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ARTICLE

Opening the black box of recurrence in innovation policy. Sources of the Matthew effect in the Argentinean case.

* *Diana Suarez*
Universidad Nacional de General Sarmiento (UNGS), Buenos Aires, Argentina
E-mail: dsuarez@campus.ungs.edu.ar

** *Florencia Fiorentin*
Universidad Nacional de General Sarmiento (UNGS), Buenos Aires, Argentina
E-mail: ffiorentin@campus.ungs.edu.ar

*** *Mariano Pereira*
Universidad Nacional de General Sarmiento (UNGS), Buenos Aires, Argentina
E-mail: mpereira@campus.ungs.edu.ar

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ABSTRACT

This paper studies the role that the three theoretical sources of recurrence – the Matthew effect – play in the process of the first and recurrent granting of innovation public funds. Those sources are a firm's "reputation", "innovation capabilities" and "formulation capabilities". The empirical analysis is based on the Argentinean Technological Fund (in Spanish, FONTAR) between 2007-2018. The results show that firms' formulation skills increase the probability of funds initially being granted, and then additional formulation skills and innovation capabilities increase the probability of recurrence, while reputation does the opposite..

KEYWORDS | Innovation policy allocation; Recurrence; Matthew effect; Innovation capabilities

1. Introduction

The objective of this paper is to analyse the process of the allocation of public funds for innovation in terms of first-granted and recurrent firms. Since the allocation process is not random –*the selection bias*– it becomes a relevant object of study from which policy recommendations on how to "select" beneficiary firms can be derived. Nevertheless, and surprisingly, it is a scarcely explored aspect in the process of public policy. The literature on the Matthew effect postulates the existence of three sources of recurrence: a firm's reputation, linked to the firm's brand; a firm's formulation expertise, related to the development of skills to formulate a project; and a firm's innovation capabilities, based on the accumulation of innovation skills (ANTONELLI; CRESPI, 2013). Based on these arguments, the literature has verified persistence in innovation policy instruments for both developed and developing countries (RADICIC *et al.*, 2014). However, they have not explored and tested the existence and incidence of the different sources.

The contribution of this paper is theoretical and empirical. On the one hand, we merge two streams of literature: that which centres on the determinants of access to public funds for innovation and that related to the Matthew effect, which might be thought of as an additional determinant. On the other hand, we provide evidence about a topic which has been scarcely explored in the literature and which is related to determinants of first and recurrent access to public funds for innovation. Hence, the first question that guides our research is about the differences between first-granted and recurrent firms. We claim that formulation and innovation capabilities and reputation could play a key role in the process of being granted funds for the first time. The second research question aims at empirically testing the theoretical explanations of recurrence; thus, it looks into the extent to which recurrence refers to different profiles of firms.

The empirical strategy is based on the Argentinean Technological Fund (abbreviated as FONTAR in Spanish), which is the main national instrument to foster innovation at the firm level (PORTA; LUGONES, 2011), for the period 2007-2018 (3,597 firms and 5,266 observations). FONTAR has been widely analysed, and results show that it triggers additionality effects, both on firms' innovation inputs and outputs and economic performance (PETELSKI; MILESI; VERRE, 2019; LERENA; MARTÍNEZ CORREA; PEREIRA, 2017; HALL; MAFFIOLI, 2008; MOORI KOENIG *et al.*, 2017). However, only a few studies have focused

on the allocation process, basically to confirm the presence of recurrence (PEREIRA; SUÁREZ, 2017).

The results prove the capability-based dimension of recurrence and the role of formulation skills in the process of being granted public funds. Firstly, the accumulation of skills linked to applying to FONTAR increases the probability of being first granted funds by 4.5 percentage points (p.p). Secondly, innovation capabilities and formulation skills positively impact the probability of recurrence by 1.5 p.p. and 0.8 p.p. respectively. However, and thirdly, the reputation source negatively impacts the probability of recurrence by 2.2 p.p. Hence, different sources of the Matthew effect not only impact on the probability of recurrence, but they also act as determinants of, or barriers to, becoming part of the club of beneficiaries.

The remainder of this paper is structured as follows. Section 2 presents a discussion of the literature and discusses the research questions. Section 3 describes FONTAR and provides some descriptive statistics. The dataset and the empirical strategy are presented in section 4. The results are shown and discussed in section 5. Finally, conclusions are presented in section 6.

2. Theoretical framework and research questions

2.1 Innovation literature, policy evaluation and the sources of the Matthew effect

The literature on innovation sustains that firms are heterogeneous in terms of routines and innovative behaviours (NELSON, 1991). When applied to the innovation process, this implies that the same investments in different firms might lead to different innovation results, and that similar results can be attained by different investments made by similar firms (COHEN; KLEPPER, 1996). The literature also highlights the relevance of the innovation process in firms' capabilities, regardless of the results of the process (VERSPAGEN, 2005). During the development of a new product or business practice, firms invest in the creation and application of knowledge, and this positively impacts on its skills and abilities linked to other areas of the firm, e.g., production, commercialization or organization (NELSON; WINTER, 1982; PENROSE, 1959). In addition, and in terms of innovation policy, an old consensus in the literature sustains the need for public policy to foster knowledge creation and diffusion and, therefore, better economic performance at the aggregate level (METCALFE, 2005; CHAMINADE; EDQUIST, 2010).

