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The influence of the regional context on firms' innovation patterns: evidence from Ecuador*

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ABSTRACT

Using data from the Ecuadorean Innovation Survey of 2015, this paper identifies the innovation patterns that can be found in Ecuador. In addition, we analyse the influence of the regional innovation systems in determining these patterns. The results show that there are six differentiated patterns of innovation, although they all are related to the adoption and imitation of technologies. Finally, we observe that different regional characteristics condition the way in which firms organise innovation.

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1. Introduction

Firms' innovation is characterised by the diversity of strategies (Freeman and Soete 1997). In the first place the way in which firms innovate differs according to their sector, since the characteristics of innovation and the sources of knowledge differ between sectors (Malerba 2005). Nevertheless, even within the same sector each firm carries out its own learning processes with the aim of innovating.

Given the diversity in the way in which firms innovate, an empirical literature has identified the patterns of innovation that can be observed in an economy. However, most of the studies have categorised innovation patterns in firms in developed countries (Vence and Trigo 2009; Ryu and Lee 2016), whereas the evidence for developing countries is limited (Milesi 2006; Forero, Laureiro, and Marín 2011; Yurtseven and Tandoğan 2012). In developing countries, the majority of firms do not have sufficient capabilities to perform R&D and most technological change occurs through the acquisition of technology (Chaminade et al. 2009). However, although the innovation patterns are mainly characterised by these aspects, there are also considerable differences between them. In this sense, it is particularly relevant to analyse the differences in the innovation patterns, since their identification can contribute to the implementation of policies that can facilitate the construction of technological capabilities.

This paper has as its primary objective the identification of patterns of innovation that are predominant among firms in an economy like that of Ecuador. Ecuador is a medium-to-low income country characterised by an innovation system that is still at an emerging stage. In addition, given that the processes of knowledge production cannot be understood if the role of spatial proximity is not taken into account (Malerba 2005), this paper also aims to make a contribution to innovation system literature by analysing which regional characteristics determine the way in which firms organise the innovation process. In this regard, an understanding of the regional characteristics that

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influence business patterns of innovation can contribute to the implementation of actions which allow the transition to more advanced regional innovation systems (RIS) that provide greater technological performance.

The remainder of the paper is organised as follows: Section 2 reviews the literature. Section 3 describes the data and the methodology. Section 4 discusses the results. Finally we conclude in Section 5.

2. Literature review

According to Nelson (1991) innovation patterns vary because firms differ in their strategies, structures and routines. However, although the patterns of innovation are heterogeneous, they are highly demarcated by the sector and the institutional context of the firms (Freeman and Soete 1997). First, due to the fact that each sector is characterised by different technological opportunities, the manner in which the firms organise their innovation process differs between sectors. Secondly, given that technological opportunities are generated by research institutions and by relations between users and suppliers of technology (Lundvall 1992), the geographical proximity between these agents generates the outsourcing of knowledge and facilitates possibilities for collaboration that may lead to firms implementing innovation processes that are different.

It is precisely because of the influence of the institutional context that the firms' innovation patterns differ according to their country's level of development. In this regard, the empirical studies on patterns of innovation indicate that it is possible to find different patterns in every country and that in developing countries there is a greater incidence of patterns that are less intensive in R&D (Forero, Laureiro, and Marín 2011; Yurtseven and Tandoğan 2012).

Given that innovation occurs through the interaction between a network of organisations and given that these interactions tend to occur through geographical proximity, the geographical location of firms determines the way in which they organise their innovation process. In accordance with the perspective of innovation systems, the innovative activities are largely limited by the characteristics of their RIS. A RIS consists of three subsystems whose interactions facilitate the generation and transmission of technological change in a geographical context (Niembro 2007): a subsystem that generates knowledge; a subsystem that exploits knowledge and a political-institutional subsystem that embraces all of the actions of the State that promote the generation of knowledge. Consequently, and given that the regions differ in the characteristics of the different subsystems, as well as the intensity of their interactions, it is reasonable to consider that these differences influence the way in which the firms organise innovation.

Several studies have analysed the effect of the characteristics of the RIS on firms' innovation activities. For example, Cruz-Castro et al. (2018) concluded that certain regional characteristics, such as the size of the economy or how the regions aim at exploiting knowledge, had a negative influence on the likelihood that the firms would abandon their R&D projects. This study also suggests that the political-institutional subsystem could also affect the way in which firms innovate, given that in those regions where the public budget for R&D increased the most, firms were less likely to abandon their R&D activities. For their part Tavassoli and Karlsson (2015) indicate that firms belonging to economically strong regions and with a greater presence in knowledge-intensive business services are the ones that are more likely to persevere with innovation. Finally, López-Bazo and Motellón (2016) found that the regional context moderates the effect of the determinants of innovation.

Despite the fact that there is a consensus with regard to the influence of regional characteristics on innovation, their influence on patterns of innovation has not been analysed. However, it is reasonable to consider that those firms whose innovation pattern is more intensive in scientific knowledge require a regional context that is characterised by a knowledge-generating subsystem that is sufficiently developed and connected to the business sector. Similarly those innovation patterns founded on the solution to specific problems through the interaction between suppliers and users of the technology will tend to predominate in regions with a business sector with sufficient

technological capabilities. Therefore it seems appropriate to consider that, in accordance with the characteristics of the RIS, firms may be more likely to establish one kind of innovation pattern rather than another.

