Beyond formal R&D: the role of capabilities in innovation profile. The case of Argentinean manufacturing firms.

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Abstract

The purpose of this article is to analyse the relationship between different research and development (R&D) profiles, capabilities, and economic performance of manufacturing firms. The starting premises of this purpose are that most of firms not performing in-house formal R&D -92% in the case of Argentinean manufacturing firms- are a highly heterogeneous group in terms of innovative behaviour, capabilities and economic performance. Thus, we propose to study firms' "R&D profile" not as a binary indicator but as a gradient that accounts for formal R&D, informal R&D, non- R&D performing firms and without innovation efforts. Then, the relation between this profile and four dimensions of firms' capabilities -the productive, organizational, accumulated and potential absorptive capacities-, is explored. Accordingly, the study of how these profiles impact on firm´s economic performance -productivity, employment and the probability of exporting- is then carried out. The empirical evidence is based on Argentinean manufacturing firms and the data arises from the National Survey of Innovation and Employment Dynamics composed by more than 3000 observations for the period of 2010-12. Results suggest that as the R&D profile becomes more complex, higher levels of capabilities are required. Likewise, this association is also related to the firms' economic performance: formal and informal R&D profiles are associated with higher levels of productivity and exports.

Key Words: R&D profile, capabilities, innovation, performance.

1. Introduction

From the beginning of the evolutionary theory of innovation, firm´s innovative behavior depends on multiple sources of knowledge and learning that go beyond formal R&D (Dosi, 1988; Freeman, 1974, 1995; Kleinknecht, 1987; Nelson and Winter, 1982; Pavitt, 1984, 2002; Rosenberg, 1982).

Nevertheless, most contributions, mainly at the empirical level, consider that formal R&D plays a decisive role in explaining innovation efforts and results. Much of this literature gives a secondary role both to the rest of innovative efforts -acquiring capital goods, quality assurance, training, engineering and design- as well as to firms' capabilities. Endogenous growth models (Aghion and Howitt, 1999; Romer and Chow, 1996; Romer, 1990), CDM model (Crépon et al., 1998) and some of their representative contributions associated (Castellacci, 2011; Hall et al., 2010; Notten et al., 2017) and many of the empirical works carried out from the theory of innovation in developing and developed countries (Chudnovsky et al., 2006; Hall and Mairesse, 1995; Verspagen, 1995) can be found in the literature.

This wide empirical literature is based on the availability of information arising from formal R&D indicators, largely based on the recommendations of Frascati and Oslo manuals (OECD, 2002, 2005). In this regard, the traditional definitions of R&D followed by these manuals emphasize the systematic search for new knowledge from basic and applied science, and less attention is placed on experimental development processes (Arundel et al, 2007). This can be partially explained because these experimental processes are more difficult to capture through surveys due to they are not necessarily carried out within formal R&D labs. Although from the evolutionary theory these informal processes of problem-solving and generation of knowledge are recognized as key elements in generating innovations, from public policy the focus has been placed on the promotion of formal R&D. Hence, in many countries, public policy has tended to support formal R&D activities that led to product innovations, narrowing the scope of this policy to high technological intensity industries (Thomä, 2017).

As a result, statistical indicators and STI policy were biased towards the learning mode based on scientific and technological knowledge that emerges from R&D activities -STI learning-. On the contrary, less attention was paid to the role of learning based on experience and non-science-based sources of knowledge –DUI learning- (Jensen et al, 2007). This kind of learning process is particularly relevant in: i) non R&D-performers, ii) firms with a lower degree of novelty and formality of its innovation efforts, iii) low and medium technological intensity industries and iv) small and medium size firms (Hirsch-Kreinsen, 2015). To a greater or lesser extent, the literature that focuses only on the indicators of formal R&D underestimates the relevance of non R&D-performing innovators.

In this context, some scholars –mainly from 2000's- have claimed the need to complement the indicators about the existence of R&D labs with others that account for different ways to organise innovative activities and the process of capability building (Bender and Laestadius, 2005; Hirsch-Kreinsen, 2008; Rammer et al., 2008; RICyT, 2000; Santamaría et al., 2009; Santarelli and Sterlacchini, 1990; Yoguel and Boscherini, 1996, among others). Firms, which this new literature calls non-R&D performing innovators represent a significant proportion in most countries. This involves half of European innovative firms, 36% in Belgium, 46% in Germany, 55% in Czech Republic, 60% in Spain, 65% in Romania and 79% in Bulgaria (Arundel, Bordoy, et al., 2007; Rammer et al., 2008; Thomä, 2017).

