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Human Capital and Innovative Performance in Manufacturing Companies: Evidence from Ecuador, Peru, and Chile

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The research examines the relationship between the variables of human capital, and the innovative performance of manufacturing companies in Ecuador, Peru, and Chile. A quantitative, non-experimental, cross-sectional study of data obtained from the countries of Ecuador, Peru, and Chile was carried out and collected from national surveys of innovation activities. A bivariate probit regression was applied to the data of each country. The results show different findings between the three countries. The findings highlight that the increase in human capital through the availability of more people in research and development (R&D), an increase in the number of workers with completed higher education, and an increase in training in innovation activities, allow, progressively, an increase in a company's resources and capacities, and improves innovative performance. The current study contributes to the literature by providing empirical evidence from three South American countries.

Keywords: *Innovation, Human capital, Innovative performance, Research and development, Personnel, Training.*

Introduction

Innovation is considered one of the main drivers of the economic development of a country (Aleknavičiūtė et al., 2016; Pejić et al., 2015). Several factors that impact innovative performance, such as company size, sector, sources of information for innovation, degree of competitiveness of the industry, and absorptive capacity of companies, have been identified (Pekovic et al., 2015). Furthermore, human capital is the basis of the knowledge stock (Sánchez et al., 2014). It is a source of innovative performance in companies (Aleknavičiūtė et al., 2016; Rupietta, & Backes-Gellner, 2019), stimulating innovation, and competitiveness (Pejić et al., 2015). The potential level of innovation depends on investment in research and development (R&D), specialised personnel, and the ability to form networks of innovation (Zanello et al., 2016), knowledge, and technology. Human capital is defined as the set of skills, knowledge, and competencies (OECD, 1998) which are expressed in terms of know-how, education, and learning capacity (Aleknavičiūtė et al., 2016). They are capitalised on the suggested concepts by Agostini, Nosella, and Filippini (2017), associating them with experiences, skills, and knowledge, as relevant factors in the ability to influence innovation (Pekovic et al., 2015; Srholec, 2011).

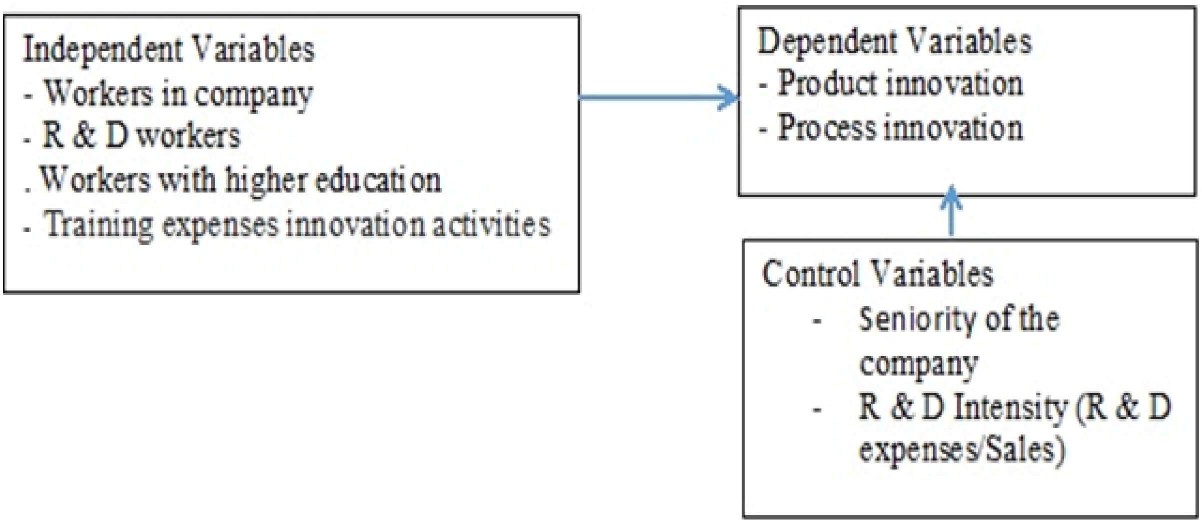
When reviewing the theories of economic growth, the central role of human capital is shown (Storper & Scott, 2009). The same that, from the evolutionary theory (Nelson & Winter, 1982), allows the accumulation of knowledge. The resource and capacity theories (Barney, 1991; Penrose, 1959; Wernerfelt, 1984) ratify them as a primary resource for innovation (Grant, 1996). Likewise, in general, companies influence the innovative performance of the countries where they are located (Pekovic et al., 2015; Srholec, 2011). However, the innovation capacity (Urgal, Quintás, & Tomé, 2011) is defined by the development of new processes or substantial improvements to current methods (OECD, 2005), allowing companies to obtain some competitive advantage (Barney, 1991; Penrose, 1959; Wernerfelt, 1984), which they report in the consubstantial knowledge of the company (Lin & Chen, 2006). This becomes a production resource generating new knowledge from the right combinations (Grant, 1996) and alliances between companies, and institutions (Amara & Landry, 2005). Therefore, being able to endogenise (Bustamante, 2015) knowledge (Cohen & Levinthal, 1990), and establish dynamic interactions with the environment.

