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The influence of technology, organizational size and age on Innovation

Eva Petiz Lousã[1,a], A. Duarte Gomes[b]
Instituto Politécnico do Porto, CEOS.PP – Centro de Estudos Organizacionais e Sociais do P. Porto, Porto, Portugal[a], Universidade de Coimbra, Coimbra, Portugal[b]

Keywords:
Organizational innovation;
technology;
organizational size;
organizational age.

Abstract
The purpose of this work is to assess the influence of organizational variables (technology, organization size and age) on organizational innovation. A total of 102 top-level managers of Portuguese organizations, from different sectors, sizes, and ages answered a questionnaire concerning innovation activity in their organization. The results of this exploratory study highlighted positive as well as negative significant relationships of these organizational variables in different dimensions of the innovation process. This can be useful to better understand how innovation occurs within and between different industries or companies. This study includes objective measures that can capture the innovative efforts in an organization more directly and identify some organizational characteristics that may affect innovation activity.

A influência da tecnologia, da dimensão e da idade da organização na inovação

Palavras-Chave:
Inovação organizacional;
tecnologia;
dimensão da organização;
idade da organização.

Resumo
O objetivo deste trabalho é avaliar a influência de variáveis organizacionais (tecnologia, dimensão e idade da organização) na inovação organizacional. Cento e dois gestores de topo de organizações portuguesas, de sectores de atividade de base tecnológica e de outros setores, de tamanhos e idades diferentes, responderam a um questionário referente à atividade de inovação na sua organização. Os resultados deste estudo, exploratório, destacaram relações positivas e significativas, assim como relações negativas e significativas, destas variáveis organizacionais em diferentes dimensões do processo de inovação, as quais podem ser úteis para entender melhor como ocorre a inovação dentro e entre diferentes indústrias ou empresas. Este estudo inclui medidas objetivas que podem captar mais diretamente os esforços inovadores numa organização e permite identificar algumas características organizacionais que podem afetar a atividade de inovação.

La influencia de la tecnología, del tamaño y edad de organización en la innovación

Palabras clave:
Innovación organizacional;
tecnología;
tamaño de la organización.

Resumen
El objetivo de este trabajo es evaluar la influencia de variables organizacionales (tecnología, dimensión organizacional y edad) en la innovación organizacional. Ciento dos altos directivos de organizaciones portuguesas, de sectores de actividad de base tecnológica y de otros sectores, tamaños y edades diferentes, respondieron a un cuestionario referente a la actividad de innovación en su organización. Los resultados de este estudio, exploratorio, destacaron relaciones positivas y significativas, así comorelaciones negativas y significativas de estas variables organizacionales en diferentes dimensiones del proceso de innovación, lo que puede ser útil para entender mejor cómo ocurre la innovación dentro y entre diferentes industrias o empresas. Este estudio incluye medidas objetivas que podrían capturar más directamente los esfuerzos innovadores en una organización y permite identificar algunas características organizativas que pueden afectar la actividad de innovación.

[1] Endereço para correspondência:
Rua, Damião de Góis, 18, 5º andar, 4050-221, Porto, Portugal. E-mail: evapetiz@netcabo.pt
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Innovation is an area of knowledge that in recent years has raised a growing interest among scholars from different disciplines, which is reflected in the growing number of academic publications in this area (e.g., Anderson, Potočnik, & Zhou, 2014; Fagerberg & Verspagen, 2009; Ramos, Anderson, Peiró, & Zijlstra, 2016; Wolfe, 1994). Therefore, it is not surprising that this domain is broad (Damanpour, 1991; Damanpour & Schneider, 2006; Ramos et al., 2016), complex and multidimensional (Wolfe, 1994). Generally speaking, innovation is perceived as essential for the survival of businesses in an increasingly competitive and globalized environment (Gumusluoglu & Ilsev, 2009a, 2009b). Companies can explore, in an innovative way, new products or services, business processes, work organization or marketing or improvements to existing ones (Organization for Economic Co-operation and Development [OECD], 2005). Organizational innovation is conceptualized as an ongoing process involving the generation of new or significantly improved ideas and their implementation (e.g., Amabile, Conti, Coon, Lazenby, & Herron, 1996; Damanpour, 1991; Van de Ven & Angle, 1989), and a process of creating value from ideas (Tidd & Bessant, 2014). We consider innovation as an ongoing process that involves the creation of new ideas, or a significant improvement, and the implementation of these ideas in the products or services, business processes, work organization or marketing. Moreover, these actions could benefit the company, its stakeholders and society in general.