This set of evidences on the relevance of the non- R&D innovators are some of the motivations of this article. Thus, we propose that besides R&D and non-R&D performers there is a set of heterogeneous firms carrying out other type of innovation efforts. In this context, we propose to explore firms' profiles of innovative behaviors that account for different situations that go beyond the traditional binary indicators. Following Thomä (2017), the patterns of knowledge creation that lie behind the innovative behavior of non-R&D innovative firms are still a "black box" that needs to be investigated in both developed and developing countries. So, informal R&D activities, quality assurance, continuous improvement systems, human resources training, and work organization are all relevant activities to fully comprehend firms' innovative efforts along with their economic performance (Arundel, Lorenz, et al., 2007; Clausen et al., 2011; Fraga et al., 2008; Frenz and Lambert, 2009; Yurtseven and Tandoğan, 2012), for some examples of different firm classifications based on other innovation indicators besides R&D). This perspective involves the assumption that in some cases and according to the specialization profile (as the predominance of low and medium technological intensity industries), innovation is incremental and widespread within organisations. In order to contribute to open this black box, this article identifies the existence of a gradient of intermediate situations between formal R&D and the absence of innovative efforts. In particular, we claim that innovative efforts beyond formal R&D could be equally likely to trigger virtuous innovation processes.

We also propose to study which kind of skills and capabilities apart from STI learning explain firms' R&D profile. Our 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 and interactive learning processes (Jensen et al., 2007; Nelson and Winter, 1982). Therefore, we propose that R&D profile is the consequence of the development of these capabilities dimensions. Then, in order to explore in what extent firms' R&D profiles are associated with economic performance, we analyse the relation between them and firms' productivity level, employment growth rate and export behaviour.

The rest of the article is organized as follows: section two presents the research analytical framework and background that leads to define the hypotheses. In section three the database and the methodology are described. In section fourth descriptive statistics are presented as well as the variables that have been used. The fifth section presents the results. Finally, some conclusions are drawn in section six.

2. The black box of the innovation process.

In Evolutionary theory of innovation there is a broad consensus that capability building is a cumulative and multidimensional process that emerge from multiple activities that are not only reduced to R&D labs (Freeman, 1974; Nelson and Winter, 1982; Pavitt, 1984). Under this framework, Nelson and Winter (1982) developed the concept of organizational routines to introduce their ideas about innovation process. According to these authors, the process of innovation equally corresponds with the search of improvement in firm´s routines and the emergence of new ones. Then, 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 emerge in the operation of the firm (innovation in routines). This latter way of innovation acquires more informal characteristics, requires the cooperation of agents that are widespread in different areas of the organisation, and complements formal activities of R&D performed by firms. Later on, this evolutionary approach was complemented with a greater conceptualisation of capabilities, with the concepts of "absorptive capacity" (Cohen and Levinthal, 1990) and "dynamic capabilities" (Teece and Pisano, 1994).

Departing from this literature, innovations derived from multiple factors that go beyond the activities developed in R&D labs and include new combinations of routines and solutions achieved both inside and outside the firm. These complementary dimensions to R&D are not considered by traditional indicators because the belief that innovations not based on R&D are not relevant. The widely diffused OECD's taxonomy is based on these indicators, which classify industries according to the R & D/sales ratio. On the basis of this taxonomy high R&D intensity is associated with high innovativeness, as if R&D was not just one possible way in which innovativeness can be attained (Kirner et al., 2009). Hence, the heterogeneity of non-R&D performers within each industry is not considered, nor is the fact that firms that do not perform R&D can be found in all industries (Kirner et al., 2009). This "binary" literature (performing versus non-performing R&D) assumes homogeneity and "typical" innovation patterns in non-R&D-intensive firms.

Therefore, when the study of innovation is reduced to the analysis of formal R&D, it is only possible to study the behaviour of a fraction of the productive structure, usually based on knowledge-intensive activities. This segment involves firms with high technological capabilities, and innovation rates, both in developing and developed countries. However, this is a small proportion of the productive structure that puts aside 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. 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). At the end of 80s, Kleinknecht (1987) have already stated that OECD's contributions about measuring R&D in SMEs were biased because they did not include informal activities generating innovation results.

Recent contributions, mainly developed in the EU, have found that an important proportion of innovative firms from developed countries do not perform internal R&D activities and have emphasised the non-centrality of formal R&D as a mechanism of innovation (Arundel, Bordoy, et al., 2007; Bender, 2006; Hirsch-Kreinsen et al., 2006)[1]. The group of non-R&D-performing innovators is heterogeneous and the main sources of knowledge for innovation originate in external labs, customers, and suppliers. For UE countries, Bender and Laestadius (2005) have found that in low- and medium-tech sectors, 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. Additionally, based on German innovation surveys, Rammer et al. (2008) state that, particularly in the case of SMEs, R&D labs can be substituted by different internal capabilities associated with human resources management, work organisation, and the search of external sources of innovation. Kirner et al (2009) suggest that experience-based, practical knowledge and distinct customer-related competences are a key source of innovation for non-R&D-performing and non- R&D intensive firms across all sectors of the German economy. Likewise, Santamaría et al. (2009) found that among medium and low technological intensity Spanish firms, innovation activities do not depend on efforts of formal R&D but on other activities such as design, advanced machinery, training, and external sources of information. In the case of Italian firms, Santarelli and Sterlacchini (1990) stress that informal activities of R&D widespread within the organisation represent an important proportion of total R&D that SMEs perform. Some contributions related to this debate can also be found in Latin America. In fact, some Latin American scholars have stated that in developing countries the level of capabilities is as relevant as R&D activities (Suarez, 2015; Sutz, 1999; Yoguel and Boscherini, 1996) Suarez, 2015). From a methodological perspective, the contributions made from the RICyT (Ibero-American Network on Science and Technology Indicators) about the importance to account for new indicators of innovation activities beyond R&D led to the publication of the Bogotá Manual in 2001. The manual considers that different performances of firms lie in the innovation process rather than in the results. From this perspective, when survey about innovation at the firm level, a broad set of innovation efforts and firm's capabilities and linkages are more relevant than the results achieved[2].

