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Persistence in the imitation of innovations in products in the manufacturing industry of Colombia

Persistencia en la imitación de innovaciones en productos en la industria manufacturera de Colombia

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Abstract

Persistence in innovation has been explained by three theoretical approaches: i) sunk costs in research and development (R&D), ii) financial constraints, and iii) innovation capabilities. This research aims to evaluate the effect of determinants proposed by these three approaches on the occurrence of persistence in the imitation of innovations in products in manufacturing industries. To achieving this goal are used research data from three surveys of innovation and technological development of Colombia (EDIT) and one zero inflate ordered probit models is estimated (ZIOP). The results obtained show that sunk costs do not explain the persistence imitation. On the other hand, the continuous access to internal and external financial resources are essentials for this persistence. Finally, the capabilities approach, which is associated with learning forms indicates that interacting lerning and training explain the ocurrence of persistence in the imitation of innovations in products.

JEL code: O31, O32.
Keywords: Persistence; imitation; sunk costs; capabilities; financial constraints.

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Resumen

La persistencia en la innovación, entendida como el fenómeno que se observa cuando una firma que ha innovado en un período muestra actividad o resultados de innovación en períodos subsecuentes, ha sido explicada por tres enfoques teóricos: i) costos hundidos en investigación y desarrollo (I&D); ii) restricciones financieras, y iii) capacidades de innovación. Esta investigación tiene como objetivo evaluar el efecto que tienen los determinantes propuestos por estos tres enfoques sobre la persistencia en la imitación de innovaciones en productos en la industria manufacturera. Se usan datos de tres encuestas de innovación y desarrollo tecnológico de Colombia (EDIT) y modelos ordenados inflados en cero (ZIOP). Los resultados obtenidos, muestran que los costos hundidos en I&D no explican la ocurrencia de este tipo de persistencia. Por su parte, el acceso continuo a fuentes de financiamiento internas y externas a la firma es fundamental para la imitación continua. Finalmente, el enfoque de capacidades demuestra que el aprendizaje relacionado con la interacción con otros agentes y la inversión en entrenamiento a los trabajadores tiene efectos positivos sobre la persistencia estudiada

Código JEL: O31, O32, O33.
Palabras clave: Persistencia; imitación; costos hundidos; capacidades; restricciones financieras.

Introduction

In statistical terms, persistence in innovation is defined as the conditional probability that innovators in time t innovate in time t+1 (Malerba, Orsenigo and Peretto, 1997). In other words, persistence in innovation is understood as the phenomenon observed when a company that has innovated in one period shows innovation activity or results in subsequent periods. It is important to note that there has been growing research interest in this area over the last ten years (see Le Bas and Scellato, 2014). This is based on the fact that empirical research on this subject provides evidence in favor of: i) the theories of endogenous growth (Duguet and Monjon, 2004), ii), the growth and differential profitability of companies and industries (Cefis and Orsenigo, 2001), iii), the existence of sectoral innovation regimes (Malerba *et al*., 1997), strategic theories based on the accumulation and development of company capacities (Cefis and Orsenigo, 2001), and finally, the achievement of competitive advantage of companies (Cefis and Ciccarelli, 2005).

The term *innovation* refers to the introduction of a new product, production technology (Nelson and Rosenberg, 1993), or organizational or distribution process (Damanpour and Wischnevsky, 2006) to the market. A central aspect of the concept of innovation is its novelty (Diyamett and Wangwe, 2006). An innovation can be considered "new to the individual adopter, to most people in the adoption unit, to the organization, to a population of organizations, or new to any company in the world" (Damanpour and Wischnevsky, 2006, p. 272). According to Damanpour and Wischnevsky (2006), this research distinguishes between the concept of *innovation in the strict sense of product* and *imitation of product innovation*: i) innovation in the strict sense refers to the development and commercial exploitation of a product that is new to the international market; ii) on the other hand, imitation of innovation is the result of the assimilation and introduction to the market of existing products or technology that are considered new to the adopting unit. Consequently, in this research *imitation of product innovations* will be understood as the development of a product by a company that had previously already been introduced in both the international and national markets.