Despite the above, innovation policy studies have mostly centred on analysing the average impacts of public instruments on firms' inputs, results and performance (DIMOS; PUGH, 2016; ZÚÑIGA-VICENTE *et al.*, 2014), while little attention has been paid to the allocation process (FISCHER; MOLERO, 2013; BLANES; BUSOM, 2004; ASCHHOFF, 2008). This type of ex-post evaluation disregards the possibility that firms' ex-ante heterogeneity might lead to different processes in the allocation of funds, with different impacts on innovation results (BUSOM; CORCHUELO; MARTÍNEZ-ROS, 2017; FISCHER; MOLERO, 2013). In this regard, scarce attention has been paid to capabilities as determinants of being granted funds. We claim that looking at the allocation process is as important as the verification of crowding-in or -out effects, because it would allow the identification of policy criteria to maximize public funds' impact and could help policy makers to prevent crowding-out situations (BUSOM; CORCHUELO; MARTÍNEZ-ROS, 2017; DIMOS; PUGH, 2016).

To the extent that the process of the allocation of funds is related both to the quality of the submitted innovative project and a firm's characteristics in terms of innovative behaviour and market reputation (THOMAS FALK; SVENSSON, 2020), the literature on recurrence postulates that granted firms are more likely to access public funding again. This is known as the Matthew effect of public policy (DUMONT, 2017; ANTONELLI; CRESPI, 2013). In this regard, persistence is verified in both developed and developing countries (DAVID, 1994; ANTONELLI; CRESPI, 2013; PEREIRA; SUÁREZ, 2017). At least three theoretical sources of the Matthew effect are identified. We refer to them as "reputation", "innovation capabilities" and "formulation capabilities" effects.

Reputation refers to those cases where persistence is mainly determined by a firm's brand (HUERGO; MORENO, 2011; ANTONELLI; CRESPI, 2013; RADICIC *et al.*, 2014). It is connected to the difficulties faced by public agencies in the selection of beneficiaries. On the one hand, this occurs because they do not access all the required information about the firm and the project or lack the capabilities to process the information. On the other, it arises because these agencies are evaluated based on "the success" of a policy, which is measured by the number of successful funded firms (LERNER, 2002; DIMOS; PUGH, 2016).

Innovation capabilities are a more virtuous source of recurrence, related to the accumulation of skills and knowledge through the development of innovation activities (PEREIRA; SUÁREZ, 2017). Innovation processes trigger learning curves, not only in the innovation results but also in the process itself (VERSPAGEN, 2005).

To the extent that the process is the same whether it was financed by public funds or a firm's own resources, previously granted firms are more likely to be re-funded.

The last source of recurrence involves the development of capabilities within granted firms by their formulating and implementing innovation projects. Granted firms must have learnt to properly design and submit an innovative project, both in terms of policy bureaucracy and its innovative complexity and novelty. Thus, their projects are more properly presented, and more likely to be selected (ANTONELLI; CRESPI, 2013).

2.2 Research questions

We focus on the allocation process in terms of first-granted and recurrent firms. The underlying hypothesis is that microheterogeneity leads to the existence of different causes of first access and recurrence. Therefore, we postulate the two following research questions (RQs):

> ***RQ1.*** *To what extent is a firm's first grant explained by its reputation, formulation skills and innovation capabilities?*
>
> ***RQ2.*** *To what extent is recurrence explained by the firm's reputation, formulation skills and innovation capabilities?*

Regarding RQ1, we analyse whether reputation, formulation and innovation skills affect the process of the allocation of public funds. Given the presence of information asymmetries between the agency and the firm, reputation could positively or negatively affect the process of allocation (ANTONELLI; CRESPI, 2013; RADICIC *et al*., 2014). We sustain that there is a need to evaluate the extent to which it is another source of micro-heterogeneity that affects the way public agencies evaluate the submitted project as well as the firm's ability to implement it. Regarding formulation skills, firms which have submitted projects but have been rejected have gone through learning processes linked to filling in forms and demonstrating the technological and economic viability of projects, and they have learnt to deal with the programmes' bureaucracy. As for innovation capabilities, these have been demonstrated to be an important determinant of being granted (BERRUTTI; BIANCHI, 2020; CLARYSSE; WRIGHT; MUSTAR, 2009; FIORENTIN; PEREIRA; SUAREZ, 2019a; GÖK; EDLER, 2012), but they have been mainly analysed as a dimension of the Matthew effect, not as a determinant of firms' first grants.

In terms of RQ2, the Matthew effect has been widely verified, but still little attention has been paid to its explanatory sources. Only a few studies analyse the relationship between firms' capabilities and recurrence, while the reputation effect emerges as a residual (BUSOM; CORCHUELO; MARTÍNEZ-ROS, 2017; FIORENTIN; PEREIRA; SUAREZ, 2019a; ANTONELLI; CRESPI, 2013). Thus, the role of the different sources of recurrence is not clear. RQ2 aims to shed some light on this subject by providing new evidence to better understand the Matthew effect phenomenon.

Our study focuses on the dynamic and path-dependent relationship between public funds and firms' characteristics, capabilities and reputations. We postulate that the determinants of the allocation of funds, such as the innovative process itself, reach beyond a firm's innovative project and are subjected to the firm's innovative and market behaviour. Accessing public funds requires skills, abilities and information that should have been accumulated by firms before they apply for public funds. Firms might have built a commercial brand that resembles some sort of "better" behaviour in terms of innovation, which is not necessarily connected to the viability of the submitted project. Seen the other way around, once the firm has entered the club of granted firms, it has accumulated experience in developing innovations, specific abilities to formulate and submit a project and innovation capabilities to successfully implement it.