3. Data and methodology

The present paper uses data from the Ecuadorean Innovation Survey of 2015[1] (ENAI) which covers the period 2012–2014 and was carried out by the National Institute for Statistics and Censuses. The ENAI is a compulsory survey carried out following the guidelines of the OECD's Oslo Manual. The ENAI is a representative sample of the Ecuadorean economy containing data on the innovation activities of 6,275 firms operating in the manufacturing, services, trade, building, extracting activities and supplies sectors. However, given our research objective, our analysis only considers innovating firms[2], which total 2,622. In accordance with the literature, this paper considers that the factors that explain differences in the way in which the innovation process is organised are those relating to the following categories: the type of innovation activities, the internal and external sources of information, cooperation with different types of partners in different activities, the introduction of organisational and marketing innovations, the appropriation mechanisms, the determinants of innovation, the objectives and the obstacles. Table 1 shows each of the variables used to determine the innovation patterns.

In order to analyse the influence of the RIS on patterns of innovation, we generate several regional indicators which attempt to characterise the different subsystems that make up a RIS. It should be

Table 1. Variables used in the identification of innovation patterns.

Category	Variables	Scale
Innovation activities	Internal_R&D(0.33; 0.47); External_R&D(0.14; 0.35); Machinery(0.85; 0.35); Consulting (0.26; 0.44); Engineering(0.07; 0.26); Training(0.42; 0.49); Market_studies(0.10; 0.30)	Binary
Internal sources	Departments of: R&D(0.64; 1.13); Marketing(1.00; 1.19); Production(1.37; 1.31); Distribution(0.98; 1.17); ICT(1.23; 1.23).	0–3[b]
External sources	Customers(2.13; 1.13); Competitors(1.40; 1.22); Suppliers(1.65; 1.18); Consultants(0.83; 1.09); Universities(0.30; 0.70); Laboratories(0.32; 0.77); R&D_organisations(0.27; 0.70); Internet(1.72; 1.26); Fairs(0.98; 1.14); Databases(0.47; 0.88); Patents(0.36; 0.79); Journals(0.82; 1.06); Other related companies(0.61; 1.00)	0–3[b]
Cooperation by type of partner and activity	Cooperation with: Suppliers and customers in R&D(0.05; 0.21); Consultants in R&D (0.03; 0.17); Institutions in R&D(0.04; 0.19); Suppliers and clients in TIT(0.68; 0.46); Competitors in TIT(0.20; 0.40); Consultants in TIT(0.25; 0.43); Institutions in TIT(0.12; 0.32); Suppliers and customers in EP(0.39; 0.48); Competitors in EP(0.02; 0.16); Consultants EP(0.06; 0.24); Institutions in EP(0.06; 0.25)	Binary[a]
Non-technological innovation	Organisational procedures(0.17; 0.38); Decision making(0.63; 0.93); External relationship(0.17; 0.69); Design(0.12; 0.32); Promotion(0.46; 0.84); Distribution(0.33; 0.95); Establishment of prices(0.31; 1.08)	Binary
Appropriation mechanisms	Patent(0.14; 0.35); Brand(0.31; 0.46); Utility model(0.02; 0.14); Industrial design(0.04; 0.21); Copyright(0.04; 0.20); Appellation of origin(0.02; 0.16); Confidentiality clauses employees(0.29; 0.45); Confidentiality clauses suppliers and customers(0.19; 0.39)	Binary
Determinants	Unsatisfied demand(0.47; 0.49); Scientific idea(0.33; 0.47); Threat competition(0.39; 0.48); Regulations(0.20; 0.40); Intellectual property standards(0.03; 0.17); Certification(0.16; 0.37); Technical problem(0.13; 0.34); internal idea(0.36; 0.48)	Binary
Objectives	Variety products(1.92; 1.15); Replace technology(1.92; 1.15); New markets(1.64; 1.20); Higher fee(1.82; 1.13); Improve product quality(2.41; 0.94); Productive flexibility (1.69; 1.19); Increase production(1.78; 1.22); Cost reduction(1.38; 1.28); Energy cost reduction(1.24; 1.24); Pollution reduction(1.54; 1.26); Occupational health(1.84; 1.24)	0–3[b]
Obstacles	Lack of internal funds(1.25; 1.19); Lack of external funds(0.92; 1.16); High costs(1.44; 1.25); Market dominated(1.15; 1.18); Uncertainty about the demand(1.18; 1.16); Lack of qualified personnel(1.01; 1.06); Lack of qualified personnel in the country(0.79; 1.01); Lack of information(0.99; 1.06); Lack of market information(0.92; 1.05); Difficulty finding partners(0.73; 1.08)	0–3[b]

Mean and standard deviation in parentheses.

[a]TIT refers to cooperation in training, information and/or technical assistance; EP refers to cooperation in engineering and design and/or product testing.