Studies on imitation processes have been at the center of the research agenda in the area of innovation over the last two decades (Lundvall, Joseph, Chaminade and Vang, 2011). This growing interest is due to the fact that imitation activities are considered central to the development and accumulation of technological, creative, and commercial capacities of companies (Kim, 1997). In this regard, it has been argued that imitation has been fundamental in the extraordinary development processes recently witnessed by countries such as Korea (Kim, 1997) or Taiwan (Fagerberg, Srholec and Verspagen, 2010).

Within the above context, official data provided by the National Department of Statistics (DANE for its acronym in Spanish, 2015, 2017a) for Colombia show that the average investment in R&D for the 2006-2016 period is less than 0.3% of the GDP—a figure that places the country below the average investment in Latin America and ranks it among the last places according to the indicator of *exports and imports per capita of products of medium and high technological intensity* published by the ECLAC (2016). In addition, the levels of patent registration (141 for 2015) (DANE, 2017a) and the rate of patent registration per million inhabitants (equal to 0.5 for the years 2012 to 2015) are very low (a trend that is repeated in most Latin American countries) (ECLAC, 2016). Consistently, the introduction of new innovations for the world (or international market) by companies of this country is very low: only 0.1% of manufacturing companies report the achievement of this type of innovation for the 2013-2014 period (DANE, 2015); whereas, for the same period, 19.3% of companies in the same sector report the development of some kind of imitation (DANE, 2015). In summary, the above data show that the manufacturing industry in Colombia bases a large part of its competitive processes on imitation, which is why it is considered an ideal scenario for the development of this research.

This research is inspired by the question posed by Geroski, Van Reenen and Walters (1997): What determines whether a company remains an imitator over time? The literature proposes three explanatory approaches to persistence (briefly described in Section 1: Hypotheses Proposal): (1) sunk costs of previous investments of the company in research and development (R&D), these costs act as significant entry and exit barriers to innovative activity (Antonelli, Crespi and Scellato, 2012); (2) financial resource constraints: a virtuous feedback loop between the commercial success of past innovations and the available capital to be invested in innovation activities is proposed herein (Duguet and Monjon, 2004); and (3) dynamic economies of scale: it is argued herein that persistence is due to the existence of dynamic economies of scale around the innovation learning of the company (Geroski *et al*., 1997).

Despite the existence of these explanatory approaches, most empirical research (e.g., Peters, 2009; Triguero and Córcoles, 2013; Suárez, 2014) focuses on whether there is real persistence in innovation (through the use of a probit or dynamic logit model): this occurs when a positive and significant effect of the past innovative behavior of the company is evident on its current innovative performance, after controlling for the influence of observed and part of unobserved heterogeneity (Peters, 2009). These studies do not relate persistence to company, technology, or market characteristics (Malerba *et al*., 1997). The scarcity of empirical explanatory studies has led Suárez (2014) to state that, in the relationship between past and present innovations, there are characteristics and behaviors that have not yet been investigated.

The second gap focuses on the fact that, despite the importance of imitation processes in economic development, there are very few studies on the persistence of imitation (e.g., Clausen and Pohjola, 2013; Ganter and Hecker, 2013). This amount is further reduced when it comes to research carried out in developing countries (e.g., Juliao-Rossi and Schmutzler, 2016). It is important to note that all the reviewed research on the persistence of imitation focuses on

finding the existence of true persistence; therefore, they share the limitations, described above by Malerba *et al*. (1997) and Suárez (2014).

This study addresses these two gaps by providing an answer to the following question: which of the determinants postulated by the three theoretical approaches has explanatory power in the occurrence of persistence of imitation of product innovations? The empirical analysis is based on three surveys of innovation and technological development (EDIT) carried out between 2003 and 2008 by the National Department of Statistics (DANE) of Colombia to companies belonging to the manufacturing sector. In this survey, according to the conceptual guidelines of the Oslo Manual, the question for the corresponding period is whether the company introduced "Goods or services that were new only for its company (they already existed in the national and/or international market)"[1] (DANE, 2017b, p. 37). Clearly, this EDIT question is consistent with the definition of imitation previously presented by Damanpour and Wischnevsky (2006). From this question, a distinction was made between companies that persistently imitate new products for the company (those that present imitation results in at least two consecutive periods), those that do so sporadically (those that present imitation results in one period), and those that do not present this (those that report zero imitations in the analysis periods). Subsequently, a zero-inflated ordered probit model (ZIOP) was estimated (described in the methodology section).