Essentially, the results of innovation surveys in Latin America reveal the need to go forward in the identification of innovation processes not centred in R&D. In Argentina, only 8% of the manufacturing firms declared having a R&D lab in 2012, which contrasts the 60% that claimed having done innovation activities (MINCyT, 2015). In Brazil, while 28% of the manufacturing firms did some innovation activity during 2011, only 3.7% declared having done activities of R&D in a continuous

[1] Following the "Innobarómetro", new questions were introduced to evaluate the importance of intermediate situations between not performing innovation efforts and having formal R&D labs. Among the new queries, they ask if these types of firms reached innovation results without R&D lab, what were the sources of knowledge that enabled these results to be achieved and which mechanisms have allowed firms to make changes in products, processes, marketing and organization (Arundel et al, 2008).

[2] The usefulness of these indicators was such that in its 2005 revision, the Oslo manual incorporated much of the recommendations made by the Bogotá manual.

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 and service firms declared having performed R&D activities between 2010-12, while more than 20% made efforts in innovation (ANII, 2015). In Mexico, while 6.1% of the manufacturing firms had R&D labs in 2012, around 15% declared having introduced new products or processes (ESIDET-MBN, 2012). Summing up, in different countries of this region 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.

In this context, innovation efforts and the learning processes associated to them appear as a relevant field of study to explain firms' behaviour. The learning processes involve the combination of knowledge, both codified and tacit, that constitutes a key component to explain firms' innovative dynamic and economic performance. This component, which is not captured by traditional R&D indicators, has been highlighted by Malerba and Orsenigo (1997), Lundvall (2007), and Jensen et al. (2007), among others. According to the later, given the non-linear nature of the processes of capability building, modes of learning centred on doing, using and interacting (DUI) are a necessary condition for the emergence of forms based on the science, technology and innovation (STI), 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). Box 1 summarizes the main contributions about formal and informal modes of innovation.

Box 1 Summarize of the literature.

	Recent contributions (after 2000s)	Old contributions (until 1999)
Non R&D innovative firms literature: theoretical perspectives	Som and Kirner, 2015; Thoma 2017; Arundel et al 2008; Hirsch-Kreinen, 2015;	Freeman 1974 and 1995; Nelson and Winter, 1982; Rosenberg, 1982; Pavitt, 1984; Dosi, 1986; Kleinknecht, 1987;
Opening the black box of non R&D-performing innovators: DUI mode of learning and developing of capability building.	Bender and Lastedius, 2005; Hirsh-Kreinen 2008 y 2015; Rammer et al 2008 ; Santamaría et al, 2009 ; Thoma 2017; Kirner, Kinkel and Jaeger, 2009; Arundel et al 2008; Kirner and Som 2015; Lundvall 2007; Jensen et al, 2007; Ricyt, 2000; Santa María et al, 2009.	Santarelli and Starlachini 1990; Kleinknecht 1987; Yoguel and Boscherini, 1994; Malerba and Orsenigo 1997
Non R&D-performing innovators vs formal I&D performing firms (including patents)	Kirner et al, 2009, Som, 2012 ; Wydra and Nuser, 2015; Neuhausher and Frietsch, 2015;	
Bias on innovation policy	(Bender, 2006; Hirsch-Kreinsen et al., 2006), Pilot Project (EU)	

2.1. R&D profiles and firms' capabilities

Starting from the theoretical and empirical evidences discussed above, this article proposes to study what we call "R&D profile" as a gradient that includes firms that do not carry out innovation efforts, firms that do perform efforts but without R&D, firms that perform informal R&D, and firms that perform formal R&D via the existence of labs exclusively dedicated to those activities. Likewise, it is claimed that the greater the complexity of R&D profiles, the better the economic performance of the firms. In this context, we stress that each of the positions reached by firms in the gradient depends on the level of development of capabilities accumulated by firms along their path dependence.

Our first hypothesis is that *the level of complexity of the R&D profile is associated with the accumulation of capabilities* (H1). We expect to find a positive relationship between R&D profiles and the multiple dimensions of capabilities: productive, absorptive and organizational ones. Thus, 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 areas (Kline and Rosenberg, 1989).

The concept of productive capabilities is derived 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 empirically approached, among other dimensions, based on quality assurance activities, which are assumed allow the improvement of the firm´s routines and the development of innovative processes. 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 (p.e.: Bessant et al., 2001; Forrester, 2000; Jensen et al., 2007).

