The role of science-oriented workers on innovation: the case of the accommodation industry in Colombia

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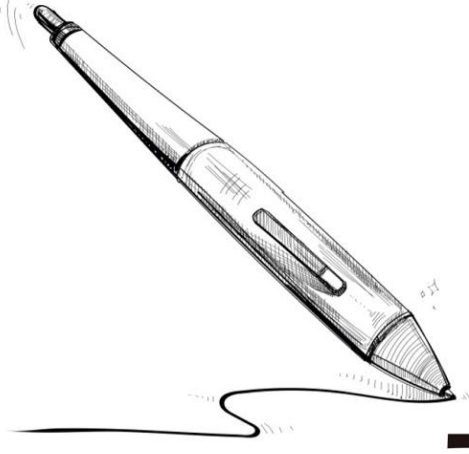

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Resumen no-técnico

Este documento estudia algunas de las variables y características asociadas con la innovación de las empresas de acomodación en Colombia, la cual incluye empresas de acomodación de corto plazo (hoteles, hostales, fincas de descanso), centros vacacionales, campamentos, casas de turismo, y otros no especificados. Se otorga especial atención al análisis del capital humano dedicado a actividades de Ciencia Tecnología e Innovación (CTI). El estudio encuentra que un aumento en la proporción de trabajadores dedicada a CTI está efectivamente asociado con mayores probabilidades de innovar en sentido amplio; esto es, la introducción de nuevas técnicas de comercialización, nuevos métodos organizacionales, y/o nuevos servicios o mejora en servicios para la compañía. No obstante, el estudio alerta sobre los bajos niveles de innovación de esta industria (comparados con otras industrias de servicios), y la falta de innovación en sentido estricto, la cual se basa en la creación de nuevos servicios para el mercado internacional (turistas extranjeros). El estudio también encuentra que cuando los establecimientos de acomodación aumentan el número absoluto de trabajadores dedicados a CTI, también se incrementa la cantidad de innovaciones registradas por parte de ellas, aunque en un número pequeño. Al final se proveen algunas iniciativas para impulsar la innovación en esta industria tan importante para el sector del turismo del país.

The role of science-oriented workers on innovation: the case of the accommodation industry in Colombia[1]

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Abstract

This study examines the role of science-oriented workers on innovation activities in the accommodation industry of Colombia using a double hurdle regression model. Data are taken from the EDITS survey of 2016-2017. The findings show that the likelihood of introducing innovations increases as the percentage of workers involved in Science, Technology and Innovation activities rises, and that the quantity of innovations the firms introduce for the company or the market grows as the number of science-oriented workers increases. The results warn the low percentage of workers that participate in STI activities in this industry, which can negatively affect the tourism sector's growth in the long run.

Key words Innovation, Human Capital, Accommodation Industry, Double Hurdle Model, Colombia
JEL Classification C24, J24, O30

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1. Introduction

Since the beginning of the industrial revolution, science, technology and innovation activities (STI hereafter) have played a fundamental role in improving living standards (Bowles et al., 2017). According to Solow (1957), technical progress explained more than fifty percent of the United States' productivity growth in the first half of the Nineteenth Century. Technological breakthroughs and/or new and improved ideas stem from engineering, marketing, logistics, amongst other enterprise activities, and represent a pivotal factor to increase industrial productivity levels in the long run (Jones et al., 2000). Technology advances have significantly increased living standards in Japan, South Korea, Singapore and other emerging economies over the last 70 years (Bolt et al., 2018; Sala-i-Martin, 2000).

There are several factors that explain industries' increasing levels of STI activities, including intellectual capital (Xu et al., 2019). Human capital is one of the components of intellectual capital that is strongly associated with the companies' level of innovation (Cohen and Levinthal, 1990; Fuentelsaz and Montero, 2015). Within human capital, the percentage share of workers that participate in STI activities (workers with diverse skills and levels of education) can mirror the companies' level of commitment toward innovation. Without human capital involved in STI, firms could not guarantee their economic growth or survival in the long run. This is because human capital is a driving force of economic growth that significantly contributes to long term productivity (Lucas, 1988; Uzawa, 1965).

In the accommodation industry, it has been noted that innovation activities increase as the number of science-oriented workers grows, *ceteris paribus* (Brunow et al., 2018). The switching from non-innovative workers to innovation-oriented workers could significantly contribute to the tourism sector's economic growth in the long run (Romão and Nijkamp, 2019). Human capital is key to increasing innovation at the firm level (Mariz-Pérez et al., 2012), regardless the economic sector that the firm belongs to. As noted by O'Rourke et al. (2017) and Ruttan (1959), who follow Schumpeter's thesis on creative destruction, companies need to adapt to new products and/or production methods (which are usually introduced by entrepreneurs), if they want to survive in the market in the long term. This adaptation to innovative products and production methods is fundamental from science-oriented workers to increase hotels' performance in the long term rather than the short term (Campo et al., 2014).