[b]Ordinal variable: 0: not use/not important; 1: low importance; 2: medium importance; 3: high importance.

Table 2. Regional variables.

Gva	Gross value added (in billions of dollars)
Business fertility	Opening of new firms for every 1000 members of the economically active population
R&D_ratio	R&D expenditure made by firms divided by the total R&D expenditure of the region
Support	Percentage of firms that have participated in a public programme to support innovation
Public investment	Regional public investment divided by the regional Gva
Cooperation	Percentage of firms that cooperate in innovation activities with external partners

borne in mind that when we refer to regions we mean the 24 provinces in Ecuador. Table 2 shows the definition of these variables which are measured in the same time period as the indicators used to determine the innovation patterns.

Given that innovation patterns are not only the result of influences from regional but also sectoral and firm characteristics, both sectoral and firm control variables will also be included. The sectoral controls are based on a technological intensity classification from which we generate 7 dichotomous variables taking on 1 if the firm belongs to one of the following sectors: low-tech industries (*Low_ind*), high-tech industries (*High_ind*), knowledge non-intensive business services (*Knibs*), knowledge intensive business services (*Kibs*), supply industries (*Supply*), extractive industries (*Extractive*) and the construction sector (*Construction*).[3] For its part Table 3 describes the firm-level variables.

Owing to the large number of indicators, which we will use to categorise the innovation patterns, we resort to a factorial analysis with the aim of explaining the correlations between the observed indicators in terms of a lower number of variables called factors (Thompson 2004). Using this method the observed variables are modelled as linear combinations of the factors plus an error term. Thus, the factorial analysis consists in the study of the correlation matrix so that most of the correlation between the variables is explained by the common factors and any portion of unexplained variance is assigned to an error term. For the method to be successful and the reduction of dimension to be significant, the variables must have certain levels of correlation. This can be verified through Kaiser–Meyer–Olkin measure (KMO). A KMO below 0.5 indicates that factor analysis is not acceptable.

We carry out a two-stage factor analysis on the variables described in Table 1. In the first stage, we draw out the factors for each of the nine categories in Table 1. The factors obtained are used subsequently in a second analysis that will enable us to draw out the list of definitive factors, on the basis of which the innovation patterns will be determined. Once the factors have been obtained their rotation is important so that they can be interpreted. Consequently the first-stage factorial analysis considers an *Oblimin* rotation, which is a variant of the oblique rotation methods. This process has the objective of simplifying the factorial matrix, which represents the relationship between the factors and the variables. This technique consists precisely in rotating the factors until they are as close as possible to the variables they represent. Subsequently, in the second-stage factorial analysis, the *Varimax* rotation is used, which enables a subset of variables to be more easily connected to a specific factor. This process also simplifies the interpretation of the factors, but in addition ensures that they are not correlated with each other, which is an important requirement for later analysis.

The next methodological step uses the definitive factors, as inputs in a k-means cluster analysis. This is done with the intention of putting firms into groups that are as homogeneous as possible with regard to the dimensions of the factors. With the aim of avoiding the classification of firms in an iterative way, we choose not to use the initial centroids obtained through the k-means

Table 3. Firm-level variables.

Size	Logarithm of the number of employees
Public	Dichotomous variable taking on 1 if the firm is a state-owned firm
Age	Age of the firm in years
Foreign	Dichotomous variable taking on 1 if more than 50% of the firm is in the hands of foreign capital
Group	Dichotomous variable taking on 1 if the firm belongs to a group
Exporter	Dichotomous variable taking on 1 for exporters

method, but rather those obtained through a prior hierarchical cluster analysis which minimises the Euclidean distance between each observation with regard to the mean of the cluster to which it has been assigned, thereby making it possible to achieve even more homogeneous groups.

Finally, once the innovation pattern to which each firm belongs has been determined, the second objective is to establish how the regional characteristics make the firms more or less prone to establish one type of pattern. In order to do this, we generated a dichotomous variable for each of the clusters identified, which takes the value of 1 if the firm belongs to a cluster with a particular innovation pattern and 0 if it offers any other. Therefore belonging to an innovation pattern can be captured by a binary choice model:

$$y_i = \begin{cases} 1 & \text{if } y_{it}^* \geq 0 \\ 0 & \text{else} \end{cases}$$

$$y_i^* = \beta_1 c_i + \beta_2 s_i + \beta_3 r_i + u_i$$

where the latent variable y_{it}^* represents the underlying propensity to belong to a particular innovation pattern of the i-th firm in the period 2012–2014, which is a function of the characteristics of the firms c_i, of the sector s_i, of the regional characteristics r_i and of an error term u_i. Given that our dependent variables are dichotomous, we shall use probit models for this stage.

4. Results

The first stage of the factorial analysis draws out the factors for each category from Table 1 which allow us to condense the statistical information in 25 factors.[4] On the basis of the 25 factors, we then carry out a second factorial analysis, the results of which are shown in Table 4 and enable the information to be condensed into 9 factors.

The first factor concerns an innovation pattern that is externally directed at research institutions and consultants as well as investment in external R&D. The second factor represents a pattern driven

Table 4. Second stage factorial analysis.

