências empíricas da influência da colaboração sobre a inovação. Assim, objetivo desta pesquisa consiste identificar e analisar o grau a influência da colaboração sobre a implementação de inovações nas indústrias brasileiras. A base teórica utilizada consistiu em textos que tratam da inovação de forma mais consistente e, especificamente, que abordam a colaboração para inovação. Para coleta de dados utilizou-se de um questionário estruturado aplicado às indústrias extrativistas e de transformação brasileiras, contando com uma amostra de 254 questionários válidos. O questionário mensurou a inovação (5 variáveis), as fontes de colaboração (9 variáveis) e os motivos para colaborar (9 variáveis). As análises foram pautadas na Análise Fatorial Exploratória, para os construtos Motivos e Fontes, e na Análise de Regressão Linear Múltipla, para verificar a influência de Motivos e Fontes sobre a Inovação. Os resultados indicam que a colaboração com filiais ou empresas do grupo, fornecedores, clientes e concorrentes apresentam impacto significativo, e mais elevado, em relação aos cinco tipos de inovação avaliados. Nos casos da inovação radical e incremental em processo e da inovação organizacional, além das fontes já mencionadas, também um dos fatores relativos aos motivos (acesso à recursos) foi significante, indicando influencia destes também sobre a implementação de inovações. Como contribuição teórica, esta pesquisa busca evidências empíricas sobre o impacto da colaboração sobre a inovação, algo ainda incipiente. Como contribuição prática, fornece subsídios para as empresas e para definição de políticas públicas.

Palavras-chave: Inovação; Colaboração; Universidades; Instituições de Pesquisa.

1 Introduction

Innovation is recognized as one of the main drivers of economic growth and competitive process (Cainelli, Evangelista & Savona, 2005), and is relevant for the growth and prosperity of organizations (Gomes, Kruglianskas, Scherer, Menezes & Kneipp, 2011), and is also a means of achieving competitive advantage (Darilo & Nascimento, 2004). That is, it is the key element of competitiveness among companies (Mello, Lima, Boas, Sbragia & Marx, 2008). But this notion is not new because Schumpeter (1997) in the early twentieth century already highlighted this meaningful aspect of the innovation.

However, currently little can be done as regards innovation without the organizations joining (Nidumolu, Prahalad & Rangaswami, 2009; Bessant & Tidd, 2009; Porto & Costa, 2013; Dodgson, 2015), and the good management of collaboration between partners in the development of innovations enables the increase of opportunities and the performance improvement (Gomes & Kruglianskas, 2009; Gomes, Kruglianskas & Scherer, 2012). According to Faccin and Balestrin (2015), the evidence is emerging that innovation comes from cooperation. An example of this is that companies like Intel, Microsoft, Cisco, Genentech, Amgen and Genzyme, despite being considered highly innovative, internally develop little basic research, but innovate from the discoveries of other organizations (Chesbrough, 2003, 2011, 2012). The collaboration relevance for innovation had also been emphasized some time ago by Rothwell (1992, 1994).

The collaboration relevance for innovation is also highlighted in more extensive texts and researches, such as the Oslo Handbook, the OCDE Handbook (2005), the Pesquisa Industrial de Inovação Tecnológica (PINTEC) Handbook, the IBGE Handbook (2016), in Brazil, and the Community Innovation Survey (CIS) Handbook and the Innobarometer Survey Handbook, in Europe. Furthermore, some researches (considering only some of the most recent national surveys) deal with the collaboration for innovation (Kayser & Schreiber, 2013; Tuccori, Luppi, Carvalho & Santos, 2014; Faccin & Balestrin, 2015; Baggio & Wegner, 2016; Bastos & Britto, 2017), with the relationship between collaboration and innovation (Kuhl, 2012; Kuhl, Cunha, Maçaneiro & Cunha, 2016;

Kuhl, Amarante & Maçaneiro, 2017), and others emphasize that the collaboration contributes to the innovative capacity (Malachias & Meireles, 2009; Mello *et al*. 2008).

Specifically in terms of the influence or impact of collaboration on innovation, is highlighted the survey by Tomlinson (2010), who explored the impact of cooperative links (basically with suppliers, customers and competing companies) on the innovation levels (product, process and both) in five sectors of the UK manufacturing industry (aerospace, ceramics, software, textiles and health care), with a sample of 436 industries.

Thus, considering that Tomlinson (2010) points out that literature and empirical evidence tend to support the notion that collaboration between companies has a positive impact on innovation, the question that will guide this research can be described as 'Which is the degree of the collaboration influence on the innovations implementation?' Therefore, the objective of this research is to identify and analyze the degree of collaboration influence on the innovations implementation in Brazilian industries. The research will be limited to a sample of the Brazilian extraction and manufacturing industry.

