



Non-technological strategic alliances and public support for innovation: what are, if any, their links?

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Santiago Acerenza[†]
Universidad ORT Uruguay

Liliana Gelabert[‡]
IE Business School
Martin Pereyra[§]
Universidad ORT Uruguay

Flavia Roldán[¶]
Universidad ORT Uruguay

July 19, 2023

Abstract

This paper studies the impact of public support for innovation on the firm's decision to form non-technological strategic alliances. We theoretically discuss the potential mechanisms at play (absorptive capacity and/or certification effect) and test them using Uruguayan data between 2007 and 2015. Our empirical analysis offers evidence of a positive causal effect of public support for innovation on the firms' likelihood to enter a non-technological strategic alliance. Moreover, we show that the absorptive capacity mechanism drives the effect while we find no support for the certification effect.

JEL: H25, H81, L2, L60, M21, O3.

Keywords: Innovation subsidies, Impact evaluation, Cooperation, behavioural additionality, IV, Mundlak device.

Documento de Investigación, Nro.136, Julio 2023. Universidad ORT Uruguay.
Facultad de Administración y Ciencias Sociales. ISSN 1688-6275.

*We thank participants at internal seminars at Universidad ORT Uruguay and the useful research assistance of Martina Core and Ignacio Jaunsolo.

[†]Departamento de Economía, Universidad ORT Uruguay; [acerenza\[at\]ort.edu.uy](mailto:acerenza[at]ort.edu.uy);

[‡]Departamento de Economía, IE Business School, Madrid; [liliana.gelabert\[at\]ie.edu](mailto:liliana.gelabert[at]ie.edu)

[§] Departamento de Economía, Universidad ORT Uruguay; [pereyra_m\[at\]ort.edu.uy](mailto:pereyra_m[at]ort.edu.uy);

[¶]Departamento de Economía, Universidad ORT Uruguay; [roldan\[at\]ort.edu.uy](mailto:roldan[at]ort.edu.uy)

1 Introduction

Can public support for innovation activities enhance the formation of non-technological strategic alliances (cooperation agreements)? If yes, which is the mechanism? In this paper, we address these issues.

At the core of the innovation policy impact evaluation literature is the question of what is the role of public support for innovation in shaping firm behavior. Specifically, researchers have studied whether public R&D subsidies encourage firms to engage in collaborative behavior. A substantial body of literature exploring this topic concentrates its efforts on understanding the impact of public R&D subsidies on the likelihood of recipient firms forming technological collaboration agreements, such as joint development of R&D or joint purchases of technological inputs.

However, while much research has been devoted to the relationship between public R&D subsidies and technological collaboration agreements, less attention has been paid to the potential impact of public support for innovation on the formation of non-technological cooperation agreements. This is a significant gap in the literature, as non-technological cooperation agreements, such as joint marketing, distribution, or purchasing agreements, can be just as important for gaining efficiency and promoting growth as technological collaboration agreements. Non-technological strategic alliances have the potential to provide firms with access to new markets, distribution channels, and expertise, thereby enabling partners to reduce costs, increase efficiency and improve their overall performance. This article aims to fill this gap by examining the relationship between public support for innovation and the probability of forming non-technological cooperation agreements. Specifically, we seek to answer two main questions: first, does public support for innovation impact the likelihood of supported firms forming non-technological cooperation agreements? Second, what factors would be mediating this relationship if that is the case?

To address these questions, we build a model that serves as a framework for our empirical analysis and provides a basis for interpreting our findings. Guided by our theoretical framework we hypothesize that public support for innovation will boost the likelihood of non-technological cooperation agreements. We argue that this causal relationship can be attributed to two mechanisms. First, public support for innovation can enhance partners' organizational capabilities for securing, developing, and sharing resources, thereby improving the capacity to manage strategic alliances (absorptive capacity effect). Second, it can serve as a stamp of approval, reducing uncertainty and providing insights into the firm's cooperative capabilities (certification effect). After the discussion of these two theoretical channels, we test the hypothesis of a causal relationship between public support for innovation and non-technological cooperation and then we explore the significance of these two potential mechanisms.

The results of our empirical analysis provide causal evidence of a positive relationship between public support for innovation and the firms' likelihood of entering non-technological cooperation agreements. Moreover, we find strong support for the absorptive capacity

mechanism and no support for the certification effect. These findings suggest that public support for innovation can play an important role in fostering non-technological cooperation among firms by improving firm capabilities that contribute to the success of strategic alliances.