The absorptive capacity idea has a long trajectory in the literature. Cohen and Levinthal (1989, 1990) define it as the firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends. The authors argue that to integrate complex technological knowledge successfully, the firm must have qualified human resources among their staff. These resources should be proficient at their own particular work field, and be familiarised with the idiosyncratic special needs, organisational procedures, routines, complementary competences and external relationships of the firm.

For the empirical study, absorptive capacities are estimated from the stock of qualified human resources, and the existence of personnel assigned to innovative activities. We consider that the stock of qualified human resources account for the accumulated absorptive capabilities at a particular moment (accumulated capabilities). We additionally analyse the possibility that an improvement on R&D profiles can be the result of systematic efforts in training. This is to say that the firm´s capabilities also relate to the management of learning processes (potential capabilities)[3].

Related to organisational capabilities, authors like Langlois (2003) point out that according to recent competition patterns associated to global value chains, they are at the centre of the process of creative destruction and generation of quasi-rents. According to Penrose (1959), the firm´s dynamics are explained by the relation between physical and human resources, and the way they are organised. Hence, organisational capabilities represent the continuous decision making process regarding production, accumulation, and the assignment of different resources of the firm. From a micro perspective, 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).

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). For different countries, evidence shows a positive impact of the

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[3] We exclude measuring absorptive capacities based on personnel assign to innovation activities given the fact that R&D activities are the variables we will analyse.

introduction of new recruitment, teamwork, and rotation practices on innovation (Jiménez-Jiménez and Sanz-Valle, 2008; Shipton et al., 2006).

In summary, we understand accumulation of capabilities as the aggregation of productive, absorptive (accumulated and potential), and organisational dimensions. Following H1, the cumulative process of capability development will impact on the firm´s R&D profile. Thus, the greater the accumulation of capabilities (in the four dimensions), the higher the probability of firms of having a formal R&D profile.

2.2. R&D profiles and economic performance.

There is a relevant empirical literature that analyses the relationship between R&D and performance, whether in terms of productivity (Crépon et al., 1998; Lööf et al., 2017; Notten et al., 2017), exports (Castellani and Zanfei, 2007; Landesmann and Pfaffermayr, 1997; Schlegelmilch and Crook, 1988; Verspagen and Wakelin, 1997; Wakelin, 1998) and employment (Pianta, 2005; Vivarelli, 2014). Within this literature, some scholars have argued that R&D expenditure, usually used as a proxy of innovation efforts; do not capture innovation impact properly. Lefebvre and Bourgault (1998) have not found positive effects of R&D intensity on exporting, while some other indicators like the share of scientific employees or external R&D cooperation proved to be significant. In a similar perspective, some scholars show that in some European countries, there are no significant differences in the productivity between R&D and non-R & D innovators (Arundel et al, 2008; Kirner et al 2007, 2009; Rammer et al, 2008; Som et al, 2013).

According to the background discussed above, multiple explanatory factors must be considered to understand the results and impacts of innovation activities that go beyond formal R&D. Thus, we start from the premise that among the group of firms non-performing R&D it is possible to find heterogeneous behaviours in terms of economic performance. More specifically, we claim that not only formalised R&D profiles have a significant impact on the economic dynamics of firms, but also informal R&D profiles are important to explain virtuous dynamics. In the same way, innovation efforts beyond R&D also constitute a differential element to explain the performance. Thus, as hypothesis 2 we claim that *firms' R&D profile is positively associated to its economic performance in terms of*:

H2.a: labour productivity level;

H2.b: probability of exporting;

H2.c: employment growth.

The underlying argument behind H2.a is that more complex R&D profiles are associated to a better economic performance given the differential capability (*à la* Penrose). Likewise, these should be associated with higher probabilities of success in the innovation process, with the consequent impact on the firm´s levels of productivity and the possibility to access to extraordinary benefits (*à la* Nelson & Winter).

H2.b is based on the idea that more complex R&D profiles lead to the development of dynamic competitive advantages and accumulation of capabilities that derive in successful exporting processes. In addition, the performance of R&D activities that lead to the development of more technologically complex innovations favour the emergence of absolute advantages associated both, to cost decrease and to new processes and products development, while accessing external markets.

Finally, H2.c suggests that more complex profiles of R&D associated to larger capabilities allow the firm to increase the level of employment as a consequence of larger market shares. This is, the complexity of the R&D profile allows firms to expand their activities, and thus improve the levels of employment[4]. Neo-Schumpeterian literature has explored the relationship between innovation and employment by distinguishing the effect on the employment of both R&D and innovation embodied efforts.

These two efforts “may imply different effects regarding employment, with R&D mainly correlated with labour friendly product innovation and embodied technological change with labour-saving process innovation” (Vivarelli, 2014: p. 132). Based on these arguments, and considering that a more complex profile involves adding R&D efforts to the embodied innovation efforts, we expect to find positive effects on employment in more complex profiles[5].

