Beyond formal R&D: firm's capabilities and its innovation profile. The case of Argentinean manufacturing firms (2014-2016)

Más allá de la I+D formal: capacidades de la firma y perfil de innovación. El caso de las empresas manufactureras argentinas (2014-2016)

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Abstract

The purpose of this article is to analyse the relationship between different innovation profiles, capabilities, and innovation results of manufacturing firms from Argentina. The premise that guides our research is that most of firms not performing formal R&D -92%- are a highly heterogeneous group in terms of innovative behaviour, capabilities and innovative performance. Thus, we propose to study firms' innovation profile as a gradient that accounts for formal R&D, informal R&D, non- R&D performing firms and firms without innovation efforts. Then, the relationship between these profiles and five dimensions of firms' capabilities -productive, organizational, connectivity, and accumulated and potential absorptive - is explored. Accordingly, the study of how these profiles correlate with firms' innovation results -products and/or processes innovations, new marketing and/or organizational changes, patents and ratio of new product sales to total sales- is also carried out. The empirical evidence is based on Argentinean manufacturing firms with data from the second wave of the National Innovation Survey composed by around 4000 observations for the period of 2014-16. Results suggest that more complex R&D profiles require higher levels of capabilities. Moreover, there seems to be a threshold of capabilities in moving from the non-R&D to the informal R&D profile. Likewise, while informal R&D is a critical threshold to increase the probability of obtaining product, process, organization and marketing innovations, formal R&D is key to get patents and to increase the share of new products on total sales.

Key words: *Innovation profile; capabilities; innovation results; manufacturing firms; Argentina.*

JEL Classification: *D21, D22, O30.*

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Resumen

El objetivo de este artículo es analizar la relación entre diferentes perfiles de innovación, capacidades y resultados de innovación en las empresas manufactureras argentinas. La premisa que guía la investigación es que la mayoría de las empresas que no desarrollan I+D -92%- son un grupo altamente heterogéneo en términos de comportamiento innovativo, capacidades y desempeño innovador. Así, proponemos estudiar el perfil de innovación de las empresas como un gradiente que incluye I+D formal, I+D informal, firmas que no realizan I+D y firmas que no realizan esfuerzos en innovación. De esta forma, es explorada la relación entre esos perfiles y cinco dimensiones de capacidades de la firma -productivas, organizacionales, de conectividad y de absorción acumulada y potencial-. Asimismo, se estudia cómo estos perfiles correlacionan con los resultados de innovación de la firma -innovaciones de producto y/o proceso, marketing y/o cambios organizacionales, patentes y ratio de nuevos productos sobre el total de ventas-. La evidencia empírica se basa en las empresas manufactureras argentinas, con datos de la segunda vuelta de la Encuesta Nacional de Innovación, que contiene alrededor de 4000 observaciones para el período 2014-16. Los resultados sugieren que los perfiles más complejos de I+D requieren mayores niveles de capacidades. Más aun, parece existir un umbral mínimo de capacidades para trasladarse del perfil que no realiza I+D al perfil de I+D informal. De la misma manera, mientras realizar I+D informal es un umbral fundamental para aumentar la probabilidad de obtener innovaciones en producto, proceso, organizacional y de marketing, la I+D formal es clave para obtener patentes y para aumentar la proporción de nuevos productos en el total de ventas.

Palabras clave: *Perfil de innovación; capacidades; resultados de innovación; firmas manufactureras; Argentina.*

Clasificación JEL: *D21, D22, O30.*

1. Introduction

The objective of this paper is to analyze the relationship between firm's capabilities, innovation profiles and innovation results. Within evolutionary theory of innovation, firms' innovative behavior depends on multiple sources of knowledge and learning that go beyond formal R&D (e.g.: Dosi, 1988; Freeman, 1974; Nelson and Winter, 1982; Pavitt, 1984; Rosenberg, 1982). Thus, capabilities matter as much as innovation efforts when trying to explain innovation results and economic performance. Nevertheless, most empirical contributions consider that formal R&D plays an exclusive role in explaining innovation efforts and results (Arundel et al., 2007). Much of this literature gives a secondary role to both the rest of innovative efforts –e.g.: acquiring capital goods, quality assurance, training, engineering and design- and firms' different types of capabilities (e.g.: Crepon et al., 1998; Hall et al., 2010; Verspagen, 1995).

To a large extent, this wide empirical literature is based on the availability of information arising from R&D indicators, mainly based on the recommendations of Frascati and Oslo manuals (OECD, 2002, 2005, 2018). In this regard, traditional definitions of R&D followed by these manuals pay more attention to "the systematic search for new knowledge from basic and applied science", than to "experimental development processes", not necessarily carried out within R&D labs (Arundel et al., 2007). This is at odds with the fact that within evolutionary literature these informal processes of problem-solving are recognized as key elements in generating innovations. Even worse, public policy has been focused on the promotion of formal R&D as well, which has also narrowed the scope of beneficiaries to high technological intensity industries (Fiorentin, Pereira and Suarez, 2018).

In other words, theoretical analysis, statistical indicators, and innovation policy were biased towards Jensen's et al (2007) "science, technology and innovation (STI) learning mode", which is based on the generation of scientific and technological knowledge through R&D activities. Conversely, less attention has been paid to the role of learning based on experience and non-science-based sources of knowledge –also known as doing, using and interacting (DUI) mode (Jensen et al., 2007). This kind of learning process is particularly relevant in: i) non R&D-performer firms, ii) firms with a lower degree of novelty and formality of their innovation efforts, iii) low and medium technological intensity industries and iv) small and medium size firms (Hirsch-Kreinsen, 2015).

Following this line, some scholars have claimed the importance of complementing indicators on R&D labs with others that account for different ways of developing innovative activities and building capabilities (Bender and Laestadius, 2005; Hirsch-Kreinsen, 2008; Rammer et al., 2009; Santamaría et al., 2009; Santarelli and Sterlacchini, 1990, among others). This claim is supported by the fact that non-R&D performing innovators represent a high proportion of firms in most countries –e.g. this involves half of European innovative firms (Arundel et al., 2007; Rammer et al., 2009; Thomä, 2017). This is also true for Latin American firms (e.g.: Dutrenit and Katz, 2005; Lugones and Suarez, 2010; RICyT, 2000; Yoguel and Boscherini, 1996) and it is what motivates this article.