Notwithstanding the previous, the shortage of human capital in companies cannot be hidden (Aleknavičiūtė et al., 2016). Although, it can be acquired through education and training (Allameh, 2018; McGuirk et al., 2015), since it has the absorptive capacity (González et al., 2016; Lund, 2006) and can stimulate innovation (Jones & Grimshaw, 2012) to interact with other organisations (Amara & Landry, 2005). It can ultimately put them to provision, tacitly, and explicitly to generate innovation (Cohen & Levinthal, 1990). In the same respect, Agostini et al. (2017) use the variable of the total number of workers to measure the stock of company knowledge. Meanwhile, Mariz-Pérez et al. (2012) use the skills and capacities or practical knowledge as a measure of human capital. In this study, the total number of R&D workers is considered variable, given that there is a relationship between R&D, and human capital because R&D provides capabilities and skills to assimilate and exploit existing knowledge that leads to innovation (González et al., 2016), and generates new skills and knowledge (Amara & Landry, 2005).

On the other hand, and in a complementary way, the workers with a higher education variable are identified by having completed higher education (Carter, 1989). Meanwhile, training increases the skills, knowledge, and skills for innovation (Lin & Chen, 2006), as well as the level of specialisation of workers (Hewitt, 2006). Goodarzi et al. (2015) developed research with a sample of 650 companies in Iran, in which knowledge development (education) had a significant impact on innovative performance.

Finally, based on the concepts analysed, this paper aims to examine the relationship of human capital variables with the innovative performance of companies by analysing data from three South American countries, namely Ecuador, Peru, and Chile. The Figure 1 describes the variables' relationships

Figure 1. Variables' relationships



Research Hypothesis

The following hypotheses were determined:

H1: workers in the company are positively related to the innovation of products and processes in manufacturing companies.
H2: R&D workers are positively related to the innovation of products and processes in manufacturing companies.

H3: workers with higher education are positively related to the innovation of products and processes in manufacturing companies.
H4: the training expenses in innovation activities are positively related to the innovation of products and processes in manufacturing companies.

Methodology

This paper applies the quantitative method using a transversal non-experimental design and with a deductive approach.

Population and Sample by Country

In Ecuador, the population was obtained from the DIEE-2014 survey of the Instituto Nacional de Estadisticas y Censo (INEC), which was distributed to 843,644 companies, with a sample frame of ten or more workers. The INEC used a stratified probabilistic sampling, with the allocation of Neyman (1934), and random selection stratified by province, and industrial sector. The sample obtained was 1,619 manufacturing companies (INEC, 2016).

The Chilean population was comprised of all the manufacturing organisations duly incorporated in 2015, which had reached a sales level of 2,400 UF (Ministry of Economy, Promotion, and Tourism, 2018), totaling 177,935 manufacturing companies. The sampling was stratified by region and economic activity, reaching a sample of 1,094 manufacturing enterprises. The data used from the period of 2015–2016 corresponds to the tenth survey on innovation in manufacturing companies.