In literature, some innovation studies were conducted by qualitative approaches, based on case-studies and in-depth interviews (e.g., Wang & Costello, 2009). And other studies, based on quantitative approaches, have presented a variety of measures of innovation (e.g., Adams, Bessant, & Phelps, 2006; Amabile et al., 1996; Damanpour, 1991; Damanpour & Schneider, 2006; Gumusluoglu & Ilsev, 2009b; Hitt, Hoskisson, & Kim 1997; Keller & Holland, 1983; Oldham & Cummings, 1996; Scott & Bruce, 1994; West & Anderson, 1996). Subsequently, several indicators are used to describe the characteristics of innovation. Concerning this diversity of measures, Adams et al. (2006) have highlighted the fragmentation of the measurement of the innovation process in a number of partial studies, since they have focused either on inputs or on outputs in innovation. Other studies have focused on the type of relationship that allow the acquisition of knowledge from the external environment to the company or the organization as a source of organizational innovation (Cohen & Levinthal, 1990; Damanpour, 1991; Damanpour & Schneider, 2006; Gumusluoglu & Ilsev, 2009b; Woodman, Sawyer, & Griffin, 1993). Furthermore, the cooperation with other companies and the development of multidisciplinary networks on different sectors may have an important impact on competitiveness, because it favors diversity, coherence and complementarity between companies (Alves, Marques, Saur, & Marques, 2007; Salazar, Hurtado Gonzalez, Duysters, Sabidussi, & Allen, 2016) and allows the acquisition of other resources. Thus, the partnerships and networks of cooperation, as well as the type of relationships that the companies can develop with other entities, are dimensions of the process of innovation (Lousã, 2013). And, in turn, the firm's engagement in networks increases the impact of innovation on performance (Salazar et al., 2016).

In addition to the academic literature, several approaches have been developed by entities responsible for public policies, in order to measure the process and innovation performance. Some innovation instruments were developed by the European Union, such as *European Innovation Scoreboar*d (Hollanders & Van Grusyen, 2008), *Community Innovation Survey* (Parvan, 2007), and, in the Portuguese case, the *Innovation Scoring System* (COTEC, 2017). Drawing on a wide body of literature and on experts interviews, Lousã (2013) used and developed a set of indicators, in order to compare enterprises of different technology sectors, age and size and to better characterize and analyze the organization in terms of its activity oriented towards innovation. While working with a Portuguese sample of enterprises, an innovation model was built on the following three dimensions: Resources, Processes and Results. The first dimension - Resources - is subdivided into data characterization of human resources, resources available and Investment in Research and Development. The second dimension - Processes - aims to analyze some organizational processes that are considered relevant to the innovative dynamic. This dimension is subdivided into Partnerships, Cooperation Networks and Protection and Enhancement of Knowledge. The third dimension - Results - aims to evaluate the outcomes of the activities of a company such as: the turnover in the last three years; the evolution of sales of new products/services or significant improvements over the last three years; and the percentage of ideas generated in the company transformed into innovative designs and the enterprise image.

Despite this conceptual work suggesting different innovation indicators and dimensions, there is a lack of studies in examining the importance of some organizational variables on innovation. Prior studies suggest that innovation may depend on organizational variables, such as the size of a company, its age and the company's sector of activity. Regarding the size of a company, Chandler, Keller and Lyon (2000) found that a culture of innovation support was negatively related to the size of the organization in a sample of industrial companies - small and midsize. The same relation was found, in a sample of Portuguese manufacturing enterprises, with a learning culture (Rebelo & Gomes, 2011). Similarly, Hansen (1992) found that the size of a company and its age tends to be inversely related to innovative output. As far as the age of a firm is concerned, Huergo and Jaumandreu (2004) found that the older companies tend to show lower innovative probabilities than the younger ones.