To operationalize the data collection, we opted for a structured questionnaire (detailed in the third section of this article) and to operationalize the analyses, we opted for the realization of the Exploratory Factorial Analysis, to group the variables into factors, and we opted for the realization of the Multiple Linear Regression Analysis to identify the degree of collaboration influence on the innovations implementation, each one detailed in the sections referring to the methodological aspects and/or to the data analysis.

2 Theoretical framework

Innovation is a theme that attracts the researcher's attention since the most ancient times (Barbieri, 2007) and from the most diverse areas (Tang, 1998), but despite a large number of studies on it, we still don't have a single consensual definition (Wan, Ong & Lee, 2005). This is justified by the fact that it is seen in different ways in the literature (Wonglimpiyarat, 2004). However, the most widely used and disseminated concept was proposed by Schumpeter (1997), whose work is considered an important milestone in the innovation studies, on the economic and business perspective (Barbieri, 2007). Another very widespread literature definition, which summarizes Schumpeter's definition, is given by the OCDE (2005, p. 55): "An innovation is the implementation of a new or significantly improved product (good or service) or a process or a new method of marketing or a new organizational method in business practices, in workplace organization or in external relations".

As of Schumpeter's definitions (1997) and from the OCDE ones (2005), it is possible to deduce that innovation has some characteristic aspects, namely: innovation type (product, process, marketing method, organizational method, etc.) and innovation intensity (new or improved). The innovation intensity is commonly assessed from two main perspectives: a new product or process (Radical Innovation) or a significantly improved product or process (Incremental Innovation). The definitions and explanations for these classifications can be conferred in the literature from Schumpeter (1997), Tushman and O'Reilly III (1997), Henderson and Clark (2001), Christensen and Raynor (2003), Burgelman, Christensen and Wheelwright (2004); OCDE (2005), Klement (2007), Davila, Epstein and Shelton (2007), Zilber, Perez and Lex (2009), IBGE (2016), among others.

Thus, within the context of this research, only 5 innovation aspects will be investigated, as shown in Table 1, where there are also references of other researches that used the same aspects (actions directed to innovation) and similar questions.

Table 1 - Actions directed to innovation

Actions directed to innovation	Innovation	Sources
We aim to develop new products/services.	Radical in product	Kuhl (2012)
We aim to make changes or improvements to current products/services.	Incremental in product	Kuhl (2012); Garcia, Torres, Garcia & Ramos (2018)
We aim to develop new processes of production and/or management.	Radical in process	Kuhl (2012)
We aim to make changes or improvements to the current processes of production/service.	Incremental in process	Kuhl (2012); Garcia *et al.* (2018)
We aim to develop or make changes or improvements to our management process.	Organizational Innovation	Kuhl (2012); Garcia *et al.* (2018)

Source: Elaborated from Kuhl (2012) and Garcia *et al*. (2018).

According to Tether (2002), the innovation has been incredibly distributed, with few companies having the skills needed for individual technological development, so much so that in the last years has grown the interest in collaborative arrangements for innovation. In this sense, it is possible to identify recent studies that deal with the themes, collaboration and innovation, jointly. Among the studies we highlight: Kuhl (2012); Kayser and Schreiber (2013); Tuccori *et al*. (2014); Faccin and Balestrin (2015); Bouncken, Pesch and Kraus (2015); Wegner *et al*. (2016); Baggio and Wegner (2016); Kuhl *et al*. (2016); Bastos and Britto (2017); Kuhl et *al*. (2017); Morales *et al*. (2018); Colet and Mozzato (2018).

The collaboration for innovation is dealt within the literature and in the business environment, by several names, such as: alliance, coalition, consortium, cooperation, partnership and even networks (Murray, Haynes & Hudson, 2010; Balestrin, Verschoore & Reyes Junior, 2010; Cropper, Ebers, Huxham & Ring, 2010). But regardless of the term used, it represents, in the innovation context, an interorganizational relationship in order to develop and/or implement innovations, which singularly the organizations would not be able to accomplish. However, more specific aspects, such as why collaborating and with whom to collaborate, depend on each organization.

The Reasons for collaborating can be complex, but the risks reduction and the access to resources are some of those that stand out (Tether, 2002; Romijn & Albaladejo, 2002; Fadeeva, 2004; OCDE, 2005; Tidd, Bessant & Pavitt, 2008; Bos-Brouwers, 2010; Daidj, 2017). Table 2 presents a summary of the Reasons found in the researched literature, as well as the respective Sources.

Table 2 - Summary of reasons to collaborate

Reasons	Sources
Risk reduction associated with the innovation process.	Tether (2002); Tidd *et al.* (2008).
Cost Reduction associated with the innovation process.	Fadeeva (2004); Tidd *et al.* (2008).
Time reduction associated with the innovation process.	Fadeeva (2004); Tidd *et al.* (2008).
Access to technological resources.	Tether (2002); OCDE (2005); Bos-Brouwers (2010); Castro, Bulgacov e Hoffmann (2011).
Access to financial resources.	Tether (2002); Bos-Brouwers (2010); Castro *et al.* (2011).