Whereas, in Peru, the population corresponds to manufacturing companies with more than 150 ITU in net sales. The sample was stratified by the department and economic sector and was comprised of 1,684 manufacturing companies, with 1,294 compulsory survey requests, and 390 elective cases corresponding to small business. The data was obtained from the national survey on manufacturing completed by 2015, containing information from the years 2012–2014.

As the economic data of the two surveys of Peru, and Chile were in a currency different from the United States dollar (USD), a Peruvian Sol-to-Dollar conversion was performed, and the following rates were obtained: 2.637 for 2012, 2.701 for 2013, and 2.837 for 2014. In the Chile case, a conversion rate of 654 Pesos per USD was used for 2015, and 677 Pesos for 2016.

Measure of Variables

A dichotomous variable was used to measure product innovation, and process innovation. This variable takes the value of 'one' for companies that have innovated in the analysed period, and the value of 'zero' for companies that have not innovated in the analysed period (Urgal et al., 2011).

In the case of human capital, the following measures were considered: the number of workers in the company, the number of R&D workers concerning total workers, the number of workers with higher education concerning total workers with education, and innovation activities concerning total sales.

Additionally, to measure the seniority of the companies, the number of company years in the business was considered (Lefebvre et al., 2015). Furthermore, to measure the variable of R&D intensity, the ratio of R&D and/or sales expenses was considered (Laursen & Salter, 2006).

Since the agencies of each country had already validated the innovation surveys through software, it was not necessary to revalidate the data. The existence of problems of endogeneity, multicollinearity, and heteroscedasticity were analysed for the econometric model. The multicollinearity was validated with the factor of variance inflation test. To prevent heteroscedasticity problems, the model incorporates robust standard error parameters. Finally, Hausman's test was used for endogeneity. Statistical quality checks were carried out in each database separately. No problems of endogeneity, multicollinearity or heteroscedasticity was found. The Table 1 describes the variables used in this research.

Table 1: Variable Composition

Variable	**Nomenclature**	**Composition**	**Variable type**
Product Innovation	Y_1	1 = there is product innovation; 0 = there is no product innovation.	Binomial
Process Innovation	Y_2	1 = there is process innovation; 0 = there is no process innovation.	Binomial
Workers in the Company	X1	Number of workers	Continuous
R&D Workers	X_2	Number of workers in R&D/total workers	Continuous
Higher Education Workers	X_3	Number of workers with complete higher education/total workers	Continuous

Staff Training	X_4	Training expenses for innovation/sales	Continuous
Seniority of the Company	X_5	Number of years in business	Continuous
R&D Intensity	X_6	R&D expenses/sales	Continuous

Econometric Modelling

The model for the analysed variables is presented in Formula 1:

$$Y = \beta_0 + \beta_1 \text{ Workers in company} + \beta_2 \text{ R \& D Workers; } + \beta_3 \text{ Workers with completed higher education} + \beta_4 \text{ Innovation Training} + \beta_5 \text{ Company's seniority} + \beta_6 \text{ R \& D Intensity} + \varepsilon_i \quad (1)$$

The dependent variable Y = innovative performance;
The independent variables are:
Workers in company = workers in the company;
R&D workers = workers in the R&D department;
Workers with higher education = workers with completed higher education; and
Training innovation = staff training expenses for innovation activities.
Finally, the control variables are:
Company's seniority = number of years in business; and
R&D intensity = degree of R&D.

The bivariate probit regression method was used in the analysis. It considers a binary dependent variable, and a discrete method of analysis applying the maximum likelihood procedure. The regressions were made through the Stata version 14 software, and the regression coefficients were verified, considering a value of >0.05 as the level of significance. The direction of the relationship was determined through a positive or negative coefficient.

Results

Descriptive Results

The Table 2 presents the expenses in R&D in the three countries under study, showing that there are differences in the allocated amounts for R&D in each country. In this regard, it is observed that the total number of workers engaged in R&D activities is different in the three countries. It is worth noting that in none of the nations, the number of workers dedicated to R&D exceeds one per cent. Moreover, the staff with higher education also show differences in each country. Finally, the training expenses in innovation activities present differences as well, especially significant differences, when compared with developed countries.