The rest of this article is structured in four sections. In the first, the research hypotheses are formulated. The second part describes the methodology implemented. Section three presents the results and those of the ZIOP model. The discussion and conclusions are presented in section four.

Hypotheses proposal

The three theoretical approaches that explain the persistence of innovation arise in different research traditions and are associated with different variables that allow us to compare them.

Sunk costs include salary payments and the training of highly skilled and experienced scientists, engineers or technicians (Hall, 2002), and the purchase of assets with "fixed costs regardless of market size for innovation" (Symeonidis, 1996, p. 17). From this perspective, R&D is an activity that cannot be easily discontinued because investments of this type are highly idiosyncratic, which means that, if they are suspended, the costs are irrecoverable (Stiglitz, 1987) and the accumulated experience is lost (Máñez, Rochina, Sanchis and Sanchis, 2009).

The following hypothesis derived from the sunk costs approach will be tested:

Hypothesis 1: Investment in R&D has a positive effect on the persistence of imitation of new products for the company.

The second theoretical approach is called success breeds success (Duguet and Monjon, 2004) or financial resource constraints (Ganter and Hecker, 2013). One of the main internal sources of resources is the commercial success of previous innovations, which provides the necessary funds to finance current innovation projects (Baldwin and Hanel, 2003) and to persistently innovate (Duguet and Mojon, 2004). On the other hand, the success of past innovations has an effect on the procurement of external resources for future innovation projects (Máñez *et al*., 2009).

[1] Within the survey it is defined that "A new good or service is a product whose fundamental characteristics (technical specifications, components and materials, built-in software, or intended uses) are new in relation to those corresponding to previous products produced by the company" (DANE, 2017, p. 37).

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The following hypotheses derived from the financial constraints approach will be tested:

Hypothesis 2a: Access to internal funds to finance innovations has a positive effect on the persistence of imitation of new products for the company.

Hypothesis 2b: Access to external funds to finance innovations has a positive effect on the persistence of imitation of new products for the company.

Hypothesis 2c: Continued access to internal funds to finance innovations has a positive effect on the persistence of imitation of new products for the company.

Hypothesis 2d: Continued access to external funds to finance innovations has a positive effect on the persistence of imitation of new products for the company.

The last approach is that of innovation capacities. It proposes that the persistence of innovation is due to the existence of dynamic economies of scale regarding the competencies that the company has to transform accumulated technological knowledge into the creation or improvement of products or processes (Geroski *et al*., 1997). The capacity of the company to innovate develops over time through different types of learning: formal R&D activities (Cohen and Levinthal, 1990), in conjunction with learning by doing, using, interacting, and training (Amara, Landry, Becheikh and Ouimet, 2008).

With regard to this approach the following hypothesis will be tested:

Hypothesis 3: The accumulation of innovation capacities has a positive effect on the persistence of imitation of new products for the company.

Methodology

Three surveys of innovation and technological development (EDIT II (2003-2004), III (2005-2006) and IV (2007-2008)) are used to test the proposed hypotheses, applied by DANE to Colombian industrial companies with 10 or more employees. The final sample was of 4491 companies. Consistent with the concept of persistence, the definition of dependent variables was made with data from the EDIT III and IV surveys. Independent variables were calculated using EDIT II and III.

Estimated zero-inflated ordered probit (ZIOP) model

Each type of persistence studied was measured by a discrete random variable. This is observable and takes the ordered discrete values of 0, 1 or 2: if a company does not report innovations in the 2005-2006 and 2007-2008 periods, it is considered non-innovative and the variable takes the value of zero. If the company reports having innovated in one of these periods, it is considered to be a sporadic innovator and the variable takes the value of 1. If the company has innovated in the 2005-2006 and 2007-2008 periods, it is a persistent innovator and takes the value of 2.