The role of science-oriented workers for introducing innovation in accommodation providers is of fundamental interest for tourism stakeholders in Colombia. Statistics from the Technical Development and Innovation in Trade and Services Sectors (EDITS) survey of 2016-2017, carried out by Colombia's National Administrative Department of Statistics (DANE), show that only 14.7 percent of accommodation providers in Colombia introduced innovations in the study period (DANE, 2018a). This is a low percentage when compared to companies that belong to other service industries, including banking (84 percent), education (76 percent), and public land transport (17 percent), amongst other industries (DANE, 2018a). Factors such as enterprises' clustering have been found to be fundamental for hotel innovation and competitiveness in Colombia (Rodríguez-Victoria et al., 2017). Little attention has been paid to the influence of science-oriented workers on innovation

activities in the accommodation industry of Colombia, despite that STI investments have been identified as a key strategy to the accommodation industry's competitiveness and growth (Jacob et al., 2010; Rogerson, 2013).

The purpose of this study is to analyze the determinants of innovation in the accommodation industry of Colombia within the period 2016-2017, paying attention to the role science-oriented workers. This examination is important to shed light on policy initiatives that can contribute toward further innovation in the accommodation industry through human capital devoted to STI activities. The accommodation industry, together with food and beverage services, have contributed an annual average of 80% of total tourism sector's value added since 2002, which is 2.8 percent of total GDP in Colombia (according to statistics from DANE). This is demonstrative of the significance of this industry to the economy. Two hypotheses to be examined in this paper are, whether growth in the proportion of workers involved in STI activities in accommodation establishments is associated with increases in the likelihood of introducing innovations. Second, whether an increase in the number of STI-oriented workers rises the quantity of innovations introduced by these accommodation establishments.

To analyze the above hypotheses, Cragg's (1971) double hurdle regression model is estimated using micro data statistics from the EDITS survey of 2016-2017 (DANE, 2018b). The use of this model is an important contribution to the literature on innovation, as this model can include two choices by companies: the decision to innovate (participation decision), and the number of innovations to introduce (the amount decision). Thus, this model identifies the factors that influence the decision of doing STI activities, and the factors that determine the number of innovations that an accommodation company introduces.

This study is organized as follows: Section 2 presents the literature review on the role of STI-oriented workers on innovation outcomes, giving emphasis to the accommodation industry. Section 3 shows the double hurdle model specified for econometric analysis, followed by a discussion of data and the estimation method used in this paper. In Section 4, empirical results and implications of the findings are considered. The conclusions and discussion are presented in Section 5.

2. A brief review of literature

Based on the Organization for Economic Cooperation and Development (OECD) and Eurostat, the concept of innovation includes the combination of products and/or processes that are new or significantly improved (OECD and Eurostat, 2018). Innovation can also be conceptualized as "the successful introduction of something new and useful, including new methods, techniques, or practices or new or altered products and services" (Bigliardi and Dormio, 2009). Nonetheless, innovation can be studied from a variety of perspectives and historic contexts.

From an economic perspective, the number of technological advances has significantly increased since the industrial revolution with the introduction of new textile, energy and transportation technologies (Bowles et al., 2017). Firms have played a crucial role in the capitalist economic system, as companies are encouraged to compete in the markets through innovation processes (using their production factors) and grow in the long run

as a result (Bowles et al., 2017). The rise in innovation activities from the Eighteenth Century (that lead to growth in the countries' living standards) has been joined by changes in economic institutions associated with markets, job contracts, money and financial system, the capitalists' societal responsibilities, among other characteristics (Chang, 2015). Ultimately, the innovation process in a country can be guaranteed through solid institutions, and vice versa.

There are several factors studied in the literature that determine companies' innovation activities. From an organizational perspective, factors that influence the decision to introduce innovations at the firm level include the need for product differentiation, the desire of increasing value added, the companies' goal of reaching more efficiency and effectiveness, the chance of getting funding, and the need to satisfy legislative demands (Bigliardi and Dormio, 2009). For Xu et al. (2019), innovation is significantly determined by the companies' level of intellectual capital, which is compounded by human capital, structural capital and relational capital. Human capital is regarded as the stock of knowledge and creativity built through education investments; investments that face trade-offs between current consumption and future productivity levels (Sala-i-Martin, 2000). The growth of workers' knowledge through education is usually linked to innovations of any type in the companies, whenever these workers are involved on STI activities. Thus, the role of science-oriented workers (with diverse levels of education and skills) on innovation activities is the factor of interest in this paper.