Definitive factors	Description of first stage factors	Correlation
Factor1	Investment in external R&D, consultancies and training	0.635
	Importance of information sources from research institutions and consultants	0.713
	Cooperation with research institutions in all innovation activities	0.643
	Cooperation with consultants in all innovation activities	0.715
Factor2	Importance of market information sources	0.616
	Innovation driven by unsatisfied demand and threat from competition	0.692
	Market objectives: variety of products, greater share, new markets	0.66
Factor3	Importance of sources of information from the production, distribution and R&D departments	0.786
	Optimisation of resources and social responsibility objectives	0.666
Factor4	Knowledge obstacles	0.832
	Financial obstacles	0.858
Factor5	Appropriation based on patents, trademarks, utility model, industrial design and appellation of origin	0.69
	Appropriation based on copyright and confidentiality clauses	0.728
Factor6	Vertical cooperation in R&D, engineering and design and product testing	0.724
	Vertical and horizontal cooperation in training, information and technical assistance	0.676
Factor7	Investment in technological acquisition	0.529
	Objectives related to the replacement of products and processes	0.688
Factor8	Marketing innovation	0.576
	Organisational innovation	0.737
Factor9	Taking advantage of scientific ideas as a determinant of innovation	0.744
	Legal determinants	−0.679
Number of observations		2622
Variation explained		59.35%
		0.804

Note: Only factors with correlations greater than 0.5 are displayed.

Table 5. Cluster analysis.

	Adopters of technology	Constrained imitators not based on science	Imitators influenced by the market	Internal product imitators	Internally and externally oriented imitators	Successful imitators
Factor1	−0.228	−0.437	0.188	−0.398	1.775	−0.195
Factor2	−1.119	−0.009	0.911	0.454	−0.191	0.182
Factor3	−0.543	0.081	−0.973	0.755	0.754	0.223
Factor4	−0.599	1.114	−0.262	−0.682	0.201	0.107
Factor5	−0.052	−0.35	0.309	−0.109	−0.07	0.686
Factor6	−0.052	−0.164	0.315	−0.387	0.377	0.235
Factor7	−0.079	0.259	0.213	−0.323	0.002	−0.19
Factor8	−0.124	−0.197	−0.237	−0.369	−0.146	1.94
Factor9	−0.06	−0.036	0.07	0.088	0.037	−0.117
Number and percentage of firms	532 20%	603 23%	430 16%	485 19%	309 12%	263 10%

by the market. The third factor represents an internally focused pattern. The fourth factor describes a constrained pattern since it groups together knowledge and financial barriers. The fifth factor reflects a pattern that gives importance to appropriation mechanisms. The sixth factor categorises a pattern focused on cooperation with business agents. The seventh factor reflects a pattern based on adopting the technology. The eighth factor shows a pattern that stresses non-technological innovation. Finally, the ninth factor represents a pattern determined by the exploitation of scientific ideas and not driven by legal factors.

Next the definitive factors are introduced into a cluster analysis with the aim of forming groups of firms that are as homogeneous as possible. These results are shown below in Table 5:

As can be seen the clusters are significantly dissimilar in terms of their innovation pattern, since each of them presents a configuration that is different with respect to their defining factors. Nevertheless, with the aim of presenting a more precise characterisation of the clusters, Table 6 presents several descriptive statistics in relation to the innovation effort and performance.

Before we begin with a description of each cluster, it is appropriate to point out that in all of them the percentage of sales derived from products new to the firm is always greater than that of products new to the market. Additionally in each case the effort put into other innovation activities is always greater than the effort dedicated to R&D. So that although there are differences between all of the clusters, they all seem to follow patterns based on the adoption and imitation of technologies. On

Table 6. Descriptive statistics of the clusters.

	Adopters of technology	Constrained imitators not based on science	Imitators influenced by the market	Internal product imitators	Internally and externally oriented imitators	Successful imitators
R&D/sales	0.11%	0.17%	0.19%	0.29%	0.51%	0.49%
Other innovation expenses/sales	2.67%	4.61%	3.48%	2.50%	4.56%	3.71%
Sales from products new to the market	3.42%	4.67%	7.54%	7.62%	9.45%	10.90%
Sales from products new to the firm	7.73%	17.28%	15.69%	15.97%	16.48%	17.88%
Percentage of firms introducing product innovations	35.15%	56.38%	66.28%	70.72%	67.64%	74.14%
Percentage of firms introducing process innovations	70.68%	76.29%	68.14%	61.86%	83.17%	81.75%

the other hand in all clusters except cluster 4 the percentage of firms that have introduced process innovations is always greater than the figure for products.

Adopters of technology: these firms score below the average in all factors which indicates that they have no bias towards any of the innovation patterns. This suggests that these firms take a passive role in the face of innovation. Moreover, these firms notably score below the average in factors 2, 3 and 4. The score below the average in factor 2 suggests that this pattern does not use information from the market, it is not driven by the existence of an unsatisfied demand and does not pursue objectives concerned with improving the competitive position. In addition, the score below the average in factor 3 indicates that their innovation process does not consider internal sources of information as relevant. Finally, the score below the average in factor 4 suggests that these firms do not face cost or knowledge barriers, possibly because their innovation activities are not sufficiently ambitious to come up against these impediments. All this, together with their weak indicators of innovation effort and performance, suggests that these firms take a passive role in the face of technological change and that their innovation strategy is based on the adoption of process technologies. Finally, the firms belonging to this cluster represent 20% of the innovating firms, making them the second largest group.