We propose that besides R&D and non-R&D performers there is a set of heterogeneous firms carrying out other types of innovation efforts that are also innovators. We explore firms' innovative behavior profiles that account for different situations beyond having or not R&D labs. Following Thomä (2017), the patterns of knowledge creation that lies behind the behavior of non-R&D innovative firms are still a "black box" that needs to be investigated. Innovation activities performed outside R&D labs -quality assurance, continuous improvement systems, human resources training, and work organization- are relevant activities to fully comprehend firms' innovative efforts along with their innovative performance (Arundel et al., 2007).

In order to contribute to opening this black box, this article identifies a gradient of intermediate situations between formal R&D and the absence of innovative efforts. We claim that innovative efforts beyond formal R&D could be equally likely to trigger virtuous innovation processes. We study which types of firms' skills and capabilities besides STI learning explain their innovation profile. Our theoretical approach assumes that the development of capabilities is the consequence of a path dependent, accumulative and multidimensional learning process associated with knowledge accumulation, routines, organizational practices, interactive learning processes and linkages with the institutions from the national innovation system (Jensen et al., 2007; Nelson and Winter, 1982). Hence, we propose that the innovation profile is the consequence of the development of these dimensions. Then we also analyse to what extent firms' profiles are associated with their performance, in terms of innovative results.

The empirical analysis draws on a database with information about almost 4000 Argentine manufacturing firms for the period 2014-2016. The data comes from the second wave of the "National Survey on Innovation and Employment" (in Spanish Encuesta Nacional de Innovación y Empleo, hereinafter ENDEI II) carried out by the Ministry of Science and Technology and the Ministry of Labour. In order to analyse the relation between firms' capabilities and innovation profiles, multinomial logistic models were estimated. Results suggest that a high threshold of capabilities is necessary to overcome in order to start performing informal R&D activities. Then, probit and tobit models were estimated to explore the relation between innovation profiles and innovation results. Results suggest that more complex innovation profiles require higher levels of capabilities. Performing R&D activities is not just a matter of overcoming funding or appropriability failures but to accumulate skills and knowledge to set up a path of innovation based on the development of new knowledge and experimental development. Likewise, results show that while informal R&D is a critical threshold to increase the probability of obtaining product, process, organization and marketing innovations, formal R&D is key to get patents and to increase the share of new products on total sales.

The rest of the article is organized as follows: section two presents literature review on the role of R&D and other innovation activities in the process of innovation. The hypotheses are defined in section three. Section four presents the database, descriptive statistics and the methodology. The fifth section presents and analyse the results. Finally, some conclusions are drawn in section six.

2. Literature Review on The Role of R&D and Other Innovation Activities in the Process of Innovation

Within Evolutionary theory of innovation there is broad consensus that capability building is a cumulative and multidimensional process that arise from multiple activities that are not only reduced to R&D labs (Freeman, 1974; Nelson and Winter, 1982; Pavitt, 1984; Rosenberg, 1982). Under this framework, Nelson and Winter (1982) claim that innovation can be the result of either standardised processes of searching for improvements (routines to innovate) or the consequence of the identification of solutions to problems that appear in the daily operations of firms (innovation in routines). This latter way of innovation acquires more tacit features, requires the cooperation of agents widespread in different areas of the organisation, and complements formal R&D activities performed by firms. Similar appreciations can be found within Cohen and Levinthal (1990) and Teece and Pisano (1994) contributions.

Based on this general framework, three streams of empirical analysis can be found, synthetized in Table 1. Firstly, those contributions focused on R&D as the only relevant input to explain firms' innovation and performance. Secondly, a set of contributions aiming to identify innovative strategies of firms to account for intra- and extra-industry heterogeneity. Thirdly, there is a relatively new literature which we have named "The Black box opened: beyond formal R&D". These studies have arisen as a critical response to the literature centred on R&D. They show that innovation processes emerge from multiple activities and that many innovative firms are non-R&D performers.

The first group -*1.Focus on R&D performing firms*-, accounts for the literature that takes R&D as the only determinant of innovation dynamic in terms of patents and/or new products and processes. For the empirical exercises, R&D is introduced as a binary (R&D performers versus non-R&D performers) or a continuous variable, the latter known as R&D intensity (R&D expenditure to sales). This literature includes two types of groups: studies aimed at explaining innovation (group 1.1) and a set of articles that also add the relationship between innovation and productivity (group 1.2) (see table 1 for the main contributions within each group).

The group *1.1.R&D and innovation* is compounded by is a set of articles that provide evidence about inputs and outputs of the innovation process. Among the inputs, R&D is introduced as an independent variable in different