3. Data and Empirical Specification

3.1 Variables

The database used in this article comes from the National Survey of Innovation and Employment Dynamics and consists of 3000 Argentine manufacturing firms with more than 10 employees for the period of 2010-12. The CIS-type questionnaire collected information about innovation activities and results, economic performance, and capabilities, along with traditional structural variables. In addition to in-house R&D, the survey collected information on the following activities: external R&D, acquisition of capital goods, hardware, software, training, consultancy, engineering, technological transference and industrial design.

For the analysis of R&D profiles, a multinomial variable was built. This variable assumes four different possibilities: 0 if the firm does not perform any innovation effort (without IE), 1 if the firm performs some effort but does not carry out R&D (IE without R&D), 2 if the firm performs R&D activities but does not have a formal area dedicated to those activities (informal R&D), and 3 if the firm has an R&D lab (formal R&D).

To characterise firm´s capabilities, four dimensions were considered: the productive dimension, the absorptive dimension (accumulated and potential), and lastly, the organisational dimension. These dimensions are composed by a set of indicators, summarised in Table 1. To achieve the integration of these indicators, the principal component methodology was used, in order to have an estimation of the latent variable associated to the different proposed aspects. In this direction, the first component was selected and correlated with the largest eigenvalue of the variance and covariance matrix, built for each dimension arising out of a set of proxy variables. 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 four 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.

[4] Literature has deeply studied the relationship between innovation and employment with mixed results (for a review of the literature see Vivarelli, 2014).

[5] The relationship claimed by the hypothesis requires that the positive effect on employment derived from R&D more than compensate the negative effect coming from the technological change embodied on the acquisition of capital goods.

Table 1. Dimensions and variables used for the analysis of principal components.

Dimension	Variables	Measure Unit
I. Productive	Specification of raw materials and critical inputs	0 if it is not being used / 1 if it is being used
	Productive process´ critical characteristics specification	
	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
	% 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
	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 5
IV. Organizational capability.	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

The **productive capability** dimension is based on a set of indicators that account for the presence of systems of continuous improvement. In the Argentinean case, Formento et al. (2013) show that quality assurance activities constitute distinguishing elements for the firms productive capabilities. The development of systems of continuous improvement, even further than the mere certification of quality norms, contribute to the accumulation of knowledge that produces commercial and productive advantages. According to these authors, quality assurance creates a threshold to advance towards much complex productive and organisational capabilities. In order to estimate this dimension, seven indicators were selected: the specification of raw materials and critical inputs, the specification of critical characteristics of the productive process, traceability, the existence of equipment for processes improvement, and special tools for project management.

To get closer to the concept of **absorption capacity** we propose to break it apart into an "accumulated" component that depends on the stock of qualified human resources, and a "potential" one, that depends on personnel training investments. **Accumulated capabilities** arise from the addition of three indicators: the participation of human resources with a university degree to total employment, the share of engineers in the total staff with a university degree, and the participation of personnel with technical qualification to total employment.

In order to estimate **potential capabilities** we identify indicators that account for investments in the development of new abilities that allow initiating and maintaining innovation processes. It is accepted that training processes have to be evaluated in terms of the existence of diagnoses about training needs, evaluations regarding the impact and need for adjustment, as well as the selection of the methodology of the process (Novick, 2002; Novick and Gallart, 1997). Thus, the following indicators are proposed: i) the amount of functions of the human resources area (see Table 1); ii) the percentage of trained personnel (at a supervisor, hierarchal and non-hierarchal levels); and iii) the amount of courses carried out.

The fourth dimension addresses the **organisational capabilities** of the firm. Based on Erbes et al. (2011), the existence of planned rotation schemes in between positons to promote diversity and knowledge interrelation inside different teams were included firstly. Secondly, the personnel´s level of autonomy in solving problems was considered. The idea behind this organisational practice is that the delegation of certain decisions is indeed effective because the personnel that face the problem has the relevant knowledge -in many cases tacit- to deal with it. Thirdly, the degree of participation of the employees in the evaluation and planning practices was considered as an indicator of *bottom-up* decision processes in the organisation.

To evaluate the impact of R&D profiles on firms´ economic performance, three indicators were considered: the level of labour productivity, employment rate growth, and probability of exporting. Labour productivity has been calculated as the ratio between total sales and employment in 2012, in natural logarithm. The impact in employment has been estimated in terms of variation in occupational levels during the period 2010-12. The impact on firms' competitiveness was analysed with a binary variable (exporting and non-exporting firms). There is a wide theoretical and empirical support for these variables as indicators of economic performance (see Barletta et al., 2014 for a review).

3.2 Empirical strategy

The relationship between capabilities and R&D profiles was estimated by 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 R&D profile is explained by a set of observable characteristics of the firm. Specifically, if *Cap* is defined as a matrix of nx4 dimension composed by the four 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 probability to choose R&D profile j is

$$p_{ij} = \Pr[y_i = j] = \frac{\exp(\beta_{cap}Cap_{ij} + \beta_{ctrl}Ctrol_{ij})}{\sum_0^3 \exp(\beta_{cap}Cap_{ij} + \beta_{ctrl}Ctrol_{ij})}, \quad j = 0,1,2,3$$

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, sector, FDI, exporting condition and capital goods investments).