Considering the sectors of activity, the use of knowledge and technology may be more intensive in some organizations than in others (OECD, 2003). In recent years, in Portugal, there has been a growing number of companies that base their activity on the intensive use of knowledge and technology - the technology--based companies (UMIC, 2012) .However, there is little empirical evidence about their innovation activities and the characteristics that can distinguish the technology-based companies from the non-technological ones (Storey & Tether, 1998). Accordingly, the research question of this study is: "What organizational characteristics (technology, organizational dimension and age) are related to innovation?" Therefore, the aim of this study is to explore the influence of organizational variables (technology, organizational dimension and age) on innovation at the organizational level.

Method

Participants

One manager per organization answered a questionnaire about the innovation activity in his organization. Due to the level at which the top management operates, we expected that they were knowledgeable regarding the resources, processes and results of the innovation of their organizations. The data was collected from 102 Portuguese organizations, 51 out of which belong to the technological sector (e.g., pharmacy; computer/information systems; biotechnology; electronics) and 51 to other activity sectors (e.g., textile; food products; paper products; wood). The age of the companies varies between two and 115 years, with an average of

19 years (18.98) and standard deviation of 19 years (18.97). The number of employees per company ranges from two to 643 people, with an average number of people per company of 61.51 and the standard deviation of 114.86. Taking into account the number of employees, there are 30.4% micro-enterprises, 38.2% small companies; 24.5% medium-sized companies and 5.9% large companies. These numbers are close to the distribution of the Portuguese business, since it is predominantly made up of micro, small and medium enterprises.

Data collection procedures and ethical considerations

After having agreed to participate, the top management of each organization was asked about the innovation activity in their organization through a questionnaire. Each one of them was instructed about the objectives and procedure of the Internet-based study via e-mail or telephone. Anonymous and strictly confidential data treatment was assured.

Instruments

The constructs of innovation were measured at the organizational level (dependent variable) with regard to their resources, processes and results.

Innovation resources measures were operationalized as follows:

- Resources available. Evaluates the degree to which the resources (e.g., time; people; funding) are considered appropriate in the organization, in order to stimulate and support creativity and innovative initiative. This is a subscale of climate innovation support from Scott and Bruce (1994). Responses were given on five-point Likert scale (ranging from "Totally disagree" to "Totally agree"). Principal component analysis was carried out, revealing only one dimension composed of five items (α = .74). This solution explains 65 percent of the total variance. All the five items have loadings above 0.50 and communalities above 0.40. An example of an item of this measure is "In this organization, there are adequate resources dedicated to innovation".
- Characterization of Human Resources (HR) which contributes to the development of innovation activities. The indicators are the number of employed and contractors, its composition according to gender, age group, level of qualifications, level of seniority in the company, as well as the percentage of workers who participated in lifelong learning activities, innovation oriented, concerning the previous year, these data were obtained in official documents.
- Investment in research and development. Assesses the investment/expenditures made by the company in R&D in the last three years, these data were obtained in official documents.

Innovation processes measures were operationalized as follows:

- Partnerships and cooperation network. The literature shows that external relationships and/or collaborative partnerships with other entities, within innovation, influence the enterprise innovative capacity (Silva, Raposo, Ferrão, & Moreno, 2005). This measures if a company develops cooperation networks with other entities towards innovation. Responses were given on a dichotomic scale ("yes" or "no"). If so, they were asked to the main partnerships or cooperation networks. To measures the partnerships, we presented a list with different types, such as group companies, competitors, suppliers, customers, universities, higher education institutions, R&D units, consultants, laboratories or institutions of private R&D, public or governmental institutions, and were asked to indicate which ones the company usually used. In the same way, we presented a list with different types of cooperation networks, such as nets or poles cooperation, international cooperation networks, networking, and asked to indicate which ones the company usually used.
- Protection and enhancement of knowledge. First we measures if companies' activities of innovation are protected using a dichotomic scale ("yes" or "no"), and, if so, we present a list with different forms (patenting, trademarks, intellectual property, copyright, processes preservation of secrecy) and asked to indicate which forms the company usually used.