Reasons	Sources
Access to knowledge, information and learning.	Tether (2002); Romijn e Albadejo (2002); OCDE (2005); Tidd *et al.* (2008); Bos-Brouwers (2010); Castro *et al.* (2011).
Access to other resources.	Tether (2002); Bos-Brouwers (2010); Castro *et al.* (2011).
Acquisition of scale economy.	Tidd *et al.* (2008).
Stakeholder Pressure.	Murray *et al.* (2010).

Source: Kuhl (2012, p. 47) e Kuhl *et al*. (2016, p. 11).

Regarding the Sources of Collaboration or with whom to cooperate, Rothwell (1992, 1994) was already highlighting, in his proposition of the 5th generation of R&D, that one of the characteristics of this generation would be the strong vertical and horizontal connection of the organizations. The researched literature includes in the list Sources of Collaboration since other companies in the same group, until competitors, from universities to consultancies (Tether, 2002; Howells & Tether, 2004; Romjin & Albaladejo, 2002; EUROSTAT, 2004; OCDE, 2005; Mansury & Love, 2008; CSO, 2009; IBGE, 2016; Faria, Lima & Santos, 2010).

Table 3 presents a summary of the Sources of Collaboration found in the researched literature, as well as the respective Sources.

Table 3 – Summary of Sources of Collaboration

Sources	Sources
Other companies within the business group.	Romijn e Albaladejo (2002); Eurostat (2004); OCDE (2005); CSO (2009); IBGE (2016).
Suppliers.	Tether (2002); Romijn e Albaladejo (2002), Howells e Tether (2004); Eurostat (2004), OCDE (2005); Mansury e Love (2008); CSO (2009), IBGE (2016).
Customers or consumers.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); Mansury e Love (2008); CSO (2009); IBGE (2016).
Competitors or other companies in the same segment.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); Mansury e Love (2008); CSO (2009); IBGE (2016).
Universities or other higher education institutions.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); CSO (2009); IBGE (2016).
Consulting.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); Mansury e Love (2008); CSO (2009); IBGE (2016).
Private research and R&D institutes and private laboratories.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); CSO (2009); IBGE (2016).
Public institutes of research or of innovation support and private non-profit institutes.	Tether (2002); Romijn e Albaladejo (2002); Howells e Tether (2004); Eurostat (2004); OCDE (2005); CSO (2009); IBGE (2016).
Professional training and technical assistance Centers.	Romijn e Albaladejo (2002); IBGE (2016).

Source: Kuhl (2012, p. 50) e Kuhl *et al*. (2016, p. 11).

The items listed in Tables 1 to 3 were transformed into questions in the questionnaire and were subsequently operationalized as the variables used in the analyses, as evidenced in the next section.

3 Methodological aspects

This is quantitative, descriptive and analytical research, with data collection through a structured questionnaire to measure the Innovation, the Reasons for Collaboration for Innovation and the Sources of Collaboration for Innovation, whose origins (sources) of issues are highlighted in Tables 1 to 3. For simplification purposes, the Reasons for Collaboration for Innovation will be called merely Reasons and Sources of Collaboration for Innovation will be called merely Sources.

The innovation operationalization took place through the insertion in the instrument of data collection of 5 questions, according to the Sources presented in Table 1, using a scale of 5 points. The Reasons operationalization took place through the insertion of 9 questions in the data collection instrument, according to the Reasons presented in Table 2, using a 5 point scale. The Sources operationalization took place through the insertion in the instrument of data collection of 9 questions, according to the Sources presented in Table 3, using a scale of 5 points.

The data collection instrument (questionnaire) was based on parts of the same data collection instrument adopted by Kuhl (2012). Only a few minor adjustments were implemented for this study, specifically in aspects related to the characterization of the respondent (individual and organization). The parts of that study used are the same that were reproduced in Tables 4 to 6 of the analyses, adjusting only the redaction of those constants in Table 4.

Although this was a questionnaire already validated, we decided to present the same to two expert professors for verification, especially due to the small adjustments made, but there were no suggestions for adjustment.

Data collection occurred from 03/20/2018 to 07/18/2018, and 258 questionnaires were collected, fully filled. However, 4 of them were from companies that didn't fit into the extractive or transformation sector, and were, therefore, withdrawn from the sample, resulting in a total of 254 questionnaires considered valid.

The collection was performed through a questionnaire made available online (Google Forms). However, many respondents requested a version in Word®, Microsoft® (practically 1/3 of the sample). The data tabulation was done in Excel®, Microsoft®, and subsequently, they were transferred to the *Statistical Package for the Social Sciences* (SPSS®) for the analysis.