To analyse the impact of these R&D profiles concerning performance, the following model has been estimated:

$$PF_i = \alpha_0 + \alpha_1 ID_{ij} + \alpha_2 Ctrol_i + \epsilon_i$$

Where the performance of the firm i, *PFi*, is measured in terms of labour productivity, probability of exporting and employment growth. In turn, firms' performance depends on the R&D profile and a group of control variables. Given the statistical distribution of each dependent variable, probit models were estimated as well as ordinary least squares (OLS). In table 2, a list of every variable used in the econometric exercises is presented.

Table 2 Variables used in the econometric model

Variable	Definition	Measure Unit
R&D 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.	
Performance Variables		
Productivity	Sales 2012/Total employment	Current Argentinean pesos
Exports	Exports, 2012	0 does not export/ 1 exports
Employment dynamics	Employment growth rate between 2010 and 2012.	%
Control Variables		
Size	Size according to employment level and sales (2010).	0 Small / 1 Medium / 2 Large
Sector	Sectorial 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%

3.3 Descriptive statistics

Table 3 summarizes firms´ structural characteristics according to each R&D profile. As the R&D profile becomes more complex, the proportion of firms decreases: while 42% do not perform IE, only 8% have R&D labs.

In terms of size distribution, while smaller firms tend to concentrate in less complex profiles (without IE and IE without R&D), larger firms are concentrated in more complex profiles (formal and informal R&D). Furthermore, medium-sized enterprises are distributed more equitably, although they do stand out among more complex profiles. The origin of capital of 94% of firms is national, a proportion that decreases to 85% in the case of formal R&D, is around 90% in the groups of firms with informal R&D and IE without R&D, and accounts for 96% in the group of firms that do not perform IE. Finally, from a sectorial perspective, firms from the following industries are overrepresented in the formal R&D group: chemical, pharmaceutical, agricultural machinery, electrical materials, household appliances, automotive and medical instruments. Then, no sectorial biases appear in the remaining groups.

Table 3. R&D profile according to structural characteristics of firms.

	Without IE	IE without R&D	Informal R&D	Formal R&D	Total
Size					
Small	50%	22%	24%	4%	100%
Medium	34%	28%	28%	10%	100%
Large	17%	28%	29%	26%	100%
Total	42%	25%	26%	8%	100%
% of foreign capital	4%	8%	7%	15%	6%
% of total outflow aimed for capital goods	1.2%	3.1%	2.6%	3%	2.3%

Source: Own elaboration based on ENDEI. Weighted values.

In relation to the capability dimensions, the descriptive statistic accounts for the existence of a strong association between R&D profiles and the four identified dimensions (Table 4). The indicators of the two groups with less complex profiles show both medians and means negatives in the four dimensions. Thus, most firms from these groups are below the mean of the whole sample. The differences between the groups of formal and informal R&D are also important. In all cases, the average of the former is considerably higher than the average of the later, particularly in terms of cumulative and potential absorption capacities.

Table 4. R&D Profile according to firms´ capability dimensions.

Dimension	Without IE	IE without R&D	Informal R&D	Formal R&D
Productive Capabilities				
Average	-1,26	-0,27	0,42	1,62
Median	-1,61	-0,33	0,48	1,97
SD	1,48	1,72	1,66	1,64
Accumulated absorption capacities				
Average	-0,46	-0,26	-0,03	0,76
Medium	-0,89	-0,60	-0,34	0,67
SD	1,03	1,01	1,12	1,28
Potential absorption capacities				
Average	-0,965	-0,25	0,08	1,17
Median	-1,37	-1,13	-0,71	1,09
SD	0,99	1,57	1,79	1,95
Organisational Capabilities				
Median	-0,35	-0,07	0,15	0,50
Medium	-0,67	-0,08	0,06	0,43
SD	0,93	1,01	1,18	1,24

SD: Standard Deviation. Weighted values. Source: Own elaboration based on ENDEI.

Finally, Table 5 compiles the economic performance indicators according to R&D profiles. In this respect, the level of labour productivity increases when moving towards more complex profiles: firms performing formal R&D reach productivity levels 36% higher than firms that do not perform IE. Relative to employment variation, differences are particularly more noticeable, although in this case the turning point can be found between those who perform IE and those who do not. Yet, the proportion of firms exporting grows systematically along the four groups.

Table 5. R&D profile according to performance variables.

	Without IE	IE without RD	Informal RD	Formal RD	Total
2012 Labour productivity (thousands of dollars)	67,4	75,9	82,9	92,0	75,4
Employment growth 2010-12	0,74%	9,08%	9,13%	8,42%	5.5%
% of Exporting firms	16,3%	30,9%	43,2	67,1%	31,0%

Source: Own elaboration based on ENDEI. Weighted values.