Innovation results measures were operationalized as follows:

- The turnovers in the last three years intend to see the evolution of the growth or the decline of an activity, these data were obtained in official documents.
- Changes in the volume of sales of new products/services or those that significantly improved in the past three years. The type of response adopted considers a scale with three options: Decreased (1), Same (2), Increased (3).
- Percentage of ideas generated in a company that are transformed into innovative projects. The response considers a range comprising the following values: None (0%); Less than 25.0%; From 26.0 to 50.0%; From 51.0 to 75.0% and From 76.0 to 100%.
- Enterprise image. Contribution that innovation activities have on the image of an organization compared to competing organizations: awareness of an organization and its products and services, attracting customers, development of the country or region, employment generation and welfare, sustainable development, and attracting qualified and creative human resources. The type of response considers a five-point scale, ranging from one (much worse) to five (much better). Principal component analysis was carried out, revealing only one dimension composed of five items (α = .82). This solution explains 53.4 percent of the total variance. All the five items have loadings above 0.66 and communalities above 0.43. An example of an item of this measure is "Innovation activities contribute to attract more customers in the face of competition."

Other measures used at the present study were operationalized as follows:

- *Size of the company.* Number of employees in the company, categorized as: Micro (1-9); Small (10-49); Medium (50-249) and Large (≥ 250).
- *Age of the company.* Number of years of the company.
- *Technology.* The manager of each company evaluated the business activity, they were asked if the company was technology-based or non technology-based.

Data analysis procedures

An indicator was built regarding the number of employees in each company by age, qualifications and seniority. We calculated

the level of each class by examining the number of subjects existing in each one of them (cf., Rebelo, 2006). The obtained value reflects the number of employees in each one of the categories. In this sense, the higher the value obtained by a company in each one of these variables, the greater the age level of seniority and the qualifications of its human resources.

The age and size of the company showed a negative bias, substantially distant from the normal distribution, and so proceeded to a logarithmic base 10 (Hair, Anderson, Tatham, & Black, 2008; Tabachnick & Fidell, 2001). Thus, the transformed variables are designated, respectively, by lg_Age_Company and lg_Dimension_Company.

Considering the reference period of the last three years of the company, we calculated: the Employment growth (difference between the number of employees in the last year and those of the antepenultimate year); R&D investment/expenditures growth (difference between the R&D expenditures in the last year and those of the antepenultimate year); and the Turnover growth (difference between the amount of money taken by a business in the last year and that of the antepenultimate year).

Results

In this section, we analyze the existence of differences in the perception of managers about the resources, processes and outcomes of innovation, due to the activity sector (technology-based company[2] vs. non technology-based company[3]). We also analyze the influence of age and size of a company in each of the innovation indicators.

Activity sector and innovation resources

To assess the existence of differences between the sectors of business activity relative to the size capabilities in innovation-driven organizations, we carried out a multivariate analysis of variance (MANOVA), taking as independent variable (IV) the activity sector and, as a dependent variable (DV), those related to the human resources characterization and the available resources of each company. The obtained multivariate test indicated a statistically significant effect of the multivariate model [*Wilks Λ*=0.68, *F*(5, 92)=8.81, *p*<.001]. The measure of association between the business sector and the combination of the five variables of the size of resources is η^2=.32 and statistical power >.999. The univariate analysis of the effects revealed the existence of statistically significant differences between the sectors of business activity and the characteristics of human resources - namely, the age level [*F*(1, 97)=18.50, *p*<.001], the level of qualifications [*F*(1, 97)=40.23, *p*<.001] and the level of seniority [*F*(1, 97)=11.40, *p*=.001]. The average age level and the level of seniority of the human resources of technology-based companies is lower than other industry firms. In turn, the average skill level is superior in technology-based firms, compared to firms in other sectors (see Table 1).

An independent-samples *t*-test was conducted to compare R&D Investment/expenditure in a technology-based company and a non technology-based company. There was no significant difference in the scores of the technology-based company (*M*=110605.83, *SD*=902307.00) and the non technology-based company (*M*=437708.89, *SD*=1586930.00); *t*(64)=1.05, *p*=.30. These results suggest that there is no effect of the business sector activity on R&D Investment/expenditure. Another independent-samples t-test was conducted to compare the employment growth scores between technology-based companies and non-technology-based companies. There are no significant differences between technology-based companies (*M*=7.85, *SD*=51.05) and the non technology--based ones (*M*=3.15, *SD*=16.16) regarding the employment growth, *t*(94)=.62, *p*=.54. These results suggest that there is no effect in the business sector activity on employment growth.