To some extent, previous processes of allocation will condition the distribution of policy on granted firms, and this type of approach should complement classical and ex-post crowding-in and crowding-out evaluations. We expect to contribute to innovation policy literature by studying how the sources of recurrence affect the process of the allocation of public funding for innovation. Therefore, the novelty of this work is related to its combination of the literature on the Matthew effect and the determinants of accessing public innovation funds in order to analyse how (and if) the same sources of recurrence affect a firm's probabilities of being granted for the first time.

3 The Argentinean Technological Fund and the dataset

This study is based on all of the firms that applied to the Argentinean Technological Fund (FONTAR) between 2007 and 2018. The dataset results from the integration of i) the register of firms that applied during this period, whether they were granted or not (grants and rejections), and ii) the innovation surveys these firms answered when they applied and once they finished the innovation project. The resulting database

is a dynamic data set made up of 3,597 firms and 5,266 observations (hereinafter FONTAR database). We grouped the period into six subperiods of two years, linked to the average duration of funded projects. Simultaneous submissions and projects are allowed. Unfortunately, information about firms that did not submit projects is not available. We can only study firms once they have applied to FONTAR, and we can only study them over time if they applied again. Therefore, the methodology was designed to study first access and recurrent access among firms that have at least once applied to FONTAR.

FONTAR is the main national source of public funding for innovation at the firm level, in terms of both the number of instruments and the size of the grants (PORTA; LUGONES, 2011). It provides financial support by means of non-reimbursable grants, tax credits, and subsidized loans. It has been operating since 1996, which means that it is a relatively new programme when compared to the Argentinean science and technology system (which was born in the 50's), but also a relatively old one, with more than two decades of accumulated experience and learning processes in the matter of promoting innovation at the firm level. Under a horizontal view, the aim of FONTAR is to foster firms' productivity through technological modernization and innovation in all firms (FIORENTIN; PEREIRA; SUAREZ, 2019a). Nevertheless, adjudication is biased towards the manufacturing industry and small and medium-sized enterprises (SMEs).

FONTAR offers funding by means of periodic calls and open window system receptions, depending on the instrument. Firms that have been funded in the past have no limits on accessing funding again, but they cannot fund the same project with different instruments at the same time or in different calls. To apply for FONTAR support, a firm must submit an innovative project. It must complete several forms with detailed accounting and administrative information, as well as information regarding the technological novelty, feasibility, and expected results of the project. Projects that meet administrative requirements are admitted. Admitted projects are then evaluated following technological and economic-financial criteria by FONTAR personnel and an ad-hoc commission made up of experts from the national science, technology and innovation system. Finally, the quantity of selected projects depends on the budget and quotas for geographical areas. Once the project is approved and implemented, FONTAR monitors the fulfillment of the declared milestones.

Evidence shows that firms that apply to FONTAR have higher levels of capabilities and more dynamic innovation behaviour than the average level in the Argentinean productive structure (BARLETTA *et al.*, 2017). Evidence also confirms

that granted firms hire more labour, attain innovation results, are more productive and increase exports (AGUER; KOENIG; CARUGATI, 2015; CASTILLO *et al.*, 2014; LERENA; MARTÍNEZ CORREA; PEREIRA, 2017). In terms of the allocation process, Pereira and Suárez (2017) have shown that the Matthew effect is positively associated with a firm's accumulation of capabilities and with other characteristics of the firm which they referred to as the reputation effect.

In terms of recurrence and impact, Fiorentin, Pereira and Suarez (2019a) found that the effects of public funding on firms' capabilities and R&D investments are the same both for recurrent and non-recurrent firms. Nevertheless, the impact on productivity is higher for recurrent than non-recurrent firms. They also found that the impact of FONTAR differs over time: FONTAR impacts firms' capabilities in the short term (1-3 years), innovation investments in the medium term (4-5 years) and productivity in the long term (6 years and more).

During the period under analysis, the number of submissions and grants increased from 332 to 1,279 firms per year, and the number of granted firms climbed from 320 to 888, linked to the higher diffusion of FONTAR (Table 1). Since there are no limits on the number of simultaneous submissions and grants, we have aggregated this information at the firm level. We consider as granted firms only those that finalized their granted projects.

We defined a firm as recurrent if it has at least one finished granted project in t and t-1 (Table 1). Under this definition, between 33% and 41% of grants went to recurrent firms. For the whole period, the ratio drops up to 23%, which means that there is a group of firms that persists over the years. This explains why the probability of being granted among recurrent firms is 60%.

TABLE 1
Submissions and grants – Number of firms

Period	Submissions (a)	Grants (b)	(b)/(a)	Recurrence (ratio to b)
2007-2008	332	320	0.96	-
2009-2010	435	408	0.94	0.35
2011-2012	702	590	0.84	0.37
2013-2014	1016	522	0.51	0.40
2015-2016	1502	888	0.59	0.34
2017-2018	1279	-	-	0.35
2007-2018	3597	2418	0.67	0.23

Source: own elaboration based on FONTAR database.

Table 2 shows that large differences are observed between granted and non-granted firms. The level of investments in innovation activities is the only variable in which non-granted firms show better behaviour, although 90% of that is explained by investments in capital goods. Among granted firms, recurrent firms are on average larger but younger, with a greater participation of high-tech companies than non-recurrent ones. Differences in terms of exports and innovation intensity are less significant, in both cases concentrated on capital goods. However, recurrent firms invest relatively higher levels in R&D activities. Regarding FONTAR, recurrent firms have a higher frequency of presentations and finalized projects than first-granted ones, and most of the former reached innovation results during the period under analysis.