TABLA 1

LITERATURE REVIEW

	Premises and hypotheses	Independent variables	Dependent variables	Literature*
1. Focus on R&D performing firms				
1.1 R&D and innovation	- Innovation depends on R&D - Innovation can be "made" through in house-R&D or "bought" by contracting external R&D	R&D as a binary variable: performers vs. non-performers R&D intensity: R&D expenditure/ sales In house vs. external R&D	Innovation results: new products and processes Patents	Cassiman and Veugelers, (2006); Vega-Jurado et al, (2008); Romijn and Albaladejo, (2002); Caloghirou et al., (2004); Duchesneau et al., (1979); Reichstein and Salter, (2006); Becker and Dietz, 2004; Poldahl (2006) Becker and Dietz (2004); Huang and Hou (2019); Pegkas, Staikouras and Tsamadias (2019)
1.2 CDM-type	R&D as determinant of innovation and productivity depending on innovation	Market share Diversification of activities R&D intensity	Patents Innovation results Labour productivity	Crepon, Duget & Mairesse, (1998); see Lööf et al., (2017) for a review; Notten et al., (2017) ; Ben Khalifa (2023).
2. Innovative strategies				
2	Inter and intra industry heterogeneity explained by firms' innovation strategies	Innovation efforts (mainly R&D and acquisition of machinery) Innovation results, Sources of information for innovation, Methods of protection	Innovation strategies. Innovation results	Clausen et al. (2011); Yurtseven and Tandoğan, (2012); Fraga et al.(2008); Srholec and Verspagen, (2012); Frenz and Lambert, (2009), see Suarez (2015) for a review
3. The Black box opened: beyond formal R&D				
3.1 DUI mode of learning	Many innovations are associated with experience-based knowledge, with or without R&D labs.	Innovation management and work organization: - Incentive schemes to innovate; - internal competition and cooperation; -Interdisciplinary workgroups; - Quality circles; - Autonomy	- Innovation results - Productivity	Thöma, (2017); Rammer et al, (2009); Kirner et al (2009); Jensen et al, (2007); Som, (2012); Kirner et al. (2009); Som and Kirner (2015); Lundvall (2006), Malerba and Orsenigo (1997); Hervas-Oliver and Sampere-Ripoll, (2012) ; Fan, Huang and Xiong (2023) .
3.2 R&D and non-R&D based activities	Many innovations derive from innovation expenditures on non-R&D activities.	R&D, Use of advanced machinery, Design, Training, Skills intensity,	- Innovation results - Propensity to patent - Methods of innovating: R&D in-house, external R&D, creative non-R&D innovators, technology adopters - Non-R&D expenditures/ total innovation expenditures	Santamaria et al, (2009); Arundel et al, (2007); Huang et al, (2011); Bender, (2006). Santarelli and Starlaccini, (1990); Bender and Laestadius, (2005); Hirsch-Kreinsen, (2008); Thu Tran and Santarelli (2013); Hirsch-Kreinsen et al (2005); Grimpe and Sofka (2008); Heidenreich (2009); Liu, Shan and Li (2023).

* Selected contributions.

ways: performers versus non-performers, R&D expenditures as a percentage of total sales, in-house versus external R&D. Articles about "make and buy" innovation are also included within this literature, to the extent that they are based on the idea that firms can "make innovation" through in-house R&D or "buy innovation" through contracting external R&D. Then, innovation results and patents are considered among the results. Results are conclusive: most of this literature finds a positive impact of R&D on innovation outcomes.

Regarding *1.2.CDM-type* literature, we include the seminal paper of Crepon, Douguet and Mairesse (1998) and articles that have followed their methodology. These papers explain firm's innovation process in three steps. The first one explains R&D intensity by means of firm's market share and diversification of activities. In a second step the estimation of R&D is used to explain innovation results and, finally, innovation results are considered in the estimation of productivity. Most of this literature arrives to similar findings: productivity is explained by patents and new product/process which in turn are explained by R&D.

The second stream of the literature aims to explain inter and intra industry heterogeneity in terms of innovation strategies (*2. Innovative strategies*). Literature about innovation persistence falls within this group. The underlying idea is that firms can pursuit innovation thought different means and with different capabilities. Accordingly, the type of innovation strategy depends on firm's decisions about how to face competition, where R&D can play a central or a marginal, and even not a role at all. Innovation strategies are defining through factor analysis and clusters methods that include input and output variables of the innovation process: efforts, results, sources of information for innovation, methods of protection, etc. Results within this literature show the existence and persistence of firm heterogeneity, which is only partially determined by industry characteristics and opportunities.

The third group is called "*3. The Black box opened: beyond formal R&D*" and it is at the centre of the theoretical motivation of this article. Studies within this group claim that innovation is the result of multiple factors that go beyond the activities developed within R&D labs, which include new combinations of routines and solutions achieved both inside and outside the firm. It is assumed that these complementary dimensions to R&D are not considered by traditional indicators because of the belief that innovations not based on R&D are not relevant. Contributions within this group claim that when the study of innovation is reduced to the analysis of formal R&D, only a fraction of the productive structure is studied, which is usually based on knowledge-intensive activities. This segment involves firms with high technological capabilities and innovation rates, both in developing and developed countries.

To illustrate the importance of this for the case of Latin America, it is worth mentioning some "traditional" statistics. In Argentina only 20,24% of the manufacturing firms had a R&D lab in 2016, which contrasts with the 71% that claimed having done innovation activities (MINCyT, 2017). In Brazil, while 28% of the manufacturing firms did some innovation activities during 2011, only 3.7% declared having done R&D activities on a continuous manner (PINTEC, 2016). In Chile, only 1.6% of firms stated having an R&D lab in 2012 against 27% that declared having innovated (EIE, 2014). In Uruguay, 7% of manufacturing firms declared having performed R&D activities between 2013-15, while more than 31% made efforts in innovation (ANII, 2015). In Mexico, while 3% of the manufacturing firms had R&D labs in 2016, 18% declared carrying on innovation activities (ESIDET-MBN, 2016). Summing up, there is a significant distance between firms that have declared having carried out any formal or continuous form of R&D and those that performed innovation activities. Therefore, to know what determines that distance is a matter of key importance to understand how to promote more complex innovative behaviors. As we shall demonstrate, the level of a multidimensional set of capabilities plays a key role in that explanation.

Studies from developed countries also suggest that a large and heterogeneous group of firms with different capabilities, innovation efforts and innovative dynamics which are not necessarily explained by formal R&D activities is ignored when R&D is assume as the only possible innovation strategy. In these cases, another type of resources and abilities account for their innovative capability that can, as well, compensate the absence of efforts in R&D (Hirsch-Kreinsen, 2008; Santarelli and Sterlacchini, 1990; Som et al., 2013).

Within group 3 we have identified two set of articles, one is focused on the doing, using and interacting (DUI) mode of learning (group 3.1.) and the other assumes a wider perspective of innovative efforts (group 3.2.). Empirical evidence comes from micro-data in both groups, but while in the former the indicators stem mainly from ad hoc surveys, the later uses the traditional indicators coming from the standardized innovation surveys.