To achieve the proposed objective and to answer the research question, we opted to perform the Exploratory Factor Analysis (EFA) to identify the main groupings of the variables (factors) within each construct, and the factors were evaluated according to their internal consistency, from the Cronbach's Alpha. Subsequently, Multiple Linear Regression Analysis was used to identify the existence or not of the collaboration influence on innovation. With innovation as a dependent variable and collaboration as an independent variable, Tomlinson used the operationalization of the Multiple Linear Regression Analysis (2010), highlighting that the variables relative to innovation and collaboration of that research are not the same of this research.

4 Data analysis

Before starting the analyses themselves, we verified the representativeness of the sample with regard to the Brazilian regions (n = 4 - North; n = 19 - Northeast; n = 13 - Midwest; n = 122 - Southeast; n = 96 - South), from the Chi-Square test or adequacy (*goodness of fit*) (p = 0,999) which, according to Maroco (2014, p. 99), “serves to verify whether two or more independent

populations (or groups) differ with regard to a particular characteristic, i.e., if the frequency with which the sample elements are distributed by the classes of a categorized nominal variable is or not identical". Thus, the sample can be considered representative by region if it is compared to the distribution data of the industries by region, obtained at PINTEC (IBGE, 2016).

Regarding the states, the sample contains industries from 21 different states, and there were no responses from Acre, Amapá, Pará, Roraima and Tocantins (all from the North Region) and neither from the Distrito Federal. São Paulo is the state with the highest number of respondent industries (n = 83), followed by Rio Grande do Sul (n = 43), Santa Catarina (n = 32) and Minas Gerais (n = 28). On the other hand, among the states of Alagoas, Maranhão, Mato Grosso do Sul, Paraíba, Rio Grande do Norte, Rondônia and Sergipe each one have had only one respondent.

Other pertinent aspects are the industries size (n = 17 - micro-enterprise; n = 60 - small business; n = 97 - average company; n = 80 - large company), and the operation time in the market (approximate average of 44 years, among them 6 with more than 100 years and only 3 with 5 years or less). As for the sectors involved, there are 21 of the 25 possible (considering the extractive and manufacturing industry, according to the sectors listed in the Classificação Nacional das Atividades Econômicas – CNAE), and the highest concentrations of respondents were in the manufacturing sectors of food products (n = 26), manufacture of computer equipment, electronic and optical products (n = 25), manufacture of pulp, paper and paper products (n = 20) and manufacture of chemical products (n = 19).

Regarding the respondents, they take up the most diverse positions, but most (approximately 53%) in steering functions (owners, directors, managers and so on) or (approximately 18%) in supervision/coordination functions, and they operate in the industry, by which they responded the questionnaires, on average in the last 13 years, and 11 among them responded that they work in the company just a year and 2 for over 50 years. Seven respondents didn't indicate the time of operation in the company.

Next are presented the Tables 4 to 6 containing the variables regarding Innovation, Reasons and Sources, as well as the values referring to the mean and standard deviation for each of them.

Table 4 – Actions directed to innovation

Variable			Average	Standard deviation
IN01	Radical in product	We aim to develop new products/services.	4.18	0.926
IN02	Incremental in product	We aim to make changes or improvements to current products/services.	4.32	0.779
IN03	Radical in process	We aim to develop new processes of production and/or management.	3.96	0.824
IN04	Incremental in process	We aim to make changes or improvements to the current processes of production/services.	4.15	0.788
IN05	Organizational Innovation	We aim to develop or make changes or improvements in our management process.	3.83	0.848

Source: Elaborated by the author.

First, as shown in Table 4, it is interesting to realize that Incremental Innovation in product and process (IN02 and IN04) presents higher averages than Radical Innovation in product and process (IN01 and IN03). This can even be considered natural, bearing in mind the complexity difference involved in both types of innovation. Beyond the complexity issue, market demands are also a factor that contributes to a more accentuated focus on Incremental

Innovations, because, according to Maçaneiro e Cunha (2011), from PINTEC's data (from 1998 to 2008), a large part of companies performed Incremental Innovations to the detriment of Radical Innovations, bearing in mind that they have focused more on market demands than in innovations developed through internal or external R&D. In this context, other important aspects are the cost and risk, involved in Radical Innovations.

In relation to the results presented by Kuhl (2012), in research focusing only on the electric-electronic sector, we perceived that the averages in this research were slightly higher, with regard to actions directed to innovation. However, we should highlight that the questions are not exactly the same, because in these questions were implemented adjustments with respect to the questionnaire that served as a basis. On the other hand, it is precisely the issue of the sector that draws attention because this research encompasses several sectors, both admittedly innovative sectors, and sectors of low propensity to innovation, while that the focus in that questionnaire was exactly one sector which is admittedly innovative, the electric-electronic sector.