Constrained imitators not based on science: this pattern which is the most common in Ecuador has above average scores in factor 4 and below average in factor 1. The score above the average in factor 4 reveals that this innovation process is hampered by knowledge and cost obstacles. While the score below the average in factor 1 indicates that it does not use information from research institutions or establishes cooperative relationships with them. The latter is not surprising given that firms hampered by knowledge obstacles have a lack of qualified personnel and of technological information to internalise the knowledge developed by research institutions. Therefore these firms do not show an innovation pattern that is merely characterised by adopting technology, but nevertheless have great difficulties when implementing their innovation activities. This means that these firms are the second in rank when it comes to putting the least effort into R&D, although they put the greatest effort into other innovation activities.

Imitators influenced by the market: these firms show above average score in factor 2 and below it in factor 3. The score above the average in factor 2 indicates that this pattern is based on information arising from the market and which aim to improve the competitive position of the firms. Such is the importance that these firms give to market information that they do not consider internal sources to be relevant, as the score below the average in factor 3 reveals. In addition this pattern shows a strong orientation towards product innovation compared to previous clusters. However, these firms have low R&D intensity, although they are slightly superior to previous clusters. All this suggest that through their innovation process these firms try to imitate existing products via information that comes from the market.

Internal product imitators: this pattern is based on the use of internal information sources. At the same time it aims at resource optimisation and social responsibility. Another feature of this pattern is that it is not characterised by major obstacles, probably because it does not exploits external knowledge. Another distinctive feature of this cluster is that it is the only one in which there are more firms introducing product innovations rather than process. Finally these firms represent 19% of the innovating firms and show an R&D effort that is slightly superior to that of previous groups.

Internally and externally oriented imitators: This cluster which represents 12% of the innovating firms is based on subcontracting R&D activities, consultancies and technical assistance. In addition these firms attribute great importance to information sources from scientific institutions and establish cooperative relationships with these agents. However, this does not mean that these firms do not attribute importance to information from their production, distribution and R&D departments and they also aim at optimisation of resources and social responsibility. The combination of internal information sources with those from scientific institutions, as well as their capacity to subcontract R&D activities suggest that these firms have a greater absorptive capacity than the previous ones. Proof of this is shown by the fact that they have a higher R&D intensity. Finally, this pattern prioritises

process innovation and that moreover these firms have relatively high percentages of new product sales compared to previous groups.

Successful imitators: the last pattern, which is the least common, is based on the implementation of organisational and marketing innovations and is the only one that attributes importance to the different mechanisms of appropriation. In addition these firms have the highest percentage of sales of new products. At the same time this group has the second highest R&D intensity. The fact that the most successful innovators are those based on organisational and marketing innovation is not surprising in the context of a developing economy, given that in these countries the firms that introduce new management practices and more flexible organisational structures are usually the most innovative (Jensen et al. 2007).

Table 7 shows the marginal effects of probit models for each pattern. As it can be seen the patterns are influenced in a different way by different regional characteristics.[5] This suggests that the different characteristics of the RIS make firms more likely to implement one innovation pattern rather than another. On the other hand it is also noteworthy that the variable R&D_ratio is not significant in any of the innovation patterns. This could indicate that in developing countries the regional aspects most associated with the exploitation and generation of knowledge have no influence on the way in which firms organise their innovation process. Below we discuss the results for each of the innovation patterns separately.

Adopters of technology: the only regional characteristic that influences the establishment of this pattern is business fertility. In addition, the coefficient sign is negative, which could indicate that the patterns exclusively based on technological adoption are more likely to establish themselves in those regions with less business dynamism. With regard to the sector categories, our results show that in comparison with low-tech industries, this innovation pattern is more common in service, supply activities and in the construction sector, which is not surprising since these are less intensive sectors in R&D and those in which the survival of firms with traditional innovation strategies is more likely. This suggests that this pattern is more likely to emerge in those sectors where the market does not demand new products. Finally, our results show that this innovation pattern is less common amongst large enterprises, which is in keeping with the Schumpeter thesis, according to which the size of the firm is positively related to the implementation of more complex innovation activities.

Constrained imitators not based on science: this pattern tends to predominate in regions with a lower gross value added, greater business fertility and a higher level of cooperation. First, the inverse relationship between regional gross value added and the implementation of this pattern is not surprising as the regions with a lower gross added value are normally characterised by less advanced regional subsystems of knowledge generation. Second, the positive sign of the coefficient of business fertility indicates that those patterns characterised by high barriers to innovation are more likely to emerge in regions where more new firms are set up, since new firms also tend to experience higher innovation obstacles (Acuna-Opazo and Castillo-Vergara 2018). Finally, the positive sign of the regional cooperation coefficient is also not surprising, since in developing countries most cooperative relationships are often not associated with R&D but have the objectives of obtaining technological information and carrying out training activities (Fernández-Sastre and Vaca-Vera 2017). Thus it is likely that firms that face obstacles when innovating tend to emerge in those regions where there is a greater degree of information exchange through cooperation networks. In addition, in comparison to low-tech industries, this pattern is less common in the high-tech industries, in services, in supply activities and in construction, whereas it is more common among extractive firms. Finally, this pattern is less common among large enterprises, among those that form part of a business group and among exporters.