The definition of persistence as an ordered discrete variable $\boldsymbol{y}$ makes it possible to use an ordered logit or probit model (or variations of these) to test its relationship with a set of covariates z. However, for several reasons, the model selected was the zero-inflated ordered probit (ZIOP) model. The main reason is that this type of model provides robust estimates in the presence of two sources of heterogeneity in relation to companies reporting zero innovations (Bagozzi, Hill, Moore and Mukherjee, 2014). In this respect, it is possible that many companies,

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in spite of having characteristics, making efforts or making strategic decisions similar to the innovative ones, have not yet achieved (at the date of the survey) any results in this regard. This group of companies clearly differs from a third group that does not invest, nor does it have innovation within its objectives. There are two different mechanisms that generate zeros. In the first, known as *circumstantial* or *incidental zeros* (Winkelmann, 2008), companies have not yet innovated but participate or have initiated innovation processes. In the second case, called *structural* or *strategic zeros* (Winkelmann, 2008), companies do not innovate because they do not intend to do so. Ignoring the difference between these two processes that generate zeros or form of unobserved heterogeneity or using an ordered probit or logit to model this type of situation leads to errors in model specification (Gurmu and Elder, 2008; Bagozzi *et al*., 2014) and problems with inference accuracy (especially type II errors) (Perumean-Chaney, Morgan, McDowall and Aban, 2013).

Another reason for choosing a ZIOP model is that it effectively addresses the problem of over-dispersal due to excess zeros (Perumean-Chaney *et al*., 2013). According to Table 1, the dependent variable used exhibits a value of zero in 63.43% of the observations. This percentage falls within the range of zeros (10% - 90%) appropriate for inflated probit models to generate unbiased and efficient estimates (Bagozzi *et al*., 2014).

Description of the ZIOP

The ZIOP model developed by Harris and Zhao (2007) discriminates between participants (category made up of companies that show positive results in innovation and those that have circumstantial zeros) and non-participants (category made up of companies with structural zeros). This distinction results from a virtual process in which individuals have to decide whether or not to participate in the phenomenon studied (e.g., whether or not they decide to innovate) and then in a process conditional on the decision to participate, in which it is determined which performance goals they bet on or achieve (e.g., how many innovation projects they undertake or complete). This second group includes companies that in a given period have obtained a zero-performance level (zero innovations), even if they have previously decided that innovation is one of their strategies. These processes are modeled in ZIOP by two latent equations: a probit selection equation and an ordered probit.

In this research, the probit selection model represents the decision to participate in innovation processes or not. According to Harris and Zhao (2007), r is a binary variable that indicates the division between regimen 0 (with $r = 0$, for non-participating subjects) and regimen 1 (with $r = 1$, for participants). r is related to a latent variable r^*, as follows: $r = 1$ for $r^* > 0$ and $r = 0$ for $r^* \leq 0$. r^* represents the propensity to participate and is given by (Maddala,1983):

$$r^* = \mathrm{x}'\beta + \varepsilon \quad (1)$$

Where x is a vector of covariates that affect, in our case, the decision to innovate or not; β is a vector of unknown coefficients; and ε is the term error that is assumed distributed in a standard normal way. Within this model, the probability of being in regimen 1 (or participating) is given by:

$$\Pr(r = 1/\mathrm{x}) = \Pr(r^* > 0) = \Phi(\mathrm{x}'\beta) \quad (2)$$

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Φ (.) is the cumulative distribution function of the univariate normal distribution.