Within the "*3.1.DUI mode of learning*" group, the key component for the explanation of firms' innovative dynamic and performance is the learning process involving the combination of tacit and codified knowledge. Given the non-linear nature of the processes of capability building, modes of learning centred on DUI are a necessary condition for the emergence of forms based on STI learning processes, associated mainly with formal R&D. Following Thomä (2017), innovation at the firm level can occur with or without R&D activities, but rarely without DUI mode competencies acquired through informal processes of learning and experience-based know-how. An overly-strong focus on promoting only formal processes of in-house R&D thus ignores the fact that DUI mode competencies are a general prerequisite for successful innovation"

(Thoma, 2017: p. 1336).

The final row of the Table 1 includes a group of studies that start from the premise that both R&D and non- R&D- based activities lead to innovation results. Thus, all innovative efforts collected by the usual innovation surveys are included in the explanation of innovation. According to this literature, mainly in low and medium-low tech industries, innovation is the result of a particular configuration of tacit and codified resources developed by firms along their path dependence, rather than on their innovation strategies based in R&D. These articles have in common that, besides R&D, the other innovation efforts also played a key role: training, design, use of machinery and advanced technology, consultancy and contracting highly qualified personnel.

This paper aims to contribute to the summarized literature in a transversal way. We recognize the importance of formal R&D in carrying out innovations and improving firms' innovative performance (group 1). At the same time, we acknowledge the relevance of understanding heterogeneous situations (a gradient) between R&D performing firms and firms that do not invest in innovation (group 2). Then, we aim to break with the dichotomy of R&D versus non-R&D performing (group 3) by means of providing empirical evidence to explain alternative situations.

3. Hypotheses

We propose to study the *"innovation profile"* of firms as a gradient that includes firms that do not carry out innovation efforts, firms that do perform innovation efforts but without caring out R&D activities, firms that perform informal R&D, and firms that perform formal R&D within labs exclusively dedicated to those activities. This gradient is ordered in the sense that R&D performer firms are those with the most complex profiles. This assumption is based on the literature summarized under group 1 meaning that we do not neglect the importance of R&D activities in developing knowledge capable of being translated into sophisticated innovations. However, and in connection with the literature summarized in group 3, other ways of learning –besides R&D- are usually a prerequisite to those more complex ways of innovating. Thus, we claim that each one of the positions reached by firms in the gradient depend on the level of capabilities cumulated by firms along their path. Then, we claim that the greater the complexity of the firms' innovation profile, the better their innovative performance.

Therefore, our first hypothesis is that *the level of complexity of the innovation profile is associated with the accumulation of capabilities* (H1). We expect to find a positive relationship between profiles and the multiple dimensions of capabilities. We understand accumulation of capabilities as the aggregation of productive, absorptive (accumulated and potential), organisational and linkages dimensions (see Table 1, Appendix). H1 means that the cumulative process of capability development will show a positive relationship with the firm's profile. Then, the greater the accumulation of capabilities (in the five dimensions), the higher the probability of firms of having a formal R&D-based profile. This way, and similarly with the literature summarized in group 3, we assume that the search for technological and organisational improvements is an interactive process, that can begin in different areas of firms and simultaneously triggers similar processes in other ones (Kline and Rosenberg, 1989).

In a second step, we analyse the relationship between *firms' innovation profile and innovation results*. According to the literature discussed in section 2, multiple explanatory factors must be considered to understand the impacts of innovation activities that go beyond formal R&D. We start from the premise that among the group of firms non-performing R&D there are heterogeneous behaviours in terms of innovation results[1]. More specifically, we claim that not only formalised R&D profiles might have a positive correlation with innovation results, but also informal R&D profiles could be important to explain virtuous dynamics. In the same way, innovation efforts beyond R&D also constitute a differential element to explain the innovation outcomes.

Thus, our second hypothesis (H2) states that firms' innovation profile is positively associated to its innovation results. This hypothesis is based on the three streams of the literature reviewed in section 2. The first group provides empirical evidence about the positive impact of formal R&D on innovation results. Group 2 establishes a positive relationship between different combinations of innovation efforts and types of results. Finally, group 3 finds evidence on the association between firms' innovation efforts not focused on formal R&D and innovation results.

4. Data and empirical specification

4.1 Imperfect Competition

The database arises from the second wave of the "National Survey on Innovation and Employment" (in Spanish Encuesta Nacional de Innovación y

1 Hypotheses proposed in this paper are focused on innovation results and not on economeic performance. The available information does not allow testing the relation between firms' R&D profile and productivity because of the existence of endogeneity. The source of this endogeneity is the simultaneity between R&D profile and economic performance because the variables were surveyed for the same period of time. On the contrary, innovation results refer to the period immediately after firms carried out their innovation efforts.

Empleo, hereinafter ENDEI II), which is a survey similar to the European CIS and based on the Oslo Manual recommendations. It consists of almost 4000 Argentine manufacturing firms with more than 10 employees for the period 2014-16.

Similarly to Arundel et al (2007)[2], a categorical variable was built for the analysis of innovation profiles. It assumes four different possibilities: 0 if the firm does not perform any innovation effort (without IE), 1 for firms that perform any innovation effort but do not carry out R&D (IE without R&D), 2 for firms that perform R&D but do not have a formal area dedicated to those activities (informal R&D), and 3 for firms with an R&D lab (formal R&D).

To characterise firm's capabilities, five dimensions were considered: productive, absorptive (accumulated and potential), connectivity, and lastly, organisational dimension. These dimensions are composed by a set of indicators, summarised in the Table 1 of the Appendix. To integrate these indicators, principal component methodology was used, in order to have an estimation of the latent variable associated to the different proposed aspects since selected variables for each one of the dimensions are assumed to be correlated (and the reviewed literature supports that). The first component for each capability dimension was selected (correlated with the largest eigenvalue of the variance and covariance matrix). The use of this methodology is based on the idea that the explanatory factors of each capability dimension are systemic and complementary. In this regard, each factor's aggregation produces synergy at an aggregated level (Laursen and Foss, 2003). It is worth indicating that the five identified dimensions respond to a conceptual segmentation of the different aspects of the firm that, in practice, are intimately related. The contribution of this article lies in the methodological separation that allows observing different relations between these capabilities and the R&D profiles.