TABLE 2
Summary of key variables of granted and non-granted firms

	Non-granted	Granted firms	
		Recurrent	First-granted
Size *(average employment per firm)*	50.54	71.56	44.58
Age *(years at t0)*	21.34	16.58	18.2
Exports *(% to sales)*	9.8	12.6	11.9
High-tech firms *(% to group)*	0.34	6.5	3.6
KIBS firms *(% to group)*	2.01	20.7	34.9
Qualified human resources (personnel with univ. degree to total employment)	42.90	33.97	39.52
Innovation intensity *($1,000 per employee)*	66.13	33.62	34.70
R&D *(% to innovation investments)*	3.85	10.99	8.55
Capital goods *(% to innovation investments)*	90.24	59.28	60.07
R&D human resources *(% to total employment)*	6.63	13.1	12.2
Innovation results *(% firms with product and process innovations to group)*	23.6	91.5	44.1
Submissions to FONTAR *(average per firm)*	1.1	4.2	1.4
Grants *(finalized projects per firm)*	0	3.3	1.1
N	1745	566	1286

Source: FONTAR database.

4 Methodology

4.1 Sources of recurrence and first grant

To analyse the different sources of being first and recurrently granted, we followed a two-step approach. Firstly, we defined each type of source according to the theoretical framework: market reputation, formulation skills and innovation capabilities. Based on section 2, we expanded the sources of recurrence to all firms that had ever applied to FONTAR, whether they were granted or not. We ran a principal component analysis (PCA) on each set of key variables on applicant firms. This allowed us to identify a common vector of means for each theoretical determinant of recurrently accessing public funds based on the whole population of applicants (JACKSON, 2003). In addition, the correlation within the variables in each set is relatively high, thus it is worth integrating them into a single value[1]. Following Srholec and Verspagen (2012) we ran a PCA separately on each set of sources of recurrence for all the firms that had applied to FONTAR. As usual, we kept the first component. The underlying idea is that each source is present in every firm, to the extent that they refer to the aspects needed to face Schumpeterian market competition.

Besides this, evidence shows that only firms with certain levels of capabilities actually apply to FONTAR, and this explains the higher levels of innovation skills and productivity when compared with the Argentinean average (MOORI KOENIG *et al.*, 2017). We claim that given micro-heterogeneity, the intensity of each source in the applicant's profile will differ. Connected to that, another element of this selection of methodology is the assumption that firms can substitute capabilities to a limited extent. Running a PCA – or any other factor analysis – on every type of source of recurrence would allow a firm to have reputation without innovation skills (without investing in innovation), or to have accumulated innovation capabilities but lack formulation skills. All of these are possible situations in terms of an empirical strategy, but they do not seem possible in terms of the literature on innovation policy.

Table 3 summarizes the variables included in the estimation of the sources of applicant firms and the rest of the model.

1 The robustness of the estimations was checked by means of regressing each significant component as a function of all variables included in each set. In all cases, the assumption of multivariate normal distribution required for PCA was tested. Results available upon request.

TABLE 3
Summary of the main variables

Variables	Definition	Unit
FONTAR	Firm granted with a grant	1 if granted in t, 0 otherwise.
First_FONTAR	First-granted firm	1 if granted for the first time in t, 0 otherwise.
Accum_FONTAR	Total number of grants in t-n.	1 to ∞.
Sub	Number of submitted projects.	1 to ∞.
Reputation		
Age	Firm's age.	1 to ∞.
L	Total employment.	0 to ∞.
Expo	Exports to total sales.	0 to ∞.
Sector	Sectorial belonging of the firm.	4 digits ISIC Rev. 3.1.
Formulation		
NRG_p	Number of presented projects to the line non-reimbursable grants.	0 to ∞.
SC_p	Number of presented projects to the line subsidized loans.	0 to ∞.
TC_p	Number of presented projects to the line tax credit.	0 to ∞.
Innovation		
RD_participation	Ratio R&D expenditures to IA expenditures.	0 to 1.
K_participation	Ratio capital goods expenditures to IA expenditures.	0 to 1.
IA	Total expenditure on innovation activities to total employment.	0 to ∞.
RD_share	Ratio total R&D employment (formal and informal) to total employment.	0 to 1.
Structural characteristics		
Region	Localization of the main facility.	5 dummies (Federal District and Buenos Aires Province, south, north-east, north-west, west).
Size	Firm size, based on employment.	4 dummies (<10; <50; <200; >=200).
Sector	OECD's classification for manufacturing and service firms according to technological intensity.	4 dummy manufacturing firms (high-, medium-high, medium-low, low). 1 if KIBS (knowledge intensive business services), 0 otherwise.
QHR	Qualified human resources. Ratio total personnel with a university degree to total employment.	0 to 1.

Source: own elaboration based on FONTAR database.

Market reputation was estimated by means of each firm's age, export intensity, level of employment and sector of activity based on ISIC. The size and age of the firm shed light on the possibilities of being known in the market. In addition, given the historical cycles of economic instability in Argentina, a firm's having survived different macroeconomic and institutional contexts sheds light on its resilience to survive (LOPEZ, 2006; SUÁREZ *et al.*, 2014). Another element included is export intensity. Since the Argentinean productive structure shows low levels of exports (BARLETTA; PEREIRA; YOGUEL, 2014; PORTA, 2006), being part of the international market means higher levels of competitiveness and thus a "higher" perception of the firm. Finally, there is the sector of activity. Given the bias of FONTAR and the specific aim to develop high-tech firms in the basis of the programme – and in the strategic national plan – there are incentives within the national agency in charge of the fund to allocate resources to such firms (PORTA; LUGONES, 2011). Results from the PCA show only one significant component that accounts for larger and older firms (Table 4).