Human capital is one factor associated with organizational capabilities to innovate and companies' ability to transfer knowledge and success in the innovation process (OECD and Eurostat, 2018). Pogodina et al. (2019) noted that qualified human capital reduces organizations' uncertainty to invest in assets that improve diverse processes. This suggests that companies with high qualified workers tend to rely on real investments that contribute to positive changes to the company through innovation. Qualified human capital can increase companies' innovation capabilities (Cohen and Levinthal, 1990; Fuentelsaz and Montero, 2015; Terziovski and Morgan, 2006) and competitiveness (Fernández-Rodríguez and Giménez, 2012; Lenihan et al., 2019) in the long run.

Tourism is an economic sector that could grow significantly in the long run from innovation activities (Romão and Nijkamp, 2019). This sector includes accommodation for visitors; food and beverage service activities; rail, road, water, and air passenger transport; transport equipment rental; travel agencies and other reservation activities; cultural activities; sports and recreational activities (UNWTO, 2010).

From a survey applied to all firms that carried out tourism activities in The Balearic Islands in 2000, Jacob et al. (2010) found evidence from a descriptive analysis of a positive relationship between innovative practices and organizations' competitiveness, especially those that pertain to the accommodation and lodging industry. Rogerson found similar results in the accommodation industry of South Africa (Rogerson, 2013), although with a dataset covering two periods: 1990 and 2010. For Campo et al. (2014), using an online survey amongst four-star hotel managers in 52 Spanish cities, the relationship from descriptive analyses between innovation activities and hotel performance is only evident in the long term.

Using a Probit model on data from two different sources of statistics (covering 115,000 firm-level observations between 1998 and 2015), Brunow et al. (2018) found that a greater number of science-oriented workers in Germany leads to an increase in the likelihood of introducing innovations. For Brunow et al. (2018), attracting human capital with high qualifications is important, as there is a comparatively low number of companies that innovate in Germany –with less than 10 and 20 percent having introduced product-related innovations and process-related innovations, respectively. Firms that can employ creative and Science, Technology, Engineering and Mathematics (STEM) workers can reach their goals of more productivity in the long run via innovation activities (Brunow et al., 2018).

Orfila-Sintes et al. (2005) argue that human capital capabilities must adjust through time for hotels to improve their innovation practices. Ultimately, disruptive innovation dynamics in the accommodation industry require practices that improve the process of adaptation, sustainability and organizational performance (Guttentag, 2015; Koh and King, 2017). A dynamic labor transformation in the tourism sector from labor-based workers to innovation-based workers must be a part of accommodation providers' goal in order to grow in the long run (Romão and Nijkamp, 2019).

A study by Rodríguez-Victoria et al. (2017), using a survey of 131 hotels in 2014 in Colombia, found clustering as one of the key factors that influences innovation and competitiveness in hotel companies. This effect is likely to occur as firms located in clusters tend to transfer knowledge more easily among them (Baptista and Swann, 1998) and identify new customer needs (Novelli et al., 2006). In Colombia, little empirical evidence exists on the nexus between innovation and STI-oriented workers. Due to the significant role that STI activities plays on innovation activities (noted in the previous analyses), the first hypothesis of this paper is:

H1: whether accommodation companies in Colombia tend to introduce innovations as the proportion of workers involved in STI activities increases.

Although this hypothesis seems to be intuitive, it is important to analyze it in the context of Colombia. Ultimately, the innovation levels of accommodation providers in Colombia are very small as compared to other services industries (DANE, 2018a); a fact that can jeopardize the accommodation industries' levels of productivity and competitiveness in the long run , and the economic development of the tourism sector, as a result.

There is a greater intensity in the accommodation industry's dynamics of innovation whenever the number of people linked to innovation activities increases (Brunow et al., 2018). The link between innovation-oriented workers and innovation dynamics is also an interesting issue to analyze, in order to understand how many innovations an accommodation provider tends to introduce (after choosing to participate in STI activities), and whether this quantity is determined by the number of workers that participate in STI activities. Following the study by Aissaoui (2014) in manufacturing industries, the second hypothesis proposed in this paper is related to the amount decision of innovation derived from human capital. This is:

H2: whether an increase in the number of STI-oriented workers in the sector leads to a rise in the number of innovations introduced by accommodation establishments that already chose to participate in STI activities.

A complementary analysis to these two hypotheses is carried out to identify whether, within the group of science-oriented workers, those with higher educational qualifications (a doctorate or master's degree) tend to be more concentrated in STI activities (due to the nature of their professional levels) as compared to workers with lower educational achievement. The following section outlines the study's methodology to examine the research hypotheses highlighted in this literature.

3. Methodology

To examine the role of science-oriented workers on companies' innovation activities in the accommodation industry of Colombia, and the key research hypotheses detailed in the previous chapter, the double hurdle regression model of Cragg (1971) is employed. This model has been applied to innovation studies in manufacturing industries (see Aissaoui, 2014). The strengths of this model and its application in this paper will be described in the following subsections.