There is a long trajectory among evolutionary studies regarding the importance of each selected dimension of capabilities. Productive capabilities derive from Nelson and Winter's (1982) ideas of productive process improvements which result from the identification and resolution of problems that emerge from the firm´s regular operations. They are identified, among other dimensions, from quality assurance and continuous improvement systems which are assumed to allow the firm to improve its routines. These methods account for the accumulation and building of capabilities, as long as they require codification and integration of tacit knowledge that is generated within the framework of the firm´s daily operations (Bessant et al., 2001; Jensen et al., 2007).

The concept of absorptive capacity has a long trajectory in the literature. Cohen and Levinthal (1990) define it as the firm's ability to recognize the value

2 They have identified four methods of innovating: in-house R&D performers, contract R&D, creative non-R&D innovators, technology adopters (machinery acquisition).

of new information, assimilate it, and apply it to commercial ends. Firms need qualified human resources in order to successfully integrate complex technological knowledge. Absorptive capacities are usually estimated from the stock of qualified human resources, and the existence of personnel assigned to innovation activities. We consider that the stock of qualified human resources accounts for the accumulated absorptive capabilities at a particular moment (accumulated absorptive capabilities). We exclude measuring absorptive capacities based on personnel assigned to innovation activities given the fact that R&D activities are the variables we will analyse. We additionally include the possibility that an improvement on innovation profiles can be the result of systematic efforts in training. This means acknowledging that the firm's capabilities also relate to the management of learning processes (potential absorptive capabilities).

The analysis of organisational capabilities has been approached from the identification of post-taylorist or post-fordist ways of work organisation. These are flexible and dynamic ways of organizing the productive and commercial process, and are found to be associated with the presence of areas specialised in human resources' management and the search for systematic mechanisms of knowledge generation and circulation within the organisation (Jansen et al., 2005; Lundvall, 2006; Roitter et al., 2013). Empirical analyses of the role of the post-fordist organisational work practices show that these favour the development of innovation results and capabilities (e.g.: Escribá Carda et al., 2013; Laursen and Foss, 2003; Shipton et al., 2006).

Connectivity capabilities address the linkages of the firm with its environment. Once again following Nelson and Winter's (1982), firms modify and shape their environment as well as their environment modify and shapes them. In addition, as it is proposed by Cohen and Levinthal (1990), there is information and knowledge outside the firm that it can incorporate and acquire, but in order to do that the firm must have the needed skills to identify knowledge, agents and institutions relevant to the firm and to speak the same language (Barletta, Robert y Yoguel, 2011). These linkages usually configure knowledge networks, then it is important to also understand the reasons of the linkages (to train the personnel, to develop a need product, consultancy for R&D activities, among others).

Finally, a set of variables to account for innovation results were selected. Four different types of results of the innovation process were analysed: i) new products or/and processes, ii) marketing and/or organizational changes, iii) patents and iv) the ratio of new product sales to total sales. These are the usual variables to test results. The third variable (patents) accounts for the most radical form of innovation. Although the critics it has received as a measure of innovation results, there is still plenty evidence about the importance of patents as a key asset of firms (Griliches, 2007). The last variable accounts, to some extent, for innovation results and firms' market performance, in the sense that new products are expected to provide the firm with quasi-rents in the Schumpeterian sense.

4.2 Empirical Strategy

The relationship between capabilities and innovation profiles is estimated using a multinomial logistic model, given the non-ordinal nature of the dependent variable. In this type of models, a set of equations is proposed, and each profile is explained by a set of observable characteristics of the firm. Specifically, if *Cap* is defined as a matrix of nx5 dimension composed by the five capabilities dimensions of the firm, and if we define *Ctrol*, as a matrix of nxk dimension where each k-vector includes a control variable; the i firm's conditional probability to choose R&D profile j is:

$$p_{ij} = \Pr\left[y_i = j \mid \mathrm{Cap}, \mathrm{Ctrol}\right] = \frac{\exp\left(\beta_{cap}\mathrm{Cap}_{ij} + \beta_{ctrl}\mathrm{Ctrol}_{ij}\right)}{\sum_0^3 \exp\left(\beta_{cap}\mathrm{Cap}_{ij} + \beta_{ctrl}\mathrm{Ctrol}_{ij}\right)}, j = 0,1,2,3$$

Where β_{cap} captures the statistical association between each capability dimension and the category of the R&D profile taken as a reference. In turn, β_{ctrl} captures the effect of control variables (size, industry, FDI, exporting condition and capital goods investments).

To analyse the relationship between these R&D profiles and innovation results, the following model has been estimated:

$$IR_i = \alpha_0 + \alpha_1 ID_{ij} + \alpha_2 Ctrol_i + \in_i$$

Where the innovation results of the firm i, *IRi*, is measured in terms of: i) new products or/and processes, ii) new marketing and/or organizational processes, iii) patents and iv) the ratio of new product sales over total sales. In turn, firms' innovation results depend on the innovation profile and a group of control variables. Given the statistical distribution of each dependent variable, Probit models were estimated for the first three indicators and a Tobit model for the last one. In Table 2 of the Appendix, the variables used in the econometric exercises are synthetized.

A clarification is in order before moving forward. Given the nature of the database, the results should be read with caution as it is not strictly possible to establish the direction of causality (from capabilities to profiles or from profiles to capabilities, for example). The literature and previous evidence reviewed in section 2 suggest that there is strong causality between the variables we selected, but the results of the model cannot be read along these lines. While there are techniques to address the endogeneity mentioned above, such as the use of instrumental variables or the CDM models mentioned above, they have limitations. The identification of instrumental variables is problematic in itself, and they smooth out the existence of micro-heterogeneity, while it is not possible to ensure that they are unrelated to the dependent variable. CDM models require thinking of the innovation process as a linear dynamic of a succession of stages, which we discussed earlier in this paper. Therefore, the model will be estimated in the detailed version, even with the endogeneity constraints. The reading should always be done in terms of the relationship between variables (either positive or negative), and never in the sense of causality.