TABLE 4
PCA results - Reputation

Variable	Reputation
Age	0.6559***
L	0.4806***
Exports	0.2313***
Sector	-0.5341***
Eigenvalue	*1.44*
Cummulative variance	*36.1*

Source: own elaboration based on FONTAR database.
Notes: *** significant at 0.01. Rotated loadings.

Formulation capabilities were estimated based on the number of presentations to the different FONTAR instruments. Each line of funding within FONTAR has different objectives and, therefore, different forms. Hence, if firms manage to submit projects to the different instruments, this is a proxy of their skills to submit a project (from lower to higher technological risk). The number of presentations also acts as learning-by-presenting proxy, assuming the accumulation of specific skills.

As with reputation, results from the PCA also show only one main component, which accounts for firms with a high rate of submissions, especially for tax credit and non-refundable grant lines of funding (Table 5).

TABLE 5
PCA results - Formulation

Variable	Formulation
NRG_p	0.5937***
SC_p	0.4792***
TC_p	0.6465***
Eigenvalue	*1.16*
Cummulative variance	*38.4*

Source: own elaboration based on FONTAR database.
Notes: *** significant at 0.01. Rotated loadings.

Finally, there is the estimation of innovation capabilities. Following the literature (CRÉPON; DUGUET; MAIRESSE, 1998; COHEN; LEVINTHAL, 1990; SRHOLEC; VERSPAGEN, 2012), we estimate this source based on R&D investments, given the proven impact on innovation skills. R&D was included in terms of intra- and extra-mural investments together with human resources specifically allocated to those activities. In line with the literature on developing countries (GOEDHUYS, 2007; DUTRENIT; KATZ, 2005; BARLETTA *et al.*, 2017), we include other investments on innovation, such as capital goods, training, consulting and information and communication technologies. The Argentinean productive structure shows that innovation is mostly based on different sources of knowledge creation and especially the incorporation of equipment (MINCyT, 2013, 2015).

Again, only the first component presents an eigenvalue higher than one (Table 6). It accounts for firms with high levels of investments on R&D, both in financial and human resources. In addition, it represents firms with relatively low investments in innovation activities, which is highly correlated with the level of participation of capital goods expenditures.

TABLE 6
PCA results - Formulation

Variable	Innovation
IA	-0.1468***
RD_participation	0.6842***
K_participation	-0.6854***
RD_share	0.2013***
Eigenvalue	*1.55*
Cummulative variance	*38.8*

Source: own elaboration based on FONTAR database.
Notes: *** significant at 0.01. Rotated loadings.

Following descriptive statistics presented in section 3, there are no significant differences in the relative level of investments in innovation activities between recurrent and non-recurrent firms. Therefore, this dimension represents firms with high levels of investments in R&D activities, which was a distinctive feature of recurrent firms both in respect of non-recurrent and non-granted ones.

Finally, Table 7 shows the average values for each group of firms for the whole period under analysis. Given the PCA, average values for the total sample are zero. Media differences between non-granted, first-granted and recurrent firms are significant for the three dimensions, according to standard analysis of multivariate variances. The same occurs if only granted firms are compared. In line with the descriptive statistics (table 3), non-granted firms reached the highest values in Reputation and the lowest in Formulation and Innovation. This means that rejected firms are on average larger and older than the rest of the sample, with a low frequency of presentations and an innovative behaviour with low investments in R&D. Meanwhile, recurrent firms surpass first-granted ones in terms of reputation and formulation, although the latter seem to have more dynamic innovative behaviour based on R&D activities.

TABLE 7
PCA results and granting profiles – 2007-2018

	Non-granted	First-granted	Recurrent
Reputation	0.1207	-0.1795	0.0359
Formulation	1.3590	1.6732	2.2544
Innovation	-0.2343	0.1872	0.1273
N	2538	1852	876

Source: own elaboration based on FONTAR database.
Note: 1563. Wilks' lambda, Lawley-Hotelling trace, Pillai's trace and Roy's largest root significant at 0.00.

4.2 Identification strategy

The methodology to approach the research questions consists of two random effect dynamic probit models, where the dependent variable is being a first-granted firm in the first model, and being recurrently granted in the other. This selection allows us to control microheterogeneity by means of the inclusion of unobserved effects using the solutions proposed by Mundlak (1978), Chamberlin (1948) and Wooldridge (2005). The rationale behind the selection of a random model is twofold. On the one hand, we have binary dependent variables, and to the best of our knowledge,

there are no standardized estimations for a fixed effect dynamic probit model. On the other hand, random effect models better suit the characteristics of the expected dynamics of learning, which means that some non-observable attributes of firms will vary over time while others will remain invariant. In addition, the inclusion of control variables according to the solutions previously mentioned allowed us to control fixed effects and the initial condition.

Formally, the first equation to estimate is:

$$P(First\_FONTAR_{it} = 1) = \beta_0 + \beta_1 Source_{it} + \beta_2 X_{it} + \beta_3\, \mu_{ti} + T_i + \in_{ti} \quad (1)$$

$$X_{it} = \beta_a Region_i + \beta_b Size_{it} + \beta_c\, Sector_i + \beta_d\, QHR_{it}$$

$$\mu_{ti} = \alpha_0 + \alpha_1 \overline{Sales_i} + \alpha_2 \overline{Employment_i} + \alpha_3 sub_{i0}$$

Where being first granted with a FONTAR grant for the firm i at time t ($First\_FONTAR_{it}$ depends on the sources of being granted (reputation, innovation and formulation) plus a set of observable and time-variant and invariant attributes (X_{it}) and a set of unobservable and time-invariant characteristics (μ_{ti}). The observable attributes are the usual structural and control variables (see Table 4 above). μ_{ti} represents the unobservable characteristics and initial condition, which were approximated by means of the average value of sales and employment ($\overline{Sales_i}; \overline{Employment_i}$), plus a dummy variable that accounts for submissions at $t_0(sub_{i0})$. T_i is a set of dummy variables to control time. $\in_{ti}$ is the usual error term.