Table 1
Mean scores and standard errors adjusted depending on the size of the resource sector of business activity: univariate tests, the value of the measure of association between variables and statistical power

Variables	Scale measure	Sector of business activity						
		TBC (*n*=50)		NTBC (*n*=48)				
		M	*SD*	*M*	*SD*	*F*(1, 97)	η^2	(1-β)
Resources available	1 to 5	3.73	0.66	3.54	0.73	2.09	.02	.299
Age level HR	1 to 6	2.83	0.07	3.23	0.07	18.50**	.16	.989
Qualifications level of HR	1 to 8	5.17	0.19	3.43	0.19	40.23**	.29	1.000
Seniority level of HR	1 to 7	3.70	0.16	4.46	0.16	11.40*	.11	.916
Lifelong learning activities	1 to 5	3.38	0.18	3.06	0.19	1.46	.02	.223

Note. *p < .01, **p < .001

Activity sector and innovation processes

To ascertain whether a difference was present between the activity sector and the type of partnerships and networks of cooperation geared towards innovation, as well as the kind of protection and enhancement of knowledge, a *r* Pearson chi-square was conducted. This statistical procedure is applied when both variables are nominal and effective contrasts are observed in our data with the expected frequencies. No cell had an expected frequency of less than five, and is therefore guaranteed assumptions for using this test.

We present, first, the results of the analysis of the differences between the business sector and type of partnerships, followed by the differences between the business sector and networks of cooperation and, finally, between the business sector and type of protection and enhancement of knowledge.

Partnerships and collaborative networks depending on the sector of activity

The result of the analysis of partnerships and collaborative networks depending on the sector of activity showed significant differences in the development of partnerships, networks or cooperation with other entities oriented towards innovation among technology-based and non technology-based companies, χ^2(1, *N*=101)=6929, *p*=.008. The effect size, measured by Cramer's V coefficient was low .26 (Cohen, 1988). Technology-based companies show a greater concern in developing partnerships, networks or cooperation with other entities innovation oriented (53.8%) compared to the non technology-based ones (46.2%). In turn, there is a higher percentage of non technology-based companies (90.0%) that have no concerns to develop such partnerships or cooperation networks comparatively to the technology-based companies (10.0%).

[2] Technology-based company (TBC)

[3] Non technology-based company (NTBC)

Type of partnerships depending on the sector of activity

The results of the chi-square test showed significant differences in the percentage of companies that develop partnerships with customers and business sector $\chi^2(1, N=101)=16.27$, $p=.004$ (cf., Table 2). The effect size, as measured by the coefficient Cramer's V was moderated .401 (Cohen, 1988). Technology-based companies develop more partnerships with customers (62.9%) than non technology--based companies (37.1%). In terms of partnerships with universities or higher education institutions, research and development units and the industry, the results indicate significant differences $\chi^2(1, N=101)=8.28$, $p=.004$, and effect size low .29. Technology-based companies develop a greater percentage (59.7%) of partnerships with universities or higher education institutions and research and development units than with non-technology-based companies (40.3%).

Table 2
Distribution of absolute and relative effective type of partnerships depending on the sector of activity of the company: Chi-square and magnitude of the effect

Type of partnerships		TBC		NTBC		$\chi^2(1,N=101)$	Cramer's V
		n	%	*n*	%		
Group Companies	No	34	50.0	34	50.0	0.02	.01
	Yes	16	48.5	17	51.5		
Competitors / Business Sector	No	30	45.5	36	54.5	1.25	.11
	Yes	20	57.1	15	42.9		
Suppliers	No	16	41.0	23	59.0	1.83	.14
	Yes	34	54.8	28	45.2		
Customers	No	6	19.4	25	80.6	16.27**	.40
	Yes	44	62.9	26	37.1		
Universities/ Higher Education Institutions/ R&D Units	No	10	29.4	24	70.6	8.28*	.29
	Yes	40	59.7	27	40.3		
Consultants, laboratories or institutions of private R&D	No	28	48.3	30	51.7	0.08	.03
	Yes	22	51.2	21	48.8		
Public or governmental institutions	No	31	44.3	39	55.7	2.49	.16
	Yes	19	61.3	12	38.7		

Type of cooperation networks depending on the sector of activity

Through the reading of Table 3, significant differences with regard to the insertion in international cooperation networks and industry, $\chi^2(1, N=101)=3925$, $p=.048$, Cramer's V coefficient, was low .20 (Cohen,1988). There is a higher percentage of technology-based companies (68.2%) that claim to be inserted in international cooperation networks than non technology-based companies (31.8%). We found significant differences at the level of networking contacts and informal relationships geared towards innovation and industry, $\chi^2(1, N=101)=6361$, $p=.012$, and the effect size low, .25. Most technology-based companies (51.2%) reported the development of networks, compared to other companies' activity sectors (35.0%).