4.2 Descriptive Statistics

As shown in Table 2, the proportion of firms decreases as the innovation profile becomes more complex. In terms of size distribution, while smaller firms –less than 100 employees- tend to concentrate in less complex profiles (without IE and IE without R&D), larger firms -100 or more employees- are concentrated in more complex ones (formal and informal R&D). Only 6% of firms have foreign direct investments (FDI), a proportion that increases to 14% in the group of formal R&D, is 4% in the groups of firms with informal R&D, 8,16% in the group IE without R&D, and accounts for 4% for non-IE performers. Finally, from an industry perspective, firms from more technological intensive industries are overrepresented in informal and formal R&D groups.

Table 3 compiles the innovation results indicators according to R&D profiles. All the indicators considered tend to increase as the innovation profile becomes more complex. An interesting result for these statistics is that a relevant share of firms categorized as informal R&D has implemented new products or/and processes, although to a lesser extent than the ones labelled as formal R&D.

TABLA 2

DESCRIPTIVE STATISTICS

	Without IE	**IE without R&D**	**Informal R&D**	**Formal R&D**	**Total**
% of firms	35,10%	23,85%	25,85%	15,20%	100%
<100 employees	37,22%	23,85%	25,78%	13,16%	100%
>=100 employees	16,33%	23,80%	26,54%	33,34%	100%
% of firms with FDI	4%	8,16%	4,37%	14,30%	6,65%
Main industries	Food	Food	Other metal products	Chemical products	
	Textiles and wearing apparel	Textiles and wearing apparel	Food	Other metal products	
	Other metal products	Other metal products	Rubber and plastics products	Food	
	Printing	Rubber and plastics products	Furniture	Electrical machinery and apparatus	
		Leather	Machine-tools	Rubber and plastics products	
				Pharmaceuticals	

Source: Own elaboration based on ENDEI II. Weighted values.

TABLA 3

R&D PROFILE ACCORDING TO INNOVATION RESULTS

	IE without R&D	Informal R&D	Formal R&D	Total
New products or/and processes (% of firms)	54,68%	87,10%	88,32%	75,47%
Innovation in marketing or/and organization (% of firms)	36,53%	49,36%	62,35%	47,69%
Patents (% of firms)	5,83%	12,35%	16,47%	10,93%
New product sales/ Total sales	13,68%	14,74%	15,83%	14,7%

Source: Own elaboration based on ENDEI II. Weighted values.

5. Results

5.1 Relationship Between Innovation Profiles and Capabilities

Results confirm H1. Table 4 presents all results relative to the base category "without IE". Findings show that the four of the five capability dimensions are positively associated to the probabilities of different profiles of R&D. Furthermore, the coefficients justify the pertinence of the R&D profiles, given the different relationships between capabilities and pertaining to a R&D profile. Results of the multinomial logistic model suggest that productive, organisational and connectivity capabilities are the main differential elements between firms with less complex profiles (without IE versus IE without R&D) (column I)[3]. The estimated probability coefficient (i.e.: the relative risk ratio) is strongly higher in the first dimension of capabilities compared to the other two. In particular, the model suggests that being the structural characteristics equal, as connectivity capabilities increase, the probability that firms carry on efforts in innovation but not R&D is a 64% higher in relation to the possibility of not carrying on any effort. This probability decreases to 17% in the case of productivity capabilities and to 10% for organisational ones. In simpler words, this implies that in order to "start moving forward" into more complexes innovation profiles, firm must have accumulated capabilities regarding quality management, work organization and networking with institutions from de innovation system.

Once the "entry threshold" is overcome, related to a minimum level of productive, organisational and connectivity capabilities, the model shows that the capabilities needed to move towards the group of informal R&D firms are associated to four of the five dimensions considered: productive, accumulated absorptive, organisational and connectivity (column II). More precisely, the ratio of probabilities in relation to firms that perform IE but not R&D indicates that the probabilities that a firm to perform informal R&D are 9%, 11% and 13% higher in response to increases in organisational, accumulated absorptive, and connectivity capabilities respectively, and boost a 28% when productive capabilities overcome the median level of the database.

Finally, the probability that a firm had internalised R&D activities through the creation of a formal department (in relation to the probability of performing informal R&D) is positively correlated with productive and connectivity capacities, with a much higher influence of quality management level (column III). This is to say, reaching the informal R&D profile is already related with a change in the level of capabilities. In particular, higher productive capabilities are required, and to a lesser extent connectivity ones.

3 The complete results are presented in Table 3 of the appendix.

TABLA 4

DIMENSIONS OF CAPABILITIES AND R&D PROFILES

	Total firms		
	Without IE to EI without R&D	**EI without R&D to informal R&D**	**Informal R&D to formal R&D**
	(I)	**(II)**	**(III)**
Potential absorption			
Productive	(+1.17)***	(+1.28)***	(+1.19)***
Organisational	(+1.10)***	(+1.09)**	
Accumulated absorption		(+1.11)*	
Connectivity	(+1.64)***	(+1.13)***	(+1.10)***
Control variables			
Industry dummies	YES	YES	YES
Size dummies	YES	YES	YES
FDI		***	***
Exports	***	**	***
Capital goods	NO	***	
Number of obs.	2539	2539	2539

Note: *, **, and *** indicate significance at 10%, 5%, 1% respectively. In brackets: risk ratio concerning the multinomial logistic model. Source: own elaboration based on ENDEI II.

In relation to the literature, outcomes points, on the one hand, to the systemic nature of innovation in terms of innovation activities and disseminated knowledge all along the organisation. In terms of Nelson and Winter (1982) firms need to develop different type of capabilities to improve routines, identify newer ones and, especially, successfully confront the process of competition. A firm that has not performed innovation activities and then radically moves into formal R&D processes would require drastic changes in its productive, organisational, and innovative activities in general. It would also require have accumulated dynamic capabilities, that would have pointed to the need to set a new strategy, and the development of ordinary capabilities, to lead it forward (Nelson, 1991). Innovation is the outcome not only of investments performed by the firms in the development of products, processes and organisational practices, but also of the construction of capabilities to progress and move forward with such a projects, which also requires the firm to link with the different institutions and agents from de innovation system (e.g.: Cohen and Levinthal, 1990; Teece and Pisano, 1994).