With respect to the level of participation, Harris and Zhao (2007) propose that under the condition that $r = 1$, the level of consumption or innovation achieved can be represented by a discrete variable y' ($y' = 0, 1..., J$), which is generated by a standard ordered probit process via a second latent variable y'^*:

$$y'^* = z'\lambda + u \tag{3}$$

z is a vector of explanatory variables with unknown coefficients λ and error u, which is assumed to follow a standard normal distribution. The variable y' is related to y'^* in the following way:

$$y' = \begin{cases} 0, \text{ if } & y'^* \leq 0, \\ j, \text{ if } & w_{j-1} < y'^* \leq w_j \ (j = 1,\ldots, J\text{-}1), \\ J, \text{ if } & w_{J-1} < y'^*, \end{cases} \tag{4}$$

Where wj ($j = 1, ..., J$-1) are limit parameters to be estimated along with the parameter vector λ. It is also assumed that $w_0 = 0$. It is important to note that this second modeling process includes as a possible result a level of innovation or zero consumption. In addition, there is no constraint that x equals z (Zhao and Harris, 2007). Under the above considerations, the probability of a specific innovation value is generated by (Maddala, 1983):

$$\Pr(y') = \begin{cases} \Pr(y' = 0/z, r = 1) = \Phi(w_j - z'\lambda) \\ \Pr(y' = j/z, r = 1) = \Phi(w_j - z'\lambda) - \Phi(w_{j-1} - z'\lambda) \ (j = 1,\ldots, J\text{-}1) \\ \Pr(y' = j/z, r = 1) = 1 - \Phi(w_{j-1} - z'\lambda) \end{cases} \tag{5}$$

Harris and Zhao (2007) propose that r and y' are observable through the following criteria:

$$y = ry'. \tag{6}$$

Consequently, to observe $y = 0$, one of the following conditions is required: i) $r = 0$ (the company does not participate in innovation processes), or ii) $r = 1$ (the company participates in innovation processes) and $y' = 0$ (the level of innovation achieved to date by the company is zero). For its part, to have a positive value of y, it is required that $r = 1$ and $y'^* > 0$. Assuming that ε and u follow standard Gaussian distributions independently, the equation of the increased ordered probit model of ZIOP is, according to Harris and Zhao (2007), given by:

$$\Pr(y) = \begin{cases} \Pr(y = 0/z, x) = \Pr(r = 0/x) + \Pr(r = 1/x) \Pr(y' = 0/z, r = 1) \\ \\ \Pr(y = j/z, x) = \Pr(r = 1/x) \Pr(y' = j/z, r = 1), \quad (j = 1,\ldots, J\text{-}1) \end{cases}$$

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Replacing:

$$\Pr(y) = \begin{cases} \Pr(y = 0/z, x) = [1 - \Phi(x'\beta)] + \Phi(x'\beta)\,\Phi(-z'\lambda) \\ \Pr(y = j/z, x) = \Phi(x'\beta)\,[\Phi(w_j - z'\lambda) - \Phi(w_{j-1} - z'\lambda), \quad (j = 1,\ldots, J-1) \\ \Pr(y = J/z, x) = \Phi(x'\beta)\,[1 - \Phi(w_{j-1} - z'\lambda)]. \end{cases}$$

The equation of the ordered increased probit calculates the probability of zero performance (not innovating) as a combination of the probability from the probit model that evaluates non-participation plus the one provided by the ordered process for zero consumption (Harris and Zhao, 2007). As a result, as verified by the empirical work of Harris and Zhao (2007) and Bagozzi *et al*., (2014), in cases where the dependent variable shows inflation in zeros, the ZIOP models allow obtaining more reliable estimates than an ordered standard model.

Dependent variable

Persistence in new products for the company (Persistence_company)

Assumes ordered values: 2, if reporting new products for the company in the 2005-2006 and 2007-2008 periods; 1, if reporting them in one period, and 2, if not reporting them in any of these periods.

Table 1 shows the descriptive statistics of the dependent variable.

Independent Variables

Variables associated with the sunk cost approach of R&D investment intensity (R&D_ Intensity)

Sum of the R&D investment made by the company in the 2003-2004 and 2005-2006 periods, divided by the number of employees.

Variables associated with the financial constraints approach

The available data do not allow the financial success of innovations to be established directly. Therefore, the following proxy variables are proposed:

Financing intensity with the resources of innovation themselves (Internal Financing): Amount of own financing used by the company in innovation activities during the 2003-2004 and 2005-2006 periods, divided by the number of employees.

Continuity of self-financing (Internal Financing Continuity.): assumes a value of 2 if the company has financed its innovation activities with its own resources during the 2003-2004 and 2005-2006 periods; 1 if the financing with own resources occurred in only one of these periods; and 0 if this source of financing was not used.