4. Results

4.1 Relationship between R&D profiles and capabilities

Results of the multinomial logistic model suggest that both productive and potential absorptive capabilities are the main differential elements between firms with less complex profiles (without IE versus IE without R&D) (column I - Table 6)[6]. The estimated probability coefficient (i.e.: the relative risk ratio) is remarkably similar to both dimensions of capabilities. In particular, the model suggests that being the structural characteristics equal, as these two dimensions of capabilities increase, the probability that firms carry on efforts in innovation but not R&D is a 25% higher in relation to the possibility of not carrying on any effort. This implies that in order to "start moving forward" into more complexes R&D profiles, firm must have accumulated capabilities regarding both quality management and human resources training processes. Therefore, productive and potential absorptive capabilities are basic elements to analyse the firm´s potential to exploit its resources and to identify the threshold of skills needed to develop innovation efforts.

Once the "entry threshold" is overcome, the model shows that the capabilities needed to move towards the group of informal R&D firms are associated to the four dimensions considered: productive, potential absorptive, accumulated absorptive, and organisational (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 7% and 23% higher in response to increases in potential absorptive, and productive capabilities respectively, and boost a 17% and a 15% when organisational and accumulated absorptive 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 accumulated absorptive capabilities, with a much higher capability-learning base level (column III). This is to say, reaching the informal R&D profile already implies a change in the level of capabilities -which is consistent with the descriptive statistics of section 4- such that the requirements to advance in the formalisation of activities of R&D demand, proportionally, less additional efforts in the development of skills.

Table 6. Dimensions of capabilities and R&D profiles.

	Without IE to EI without R&D (I)	**EI without R&D to informal R&D (II)**	**Informal R&D to formal R&D (III)**	**Without IE to informal R&D (IV)**	**Without IE to formal R&D (V)**	**IE without R&D to formal R&D (VI)**
Potential absorption	(1.25)***	(1.07)**		(1.33)***	(1.41)***	(1.13)***
Productive	(1.25)***	(1.23)***	(1.27)***	(1.54)***	(1.96)***	(1.56)***
Organisational		(1.17)***		(1.27)***	(1.31)***	(1.21)***

[6] The complete results are presented in the statistical appendix.

Accumulated absorption	(1.15)***	(1.26)***		(1.36)***	(1.45)***

Obs.: 3296. *, **, and *** indicate significance at 10%, 5%, 1% respectively. In brackets: risk ratio concerning the multinomial logistic model. Source: own elaboration based on ENDEI.

Columns IV to VI of Table 6 show relations between R&D profiles and capabilities comparing non-adjacent groups; in a sense, in terms of leapfrogging processes. To reach the formal R&D group the development of capabilities in their multidimensionality is required, which means that all dimensions are significant.

In relation to literature, the outcomes highlight, on the one hand, the systemic nature of innovation in so far as depending on accumulation and application of disseminated knowledge all along the organisation. In terms of Nelson and Winter (1982) firms need to develop dynamic and ordinary capabilities to improve routines, identify newer ones and, specially, successfully confront the process of selection. To think of a firm that has not performed innovation activities and then radically alters into formal R&D processes would imply drastic changes in its productive, organisational, and innovative activities associated with dynamic capabilities that would enlighten that need to create a 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 projects (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 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 perform and do not perform R&D. Advancing 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).

4.2 Relationship between R&D profile and performance.

Results regarding the firm´s performance show that the R&D profile gradient works on some performance variables (Table 7). In terms of productivity, even though there are no differences between firms that perform formal and informal R&D, the difference in productivity level turns significant in firms that perform informal R&D with regard to the ones that perform innovative efforts without R&D. Hence, evidence partially confirms H2.a. When considering the probability of exporting, estimations exhibit an increase as a result of more complex R&D profiles, verifying thus H2.b. Lastly, in employment´s variation the distinctive element seems to be the performance of innovation efforts rather than the grade of R&D formality. In this case, the gradient situation is not verified and therefore H2.c. is not supported.

Table 7. R&D profiles and performance.

	2012´s productivity OLS			Probability of exporting Probit			Employment growth OLS		
Without EI		-0.055*	-0.123***		-0.100***	-0.195***		-7.707***	-8.947***
EI without R&D	0.055*		-0.067**	0.100***		-0.094***	7.707***		-1240
Non formal R&D	0.123***	0.067**		0.195***	0.094***		8.947***	1240	
Formal R&D	0.116***	0.061*	-0.007	0.311***	0.211***	0.116***	7.210***	-0.497	-1737
Size									
Medium	0.171***	0.171***	0.171***	0.105***	0.105***	0.105***	-3.619**	-3.619**	-3.619**
Large	0.314***	0.314***	0.314***	0.278***	0.278***	0.278***	-8.264***	-8.264***	-8.264***
Capital origin	0.192***	0.192***	0.192***	0.089***	0.089***	0.089***	8.010**	8.010**	8.010**
2010´s Productivity				0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Exports	0.166***	0.166***	0.166***						
Constant	12.15***	12.21***	12.27***				1533	9.24***	10.48***

Obs.: 2904. All estimations include sectorial fixed effects. Standard error robust to heteroscedasticity. In the model that is referred to in the exporting propensity there are marginal effects reported. *, ** and ***indicate significance at 10%, 5% y 1% respectively. Source: Own elaboration based on ENDEI (in English, National Survey of Employment Dynamics and Innovation).