On the other hand, and assuming that R&D activities are a good proxy of more complex innovation projects, results show the relevance of studying less formalised innovation processes, as is the case of firms that carry out informal R&D. The sudden leap in terms of capabilities is produced precisely between firms that do and do not perform R&D (regardless the level of formalization). Moving towards less formalised R&D schemes represents a great improvement upon skill levels, knowledge, and competences. This matches the aforementioned literature according to which R&D only captures a small part of innovative processes, usually associated with high technological intensity firms as well as larger in size. In contrast, an important proportion of firms bases its innovative activity on less formal investments and even quite distinct from R&D, but equally relevant for its economic performance (e.g: Santarelli and Sterlacchini, 1990; Som et al., 2013).

Finally, it is worth to mention the relevance of accumulated over potential absorption to move towards a profile of greater complexity in terms of innovation activities. Even when potential absorption capabilities are demonstrated to be relevant to carry out innovation efforts, and obtain innovation results, they are not required for firms to change of innovation profile. In this regard, productive and connectivity capabilities are the most required ones to move to more complex innovation profiles.

5.2 Relationship Between R&D Profile and Innovation Results

Results regarding the relationship between R&D profile and firm´s innovation results are presented in Table 5. These estimations were run for a smaller number of firms given that firms that did not perform innovation efforts were not surveyed about results. Thus, the first category of innovation profile was drop from the analysis (without IE). According to the binary definition of the dependent variables three probit models were estimated, one for each one of the dependent variables: i) product and/ or process innovators; ii) marketing and/ or organization innovators and, iii) patents. In addition, a tobit model was estimated for the weight of new products in total sales, which ranges from 0 to 100.

Results of the estimation of new products and/or processes show that the passage from EI without R&D to informal R&D increases the probability of obtaining innovation results by 12%. On the contrary, moving from informal to formal R&D is not significant, meaning that pertaining to the formal R&D group is not correlated to higher probabilities of obtaining new processes or products, compared to the ones that carry out informal R&D.

Secondly, first column of Model II shows that moving from EI without R&D to informal R&D increases the probability to generate innovations in marketing and organization in 8,2%. In addition, different from the above case, moving from informal to formal R&D is significantly and positively associated to the probability of developing organizational or marketing innovations, which reaches 11,6% (column 2 of Model II). Thirdly, Model III shows that moving from informal to formal R&D significantly increases the probability of obtaining patents (+9,5%). Thus, results show that while informal R&D is a critical threshold to increase the probability of obtaining product, process, organization and marketing innovations, formal R&D is key to get patents. This result is consistent with the higher complexity of the profiles in terms of the possible outcomes of the innovation process, and to the descriptive statistics analyzed in section 4.3.

Finally, Model IV shows that the weight of new products on total sales increases when R&D profile becomes formal, and is not significant in the passage from EI without R&D to informal R&D.

All in all, hypothesis 2 is supported by results.

TABLA 5
R&D PROFILES AND INNOVATION RESULTS

	New products and/or processes (I) PROBIT		Marketing and organizational changes (II) PROBIT		Patents (III) PROBIT		% of new products on total sales (IV) TOBIT	
Base category	**IE without R&D**	**Informal R&D**	**IE without R&D**	**Informal R&D**	**IE without R&D**	**Informal R&D**	**IE without R&D**	**Informal R&D**
Informal R&D	0.121***		0.0823***		0.0306**		3.0136	
	(0.0195)		(0.0266)		(0.0128)		(2.2334)	
Formal R&D	0.143***	0.0219	0.198***	0.116***	0.125***	0.0946***	5.839***	2.825***
	(0.0198)	(0.0154)	(0.0280)	(0.0268)	(0.0173)	(0.0183)	(2.3201)	(1.3355)
FDI	0.0265	0.0265	-0.0576	-0.0576	-0.0508***	-0.0508***	2.6642	2.6642
	(0.0226)	(0.0226)	(0.0361)	(0.0361)	(0.0174)	(0.0174)	(1.7030)	(1.7030)
Industry	YES	YES	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES	YES	YES
Number of obs.	2054	2054	2054	2054	2598	2598	2207	2207

Note: *, ** and ***indicate significance at 10%, 5% y 1% respectively. In models I, II, and III marginal effects are reported. Standard errors in parentheses. Source: Own elaboration based on ENDEI II.

6. Conclusion

This article analysed the relationship between the level of firms' capabilities, innovation profiles and innovation results. H1 stated that the level of complexity of the R&D profile is associated with the accumulation of productive, absorptive, connectivity and organizational capabilities. H2 proposed that innovation results -in terms of new products or processes, new forms of marketing and organization, patents and the share of new product sales on total firms' sales- increase with the complexity of R&D profile.

Results of the empirical exercise suggest that performing formal R&D is positively associated with the existence of greater productive and connectivity capabilities. Moreover, greater capabilities are required in all the dimensions proposed -except for potential absorptive- for firms performing informal R&D in relation to firms performing innovation efforts without R&D. Thus, results support H1 and provide an approximation to the idea of a threshold of capabilities firms have to overcome in order to start doing informal R&D activities –and not just a funding-related market failure.

Similarly, results also confirm hypothesis 2. They highlight that the development of both formal and informal R&D activities is associated with higher probabilities of obtaining innovations. However, some differences are found depending on the considered dependent variable. Informal R&D seems to be a necessary threshold for the introduction of new product, process, marketing, and organization innovations and patents. Formal R&D performing firms have higher probabilities of obtaining patents, marketing and organization innovations, as well as for the share of new products on total sales.

These results contribute to the debate on the scope of public policy actions aimed at promoting R&D activities. On the one hand, they account for the importance of acting on different dimensions of capabilities as a mean to promote more complex R&D processes. On the second, results show the need to account for the micro-heterogeneity and differentiate policy actions according to the firm's level of capabilities. Therefore, the results of this paper suggest that non-R&D innovators should be considered within the innovation policy target in order to avoid the policy bias towards STI based innovation in high technological intensity industries. Thus, it is relevant to think about innovation policies in a wider sense, so that it addresses firm's restrictions to innovate in terms of the different levels of capabilities.