3.1 Double hurdle regression model

Cragg's (1971) double hurdle regression model was designed for limited dependent variables that exhibit two separate moments to know: first, the participation decision (whether a particular event occurs or not); and second, the amount decision (the magnitude of the event when this occurs). In this paper, the double hurdle model is used to get the best goodness of fit of the data employed, which show a high relative frequency of accommodation firms that do not participate in innovation (the number of innovations is zero), and a relatively small proportion of firms that innovate in different levels (the number of innovations introduced by these firms varies).

Following Wooldridge (2010) and Burke (2009), the general equation is presented as $y_i = s_i w_i^*$. The variable y_i is the dependent variable's observable value (the magnitude of the event), s_i (the selection variable) is a binary number that equals one if y_i is greater than zero (it is not bounded) and equals zero otherwise, and w_i^* is a continuous latent variable that is observed if s_i is equal to one. This model never predicts negative outcomes on the latent variable y_i (Wooldridge, 2010), and can be expressed as follows:

$$s_i = \begin{cases} 1 & \text{if } z_i\gamma + e_i > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

and

$$w_i^* = \exp(x_i\beta + u_i) \quad (2)$$

Where z_i and x_i are vectors of explanatory variables; γ and β are vectors of coefficients; and e_i and u_i are the idiosyncratic error terms that are normally distributed. In this paper, w_i^* is modelled assuming an exponential link function. A linear link function of the form $w_i^* = z_i\beta + u_i$ was also examined; however, the exponential

function fitted the data used in this study in a better way. The terms e_i and u_i from Equations (1) and (2), respectively, are assumed to be independent to each other, and independent of explanatory variables. Therefore, s_i and w_i^* are independent conditional on the covariates (Wooldridge, 2010). The expected value of y_i conditional on the vector z_i for the exponential function (2) is:

$$E(y_i|z_i) = \Phi(z_i\gamma)e^{x_i\beta+\frac{\sigma^2}{2}} \quad (3)$$

And the semielasticity of $E(y_i|z_i)$ with respect to x_j for the exponential function becomes:

$$[\gamma_j\lambda(z_i\gamma) + \beta_j] \cdot 100 \text{ , where } \lambda(\cdot) \text{ is the inverse Mills ratio} \quad (4)$$

In this study, the variable s_i represents the decision of doing STI activities by accommodation establishments in Colombia (yes or not), and w_i^* accounts for the number of innovations introduced by these establishments. Based on DANE (2018a) and following guidelines on technological innovation data from the Oslo Manual of 2018 (OECD and Eurostat, 2018), the innovations that an accommodation enterprise can introduce are categorized in five classes. i) New services for the company, or for the national market, or for the international market. ii) New significantly improved services for the company, or for the national market, or for the international market. iii) New significantly improved methods of production, distribution, or logistic systems. iv) New organizational methods within the company. v) New commercialization techniques in the company. Parameters and regressors for s_i and w_i^* may differ for modelling purposes (Burke, 2009). Therefore, the explanatory variables for s_i and w_i^* that better predict the dependent variables in this study are the following:

$$y_i(s_i = 1) = c + \gamma_1 \text{ocuparate}_i + \gamma_2 \text{median}_i + \gamma_3 \text{large}_i + u_i \quad (5)$$

$$y_i(w_i|z_i = 1) = c + \beta_1 \ln \text{ocupasti}_i + \beta_2 \text{media}_i + \beta_3 \text{large}_i + \beta_4 \text{export}_i + \beta_5 \text{propintel}_i + \beta_6 \text{coop}_i + u_i \quad (6)$$

The first variable of interest is ocuparate, which is the proportion of employees within an accommodation provider involved in STI activities. These are workers in charge of creating new services for the company or for the national/international market or involved in any of the remaining four classes of innovation activities that an accommodation company can introduce (see above). This variable belongs to the companies' human capital stock, as it involves workers with diverse educational levels that contribute to STI activities through their skills, knowledge, and abilities. Based on the first research hypotheses of this study, it is expected that the likelihood of doing STI activities within an accommodation enterprise increases as *ocuparate* rises. The variable *ocupasti*, the second variable of interest in this study, is the number of employees (in log scale) involved in STI activities within an accommodation enterprise. It is expected that an increase in the number of STI-oriented workers (with diverse educational levels) leads to an increase in the number of innovations introduced by accommodation companies.