Summing up, results confirm the importance of understanding innovation as a gradient of possible situations, where expenditures in R&D are a key factor to explain the economic performance of firms, but again, not the only attribute to be identified. In this sense, investing in innovation, with or without R&D, accounts for different economic results. Depending on the innovative strategy followed by the firm (based on R&D, the acquisition of capital goods, engineering activities, etc.) innovative process results can produce improvements in productivity, exporting, or employment (Barletta *et al.*, 2014). Therefore, results show that the phenomenon´s approach from an R&D profile perspective constitutes a way to advance in the explanation of such differences.

5. Conclusions

This article analyses the relationship between the level of capabilities, R&D profile and firms economic performance, in terms of labour productivity, exports, and employment growth. The first hypothesis states that the degree of complexity of the R&D´ profile is associated to the accumulation of capabilities, built along an evolutionary path of firms, which are understood from a multidimensional perspective. The second hypothesis proposes that the complexity of R&D profile is associated to firm´s economic performance.

Results of the empirical exercise suggest that performing formal R&D is positively associated with the existence of greater productive and accumulated absorption capabilities. Moreover, greater capabilities are required in the four dimensions proposed for firms performing informal R&D in relation to the group of firms that perform innovation efforts without R&D. The relation verified between R&D profile and capabilities suggests that innovation efforts in general and R&D in particular are the result of an evolutionary capability building path, which is not necessarily linear or continuous and is not free of obstacles. Similarly, results highlight that the development of both formal and informal R&D activities is associated with higher levels of productivity and exports. Nonetheless, the relationship is not linear, but discrete changes are observed. Even though every R&D profile has its correlation in a gradient impact on the exporting propensity, the positive effect of R&D in productivity levels is independent of the level of formality of such activities. Differently, employment variation is not associated with R&D profile.

These results are thus connected with other analysis that show that the lower expenses of R&D in developing countries is explained by "capabilities failures" more than by restrictions on financing access or even by the fact that knowledge´s nature is to be a public good (Lee, 2013). Hence, our contribution to Neo-Schumpeterian literature is to manifest how this works at the microeconomic level: the accumulated level of capabilities determines R&D profiles, and this, the level of economic performance.

These results contribute to the debate on the scope of public policy actions aimed at promoting R&D activities. In the first place, they give account for the importance of acting on different dimensions of capabilities as a mean to promote even more complex R&D processes. In the second place, results show the need to account for the micro-heterogeneity and differentiate policy action according to the firm's level of capabilities. Therefore, according to other results found for developed countries (Arundel et al, 2008; Pilot Project), 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 innovation based in science and 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 and its temporal evolution.

Finally, 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 profiles and capabilities. In this respect, new survey waves will allow to approach these issues from a panel analysis, which will allow deepening the research on the relationship between capabilities, innovative processes, and economic performance of Argentine manufacturing firms.

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Statistical appendix

Table 1. Relationship between capabilities and R&D profiles – Multinomial Logistic Regression.

	Without IE to EI without R&D		**EI without R&D to informal R&D**		**Informal R&D to formal R&D**		**Without IE to informal R&D**		**Without IE to formal R&D**		**IE without R&D to formal R&D**	
	RR	SE	RR	SE	RR	EE	RR	EE	RR	EE	RR	EE
Potential absorption	1.25***	0.05	1.07**	0.04	1.06	0.04	1.33***	0.05	1.41***	0.07	1.13***	0.05
Productive	1.25***	0.04	1.23***	0.04	1.27***	0.06	1.54***	0.05	1.96***	0.10	1.56***	0.08
Organisational	1.08	0.05	1.17***	0.06	1.03	0.06	1.27***	0.06	1.31***	0.09	1.21***	0.07
Accumulated absorption	0.94	0.05	1.15***	0.05	1.26***	0.07	1.08	0.05	1.36***	0.08	1.45***	0.08
Size												
Medium	1.59***	0.17	0.73***	0.08	1.54*	0.26	1.15	0.13	1.77***	0.31	1.12	0.20
Large	1.94***	0.31	0.48***	0.07	2.63***	0.49	0.93	0.16	2.44***	0.53	1.26	0.25
FDI	0.95	0.19	0.48***	0.09	1.06	0.21	0.46***	0.11	0.49***	0.13	0.51***	0.11
Exports	1.61***	0.19	1.47***	0.16	1.52***	0.22	2.37***	0.28	3.60***	0.58	2.23***	0.34
Capital goods	0.02***	5.32	0.98*	0.01	1.00	0.01	1.07***	0.02	1.07***	0.02	0.98	0.01
Constant	0.53***	0.05	1.26**	0.12	0.13***	0.02	0.67***	0.06	0.08***	0.01	0.16***	0.03

Obs.: 3296. *, **, and *** indicate significance at 10%, 5%, 1% respectively. RRR: risk ratio. SE: standard error.
Source: own elaboration based on ENDEI.