Table 5 - Summary of reasons to collaborate

	Variables	Average	Standard deviation
M01	Risk reduction associated with the innovation process.	3.75	0.910
M02	Cost reduction associated with the innovation process.	4.06	0.887
M03	Time reduction associated with the innovation process.	3.97	0.861
M04	Access to technological resources.	4.09	0.810
M05	Access to financial resources.	3.93	1.003
M06	Access to knowledge, information and learning.	4.21	0.782
M07	Access to other resources.	3.51	0.833
M08	Acquisition of scale economy.	3.82	0.992
M09	Stakeholder pressure.	3.42	1.074

Source: Elaborated by the author.

Considering Table 5, in this case, compared to the results of Kuhl's research (2012), the averages were higher in all variables (between 4% and 12% higher). We emphasize the highest averages (the variables M06, M05, M04 and M02), and also the variables with lower averages (M09 and M07). Here, it is interesting to note that the average of the variable M05 was not so high since the lack of financial resources to invest in innovation is a constant reality in Brazilian companies. Thus, the variables and the questionnaire questions are the same ones used by Kuhl (2012).

Table 6 – Summary of Sources of Collaboration

	Variables	Average	Standard deviation
F01	Other companies within the business group.	3.02	1.489
F02	Suppliers.	3.40	0.963
F03	Customers or consumers.	3.75	0.948
F04	Competitors or other companies in the same segment.	2.22	1.076
F05	Universities or other higher education institutions.	2.56	1.154
F06	Consulting.	2.43	1.226
F07	Private research and R&D institutes and private laboratories.	2.20	1.121
F08	Public institutes of research or of innovation support and private non-profit institutes.	2.49	1.148
F09	Professional training and technical assistance Centers.	3.00	1.123

Source: Elaborated by the author.

Also, in this case, the variables and the questionnaire questions are the same ones used by Kuhl (2012). Considering Table 6, in 7 of the 9 variables, the averages obtained are inferior to the averages obtained by Kuhl (2012), and in one of the others (F03) the average is approximately 8% higher, and in the other variable (F02) the average is practically equal. Analyzing only the averages obtained in this research, we highlight the high averages of collaboration with customers and suppliers, and the low average in the case of collaboration with competitors and public or private research institutes. We highlight also the average obtained by universities, bearing in mind that these are, in Brazil, the main organizations focused on research and with the potential to develop innovations.

After these initial verifications and considering that the variables of the Sources and the variables of the Reasons are correlated with each other within each construct, we passed to the EFA, so as to group the variables contained in the groups referring to the Sources of Collaboration and the Reasons for collaborating, using the main component method, eigenvalues of 1 and the Varimax rotation, according to the indications of Field (2009), Hair *et al*. (2009), Fávero *et al*. (2009), Maroco (2014) and Fávero and Belfiore (2017). The viability of the EFA was verified from the results of the Kaiser-Mayer-Olkin (KMO) tests and Bartlett's sphericity tests. According to Kaiser (1974 *apud* FIELD, 2009, p. 579), for the KMO, "the values between 0.5 and 0.7 are mediocre, the values between 0.7 and 0.8 are good, the values between 0.8 and 0.9 are great and the values above 0.9 are excellent." Thus, Table 7 presents the results of the tests for the two constructs.

Table 7 - Result of EFA feasibility tests

Feasibility tests		Reasons	Sources
Kaiser-Meyer-Olkin measure of sampling adequacy.		0.840	0.840
Bartlett's sphericity Test	Approx. chi-square.	840.293	862.341
	Df	36	36
	Sig.	0.000	0.000

Source: Elaborated by the author.

Considering that the EFA is feasible based on the results indicated in Table 7, we noted in the board of the explained variance and the graph *Scree Plot*, that the variables are grouped in two factors both in the Reasons and in the Sources. The total variance explained by the 2 factors in the case of Reasons is 58.93% and in the case of Sources is 58.74%.

Due to these results, we verified the internal consistency of the obtained factors (constructs), using the Cronbach's Alpha coefficient, as this is indicated as a measure of reliability. As a parameter, Malhotra (2006) and Hair *et al*. (2009) indicate that values above 0.6 are acceptable. Table 8 presents the factors (constructs) obtained from the EFA with the values of the averages of these constructs and the Cronbach's Alpha coefficient value.

Table 8 - Constructs

Constructs			Variables	Explained Variance	Average	Standard-deviation	Cronbach's Alpha
Reasons	Reason1	4	M01 a M04	46.03%	3.97	0.688	0.802
	Reason2	5	M05 a M09	12.90%	3.78	0.678	0.766
Source	Source1	5	F05 a F09	44.14%	2.54	0.907	0.845
	Source2	4	F01 a F04	14.60%	3.10	0.820	0.688

Source: Elaborated by the author.