There are several control variables included in equations 8 and 9. The dummy variables $medium$ and $large$ are included to identify whether the accommodation establishment is a medium-size or large-size enterprise, respectively. Small-size enterprises is used as the control group. Following the study by Orfila-Sintes et al. (2005) and Wikhamn et al. (2018), it is likely to find differences between firms (measured through plant size) regarding the likelihood of introducing innovation, although it is unknown whether firm size influences the number of innovations to be introduced by the accommodation firms.

Based on Brunow et al. (2018), the dummy variable $export$ is included to analyze whether the accommodation provider supplies services to international tourists; this is, whether the accommodation enterprise is export-oriented. Based on Aissaoui (2014), it could be expected that export-oriented companies tend to be more innovation oriented. The underlying logic of this inclusion is that export-oriented accommodation firms are encouraged to innovate more than their counterparts due to their commitments with travel agencies and/or other intermediary agents in the provision of high-quality services for overseas.

The variable $propintel$ is a dummy variable that equals one if the company already has registered intellectual property. This variable can be used as a proxy variable of structural capital, which accounts for investments in Research and Development activities -the main factor of unique processes, copyrights and innovations (Nadeem et al., 2019). It is therefore assumed that accommodation providers that already possess intellectual property have built structural capital that could potentially propel new innovations in the companies.

The variable $coop$ is a dummy variable that identifies whether the enterprise has cooperation arrangements with other national and/or international entities. Cooperation can be done with other firms of the same economic group, suppliers, clients, competitors, consultants, universities, and/or other national or international entities (DANE, 2018a). This dummy variable can account for the companies' relational capital (also called customer capital), which includes "the value of an organization's relationship with the people with whom it does business" (Stewart, 1997), and companies' cooperation with other public and private establishments (Kar and Khavandkar, 2013). Based on game theory (see Pastine et al., 2017), cooperation between accommodation providers and hotel industry's interest groups can make the parties maximize their gains as compared to the strategy of acting individually. Cooperation is one source of knowledge spillovers between companies that boosts the firms' level of innovation (Fritsch and Franke, 2004).

3.2 Data

Data to analyze the decision to introduce innovations by accommodation providers and the number of innovations introduced by them are taken from the EDITS survey of 2016-2017. EDITS is a survey of cross-section units carried out by DANE (DANE, 2018b). The International Standard Industrial Classification (ISIC) revision 4 and adapted to Colombia is employed in the EDITS survey. This study examines Division 55, the industry of accommodation services. The ISIC of accommodation services in Colombia includes short term accommodation (ISIC I5511 and I5512), vacation centers (ISIC I5513), camp grounds (ISIC I5520), and tourist houses and other accommodation establishments (ISIC I5514 and I5519) (DANE, 2012). A total of 317 accommodation establishments comprise the pooled cross-section sample. In Colombia, large enterprises have

more than 200 employees; medium enterprises have between 50 and 200; and small-micro firms have less than 50 (Congreso de Colombia, 2004).

According to the EDITS survey, only 14.82 percent of accommodation establishments introduced innovations in the period 2014-2015. Out of this percentage, 31.4 percent introduced new commercialization techniques; 25.7 percent introduced new production, distribution, and logistics methods; 20 percent introduced new organization methods; 15.7 percent introduced improved services for the company; and the remaining 7.14 percent introduced new services for the company. The EDITS survey also asks for the number of innovations introduced by these establishments and shows answers that range from one to eight innovations within 2016-2017. To model this type of response variable and its statistical distribution, the double hurdle regression model is suitable for parameter estimations as described in section 3.1

Based on DANE's typologies of innovation (DANE, 2018a), none of the accommodation companies belong to the group "innovators in the strict sense", which is the maximum typology of innovation for a company. To belong to this category of innovators, services companies such as accommodation providers must report the introduction of innovations associated with new services significantly improved for the international market. For instance, the introduction of a service that can attract international visitors due to its uniqueness or highly perceived quality. Therefore, most of the accommodation providers in Colombia that innovate are "innovators in a wide sense" (DANE, 2018a).

3.3 Estimation method

The maximum likelihood (ML) method is used to estimate equations 5 and 6. Based on García (2013), the log-likelihood function for models with lower corner (equals to zero in this study) is as follows:

$$\log(L) = \sum_{y_i=0} \left[\log\left\{1 - \Psi\left(z_i\gamma - c, \frac{x\beta - c}{\sigma}, \rho\right)\right\}\right] + \sum_{y_i>0} \left[\log\left\{\Phi\left(\frac{z_i\gamma - c + \frac{\rho}{\sigma}(y_i - x_i\beta)}{\sqrt{1-\rho^2}}\right)\right\} - \log(\sigma) + \log\left\{\phi\left(\frac{y_i - x_i\beta}{\sigma}\right)\right\}\right] \quad (7)$$

Where: $\Psi(\cdot)$ is the Cumulative Distribution Function (CDF) of the bivariate normal with correlation ρ; $\Phi(\cdot)$ is the standard normal CDF; and $\phi(\cdot)$ denotes the standard normal probability density function (PDF). Due to the presence of heteroskedasticty in our dataset (found through the White General test for heteroscedasticity), the robust estimator of variance is employed. No signs of multicollinearity were encountered.