Protection and enhancement of knowledge

The sector of activity proved to be influential in the protection and enhancement of knowledge, $\chi^2(1, N=101)=4.47$, $p=.035$, with significant differences at the level of concern to protect and enhance the results achieved by innovation activities, or research and development of technology-based companies and other industries. The effect size, as measured by Cramer's V coefficient was low .21 (Cohen, 1988). Technology-based companies show greater concern to protect and enhance the results achieved by the activities of innovation or research and development (56.3%) compared to other sectors (43.7%). Chi-square test showed significant differences only regarding procedures to preserve confidentiality (e.g., preserving formulas and models; confidentiality agreements with employees, suppliers and customers) between technology-based companies and other industries, $\chi^2(1, N=101)=7.25$, $p=.007$, effect size according to Cramer's V coefficient low, .27 (Cohen,1988). Technology-based companies make greater use of secrecy preservation processes (64.4%) than the non-technological based companies (35.6%).

Table 3
Distribution of absolute and relative effective type of cooperation networks depending on the sector of activity of the company: Chi-square and magnitude of the effect

Type of cooperation networks		TBC		NTBCl		$\chi^2(1,N=101)$	Cramer's V
		n	%	*n*	%		
Nets or poles cooperation	No	31	48.4	33	51.6	0.08	.03
	Yes	19	51.4	18	48.6		
International cooperation networks	No	35	44.3	44	55.7	3.93*	.20
	Yes	15	68.2	7	31.8		
Networking	No	24	39.3	37	60.7	6.36*	.25
	Yes	26	65.0	14	35.0		

Note. *$p<.05$; **$p<.001$

Table 4
Distribution of absolute and relative effective form of protection and enhancement of knowledge depending on the sector of activity of the company: Chi-square and magnitude of the effect

Form of protection and enhancement of knowledge		TBC		NTBC		$\chi^2(1,N=101)$	Cramer´s V
		n	%	*n*	%		
Patenting	No	32	45.7	38	54.3	1. 31	.114
	Yes	18	58.1	13	41.9		
Trademarks	No	22	44.9	27	55.1	1.25	.089
	Yes	28	53.8	24	46.2		
Intellectual Property/ Copyright	No	37	47.4	41	52.6	0.59	.076
	Yes	13	56.5	10	43.5		
Processes preservation of secrecy	No	21	37.5	35	62.5	7.25**	.268
	Yes	29	64.4	16	35.6		

Note. **$p<.01$

Activity sector and innovation results

Considering the influence of variable Sector activity in dimension results, we analyzed the four variables in standardized form, due to their different units of measurement. A multivariate analysis of variance (MANOVA) was carried out taking as VI Sector of business activity and VDs variables on the four variables turnover growth, growth in turn over from sales of products or new or significantly improved services, transformed ideas into innovative projects and enterprise image.

The obtained multivariate test indicated a statistically significant effect of the multivariate model [*Wilks* $\Lambda=0.86$, $F(4,82)=3.24$, $p<.05$]. The measure of association between the business sector and the combination of the five variables of the size of resources is $\eta^2=.14$ and statistical power >.811. As it can be seen in Table 5, the analysis of univariate effects revealed the existence of statistically significant differences between a company's sector of activity and the evolution of turnover of sales of new (or significantly improved) products or services [$F(1,85)=9.63$, $p<.01$]. It appears that technology-based companies show a positive trend compared to non-technology-based companies. Regarding the other variables in this dimension, there are no significant differences (see Table 5).