The composition of the constructs Reasons and Sources is slightly different from those found by Kuhl (2012) when researching the electric-electronic sector. Regarding that research, the aspect that deserves emphasis is the average of the factor that contains universities and research institutions, that was inferior to the other construct referring to the Sources (3.08 versus 3.42 in that research), and that in this research the averages were still smaller for Source1 (composed of universities, research institutions and consultancies) with regard to Source2 (2.54 versus 3.10), further increasing the relative distance between both. This result may be associated with the involved sectors since in this study there are several sectors and in that study, only the electric-electronic sector was researched.

This result shows that in Kuhl's research (2012) the priority sources of collaboration were customers and suppliers, coinciding with the results pointed out by Tether (2002), and Howells and Tether (2004), within the perspective of vertical link indicated by Rothwell (1992, 1994). The fact is repeated in this research, indicating the low propensity of the various sectors included in this study to seek collaboration with universities and research institutes, which are institutions focused on the development of research. This result is not in harmony with what Etzkowitz (2003) calls an arrangement between the institutional spheres, in this case, the cooperation between University and Enterprise, which is appointed as advantageous under several perspectives (Bonaccorsi & Piccaluga, 1994; Segatto-Mendes; Sbragia, 2002; Noveli & Segatto, 2012; Camargo Filho, Lima & Mendina, 2014), and that can occur in different ways (Plonski, 1999; Noveli & Segatto, 2012; Segatto-Mendes & Sbragia, 2002; Gusberti, Dorneles, Dewes & Cunha, 2013; Dias, 2001; Camargo Filho *et al.*, 2014; Ipiranga & Almeida, 2012).

But we perceive that, in the case of the electric-electronic sector, the averages of Sources are higher in all constructs and in all variables in relation to this research that gathers all sectors of the manufacturing industry and the extractive industry, which indicates that collaboration is better perceived by one of the sectors that is admittedly more innovative (Stein, 2000; Scandelari, 2011; Kuhl, 2012).

Already with regard to the Reasons for collaborating, we perceive that the groupings are the same as those identified by Kuhl (2012), but with slightly higher averages in this study, especially in Reason1 grouping, that Kuhl (2012) calls aspects related to "reduction of problems". This result may indicate that both the electric-electronic sector and the others present similar characteristics in relation to the Reasons for seeking collaboration.

The next step in the analyses is to effectively identify and analyze the collaboration influence on the innovations implementation, using for this the Multiple Linear Regression Analysis, following the parameters indicated by Field (2009), Hair *et al*. (2009), Fávero *et al*. (2009), Maroco (2014) and Fávero and Belfiore (2017). For this purpose, 5 multiple linear regression models were generated, where the independent variables (x) were the Sources of Collaboration (Source1 and Source2) and the Reasons for collaborating (Reason1 and Reason2), while the dependent variable (γ) was each of the variables inserted in Table 1, referring to innovation. The equation is presented below:

$$\gamma = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \varepsilon \qquad (1)$$

Where: γ = Innovation;
χ_1 = Source1;
χ_2 = Source2;
χ_3 = Reason1;
χ_4 = Reason2

Tables 9 to 11 present the results of the Multiple Regression Analysis for each of the regression models, considering that in the respective models the dependent variables are Radical Innovation in Product (model 1), Incremental Innovation in Product (model 2), Radical Innovation in Process (model 3), Incremental Innovation

in Process (model 4) and Organizational Innovation (model 5). Information on non-infringement of the basic assumptions of the linear regression classic model (autocorrelation, heteroscedasticity and multicollinearity) is also presented.

Table 9 - Summary of the models

Model	R	R^2	R^2 adjusted	Standard error of estimation	Estatísticas de mudança					Durbin-Watson
					Alteration of R2	Alteration F	df1	df2	Sig. Alteration F	
1	0.294	0.086	0.083	0.887	0.086	23.784	1	252	0.000	2.120
2	0.268	0.072	0.068	0.752	0.072	19.542	1	252	0.000	1.921
3	0.365	0.133	0.126	0.770	0.033	9.645	1	251	0.002	2.090
4	0.373	0.139	0.132	0.734	0.021	6.231	1	251	0.013	1.921
5	0.421	0.177	0.170	0.772	0.052	15.732	1	251	0.000	2.136

Source: Elaborated by the author.

In Table 9, it is possible to verify the overall adjustment of the models (R, R2 and adjusted R2), that is, how much of the innovation variation can be explained by the Sources and Reasons. We perceive that the Sources and Reasons explain a small but significant portion of innovation. Furthermore, the result of the Durbin-Watson test is presented, which indicates the autocorrelation lack of the residues, that is, independence of mistakes.