Intensity of the use of external sources of financing (External Financing): Amount of external financing (public resources, private banking, capital funds) used by the company in innovation activities during the 2003-2004 and 2005-2006 periods, divided by the number of employees.

Continuity in the use of external sources of financing (External Financing Cont.): Takes the value 2 if the company has financed its innovation activities with external resources during the

2003-2004 and 2005-2006 periods; 1 if the financing with external resources was given in only one of these periods; and 0 if this source was not used.

Variables associated to the accumulation of innovation capacities approach

Within the innovation capacities approach, it is proposed to include the percentage of professionals within the payroll of the company and a set of variables that suggest the definitions of Amara *et al*. (2008) of different types of learning of the company.

Educational level: ratio of employees with at least a university degree in the 2003-2004 and 2005-2006 periods.

Learning by training: amount invested per employee in technological training in the 2003-2004 and 2005-2006 periods.

Learning by doing: amount of investment per employee in machinery and equipment in the 2003-2004 and 2005-2006 periods.

Learning by using: investment per employee in technology transfer (ownership rights, licenses, or unpatented inventions) in the 2003-2004 and 2005-2006 periods.

Learning by interacting: Sum of sources of ideas for innovation from clients, suppliers, competitors, universities and research centers, technological development centers, trade unions and chambers of commerce, which the company reports having used in the 2003-2004 and 2005-2006 periods.

Control variables[2]

The following recognized determinants of innovation, measured in the t period, are included:

1. Size of the company: Natural logarithm of the number of staff employed by the company in the 2003-2004 period.
2. Foreign property: if 25% or more of the capital of the company has foreign ownership, this variable takes the value of 1, it takes the value of 0 otherwise.
3. Sectorial Dummies Pavitt (Pavitt): One way to take into account the sectorial characteristics is to use the grouping of companies according to the classification proposed by Pavitt (1984). It groups industrial sectors according to similarities in innovation processes: supplier-dominated; intensive in economies of scale; specialized suppliers; and science-based suppliers. Three of the following four variables are included, which indicate belonging to one of these groups: pavitt_supp, pavitt_scale, pavitt_special, and pavitt_science.

Tables 2 and 3 present the descriptive statistics of the independent variables. The VIF test in Stata rules out multicollinearity problems between independent variables.

Table 1.
Summary of the descriptive statistics of the dependent variables

	Persistence Adoption Company		
Observed Value	Freq.*	Percent	Cum.
0	3 015	63.43	63.43
1	1 437	30.23	93.67
2	**301**	**6.33**	**100.00**
Total	4 753	100.00	

*Frequency (Freq.) is measured in thousands.
Source: Own elaboration.

[2] The age of the company was not included because the data source (EDIT) does not provide this information.

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Table 2.
Summary of the statistics of the independent variables

Variable	Descriptive			
	Mean	Std. Dev.	Min	Max
R&D_Intensity	87.12911	635.7786	0	20 916.85
Internal Financing	4 725.99	21 634.91	0	644 512.6
External Financing	3 101.347	12 788.2	0	379 502.4
Educational Level	.2439051	.2092149	0	1.584603
Learning by Training	235.8228	1 726.242	0	67 160
Learning by DoingEdit3	2 810.409	11 998.63	0	594 701.7
Learning by Using	240.6904	2 127.956	0	97 939.98
Learning by Interacting	2.265538	3.093661	0	14
Size of the Company	3.5935	1.200953	.6931472	8.839711

Source: Own elaboration.

Table 3.
Descriptive statistics of the binary or ordinary variables

Variable	Observed Value				
	0	1	2	**Total**	
Int. Fin. Cont.	1 571	2 805	821	5 197	Freq.*
	30.23	53.97	15.80	100.00	Percent
Ext. Fin. Cont.	3 287	1 575	335	5 197	Freq.
	63.25	30.31	6.45	100.00	Percent
Foreign Ownership	6 246	423	-	6 669	Freq.
	93.66	6.34	-	100.00	Percent
pavitt_supp	4 053	2 616	-	6 669	Freq.
	60.77	39.23	-	100.00	Percent
pavitt_scale	4 271	2 398	-	6 669	Freq.
	64.04	35.96	-	100.00	Percent
pavitt_special	6 251	418	-	6 669	Freq.
	93.73	6.27	-	100.00	Percent
pavitt_science	5 425	1 244	-	6 669	Freq.
	81.35	18.65	-	100.00	Percent

*Frequency (Freq.) is measured in thousands.