Imitators influenced by the market: this innovation pattern, which is based on market information, tends to predominate in those regions with a lower public sector presence, possibly owing to the importance that these firms attribute to information from business agents. This pattern is also more common in regions where there is greater public support for business innovation, which

Table 7. Regional determinants of innovation patterns: marginal effects.

	Adopters of technology	Constrained imitators not based on science	Imitators influenced by the market	Internal product imitators	Internally and externally oriented imitators	Successful imitators
Regional characteristics						
Gva	0.001 (0.001)	−0.005*** (0.001)	−0.001 (0.001)	0.002** (0.001)	0.001 (0.001)	0.001* (0.000)
Business fertility	−0.006* (0.002)	0.005* (0.002)	0.000 (0.002)	0.002 (0.002)	−0.005** (0.002)	0.004* (0.002)
R&D_ratio	0.021 (0.020)	0.006 (0.019)	−0.026 (0.017)	−0.019 (0.020)	0.019 (0.015)	0.002 (0.015)
Support	−0.551 (0.403)	−0.051 (0.411)	0.895** (0.351)	−0.116 (0.406)	−0.174 (0.318)	−0.008 (0.333)
Public investment	−0.055 (0.117)	0.036 (0.095)	−0.683** (0.230)	0.012 (0.081)	0.066 (0.071)	0.042 (0.068)
Cooperation	−0.383 (0.291)	0.573* (0.294)	0.361 (0.246)	−1.271*** (0.354)	0.565** (0.216)	−0.017 (0.253)
Firm characteristics						
Size	−0.013* (0.007)	−0.030*** (0.007)	0.007 (0.005)	0.005 (0.006)	0.011* (0.005)	0.013** (0.004)
Public	−0.027 (0.063)	0.118 (0.098)	−0.092 (0.032)	−0.061 (0.053)	0.060 (0.068)	0.015 (0.050)
Age	−0.000 (0.000)	−0.000 (0.000)	0.001** (0.000)	0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Foreign	0.031 (0.044)	−0.042 (0.044)	0.063 (0.039)	0.008 (0.038)	−0.019 (0.027)	−0.051* (0.018)
Group	0.021 (0.021)	−0.080*** (0.020)	0.009 (0.018)	0.017 (0.002)	0.002 (0.016)	0.020 (0.016)
Exporter	−0.018 (0.023)	−0.073** (0.022)	−0.031 (0.018)	0.061 (0.024)	0.053** (0.021)	−0.005 (0.015)
Sectoral characteristics						
High_ind	−0.036 (0.031)	−0.083** (0.025)	0.007 (0.037)	0.063** (0.031)	0.012 (0.024)	0.032 (0.025)
Knibs	0.127*** (0.022)	−0.135*** (0.018)	0.246*** (0.025)	−0.110*** (0.016)	−0.050*** (0.014)	0.008 (0.014)
Kibs	0.069** (0.027)	−0.132*** (0.017)	0.348*** (0.035)	−0.119*** (0.016)	0.007 (0.018)	−0.014 (0.016)
Supplies	0.242** (0.092)	−0.150** (0.038)	0.073 (0.104)	−0.119* (0.032)	0.111 (0.076)	−0.019 (0.041)
Extractive	0.132 (0.085)	0.149* (0.083)	–	−0.127** (0.028)	−0.008 (0.051)	−0.063 (0.031)
Construction	0.182*** (0.044)	−0.102*** (0.025)	0.075 (0.047)	−0.032 (0.027)	0.018 (0.027)	−0.036 (0.020)

Note: Robust standard errors in parentheses; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

suggests that the Ecuadorean innovation support programmes tend to facilitate the implementation of this innovation pattern. With regard to sector indicators, we note that none of the firms dedicated to extractive activities presents this innovation pattern. In addition this pattern is more common among service firms, which is not surprising given that there is significant evidence regarding the positive effect of the orientation towards the market in the innovation of services (Al-Dmour and Basheer 2012). Finally this innovation pattern tends to be implemented in older firms which suggests that the use of information from the market requires some productive experience.

Internal product imitators: this pattern tends to be found in the regions with higher gross value added which indicates that companies with internal innovation capacities tend to predominate in the regions with greater economic development. Furthermore, this pattern is also more likely to emerge in those regions with a lower level of technological cooperation, which is not surprising since this innovation process is based on the exploitation of internal sources of information. On the other hand, the sector indicators show that this pattern can be found principally among manufacturing firms and in particular among those with high technological intensity. This shows that industrial innovation in developing countries is viewed by most firms as an internal activity and that this is particularly the case with firms belonging to sectors of high technological intensity. Consequently this result shows the disadvantage suffered by high-tech manufacturing firms in developing countries, given that access to external sources of information is especially relevant to innovation in this kind of sector (Malerba 2005). Finally we note that there is no firm level characteristic that has a decisive influence on this pattern.