Table 10 - Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Average Square	F	Sig.
1	Regression	18.716	1	18.716	23.784	0.000
	Waste	198.311	252	0.787		
	Total	217.028	253			
2	Regression	11.049	1	11.049	19.542	0.000
	Waste	142.479	252	0.565		
	Total	153.528	253			
3	Regression	22.846	2	11.423	19.273	0.000
	Waste	148.761	251	0.593		
	Total	171.606	253			
4	Regression	21.795	2	10.897	20.229	0.000
	Waste	135.217	251	0.539		
	Total	157.012	253			
5	Regression	32.157	2	16.079	26.984	0.000
	Waste	149.563	251	0.596		
	Total	181.720	253			

Source: Elaborated by the author.

Table 10 shows the result of ANOVA (test F and its respective significance), indicating that the models present significant adherence to the data.

Table 11 - Coefficients of the regression models

Model		Non-standardized Coefficients		Standardized Coefficients	*t*	Sig.	Collinearity Statistics	
		Beta (*β*)	Standard Model	Beta (*β*)			Tolerance	VIF
1	(constant)	3.150	0.218		14.455	0.000		
	Source2	0.332	0.068	0.294	4.877	0.000	1.000	1.000
2	(constant)	3.533	0.185		19.131	0.000		
	Source2	0.255	0.058	0.268	4.421	0.000	1.000	1.000
3	(constant)	2.290	0.291		7.862	0.000		
	Source2	0.253	0.063	0.251	4.032	0.000	0.889	1.125
	Reason2	0.235	0.076	0.194	3.106	0.002	0.889	1.125
4	(constant)	2.607	0.278		9.387	0.000		
	Source2	0.280	0.060	0.291	4.682	0.000	0.889	1.125
	Reason2	0.180	0.072	0.155	2.496	0.013	0.889	1.125
5	(constant)	1.766	0.292		6.048	0.000		
	Source2	0.342	0.076	0.274	4.506	0.000	0.889	1.125
	Reason2	0.249	0.063	0.241	3.966	0.000	0.889	1.125

Source: Elaborated by the author.

Initially, we verify in Table 11 that the values of the collinearity statistics indicate that the models don't present problems related to multicollinearity. Still with regard to the assumptions, the Glejser test, in which the regression of the error terms is made in function of the explanatory variables, indicated that there is no relationship between the explanatory variables and the error terms obtained in the models, confirming the non-existence of heteroscedasticity.

It is also possible to see in Table 11 the coefficients of the models, as well as the significance of each of the variables. By choice, only the variables that are significant in each model are presented.

Thus, in the first two models, only the variable Source2 is significant, and the variation of this explains approximately 8% and 7%, respectively, of the variation of Radical Innovation in product and the variation of Incremental Innovation in product. In the other three models, the variables Source2 and Reason2 are significant, and the variations of these explain approximately 13%, 14% and 18%, respectively, of the variation in the Radical Innovation in process, in the Incremental Innovation in process and in the Organizational Innovation. In this case, we note the influence of some Sources (Source2) and some Reasons (Reason2) on innovation in process (organizational or in product).

From the obtained results, we perceive the Sources of Collaboration of the Source2 construct (company subsidiaries and other companies of the group, customers, suppliers and competitors), which are constant. These are the Sources that effectively influence the development and implementation of innovation, in any type (product, process or organizational) and at any intensity level (radical or incremental). And in each of the 3 regression models in which two variables are inserted (that is, in the 3 last models), the values of the standardized coefficient ß are higher in the Factor1, indicating that the influence degree of this on the dependent variable is higher than on the other variable.

Likewise, the Reasons for collaborating, inserted in Reason2 (access to technological resources; to financial resources; to knowledge, information and learning; access to other resources; acquisition of scale economy; stakeholder pressure) are factors that effectively influence the development and implementation of innovation, but, in this case, only innovation in process (radical and incremental) and Organizational Innovation.

The same regressions were also performed, including the size as a control

variable, following the Tomlinson procedure (2010), but on a different scale, and in none of them the size was statistically significant in the model, nor did it improve significantly the explanatory power (R2) of the same.

5 Final considerations

The objective of this research was to identify and analyze the influence degree of collaboration on the innovations implementation in Brazilian industries, limiting the sample to the Brazilian extraction and manufacturing industries.

For this purpose, a questionnaire was elaborated, forwarded to the Brazilian extraction and manufacturing industries, and 254 industries had responded to it until the time of the analyses for this research.

To operationalize the analyses of the data collected through the questionnaire, we started with Exploratory Factor Analysis (EFA), to group the variables into factors and, subsequently, we utilized the Multiple Linear Regression Analysis to identify the existence, or not, of the collaboration influence on the innovations implementation, both detailed in the sections referring to the methodological aspects and/or data analysis.