Regarding the literature, our results show the importance of acknowledging micro-heterogeneity and the non-linearity of the innovation process. Even though they re-confirm the importance of R&D formal activities in terms of innovation results, they also showed the relevance of other ways of performing innovation efforts, that could be equally important for the firm. At the same time, the association between R&D and capabilities call the attention on the relationship between causes and consequences. If R&D activities depend on the accumulation of capabilities, the low levels of R&D investments among firm's from developing countries is a symptom of low capabilities and it is not the cause of the underdevelopment of the productive structure (evidence at the country level seems to point that way – see Kim and Lee (2015)). In this respect, more research is required to shed light on the order of events between R&D activities and capabilities –which most probably co-evolve.

Finally, and connected to the last sentence, the limitations of this article are related to the nature of the available *cross-section* information, which restricts the possibility of analysing casual relationships and the estimation on leaps between R&D profiles and capabilities. In this respect, new survey waves will allow to approach these issues with panel analysis techniques, which will allow deepening the research on the relationship between capabilities, innovative processes, and innovation results of Argentine manufacturing firms.

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Appendix

TABLA A1
DIMENSIONS AND VARIABLES USED FOR THE ANALYSIS OF PRINCIPAL COMPONENTS

Dimension	Variables	Measure Unit
I. Productive	Productive process´ critical characteristics specification	0 if it is not being used / 1 if it is being used (one binary variable for each type of activity)
	Traceability	
	Equipment for process improvement	
	Tools for systems of continuous improvement	
	Routines to orientate activities of design	
	Specific tools for project management	
II. Accumulated absorptive capacity	% of personnel with university degree to total employment	0 to 100 in percentage points (one continuous variable for each type of personnel)
	% of engineers to total personnel with university degree	
	% of personnel with technical qualification to total employment	
III. Potential absorptive capacity	Quantity of functions of the area responsible for organising training activities (diagnosis, planning, methodology design, definition of working hours, careers plans, and evaluation practices)	0 to 7
	Percentage of personnel trained at a hierarchical level	0 to 100 in percentage points (one continuous variable for each type of level)
	Percentage of personnel trained at a supervisor level	
	Percentage of personnel trained at a non-hierarchical level	
	Number of provided courses (management, organisation and enterprises direction/administration; strategic planning; scientific and technical update; commercial management of logistics and distribution; informatics)	0 to 7
IV. Organizational capacity.	Staff rotation	0 if they do not rotate / 1 if they do rotate
	Degree of personnel´s autonomy (response to problems at the workstation: calling the supervisor, solving and communicating the supervisor, solving without communicating , solving and documenting)	0 to 3
	Personnel involvement in HR activities (non-participation, efficiency evaluation, improvement plan and evaluation, self-evaluation and implementation of the new improvement suggestion, and so on)	0 to 3

V. Connectivity capacity	Set of binary variables for linkage with a firm, university, S&T public institution or a consultant.	0 if the firm was not linked / 1 if the firm was linked (one binary variable for each type of institution/agent, in total 4 variables)
	Set of binary variables for linkage to personnel training, R&D, test and trials, technological exchange, organisational changes or improvements, product or process development or improvements, industrial design or engineering activities	0 if the firm was not linked to the purpose / 1 if the firm was linked to the purpose (one binary variable for each type of purpose, in total 7 variables)

TABLA A2

VARIABLES USED IN THE ECONOMETRIC MODEL

Variable	Definition	Measure Unit
Innovation profile	Categorical variable that captures the innovative efforts (IE) of the firm	0 without IE / 1 IE without R&D / 2 informal R&D / 3 formal R&D
Firm´s Capabilities		
Productivity Capability	First principal component associated to the efforts in quality management.	Variable centred in 0 that takes values in all the range of possibilities.
Accumulated absorptive capacity	First principal component associated to the Human Resources qualification.	
Potential absorptive capacity	First principal component associated to the Human Resources training.	
Organisational Capability	First principal component associated with the work organisation.	
Connectivity capability	First principal component associated to links with different types of institution and with different objectives.	
Innovation results		
New products and processes	% of firms that introduced new products and/or processes in 2012	0 No/ 1 Yes
Marketing and organizational changes	% of firms that introduced marketing and/ or organizational changes in 2012	0 No/ 1 Yes
Patents	% of firms that patented in 2012	0 No/ 1 Yes
% of new products on total sales	Ratio between new products sales and total firms sales in 2012	Continuos variable that ranges between 0 and 100
Control Variables		
Size	Size according to employment level and sales (2010).	0 Small / 1 Medium / 2 Large
Industry	Industry classification according to ISIC Rev.3.1	
Origin of capital	Existence of FDI (2010-12)	0 No /1 Yes
Exports	Exports (2010-12)	0 does not export / 1 does export
Capital goods	Proportion of total expenditures allocated to buying equipment and machinery (2012)	From 0 to 100%

TABLA A3

RELATIONSHIP BETWEEN CAPABILITIES AND R&D PROFILES – MULTINOMIAL LOGISTIC REGRESSION

	Total firms		
	Without IE to EI without R&D	**EI without R&D to informal R&D**	**Informal R&D to formal R&D**
	(I)	**(II)**	**(III)**
Potential absorption	(+1.06)	(-0.94)	(+1.01)
Productive	(+1.17)***	(+1.28)***	(+1.19)***
Organisational	(+1.10)***	(+1.09)**	(-0.93)
Accumulated absorption	(+1.07)	(+1.12)*	(+1.10)
Connectivity	(+1.64)***	(+1.13)***	(+1.10)***
Control variables			
Industry dummies	YES	YES	YES
Size	YES	YES	YES
Medium	(+1.18)	(-0.96)	(+1.46)***
Large	(-0.88)	(-0.86)	(+1.82)***
FDI	(+1.18)	(+2.6)***	(-0.59)***
Exports	(+1.79)***	(+1.35)***	(+1.63)***
Capital goods	NO	(-0.99)	(+1.00)
Constant	(-0.91)	(+0.51)**	(-0.30)***
Number of obs	2539	2539	2539

Note: *, **, and *** indicate significance at 10%, 5%, 1% respectively. Risk ratio concerning the multinomial logistic model. Source: own elaboration based on ENDEI II.