To study research question 2, we estimate the same probit model, but this time for all firms ever granted with funding from FONTAR. We also include past grants in t-1 ($Accum\_FONTAR_{it-1}$) and the interaction between accumulated grants and the sources of granting *(β3Accum_FOTARit-1*ourceit)* . Formally:

$$P(Rec_{it} = 1) =$$
$$\beta_0 + \beta_1 Accum\_FONTAR_{it-1} + \beta_2 Source_{it} + \beta_3 Accum\_FONTAR_{it-1} * Source_{it} +$$
$$\beta_4 X_{it} + \beta_5\, \mu_{ti} + T_i + \in_{ti} \quad (2)$$

5 Results and discussion

Table 8 shows estimated results according to equation 1[2]. Only formulation skills play a significant role in first accessing FONTAR. The accumulation of formulation capabilities increases the probabilities of being granted for the first time by 4.5 percentage points (p.p.) in the most conservative estimation. Based on the descriptive statistics presented in section 3, first-granted firms have submitted three-times more projects that non-granted firms, and this significantly explains differences between groups.

The lack of significance in the reputation dimension is also worth mentioning. The results show that a firm's market reputation is not relevant when it comes to becoming granted for the first time. In terms of the literature, this might imply that imperfect and asymmetric information does not seem to impact on the process of grant allocation. Differences in terms of firms' innovation profiles are not significant either. This contrasts with what is stated in the literature in terms of capability thresholds, this time in terms of innovation skills. However, since firms that apply to FONTAR have on average higher levels of innovation capabilities than the rest of the productive structure (section 3), the lack of significance in our results might only imply that the threshold has been overcome. In this regard, the estimation of the relation between formulation skills and first accessing FONTAR is quite novelty, and it highlights the relevance of taking into account a complex set of different capabilities as determinants of accessing public funds (e.g.: BUSOM; CORCHUELO; MARTÍNEZ-ROS, 2017; BLANES; BUSOM, 2004; GONZÁLEZ; JAUMANDREU; PAZÓ, 2005, among others).

Estimation results of equation 2 are reported in table 9[3]. Among granted firms, reputation is the only source of accessing FONTAR that is found to be positive and significant, which means that it increases the probability of being granted (by between +5.1 p.p. and +4.9 p.p.). However, reputation among past-granted firms negatively impacts on the probability of accessing, which means that the reputation source of the Matthew effect does not play the role expected in the literature ($Accum\_FONTAR_{it-1} * Reputation_{it}$). The market reputation of firms that were granted in the past reduces the probability of being granted in the present by between 2.2 p.p. and 2.3 p.p. However, since reputation suggests larger and elder firms, the negative sign implies that younger and smaller firms have higher probabilities of recurrence.

2 In Annex 1, we present the Hausman Test (Table 2)

3 In Annex 1, we present the Hausman Test (Table 3)

TABLE 8
Estimation results – Dep. Variable First_FONTAR

	Pooled probit	Panel Probit	
		RE	Chamberlain-Mundlak RE
$Reputation_{it}$	0.0015	0.0015	0.0014
	(0.0134)	(0.0132)	(0.0189)
$Formulation_{it}$	0.0474***	0.0474***	0.0455***
	(0.0106)	(0.0111)	(0.0109)
$Innovation_{it}$	0.0111	0.0111	0.0122
	(0.0111)	(0.0110)	(0.0110)
Obs.	962	962	962
Firms.		884	884
FE	YES	YES	YES
Time averaged characteristics$_i$	NO	NO	YES
Initial condition$_i$	NO	NO	YES

Source: own elaboration based on FONTAR database.
Notes: marginal effects. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. RE: random effect. FE (fixed effects): QHR, sector, size, region, time.

Conversely, the innovation and formulation capabilities sources of the Matthew effect impact positively and significantly on the probabilities of recurrence ($Accum\_FONTAR_{it-1*}$ $Formulation_{it}$ and $Accum\_FONTAR_{it-1*}$ $Innovation_{it}$). The interaction between past grants and formulation skills increases the probability of being recurrent by 0.8 p.p. The interaction between past grants and innovation capabilities increases the probability of recurrence by around 1.5 p.p. These results are in line with previous evidence that shows the crowding-in effects of FONTAR, without differences among recurrent and non-recurrent firms (FIORENTIN; PEREIRA; SUAREZ, 2019a), given that beneficiary firms may not act as *free riders*.

Besides these significant results, there are other dimensions of a firm that are equally relevant in explaining recurrence: high-tech manufacturer firms, knowledge intensive business services, small, medium and medium-large firms are more prone to being recurrent than micro firms that belong to low-tech industries or non-knowledge intensive business services. These last characteristics might be more the result of policy design, in the sense of promoting high-tech innovation projects,

than the result of attributes that better explain being granted, which is why this information was omitted in the tables.