Regarding the training expenses in innovation activities, Sánchez et al. (2014) mentioned that in Spain, the ratio of training expenses for innovation activities and/or sales for the year 2007, during a time of crisis, was 0.04 per cent. In the year 2011, it was 0.12 per cent. Both results possess higher ratios than those obtained by the countries examined.

Table 2: Expenditures, workers, and training in R&D in reference countries

	Expenditure on R&D with respect to GDP			
		Ecuador	Peru	Chile
R&D expenses		0.19%	0.12%	0.38%
	Workers, R&D workers, and workers with higher education from manufacturing companies			
		Ecuador	Peru	Chile
Worker in company	(media) (desv St)	147 387	257 663	162 481
R&D Workers	(media)	0.9%	1.67%	0.7%
	(desv St)	3%	3.9%	3.7%
Workers with higher education	(media) (desv St)	21% 19%	19% 17%	29% 27%
	Expenditure on training in innovation activities in manufacturing companies			
		Ecuador	Peru	Chile
Company's Annual average	(media)	US $2,891	US $1,926	Us $3,106
Training Expenses Ratio innovation/Total Sales	(media) (desv St)	0.06% 0.7%	0.04% 0.18%	0.03% 0.56%

Bivariate Probit Regression Results

The results of the bivariante probit regression, as applied to the data from Ecuador, Peru, and Chile, are detailed in Tables 3, 4, and 5.

Table 3: Results of the Bivariate Probit Regression found in analysed data from Ecuador

Bivariate Probit Results - Ecuador		
Variables	***Product Innovation***	***Process Innovation***
Workers in Company	0.4181808*** (0.0583771)	0.4494727 *** (0.0581024)
R&D Workers	6.556077*** (1.131073)	2.966289 *** (1.131538)
Staff Training	1.526965 (4.20776)	48.89847*** (17.15805)
Higher Education Workers	0.4423137 *** (0.1704727)	0.3799928 ** (0.1692117)
R&D Intensity	6.919214 *** (2.015068)	13.10935 *** (3.011038)
Seniority of the Company	0.2010004 (0.1254676)	0.0801245 (0.1234838)
Constant	-1.439572*** (0.1673897)	-1.113116 *** (0.1647268)
Number of observations	1614	
Wald chi2 (12)	185.98	
Prob > chi2	0.0000	

Note: *** p value <0.01, ** p value <0.05, * p value <0.10

Table 4: Results of the Bivariate Probit Regression found in analysed data from Peru

Bivariate Probit Results - Peru		
Variables	***Product Innovation***	***Process Innovation***
Workers in Company	0.3574353 *** (0.0573874)	0.3430747 *** (0.056938)
R&D Workers	6.057004***	3.189435***
	(0.9946366)	0.9835265
Staff Training	91.26383 *** (30.23336)	119.205 *** (31.58352)
Higher Education Workers	0.1714587 (0.2051729)	-0.1085273 (0.2041255)
R&D Intensity	25.36768 *** (5.099059)	26.29543 *** (5.360167)
Seniority of the Company	0.1071529 (0.1214068)	0.0881254 (0.120888)
Constant	-1.105594 *** (0.1640993)	-0.9606877 *** (0.1628722)
Number of observations	1,436	
Wald chi2(12)	160.32	

Prob > chi2	0.0000	

Note: *** p value <0.01, ** p value <0.05, * p value <0.10

Table 5: Results of the Bivariate Probit Regression found in analysed data from Chile

Bivariate Probit Results - Chile		
Variables	***Product Innovation***	***Process Innovation***
Workers in Company	0.7685828 *** (0.0810443)	0.7028248*** (0.0750447)
R&D Workers	9.418896 *** (1.487429)	6.142475*** (1.717746)
Staff Training	1.723636 (14.81149)	8.315006 (6.316338)
Higher Education Workers	0.4819822** (0.1899923)	0.4187585** (0.1747067)
R&D Intensity	3.978407** (1.920262)	1.009234 (2.357074)
Seniority of the Company	0.0564983 (0.1855388)	-0.1789072 (0.1731692)
Constant	-2.748074 *** (-2.748074)	-2.068891 *** (0.2477761)
Number of observations	1082	
Wald chi2 (12)	181.63	
Prob > chi2	0.0000	

Note: *** p value <0.01, ** p value <0.05, * p value <0.10

In respect to the hypothesis one, and workers in the company, it is positively related to the innovation of products and processes of the manufacturing companies in the three countries. The bivariate probit regression shown in Tables 3, 4, and 5, enables accepting this hypothesis for the three countries regarding both the product innovation, and process innovation.