Source: Own elaboration.

Results

In model 1, Table 4 shows that the approach of sunk costs—represented by the intensity in R&D—does not explain the persistence in new products for the company.

Table 4.
Persistence ZIOP model

	Persistence in New Products for the Company	
Variables	Model 1 Outcome equation	Model 2 Inflate
Approach of sunk costs		
R&D_Intensity	0.0126	20.82*
	(0.0163)	(11.28)
Financial approach		
Int. Fin.	-0.0103	2.320
	(0.0175)	(2.049)
Ext. Fin.	0.0103	-0.410
	(0.0181)	(0.283)
Int. Fin. Cont.	0.155***	-0.455
	(0.0344)	(0.305)
Ext. Fin. Cont.	0.174***	-0.197
	(0.0363)	(0.309)
Capacity approach		
Educational Level	-0.0112	2.968
	(0.0362)	(2.797)
Learning by Training	0.0722**	-0.433
	(0.0326)	(0.335)
Learning by Doing	0.0111	0.994
	(0.0121)	(0.824)
Learning by Using	-0.0298	-0.154*
	(0.0235)	(0.0877)
Learning by Interacting	0.170***	0.194
	(0.0255)	(0.165)
Control variables		
Size of the Company	0.216***	-0.215
	(0.0219)	(0.327)
Foreign Ownership	-0.0403	-0.295
	(0.0846)	(0.540)
pavitt_science	0.174***	
	(0.0554)	
pavitt_scale	0.0580	
	(0.0481)	
pavitt_special	0.142*	
	(0.0810)	
cut2	1.498***	
	(0.0421)	
Constant	-1.682***	8.263
	(0.0963)	(5.373)
Observations	4 491	4 491
Wald chi2	849.74	
Prob > chi2	0.0000	
Log pseudolikelihood intercept only	-3 744.03	
Log pseudolikelihood full model	-3 134.47	
Maximum Likelihood R2	0.162807	

*= level of significance at 10%; **= level of significance at 5%; ***= level of significance at 1%.
Source: Own elaboration.

The financial constraints approach explains the occurrence of persistence in imitation. In this respect, the variables of access to financial funds present a similar pattern of relationships. The continuity of internal and external financing has a positive and significant impact of 1%. The amount of internal and external financing is not significant.

From the point of view of innovation capacities, model 1 reports that only learning by training and learning by interacting have positive effects (at 5% and 1%, respectively).

The results of the models were subjected to three tests indicating that they are robust (available on request). Two new variables were initially included. The first is continued investment in R&D. Also, to consider some of the heterogeneity not observed in relation to the initial conditions of the companies for each type of innovation studied, a variable was introduced in the respective models to indicate whether the company obtained new products for the company in the EDIT II survey. These regressions offer similar results to those of the central models. In additional tests, the results are maintained when the independent variables added to two surveys are replaced, calculated based on the sum of the items reported in EDIT II and III by their values in each individual survey. In the second test, no major changes are observed when it is assumed that the errors of the ordered regression and the probit correlate (zero-inflated ordered probit with correlated errors, ZIOPC). In the third test, a zero-inflated poisson (ZIP) regression was estimated as an alternate functional form and it is concluded that the change in functional form shows robustness of the central models of the previous table.