Regarding the results of the EFA, these ones point to two groupings (factors) of variables, both in the Sources of Collaboration and in the Reasons to collaborate. These results are similar to the results obtained by Kuhl (2012) because in that research the EFA also indicated the existence of two factors in each of the sets. However, the factors generated in both researches are not exactly the same, as was already evidenced in the analyses.

Regarding the results of Multiple Linear Regression, this one allowed to identify the variables in each of the 5 models tested, and the variables listed below were those that were shown as significant predictors:

- Model 1 – Source2 (β=0.332; t=4.877; p<0.01);
- Model 2 – Source2 (β=0.255; t=4.421; p<0.01);
- Model 3 – Source2 (β=0.253; t=4.032; p<0.01) e Reason2 (β=0.235; t=3.106; p<0.01);
- Model 4 – Source2 (β=0.280; t=4.682; p<0.01) e Reason2 (β=0.180; t=2.496; p<0.05);
- Model 5 – Source2 (β=0.342; t=4.506; p<0.01) e Reason2 (β=0.249; t=3.966; p<0.01).

Thus, the final models are:

- Model 1 → Innovation = 3.150 + 0.332Source2;
- Model 2 → Innovation = 3.533 + 0.255Source2;
- Model 3 → Innovation = 2.290 + 0.253Source2 + 0.235Reason2;
- Model 4 → Innovation = 2.607 + 0.280Source2 + 0.180Reason2;
- Model 5 → Innovation = 1.766 + 0.342Source2 + 0.249Reason2.

All models are significant and explain a part of the Innovation variability, according to the data presented in Tables 9 to 11. However, the factors Source1 and Reason1 were not significant in any of the models. The inclusion of the size as a control variable had no effect on the models, not being significant and neither improving the explanatory power of the same.

Tomlinson (2010) included in his models only some of the Sources of Collaboration (suppliers, customers and competitors), which in this research are grouped into factor Source2, which turned out to be significant in all models. This is totally coherent with the Tomlinson's

finding (2010) because in three of his models these Sources were statistically significant (considering $p < 0.05$). In the three complete models (in which the dependent variables were product innovation, process innovation and product/process innovation) cooperation with competitors was statistically significant.

Regarding the influence degree of collaboration on innovation, it is possible to affirm that this one is perceptible, that is, there is influence, but is reduced, bearing in mind that the determination coefficients are low and the beta coefficients are also not high, being the influence degree of factor Source2 slightly higher than that of factor Reason2, considering those influences when both the factors were included in the models.

Thus, we concluded that collaboration is effectively a factor that impacts on innovation, but still in an incipient way, because although some collaboration aspects (Sources and Reasons) appear in the models, the models themselves don't present an elevated explanatory power (R2). Thus, this result matches the result obtained by Tomlinson (2010), that is, that the collaboration impacts on innovation, and therefore contributes to reinforcing the indication of Faccin and Balestrin (2015) that evidence is emerging that innovation comes from cooperation.

We still perceive that the results are partially aligned with the indication of Rothwell (1992, 1994), that organizations are tending to present horizontal and vertical links for the development of innovations (more specifically for R&D). In this case, we highlight the vertical alignment (customers and suppliers). Tomlinson (2010) followed this path and explored the impact of cooperative ties (basically with suppliers, customers and competitors) on the levels of innovation (product, process and both).

As a theoretical contribution, this research deepens a little further the studies that relate collaboration with innovation, in order to seek to identify whether there is effectively collaboration influence on innovation, bearing in mind that the literature largely suggests this, but doesn't present empirical data. The few studies reached that seek empirical evidence of the existence of relationship and/or influence, specifically in the Brazilian reality, are still incipient in order to constitute a theoretical framework sufficiently consistent to give subsidies to more forceful conclusions.

As a practical contribution, this research presents features that can serve as a basis for public policies to encourage innovation, specifically in the sense that innovation is not a support activity, that is, collaboration contributes substantially to innovation. Furthermore, it contributes companies themselves to perceive the factors that play a role in the development and implementation of innovations.

Among the limitations of this study, the main one is the size of the sample, which is not representative of the set of Brazilian extraction and manufacturing industries, mainly due to the small propensity of Brazilian companies to participate in scientific research. In this sense, a summary report with the preliminary results was elaborated and this one was forwarded to all respondents, as a demonstration of the seriousness of the study and as an incentive to participate in other researches.

Another limitation is the studies lack that aim to measure the collaboration influence for innovation, a fact that would allow relating findings and conclusions with a view to scientific development on the topic. Finally, another limitation concern the data collection instrument, which doesn't contemplate other aspects that impact on the propensity to innovation, a subject that may be one of the aspects to be addressed in future studies.

Still, in relation to future researches, these will also be able to analyze some of the Sources and/or Reasons in an individualized way with respect to innovation, as well as the insertion of more aspects related to innovation with regard to the Sources and the Reasons mentioned here. The use of other variables as a way of measuring innovation can also be interesting.

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