4. Results

Estimates of the double hurdle model presented in Equations (1) to (6) using the maximum likelihood method of Equation (7) is reported in Table 1. Interest is placed to identifying, first, whether the likelihood of introducing new innovations by accommodation providers increases as the proportion of employees involved in STI activities (as a percentage of total workers) increases. Second, whether the number of innovations reported by accommodation firms increases if the number of employees involved in STI activities rises, *ceteris paribus*.

Results in Table 1, Panel A, show that the likelihood of introducing innovations in accommodation companies is greater in medium-size companies and large-size companies compared to small-size companies. This result is consistent with the findings by Orfila-Sintes et al. (2005) and Wikhamn et al. (2018) for the hotel sector in The Balearic Islands and Sweden, respectively. Between medium-size and large-size accommodation companies in Colombia, the latter tends to introduce more innovations.

Table 1 Determinants of innovation in accommodation establishments

	Coef.	Robust Std. Err.	z	P>|z|	95% Conf.	Interval
Panel A. Likelihood of innovation (s_i)						
$ocuparate_i$	12.50	6.17	2.03	0.04	0.402	24.60
$median_i$	0.735	0.33	2.19	0.02	0.078	1.392
$large_i$	1.197	0.38	3.12	0.00	0.445	1.949
$const_i$	-2.26	0.29	-7.59	0.00	-2.851	-1.680
Panel B. Number of innovations (w_i)						
$ln\ ocupasti_i$	0.033	0.013	2.52	0.01	0.007	0.058
$\partial y_i/\partial\ ln\ ocupasti_i$	0.0006	0.00032	1.97	0.04	0.0003	0.0012
$median_i$	0.076	0.121	0.63	0.53	-0.162	0.315
$large_i$	0.031	0.191	0.16	0.87	-0.342	0.4061
$export_i$	0.186	0.089	2.09	0.03	0.012	0.361
$propintel_i$	-0.4490	0.1071	-4.19	0.00	-0.659	-0.239
$coop_i$	0.248	0.104	2.38	0.01	0.043	0.453
$const_i$	-0.28	0.09	-2.83	0.00	-0.474	-0.086
ln sigma	-1513	0.106	-14.18	0.00	-1.722	-1.304
Covariance	0.220	0.023			0.178	0.271
Observations	317					
Pseudo R-square	0.3212					
Prob (Wald χ^2)	0.000					

Table 2 below extends the analyses of innovation by company size, providing statistics on the distribution of firms that innovate. Column (i) shows that most accommodation establishments in Colombia are medium-size (50.2 percent) and small-size (37.2 percent). Out of 47 enterprises that introduced innovations in the study period (see column (ii)), 59.6 percent were medium-size firms and 21.3 percent were large-size companies. However, column (iii) shows that as the accommodation provider becomes larger, the proportion of accommodation establishments of the same size involved in STI activities increases. Thus, while only 7.63 percent of small size firms introduced innovation in the period 2016-2017, 17.6 percent and 25 percent of medium-size and large-size firms did the same in the same period, respectively. Based on Wikhamn et al. (2018), this is likely to occur due to significant financial and human capital endowments that large-size hotels own as compared to small-size hotels.

Table 2 Distribution of firms that do STI activities by firm size

Size of Firm	Total firms (i)		Firms doing STI activities (ii)		Enterprises in STI (% of total firms) (iii)
	Number	%	Number	%	%
Small	118	37.2	9	19.1	7.63
Medium	159	50.2	28	59.6	17.6
Large	40	12.6	10	21.3	25.0
Total	**317**		**47**		**14.8**

Key findings in Table 1, Panel A, show that a representative accommodation establishment is more likely to introduce innovations if the proportion of workers involved in STI activities (as a percentage of total employees) ($ocuparate$) increases. The estimated coefficient is statistically significant at the 5 percent level and confirms the importance of increasing the proportion of employees that work in innovations oriented toward new commercialization techniques; new production, new distribution, and logistics methods; and/or new organizational methods.

Table 3 extends this finding to identify workers' professional profiles that are involved in STI activities in the accommodation industry. Column (i) shows that accommodation enterprises primarily employ workers with a secondary education degree (40.7 percent), followed by workers with a technology-technical degree (31.6 percent), and a university degree (13.5 percent). According to results in column (ii), most workers involved in STI activities have a university degree (55.12 percent), followed by a technology-technical degree (23.62 percent). Only 6.5 percent of total workers that do STI activities hold doctorate or master's degrees. However, the concentration of workers with these professional degrees in STI activities is higher than the concentration of workers with other professional degrees (see column (iii)). The figures show that fifty percent of employees with a doctoral degree are involved in STI activities, followed by 4.6 percent of workers with a master's degree. Based on Martínez-Ros and Orfila-Sintes (2012), the accommodation industry could find an appropriate path to success in the innovation process if there is an optimal combination between the number of people linked to innovation and the level of human capital formation that these workers hold.