Internally and externally oriented imitators: this pattern tends to be found in the regions with the highest level of cooperation. However, the results also indicate that it is in the least fertile business regions that this type of pattern is most common. All this could indicate that the implementation of this pattern requires a competitive environment with a degree of stability in order for firms to get involved in innovation processes that integrate both internal and external sources of information, as well as a context characterised by a greater level of cooperation, given the importance that these companies give to external sources of knowledge. With regard to sector influence, this innovation pattern is only less common among Knibs. Finally, our results show that it is the large exporting firms that are more likely to implement this pattern.

Successful imitators: as expected this pattern, which is the most successful in terms of innovative performance, tends to be found in the regions of greatest value added and greatest business fertility, while the rest of the regional indicators do not appear to be significant. On the other hand, this is an innovation pattern that can be found among firms in all economic sectors, which means that an innovation process based on organisational and marketing innovation is the most successful innovation mode in all of the sectors of the Ecuadorean economy. This is consistent with Chaminade et al. (2009), who suggest that the firms in developing countries should focus on the development of management and technological capabilities through organisational changes and new marketing strategies until they have sufficient capabilities to get involved in R&D activities. Finally, we note that this innovation pattern tends to be found among larger firms and is less common among foreign firms.

5. Conclusions

This paper identifies six innovation patterns that are to be found among Ecuadorean firms. The patterns present certain similarities, given that all of them are mainly dedicated to the adoption and imitation of technologies. However, despite these similarities, the innovation patterns reveal differences in relation to the innovation inputs, the use of internal and external information sources, the establishment of cooperative relationships and the determinants, objectives and obstacles of innovation. On the other hand, our results indicate that in Ecuador those innovation patterns that are less intensive in R&D tend to predominate. By contrast, there are far fewer firms with patterns that are more intensive in R&D, that show greater innovative performance and are capable of combining internal and external information sources.

Having identified patterns of innovation, we analyse the influence of regional, sectoral and business characteristics in determining them. Our results indicate that certain regional characteristics such as gross value added, business fertility, public investment, public support and the level of cooperation determined whether firms were more or less inclined to implement one kind of pattern rather than another. On the other hand, the results indicate that the regions with the highest gross value added tend to favour the implementation of more intensive R&D innovation patterns, particularly those that base their innovative process on internal sources of information and those that show a greater innovative performance. By contrast innovation patterns that face greater obstacles to innovation and with less R&D intensity tend to have a greater presence in regions with the lowest gross value added. For their part, those regions in which there is a higher level of new companies tend to dominate the innovation patterns with greater innovative performance and those that deal with major obstacles, whereas those that consider technological change as exogenous and those that use both internal and external sources of information tend to be less numerous. With regard to the level of regional cooperation, the greater the number of firms that establish cooperative relationships, the more likely is it that the firms will implement innovation patterns that combine internal and external sources of information and deal with major obstacles, whereas it is less likely that patterns will emerge that are exclusively based on internal sources of information. In addition, regional public investment has only a negative effect on firms establishing innovation patterns influenced by the market, possibly owing to the importance that these firms attribute to information from private business agents. Finally, in those regions in which more firms participate in public innovation support programmes, firms are more inclined to base their innovation on information from the market, which is not surprising given that support programmes in Ecuador emphasise the creation of climates for the establishment of commercial relationships.

Our results have important implications for the industrial policies of developing countries, since they indicate that policies at the regional level can have a great influence on the desirable catching-up process. Another important policy implication is that in order to be successful in terms of innovative performance, firms in developing countries should focus on the development of management and technological capabilities through organisational changes and new marketing strategies until they have sufficient capabilities to get involved in R&D activities.

Notes

1. http://www.ecuadorencifras.gob.ec/encuesta-nacional-de-actividades-de-ciencia-tecnologia-e-innovacion-acti/
2. The ENAI considers that a firm is innovative if it has introduced new products or processes; developed or kept innovation activities; abandoned innovation activities.
3. According to the ISIC 2-digits classification, the economic activities included in each sectoral category are: *Low_ind*(C10-C19, C23-C25, C31-C33, S95); *High_ind*(C20-C22, C26-C30); *Knibs*(B09, G45-G47, H49-H53, I55, I56, L68, M73, N77-N79, N81, N82); *Kibs*(J58-J63, K64-K66, M69-M72, M74, M75, N80, P85, Q86-Q88, R90-R93); *Supply*(D35, E36-E39); *Extractive*(B05-B08); *Building*(F41-F43).
4. These results are available upon request to the corresponding author
5. Appendix 1 displays the number of firms by type of cluster that can be found in each of the 24 Ecuadorian provinces.

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No potential conflict of interest was reported by the authors.

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References

Acuna-Opazo, C., and M. Castillo-Vergara. 2018. "Barriers to non-Technological Innovation: Impact on Business Performance in an Emerging Economy." *Contaduría y Administración* 63 (3): 1–22.