Table 5
Mean scores and standard errors adjusted variable results depending on the size of the sector of business activity: univariate tests, the value of the measure of association between variables and statistical power

Variables	Sector of business activity						
	TBC (*n*=41)		NTBC (*n*=46)				
	M	*SD*	*M*	*SD*	*F*(1,85)	η^2	(1-*b*)
Turnover growth	0.07	0.38	-0.21	1.14	2.49	.03	.390
Sales of new products/ services or significantly improved	0.31	0.74	-0.35	1.14	9.63*	.10	.866
Ideas into innovative projects	0.27	1.13	-0.20	0.88	1.16	.01	.187
Enterprise Image	0.14	0.87	-0.16	1.05	1.70	.02	.252

Note. *p<.01

The age and size of the company and its relations with the level of resources, processes and results of innovation

We made a simple correlation analysis to evaluate to what extent the age and size of a company are related to each one of the indicators of the dimensions resources, processes and outcomes of innovation. The age of a company, as well as its size, are strongly correlated, r=.63, p<.01 (cf., Table 6). The coefficients found with each one of the variables show that the characteristics of human resources - age, skill and seniority levels - are significantly correlated with both variables (a company's age and size). The level of qualifications of the human resources is correlated negatively with a company's age and size, suggesting that the higher the age of a company and the larger the size of it, the lower the level of qualifications of its human resources. It was also found that growth in the intensity of research and development tends to increase with the age of a company and its size. While the turnover growth tends to decrease with the age of the company, the employment growth tends to increase with the size of the firm.

Table 6
Pearson correlations between company's age, company's size and resources, processes and results of innovation

Variables	lg_Age_Company	lg_Dimension_ Company
lg_Age_Company	-	
lg_Dimension_Company	.63**	-
Resources		
Resources available	-.02	.15
Age level HR	.59**	.40**
Qualifications level of HR	-.57**	-.56**
Seniority level of HR	.77**	.43**
Employment growth	-.10	.21*
Lifelong learning activities	-.03	-.05
R&D Intensity/expenditures	.25*	.34**
Processes		
Partnerships	-.18	.02
Networks	-.16	-.01
Knowledge protection	-.09	.04
Results		
Turnover growth	-.24*	-.16
Sales of new products/services or significantly improved	-.14	.07
Ideas into innovative projects	-.11	-.08
Enterprise Image	-.03	.08

Note. *p < .05, **p < .01

Discussion

In summary, this paper reports to an exploratory study about the influence of technology, organizational size and age on the innovation in the organization, from different Portuguese companies.

The analysis of the differences between the business sector and the resources dimension showed that technology-based companies tend to be more recent, and their human resources are more skilled and younger. In turn, older companies, and also larger companies, have human resources that are older and have a higher level of seniority. In line with the study done by Rebelo and Gomes (2009), which identified the age characteristics of human resources as inhibitors of a learning-oriented culture, we also understand that these characteristics inhibit a company's ability to innovate. Moreover, these features appear in this study as negatively related to changes in the volume of sales of new or significantly improved products or services, showing that it also has a negative impact on the financial results of a company. Although the results of the present study did not show significant effects on the relationship between the company's size and lifelong training activities, there are some empirical evidence that small companies employing managers who participate in training activities and that are willing to change are more likely to innovate (e.g., in service/ products or process innovation), and in turn larger-sized companies employing managers who participate in training activities are more likely to process innovate (in terms of new ideas or behaviours that lead to significant improvements in the way the work is carried out) (McGuirk, Lenihan, & Hart, 2015). These results suggest that, in addition to the employees' level of education, the training activities in which managers participate could have a positive impact on innovation, attenuating the potentially inhibiting effects of age and seniority.

While analyzing how the companies' business sector articulates and develops its relationship with external entities, more specifically, the cooperation with other entities, in order to stimulate the innovation process, we found that technology-based companies are more likely to develop partnerships and networks with other entities oriented towards innovation than with companies of other sectors, and to protect and enhance the results achieved by the innovation activities. Technology-based companies develop a greater number of partnerships with customers, higher education institutions and R&D units. They tend to develop more international cooperation networks, and, also, to rely more on networks than non-technology-based companies. Some studies suggest that such partnerships stimulate more the activity of the company for product innovation in the market (e.g., Silva et al., 2005) and at its highest know-how, they may be considered as producers or suppliers, solutions tailored to the client to other companies (e.g., Vieira & Romero, 2005). Therefore, their localization on science and technology parks allows them to act on network, closer to universities and other higher education institutions, and they are expected to develop a greater number of relationships with these entities, as noted (cf., Silva et al., 2005). Such as Salazar et al. (2016) highlights, in their recent meta-analysis, the experience of participating in networks or being a partner of a strategic alliance, increase the innovation process in companies. And, as Trantopoulos, Krogh, Wallin and Woerter (2017) emphasize, in addition to the importance of networks as external sources of knowledge, the internal skills play an important role in this context and have a direct and positive impact on the companies' process innovation performance.