One fact that surprises the most from the results in column (iii), Table 3, is that only 0.31 percent of workers in the accommodation industry are involved in STI activities. This percentage is very low when compared to the percentage of science-oriented employees that work in other service industries (which have comparatively high levels of innovation), including education (7.0 percent), banking (3.3 percent), telecommunication and informatics (2.8 percent each). Interestingly, the EDITS survey shows that 43 percent and 48 percent of accommodation companies that innovate believe that the lack of qualified workers is a minor or moderate obstacle to introduce innovations, respectively. Only 9 percent of these companies believe that the lack of qualified workers is a high obstacle to innovate. This perception on the extent to which the lack of qualified workers obstruct innovation suggests two possible explanations: first, there is not scarcity of qualified workers to be worried about; and second, innovation activities can be perfectly done by workers that hold a

technical/technology degree or a university degree -these are the professional degrees that accommodation companies hire the most to do STI (see Table 3, column (ii)).

Table 3 Distribution of workers in STI activities by professional degree

Degree	Total workers (i)		Workers in STI activities (ii)		Workers in STI (% total workers) (iii)	Years of education (iv)
	Number	%	Number	%	%	
Doctorate	4	0.01	2	1.57	50.00	21
Master	108	0.27	5	4.94	4.62	17
Specialization	663	1.63	11	8.66	1.65	16
University	5,496	13.52	70	55.12	1.27	15
Technology-technical	12,845	31.60	30	23.62	0.23	13
Secondary	16,552	40.72	9	7.09	0.05	11
Primary	3,202	7.88	0	0.00	0.00	5
SENA	1,275	3.14	0	0.00	0.00	2
No studies	504	1.24	0	0.00	0.00	0
Total	**40,649**	**100**	**127**	100	**0.31**[a]	

[a] This is 127 over 40,649 (the total proportion of employees involved in STI activities)

Based on results from column (iii) and (iv) in Table 3, it is plausible to believe that the higher the level of a worker's professional degree is (which implicitly involves more years of education), the greater the involvement of that worker in STI activities. This is not a surprise due to the scope of high-qualification studies such as PhDs and masters, which lies on generating, transferring and applying knowledge to solve problems through research (Ministerio de Educación, 2001). In the accommodation industry, solutions to identified problems by these professionals can ultimately be materialized in the companies' level of innovation. Returns to education at a postgraduate level in Colombia is fifteen and nineteen percent points higher than returns to education at the secondary and primary levels, respectively (Estrada Jabela et al., 2016). Therefore, highly qualified professional workers tend not to be employed due to high labor costs for accommodation companies.

Results in Table 1, Panel B, analyze some factors that determine the number of innovations introduced by accommodation providers (those who decide to participate in innovation activities). Findings show -at the 1 percent significance level- that a rise in the number of employees involved in STI activities ($ln\ ocupasti_i$) tends to increase the number of innovations introduced by accommodation enterprises. Data from the EDITS survey show that most of the companies with workers involved in STI activities introduced between one and two innovations (56 percent). Results from marginal effect analysis ($\partial y_i / \partial\ ln\ ocupasti_i$) show that a one-percent increase in the number of employees involved in STI activities leads to an increase in the number of innovations by 0.06 percent at the mean levels of the population. Although the marginal effect is low, it highlights the importance of increasing the number of workers involved in STI activities to introduce more innovations. Similar results were found by Brunow et al. (2018) for the German case, in that the presence of more innovation-oriented workers was noted to increase the accommodation companies' intensity of innovation.

The estimated coefficients of $median_i$ and $large_i$ in Panel B of Table 1, although positive, are not statistically significant at conventional levels. Therefore, there is no evidence to suggest that the number of innovations introduced by accommodation establishments depends on the firm size. Table 4 analyses the distribution of innovations by firm size and shows that most of the companies that innovate -regardless their plant size- introduced between one and two innovations (see columns (i) to (iv)). Only large-size and medium-size firms introduced four innovations or more.