Al-Dmour, H. H., and E. Basheer. 2012. "The Effect of Market Orientation on Service Innovation: A Study on the Information and Communication Technology Sector in Jordan." *International Journal of Humanities and Social Science* 2 (19): 232–253.

Chaminade, C., BÅ Lundvall, J. Vang-Lauridsen, and K. Joseph. 2009. "Innovation Policies for Development: Towards a Systematic Experimentation-Based Approach." In *Handbook of Innovation Systems and Developing Countries*, edited by BÅ Lundvall, K. Joseph, C. Chaminade, and J. Vang-Lauridsen, 360–379. Cheltenham, UK: Edward Elgar.

Cruz-Castro, L., A. Holl, R. Rama, and L. Sanz-Menéndez. 2018. "Economic Crisis and Company R&D in Spain: do Regional and Policy Factors Matter?" *Industry and Innovation* 25 (8): 729–751.

Fernández-Sastre, J., and C. E. Vaca-Vera. 2017. "Cooperation for Innovation in Developing Countries and its Effects: Evidence from Ecuador." *Journal of Technology Management and Innovation* 12 (3): 48–57.

Forero, C., D. Laureiro, and A. Marín. 2011. "Innovation Patterns and Intellectual Property in SMEs of a Developing Country." *Innovar* 21 (42): 113–128.

Freeman, C., and L. Soete. 1997. "Innovation and the Strategy of the Firm." In *The Economics of Industrial Innovation*, edited by C. Freeman, and L. Soete, 265–285. Cambridge: MIT Press.

Jensen, M. B., B. Johnson, E. Lorenz, and BÅ Lundvall. 2007. "Forms of Knowledge and Modes of Innovation." *Research Policy* 36 (5): 680–693.

López-Bazo, E., and E. Motellón. 2018. "Innovation, Heterogeneous Firms and the Region: Evidence from Spain." *Regional Studies* 52 (5): 673–687.

Lundvall, BÅ. 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

Malerba, F. 2005. "Sectoral Systems: How and why Innovation Differs Across Sectors." In *The Oxford Handbook of Innovation*, edited by J. Fagerberg, D. Mowery, and R. R. Nelson, 380–406. New York: Oxford University Press.

Milesi, D. 2006. Patrones de innovación en la industria manufacturera argentina (Documento de Trabajo N1/2006). http://www.funcex.org.br/material/redemercosul_bibliografia/biblioteca/ESTUDOS_ARGENTINA/ARG_108.pdf.

Nelson, R. R. 1991. "Why Do Fims Differ, and How Does it Matter?" *Strategic Management Journal* 12 (S2): 61–74.

Niembro, A. 2017. "Towards a First Typology of Regional Innovation Systems in Argentina." *Investigaciones Regionales* 1 (38): 117–149.

Ryu, H. S., and J. N. Lee. 2016. "Innovation Patterns and Their Effects on Firm Performance." *The Service Industries Journal* 36 (3–4): 81–101.

Tavassoli, S., and C. Karlsson. 2015. "Persistence of Various Types of Innovation Analyzed and Explained." *Research Policy* 44 (10): 1887–1901.

Thompson, B. 2004. *Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications*. Washington, DC: American Psicologic Association.

Vence, X., and A. Trigo. 2009. "Diversity of Innovation Patterns in Services." *The Service Industries Journal* 29 (12): 1635–1657.

Yurtseven, A. E., and V. S. Tandoğan. 2012. "Patterns of Innovation and Intra-Industry Heterogeneity in Turkey." *International Review of Applied Economics* 26 (5): 657–671.

Appendix 1.

Table A1. Regional distribution of firms by type of cluster

PROVINCE	Adopters of technology	Constrained imitators not based on science	Imitators influenced by the market	Internal product imitators	Internally and externally oriented imitators	Successful imitators
AZUAY	25	59	18	76	13	25
BOLÍVAR	1	2	2	2	2	2
CARCHI	7	4	8	2	0	2
CAÑAR	2	3	4	3	4	2
CHIMBORAZO	12	22	20	6	8	4
COTOPAXI	20	40	13	8	7	5
EL ORO	13	30	9	10	5	5
ESMERALDAS	7	31	5	4	6	1
GALÁPAGOS	0	0	1	0	1	0
GUAYAS	107	49	50	108	59	47
IMBABURA	22	32	17	17	7	10
LOJA	9	15	5	12	7	2
LOS RÍOS	14	5	2	6	5	2
MANABÍ	22	14	13	12	22	7
MORONA SANTIAGO	1	3	0	1	0	0
NAPO	2	5	0	0	3	1
ORELLANA	10	14	8	0	3	0
PASTAZA	5	1	7	0	0	0
PICHINCHA	187	162	191	169	125	124
SANTA ELENA	5	4	0	5	2	1
SANTO DOMINGO	19	14	6	10	5	4
SUCUMBÍOS	13	8	6	2	2	4
TUNGURAHUA	29	84	45	31	23	15
ZAMORA CHINCHIPE	0	2	0	1	0	0
Total	**532**	**603**	**430**	**485**	**309**	**263**