As to the hypothesis two, and R&D workers, it is positively related to the innovation of products and processes of the manufacturing companies in the three countries. The probit regression depicted in Tables 3, 4, and 5, enables accepting this hypothesis for the three countries regarding both product innovation, and process innovation. This result shows that the flow of knowledge, skills, and abilities for innovation which is concentrated in the R&D workers is positively related to innovative performance. This result is consistent with the assertions made by Amara and Landry (2005). They expressed that the R&D department concentrates the knowledge and skills for the development of innovations, which is the most critical factor in increasing innovative performance.

Despite the small number of companies that carry out internal R&D in these three countries, a strong relationship between R&D workers, and product and process innovation is determined. According to Zanello et al. (2016), in developing countries, companies are more likely to acquire technologies than to develop them. Therefore, the number of companies implementing R&D is low, while the percentage of R&D workers has a substantial impact on innovative performance.

The base of R&D workers is part of the so-called 'internal sources for innovation', since it is through the R&D department that the knowledge and technologies which are available to the company for product development are provided. At the same time, these R&D workers are the fundamental pillar to learn, assimilate, and put into practice the external knowledge that comes as a result of the company's interactions with other organisations. These findings allow us to infer and explain the strong relationship between R&D workers, and the innovative performance of organisations.

In terms of the hypothesis three, and workers with a higher education, it is positively related to the innovation of products and processes of manufacturing companies. The bivariate probit regression shows different results between the three countries. Thus, hypothesis three can be accepted in the regression corresponding to the data from Ecuador, and Chile, and for both the product innovation, and process innovation dimensions. However, hypothesis three is rejected in the regression of the Peruvian data.

These results show that the quality of the knowledge and skills available to workers with a higher education is positively related to innovative performance. This relation results from the fact that these workers have the best knowledge to contribute to the development of company knowledge, and have more skills to combine knowledge, and generate new knowledge. It can also be assumed that they have more skills to assimilate and endogenize the external knowledge that reaches the company through external sources of information. However, higher education must be strengthened in key knowledge and skills to increase the innovative potential of the company.

As to the hypothesis four, and training expenses in innovation activities, it is positively related to the innovation of products and processes of manufacturing companies. The bivariate probit regression delivers differentiated results. First, it allows hypothesis four to be accepted for the data from Peru regarding the product innovation, and process innovation dimensions, and for Ecuador, in process innovation. Still, it is rejected for Chile, regarding both the innovation of products, and process innovation dimensions. These results show that training expenses in innovation activities are positively related to innovative performance because the training covers deficiencies that workers present to develop skills and abilities. It is also appreciated that not every training is appropriate for all workers, especially if the training does not develop skills, and abilities or bring new knowledge, which is effectively useful for the development of innovations in companies.

In general, the results obtained in this analysis contribute to explaining the low levels of innovation presented by the companies in the countries examined. It further shows that having lower levels of human capital not only limits the knowledge, skills, and talents required for product and process innovation, but also limits the relationship between human capital, and a company's absorptive capacity. This means that companies are limited by their ability to use and benefit from knowledge which arrives from external sources.

In reference to the control variables, the seniority of the company variable was not statistically significant in any of the three countries examined. This result implies that companies with more time in the business accumulate more knowledge, and capacities. Still, it does not lead to a higher capacity for innovation. As a result, the length of time a company has been in operation is not a practical advantage for innovation.

Finally, the variable intensity of R&D is significant in the regression from Ecuador, and Peru for the innovation of products, and processes, and in Chile, only for the innovation of products. Hence, companies with higher ratios in this variable have a greater probability of innovating products, and processes.

Discussion

Considering the hypothesis one, this hypothesis was accepted in all three countries examined. This outcome is consistent with the results found by Sánchez et al. (2014) in Spain. In this study, the effect of the total worker variable on innovative performance indicates that companies that introduce organisational innovations elevate their innovative performance over time.