Discussion and conclusions

The explanatory power of the three theoretical approaches of persistence in the imitation of new products for the company has been contrasted with a sample of companies belonging to the Colombian manufacturing industry. The main results are presented below:

a. Sunk costs. The sunk cost approach does not explain the persistence of imitation of new products for the company. This means that no support has been found for hypothesis 1, which assumed positive effects in this relation (statistical significance[3] higher than 10%). On the one hand, this evidence coincides with that provided by the research of Juliao-Rossi and Schmutzler (2016) on Colombian manufacturing companies (these authors use a dynamic probit with random effects in a panel of three EDIT surveys). However, this result contrasts with what is happening in an emerging economy, in relation to what some researchers propose: a significant part of R&D spending in industrialized countries is directed towards imitation activities (Mansfield, Schwartz and Wagner, 1981). In their study on persistence, Ganter and Hecker (2013) also report a dynamic positive effect of R&D on new products for the company. However, Clausen and Pohjola (2013) find no evidence of this relationship when estimating a similar statistical model (both using similar models to Juliao-Rossi and Schmutzler (2016)). Ganter and Hecker use continuity in R&D, while Clausen and Pohjola (2013) use intensity in R&D, which may explain their differences. Another explanation suggests that, with greater technological leadership in the country of origin, local companies are likely to use more sophisticated imitation strategies that require R&D (Ganter and Hecker, 2013). In this sense, as our results show, it is to be expected that companies in an emerging economy will use imitation in a more informal way.

[3] One percent and 5% have been chosen as levels of significance (α) or probabilities of making the type I mistake (incorrectly rejecting the null hypothesis; as is conventionally accepted. See Hair, Black, Babin and Anderson, 2014).

b. Financial constraints. The persistence in the imitation of new products for companies in the manufacturing sector is supported by continued access to internal and external sources. Specifically, hypotheses 2c and 2d are confirmed with a significance of 1%. This result is consistent with several studies that have identified difficulties in access to financial resources as the main obstacle to undertaking innovation projects (e.g., Suárez, 2014).

The inclusion of another dimension of financing, in this case the continuity and data lag structure used, allowed capturing a more complex strategic behavior than that suggested by the pecking order financial structure theory (Myers and Majluf, 1984): when there is information asymmetry between manager and potential investor (as occurs in innovation projects), companies tend to initially finance their projects with their own resources, then with debt, and finally capitalizing. Several research studies on innovation provide evidence in favor of this theory for industrialized countries (e.g., Giudici and Paleari, 2000). Our results, in contrast, suggest that Colombian companies that persistently imitate have managed to implement a financial strategy of complementarity between internal and external resources.

c. Innovation capacities. The persistence of new products for the company is based on only two means of learning. The results show that learning by training is positively related to persistence in imitation, with a significance of 5%. In addition, learning by interacting shows a positive and significant 1% relation with our dependent variable. The remaining types of learning (educational level, learning by doing, and learning by using) have a non-significant relationship with persistence in imitation.

The low number of means of learning related to this type of innovation may be due to two reasons. The first is that most of the uncertainties and questions regarding the characteristics, production, and consumption of the product to be imitated are resolved (Mansfield *et al*., 1981). The second is that imitation processes do not require the company to create new knowledge (Kim, 1997). However, our results show that this type of imitation does not occur in a vacuum: it seems essential for the company to learn routines or develop skills to choose the appropriate technical assistance and assimilate it (Kim, 1997). Finally, our results contrast with those of Juliao-Rossi and Schmutzler (2016), who found no evidence to link any learning to the occurrence of persistence in imitation.

The main limitation of this research is that only data from three surveys were used, which is why a short panel was constructed. Nevertheless, an advantage of using these surveys is that the independent variables of the models used in this research were calculated based on EDIT II and III. These cover the period from 2003 to 2006, which is characterized by high stability and economic growth in Colombia (during this period the average GDP growth of the country was of 4.8%). This allowed the results obtained to be shielded from sudden macroeconomic variations and to more precisely identify the determinants of each type of persistence.

Despite the aforementioned limitations, this research represents progress in innovation studies. On the one hand, this is the first known research on this topic to use a ZIOP model. On the other hand, it has been proposed and proven that the continuity of access to financial resources (external and internal) is another dimension that determines the three types of persistence studied in the financial constraints approach. Finally, two contributions are also made to the innovation capacities approach. In previous research, innovation capacities have generally been measured through variables of average educational level of the staff. In this study, it was found that the capacities related to persistence in adoption are generated by a greater set of learning.

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