Table 4 Number of innovations distributed by firm size

Number of Innovations	**Large size firms (i)**		**Medium size firms (ii)**		**Small size firms (iii)**		**Total firms (iv)**	
	Number	%	Number	%	Number	%	Number	%
0	30	75	131	82	109	92	270	85
1	4	10	16	10	6	5	26	8
2	4	10	7	4	1	1	12	4
3	0	0	3	2	2	2	5	2
4	1	2.5	1	1	0	0	2	1
6	0	0	1	1	0	0	1	0.3
8	1	2.5	0	0	0	0	1	0.3
Total firms	**40**		**159**		**118**			

Other results in Table 1, Panel B, show that export-oriented firms ($export_i$) (accommodation companies that are oriented toward the international tourism market) tend to innovate 18.6 percent more than the control group (non-export-oriented firms). This result is significant at the 5 percent statistical level, and contrasts the result by Brunow et al. (2018), who found no evidence for the German case. Aissaoui (2014) found in France that export orientation in manufacturing industries only influences the decision to innovate but does not determine the intensity of innovation.

Table 1, Panel B, also shows that accommodation companies that possess structural capital in the form of intellectual property ($propintel_i$) are less likely to innovate as compared to providers that do not own intellectual property. It is highly likely that those accommodation establishments that do not have intellectual property tend to catch up with those accommodation providers that already own registered intellectual property. This situation tends to occur due to competition between companies. In Spain, for instance, hotels that were no innovators decided to hire qualified employees to compete and gain market share through the introduction of new services (Orfila-Sintes et al., 2005).

Lastly, the results in Table 1, Panel B, show that the accommodation providers that cooperate with other companies ($coop_i$) tend to innovate 24.8 percent more than providers that do not cooperate with other companies. This result demonstrates the significant role that relational capital can play in the accommodation industry to increase the number of innovations. As found by Lopes-Costa and Munoz-Canavate (2015) for the

Portuguese hotel industry, relational capital (via cooperation with the hotel industry's stakeholders) have a positive impact on innovation and organizational performance. Conversely, Nieves and Diaz-Meneses (2018) found no evidence in Gran Canaria Island's hotels of a greater probability of innovations derived from sources of local and non-local knowledge.

5. Conclusion

This study analyses the factors that influence STI activities in the accommodation industry. A double hurdle regression model is employed to test hypotheses regarding the role of science-oriented workers on the likelihood to innovate and the number of innovations to introduce. The findings of this research highlight several challenges to the accommodation industry to increase innovation activities and productivity levels as a result.

Findings show that the likelihood to innovate by accommodation companies tend to increase as the percentage of workers involved in STI activities rises, and that the number of innovations introduced by these firms grows as the number of science-oriented workers increases. Based on these results, accommodation firms in Colombia are encouraged to raise the proportion and number of workers involved in STI activities, as this strategy can increase the likelihood of introducing innovation in any type of administrative process or service, and the number of innovations to produce.

Complementary results show that more years of education and degrees achieved by workers are associated with a greater concentration in STI activities by these workers. The key focus for the accommodation industry and the government is an active plan to increase the percentage of workers involved in STI activities, as the current percentage is less than one percent; a fact that represents an obstacle for the development of this industry and the tourism sector. This plan can involve tax incentives and subsidies for accommodation firms that promote science and innovation activities amongst workers.

The low probability of hiring human capital with PhDs and/or master's degrees is likely to be a reason of low levels of innovation in the accommodation industry. An optimal trade-off between employing more PhDs and research-oriented Magisters against other professional profiles (a decision that implicitly involves increasing labor costs) should be gradually pursued in this industry. The introduction of "new services for the company" and "new services significantly improved for the international market" could be the innovation types in which PhDs and magisters could contribute most effectively in their companies. The latter innovation type is fundamental in Colombia due to strong commitments by the government to increase the number of inbound visitor arrivals and international tourists´ preferences for Colombia in the long run. Colombia's Ministries of Education and Science, Technology and Innovation could encourage education providers to produce innovation for the accommodation industry from Master and PhD levels.

A challenge for the government and other hotel industry stakeholders is to engage small size accommodation firms in innovation, as the current percentage of firms that introduce innovations in this group is low. To encourage firms that already participate in innovation processes to increase their innovation intensity (the

number of innovations introduced) is necessary to drive a strategy based on incentives from the public and private sectors. Strategies to propel innovation outcomes applied for the banking and education sectors (the service sectors that innovate the most in Colombia) could serve as a guide for this purpose. Also, policy initiatives that promote innovation in the accommodation industries of other countries could provide valuable insights for the Colombian case.

Finally, strategies to increase relational capital through cooperation with diverse public and private entities is essential to maximize innovation activities in the accommodation industry using existing human capital. Universities and research centers are of fundamental support to increase innovation via cooperation, especially for small and medium size firms. Hotel associations can also support innovation activities through research funding and/or the realization of research that address common innovation problems in the industry. Cooperation with private and public entities that directly or indirectly transfer knowledge to accommodation providers could be a fundamental strategy to innovate at different levels and create long term economic grow.

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