TABLE 9
Estimation results – Dep. Variable Accum_FONTAR

	Pooled probit	Panel Probit	
		RE	Chamberlain-Mundlak RE
$Accum\_FONTAR_{it-1}$	-0.0063	-0.0063	-0.0064
	(0.0144)	(0.0147)	(0.0148)
$Reputation_{it}$	0.0514*	0.0512**	0.0496*
	(0.0274)	(0.0274)	(0.0275)
$Formulation_{it}$	0.0112	0.0112	0.0095
	(0.0115)	(0.0118)	(0.0121)
$Innovation_{it}$	-0.0213	-0.0212	-0.0213
	(0.0201)	(0.0198)	(0.0199)
$Accum\_FONTAR_{it-1} * Reputation_{it}$	-0.0225**	-0.0225***	-0.0230***
	(0.0088)	(0.0087)	(0.0086)
$Accum\_FONTAR_{it-1} * Formulation_{it}$	0.0079*	0.0078*	0.0082*
	(0.0045)	(0.0045)	(0.005)
$Accum\_FONTAR_{it-1} * Innovation_{it}$	0.0149**	0.0148**	0.0153**
	(0.0072)	(0.0070)	(0.0068)
Obs.	652	652	652
Firms		423	423
FE	YES	YES	YES
$Sector_i$	YES	YES	YES
$Time\ averaged\ characteristics_i$	NO	NO	YES
$Initial\ condition_i$	NO	NO	YES

Source: own elaboration based on FONTAR database.
Notes: marginal effects. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. RE: random effect. FE (fixed effects): QHR, sector, size, region, time. Source: own elaboration based on FONTAR database.

Summing up, results about first grants confirm the need to have accumulated certain levels of skills to apply for innovation funds. This is especially relevant in

the case of FONTAR, where submissions are based on a pass-fail criterion instead of a process of interaction between the applicant firm and the agency, such as is the case of other similar funds in the region (e.g., FINEP funds in Brazil). Surprisingly, while the literature has largely alerted us about the presence of capability thresholds regarding access to public funds for innovation, scarce attention has been paid to formulation skills in the literature that evaluates public policy. To some extent, even literature on the Matthew effect has disregarded the impact of formulation skills by including them in the same capability feedbacks between past and present grants (see section 2).

This paper demonstrates that formulation skills are relevant when it comes to analyzing first accessing public funds for innovation. Therefore, it contributes to literature which has considered this possibility but has not explored it in depth (DAVID, 1994; ANTONELLI; CRESPI, 2013). In this regard, to the extent that projects' quality may depend on formulation skills, the results are in line with Blanes and Busom (2004), who found that projects with more chance of commercial success are more likely to be selected in Spain. Thomas Falk and Svensson (2020) also showed that projects with knowledge spillover expectations had more probabilities of being selected in Austria.

Regarding the Matthew effect, this paper was the first to analyze all the sources of recurrence explained in the literature together. Two of them were verified. Positive associations between past grants and innovation and formulation skills increase the probability of accessing in the present. The traditional source of recurrence at the origins of the Matthew effect – i.e., reputation – was verified but with the opposite impact for larger firms. Since FONTAR results are public information, these results might imply that being a large and old well-known firm negatively impacts on the predisposition of the public agency to repeatedly grant funds. The opposite occurs in the case of young and small firms, where the results might point to a certain predisposition of public agencies to accompany the development of this type of firm, at least in terms of innovation (SILVA; SILVA; CARNEIRO, 2017).

Regarding the literature on recurrence, our results disagree with those found in Crespi and Antonelli's (2012) discoveries, to the extent that they found the predominance of the vicious Matthew effect (linked to low-tech firms) over the virtuous one (high-tech firms). They also disagree with our initial findings regarding the Matthew effect within FONTAR (PEREIRA; SUÁREZ, 2017) since when capabilities are properly accounted for, the reputation effect is not verified. However, they strongly agree with our initial claim that capabilities are key elements for

understanding and analyzing public policy allocation. In this regard, our results are largely in line with the literature on recurrence (DUGUET, 2003; TANAYAMA, 2007; PEREIRA; SUÁREZ, 2017; ANTONELLI; CRESPI, 2013) in terms of verifying the phenomenon. Moreover, they reinforce the idea that the recurrence of being granted public funds to foster innovation is strongly related to a firm's capabilities (BARLETTA *et al.*, 2017; FIORENTIN; PEREIRA; SUAREZ, 2019a). In fact, a dynamic innovative profile is required to access innovation funds and to maintain innovative behaviour. Therefore, the results confirm that firms which have been previously granted are more likely to possess these characteristics and thus be granted again (FIORENTIN; PEREIRA; SUAREZ, 2019b; PEREIRA; SUÁREZ, 2017).

Finally, this research shows the relevance of considering the allocation process when it comes to studying innovation policy and the different stages associated with this process. Policy evaluation must go beyond the analysis of average ex-post impacts, which ignore the ex-ante allocation process and, thus, its heterogeneous nature. In this regard, although it lies outside from the scope of this article, these results show the importance of the policy design phase. This is even more relevant for the case of developing countries such as Argentina, where the productive structure is also underdeveloped and biased towards low-tech activities, which is the opposite of what is expected in this type of innovation policy. In other words, if there is a reduced number of firms with the required level of technological complexity required to be granted funds, these must access the fund recurrently.

6 Conclusions

The objective of this paper was to analyse the process of the allocation of public funds for innovation in terms of first and recurrent granting. Following the literature, there are three sources of recurrence, named the Matthew effect: a firm's reputation, linked to its brand; a firm's formulation expertise, related to its skills to formulate a project; and a firm's innovation capabilities, based on its accumulation of innovation skills and abilities. To the best of our knowledge, the Matthew effect and the determinants of accessing funds had not been analysed together in previous works. We claim that the three Matthew effect sources might apply to both first and recurrent granting, although with different roles respectively.