Regarding the hypothesis two, it was accepted in Ecuador, Peru, and Chile, and is consistent with the statements made by Amara and Landry (2005). They expressed that the R&D department concentrates the knowledge and skills for the development of innovations, and it is an essential factor in increasing innovative performance.

As to the hypothesis three, it was accepted in the case of Ecuador, and Chile, and it can be said that such an outcome is consistent with a series of studies conducted in Spain (Sánchez et al., 2014), whose findings indicate that workers with a higher education are positively related to performance innovation in businesses. Additionally, McGuirk et al. (2015), in Ireland, found that workers with a higher education were significant for all kinds of innovation in small, and large enterprises. These findings also indicate that workers who received training in innovation activities were a substantial factor for innovation. Additionally, Van Uden et al. (2014), in Kenya, Tanzania, and Uganda, determined that there is a positive relationship between the degree of schooling of workers, and a company's innovative performance. A similar determination was made by Alshekaili, Sar, and Boerhannoeddin (2011), in Onami. These researchers found that there is a positive relationship between workers with a higher education, and innovative performance.

However, the hypothesis three was rejected for the case of Peru. This outcome is similar to the results found by Koroglu and Eceral (2015) in their study in Turkey. They determined that there is no relationship between the workers with a higher education, and the innovative performance of a company. This result also matches the findings of Aleknavičiūtė et al. (2016), whose research included data from 26 countries from the European Union. These findings highlight that achievement in education has ambiguous results. In countries with low levels of innovation, increasing achievement in education is negatively related to innovative performance. However, in countries with a high level of innovation, achievement in education is positively associated with innovative performance.

Assessing the hypothesis four — which was accepted for Ecuador in process innovation; and Peru in product, and process innovation — it coincides with the results from the Sánchez et al. (2014) study conducted in Spain. It was determined, in this analysis, that training in innovation activities is positively related to innovative performance, especially in small and medium-sized enterprises, who are increasing innovative performance over time. Similarly, Van Uden et al. (2014) in Kenya, Tanzania, and Uganda, also found that training in innovation activities has a high impact on innovative performance in enterprises.

On the other hand, the hypothesis four was rejected for Ecuador in product innovation, and rejected for Chile in both product, and process innovation. These results confirm the findings from Koroglu and Eceral (2015) in their study in Turkey, which determined that there is no relationship between specialised training, and innovative performance.

In general, the results of this research confirm the theory of resources and capacities (Barney, 1991; Penrose, 1959; Wernerfelt, 1984). This theory maintains that companies, as they increase or accumulate resources and capabilities, also increase their innovation capacities. This theory also emphasises that knowledge is one of the leading resources for this increase, since it acts as a critical inducer for innovation.

The findings outlined above show that the increase in human capital through the availability of more people in R&D, an increase in the number of workers with completed higher education, and an increase in training in innovation activities, allow, progressively, an increase in a company's resources, and capacities. This is possible because knowledge is a key factor in the rise of the innovative potential of business organisations.

Conclusions

In general, the results of this analysis help to explain the low levels of innovation of the companies in the countries examined. In these countries, their corresponding manufacturing companies have low percentages of staff working in R&D, a small percentage of workers with higher education, and allocate low amounts for training and innovation activities in relation to developed countries. All of these factors stall any increase in the knowledge and development of skills in workers, and thus, they also prevent a company's innovative potential.

The results show that the R&D workers that represent the stock of knowledge, skills, abilities, and know-how are positively related to innovative performance. Moreover, it is determined that the workers with a higher education are positively associated with innovative performance in Ecuador, and Chile. However, this result was not verified in Peru. On the other hand, the training in innovation activities is positively related to the innovative performance in Ecuador for process innovation, and Peru for both product, and process innovation. However, it was not verified in Chile.

This study contributes to the literature by providing empirical evidence from three South American countries. It provides evidence regarding the number of workers in a company, the number of R&D workers, the number of workers with a higher education, and training expenses in R&D activities, which influence the innovative performance of company. It is also observed that there is a need to investigate these variables in the other South American countries by considering how relevant it can be for them to deepen their corresponding absorptive capacity, which is an inducing factor of R&D.

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