With regard to the protection and enhancement of the results achieved by innovation activities and research and development, technology-based companies rely more on processes to preserve

confidentiality with their clients than with other processes (e.g., registration of patents, trademarks or copyrights). As Archibugi and Pianta (1996) suggest, the registration of patents is not viewed as a priority and many companies are not patenting their inventions because of the high costs. They do not recognize any advantage in doing so, or they are likely to do so only for inventions that provide a return on investment. To preserve confidentiality it is an easier process. We did not find significant effects regarding the process dimension relationship and the characteristics of the company's age and size.

Concerning the results of the dimension, technology-based companies had a more favorable evolution of sales of new or significantly improved products or services compared to companies in other sectors. The evolution of sales of new or significantly improved products or services is more favorable in technology-based companies compared to companies in other sectors, which is an expected result, since these companies base their activity on the development of new products or services and, accordingly, they must have a return of their activity, in order to remain competitive and survive.

The results also reveal that the intensity of the research and development, the number of human resources, their age and seniority tend to increase with the size of the company. However, given the age of the companies, the human resources qualifications and the turnover of companies, tend to decrease with the seniority of those corporations.

As we pointed out at the beginning of this article, innovation is a dynamic and complex process. We hope that the results presented in this article provide a foundation on which future researches can build and hold significant implications in the field of psychology of organizations, work and human resources. Recent reviews on innovation (e.g., Anderson et al., 2014; Ramos et al., 2016) have shown, not only the progress that has been made in this field, but also their major challenges and the interest that continues to grow. The current study contributes to the innovation literature by identifying some organizational characteristics that distinguish companies with regard to their innovation activity. This study highlights the importance of these variables in the organizational innovation process and it may provide contributions for managers to evaluate or explore their organization innovation activity and to identify areas of improvement within and across different industries or companies.

Implications for human resources practice

Human resources practitioners would be wise if they familiarize themselves with the research on organizational innovations. The results of the present study highlight the importance of human resources practitioners knowing the skills across the enterprise, and invest in a clear understanding of their capabilities, to face the future challenges of the organization, on an innovation context. From the point of view of the strategic development of the organization, it will be important to evaluate what future skills will be relevant for the organization's capacity for innovation. As mentioned above, one of the practical implications of this study is the need to improve peoples' qualifications, in order to increase the capacity of organizational innovation. The development of strategic partnerships can help organizations to expand their workforce and capabilities. Human Resources professionals can contribute to the promotion of effective programmes that enable not only the acquisition and development of technical skills geared to innovation activities, but also others capable of stimulating creativity and encouraging anyone in the organization to contribute with their ideas and to generate solutions for the improvement of their work, organization and social welfare. Additionally, the development of human resource systems that promote employee domain-relevant skills facilitating the employee's creativity will be an advantage (cf., Dong, Yaping, Jing, & Jia-Chi, 2017). Also, human resource practitioners can contribute to the development of work organization models that promote organizational learning, through the creation, sharing and dissemination of individual and organizational knowledge. We highlight the importance of engaging the leadership in the promotion of a culture oriented to learning and innovation and that stimulates the transference and application of newly acquired knowledge in the workplace (Lousã, 2013; Rebelo & Gomes, 2011).

Limitations and future research

Apart from the contributions of this research, our study has some limitations. First, given the study's cross-sectional and non-experimental design, we cannot draw conclusions about causal relationships. Second, the generalization of the findings to other national contexts should be made with caution, although the sample is diverse and includes a variety of organizations from different sectors, sizes and ages, the findings may not be generalized with regard to organizations of different countries.

Accordingly, future research would clearly benefit from longitudinal and experimental designs to better analyze the scope of the organizational innovations. It might also be interesting to replicate the present research in organizations of different countries. Furthermore, our study was conducted at the organizational level, and future studies should integrate a multilevel approach to the innovation process (Anderson et al., 2014).

A promising area for future studies would be the investigation of these variables as moderators and mediators of the innovation process, and other types of categorizations. We propose that future studies analyze the impact of other variables in the innovation process, such as the leadership style, organization culture, and the role of the customers or clients, among others. Another issue that may be interesting to analyse is whether the different dimensions of the innovation activity under analysis, in this study, have the same effects on the performance of the organization or not.

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