The results for FONTAR show that formulation skills play a significant role among first-granted firms in respect to firms with rejected projects. In addition,

they show that the reputation effect negatively impacts the probability of recurrence, while formulation and innovation capabilities impact positively. Therefore, only two of the three sources of recurrence identified in the literature are verified, while the most traditional source, linked to the origins of the Matthew effect, presented the opposite.

We also found that formulation skills are key to first accessing innovation public policy, thus confirming what is a widely accepted assumption in the literature but one that has been scarcely explored in empirical terms. One-shot instruments such as FONTAR require firms to have overcome certain thresholds in terms of formulation capabilities. This might explain the existence of a vicious cycle of lack of formulation capabilities that prevents firms from successfully applying for public funds, which leads to poor innovative performance that feedbacks with poor learning processes and accumulation of capabilities, formulation skills included.

Limitations of this research emerged from the availability of data. A key limitation of our database is the lack of information on firms that did not apply to FONTAR. This type of database is not available in Argentina at the present time. In this regard, the results regarding first access could overestimate the role of firms' capabilities, but those related to recurrent access should not have been affected since the analysis is centred on those firms that have already been funded in the past. Another limitation is the possibility to identify how the sources of granting affect the impact of FONTAR on granted firms. Previous studies based on the same data showed that FONTAR impacts on firms' innovative and economic performance at different moments (see Section 2). Testing different impacts of different recurrence profiles over time, allowing firms to change between predominant profiles, would demand an amount of data not yet available, given the age and extension of FONTAR. We hope that future additions of cases to the database will allow us to expand the research questions.

Regardless of these limitations, our results provide some relevant insights in order to go deeper in the analysis of innovation policy. Firstly, they highlight the need to evaluate policy beyond the ex-post impacts, since the different allocation trajectories might shed light on different types of firms and innovative profiles. Ultimately, the allocation process determines the type of firms – in terms of their trajectories and innovative profiles – where impact evaluations will be carried out. In other words, the allocation process sets the limits for the impact evaluation studies. The corollary is that policy evaluations must take all of the policy cycle into account.

Secondly, and focusing on the Argentinean case, innovation policy is implemented to increase the level of innovative firms, but our results show that it is oriented to a certain kind of firm (highly innovative with higher skills) which does not predominate in the Argentinean productive structure (low innovation profiles). Therefore, it makes sense to expect the same firms to access public funds repeatedly. This reflection raises a question about the group of less dynamic firms which are not able to access FONTAR and about what would be good instruments to promote a higher level of high-profile innovative firms.

Thirdly, formulation and innovation skills sources of recurrence are an intrinsic part of the innovation policy process, while reputation is not. Our results provide new elements for the theoretical debate about the phenomenon of recurrence in accessing public policy for innovation.

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Author's contribution

A. theoretical and conceptual foundations and problematization: Diana Suarez and Florencia Fiorentin

B. data research and statistical analysis: Diana Suarez and Mariano Pereira

C. elaboration of figures and tables: Diana Suarez and Mariano Pereira

D. drafting and writing of the text: Diana Suarez and Florencia Fiorentin

E. selection of bibliographical references: Diana Suarez and Florencia Fiorentin

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Annex 1

TABLE 1
Pairwise correlation among variables

	FONTAR Grant	Reputation	Formulation	Innovation
FONTAR Grant	1.00			
Reputation	-0.05	1.00		
Formulation	0.11	0.23	1.00	
Innovation	0.07	-0.33	-0.19	1.00

Source: own elaboration based on FONTAR database.

TABLE 2
Hausman Test

	Coefficients		Difference	sqrt(diag(V_b-V_B))
	(b) fe	(B) re	(b-B) Difference	S.E.
Reputation	**4.28**	**0.02**	**4.26**	**3.22**
Formulation	0.61	0.35	0.26	0.40
Innovation	1.26	0.07	1.19	0.59
QHR	1.71	-0.55	2.26	3.25
Size				
Small	-2.04	0.14	-2.18	2.13
Medium	-0.62	-0.25	-0.37	2.55
Big	-4.38	-0.07	-4.30	3.58
Trend				
2009-2010	0.16	-0.46	0.62	0.90
2011-2012	-3.16	-1.69	-1.47	1.24
2013-2014	-5.62	-3.03	-2.58	1.69
2015-2016	-5.85	-2.86	-2.99	1.82

Ho: difference in coefficients not systematic
Chi2(12): 8.68
Prob>chi2 = 0.7299

Source: own elaboration based on FONTAR database.

TABLE 3
Hausman Test

	Coefficients		Difference	sqrt(diag(V_b-V_B))
	(b) fe	(B) re	(b-B) Difference	S.E.
Reputation	**4.49**	**-0.04**	**4.54**	**3.27**
Formulation	0.65	0.35	0.30	0.41
Innovation	1.33	0.07	1.26	0.60
QHR	0.66	-0.51	1.17	3.21
Size				
Small	-2.24	0.09	-2.33	2.07
Medium	-1.02	-0.23	-0.79	2.51
Big	-5.07	-0.01	-5.06	3.70
Trend				
2009-2010	-0.31	-0.52	0.22	0.79
2011-2012	-3.42	-1.70	-1.73	1.26
2013-2014	-5.98	-3.02	-2.96	1.74
2015-2016	-6.11	-2.84	-3.27	1.88
Ho: difference in coefficients not systematic				
Chi2(12): 8.57				
Prob>chi2 = 0.6612				

Source: own elaboration based on FONTAR database.

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