The empirical analysis is based on comprehensive panel data at the firm level, spanning a variety of industries. We take into account a range of firm and industry-level characteristics, including size, age, and sector, as well as the level of public support for innovation received by each firm. We rely on the Business Innovation Survey (BIS) from Uruguay spanning from 2007 to 2015. From this survey, we leverage a crucial self-reported measure that sheds light on the type of collaborative agreement a firm participates in, enabling us to explore whether these firms establish non-technological alliances.

This study contributes both theoretically and empirically to the innovation policy evaluation literature. From a theoretical point of view, we ground on the strategic alliance's literature to discuss the theoretical mechanisms that could explain why public support for innovation can incentivize non-technological collaboration which is an outcome that was almost ignored in the behavioral additionality literature. Our theoretical analysis discusses different channels by which public support can influence the propensity to enter and undertake non-technological collaboration. From an empirical point of view, our empirical strategy allows us to test for the causal effect of public support for innovation on non-technological alliances and for the relative significance of the hypothesized channels.

This study has important implications for policymakers, managers, and researchers. By shedding light on the factors that influence the formation of non-technological cooperation agreements, our findings can inform the design of more effective innovation policies. Moreover, our results can help managers to better understand the conditions under which non-technological cooperation agreements are more likely to be formed and can guide future research on the link between innovation policy and firm-level behaviors and outcomes.

The remainder of the paper is structured as follows. Section 2 provides a review of the literature on strategic alliances, innovation policy, and the link between the two. Section 3 presents our theoretical framework and derives some testable hypotheses. Section 4 describes the data while Section 5 explains the empirical strategy. Section 6 presents the results, and section 7 concludes.

2 Non-technological alliances and public support for innovation.

This section reviews the existing literature on firm cooperation and on the effect of public support on cooperation.

Strategic alliances are collaboration agreements between two or more independent firms to pursue common goals that facilitate firm growth and expansion. By forming a strategic alliance firms can pool their resources, capabilities, and expertise to achieve mutual benefits.

The most common reasons for the formation of strategic alliances include leveraging complementary resources and capabilities, accessing new markets sharing risks and costs, gaining competitive advantage, and acquiring new knowledge or technology. By forming strategic alliances, firms can tap into the strengths of their partners and overcome individual limitations, thereby enhancing their competitive position in the market (Grant, R. M., Baden-Fuller, C. (2004)).

Although the decision to form a strategic alliance is a very complex one, it is typically guided by a firm's assessment of the expected success. Specifically, a firm will enter into a strategic alliance if it expects to derive positive net value from the partnership.

What determines the success of strategic alliances? The literature that studies the success of strategic alliances points out that the success of these alliances depends on a combination of factors, including the complementary resources and capabilities of partners (resource-based view¹), effective alliance management practices (competence-based view²), strong relational factors (relation factors view³), and the ability to create a competitive advantage (competitive advantage view⁴).

Each approach generates valuable insights regarding determinants of the formation and the success of strategic alliances. In particular, according to the resource-based view, alliance success is attributed to partners bringing complementary resources to the alliance and developing unique resources during the course of the alliance. On the other hand, the competence-based view emphasizes the critical role of established organizational capabilities in securing and managing alliances, which ultimately boosts their likelihood of success (Gulati et al (2012)). All these previously mentioned perspectives shed light on factors related to distinct facets of the dynamic concept of absorptive capacity.

The absorptive capacity effect. Absorptive capacity, a concept coined by Cohen and Levinthal (1989) and Cohen and Levinthal (1990), refers to an organization's ability to identify, acquire, assimilate, and apply external knowledge. More specifically, absorptive capacity is often seen as a multi-dimensional concept, consisting of *potential* absorptive capacity (the ability to recognize and assimilate new knowledge) and *realized* absorptive capacity (the ability to transform and exploit new knowledge). In this article, we focus on the *potential* absorptive capacity and its role in the context of collaboration, where organizations engage in cooperative arrangements to access and leverage external knowledge for mutual benefit.⁵ Numerous studies (Muscio, A. (2007) and Flatten et

¹Barney, J. (1991), Jap, S. D. (1999)

²Hunt, S. D., Lambe, C. J., Wittmann, C. M. (2002), Lambe, C. J., Spekman, R. E., Hunt, S. D.

(2000), Sivadas, E., & Dwyer, F. R. (2000)

³Dwyer, F., Schurr, P. and Oh, S. (1987), Morgan, R.M. and Hunt, S.D. (1994)

⁴Aaker, D. (1995), Barney, J. (1991), Day & Wensley (1988), Porter, M. (1985)

⁵Collaboration alliances are often established for exploration purposes, where firms seek to explore new

al (2011), among others) have highlighted the positive impact of absorptive capacity on collaboration. They show that higher levels of absorptive capacity enable organizations to better understand and interpret external knowledge, integrate it with their existing knowledge, and apply it to collaborative efforts. This leads to improved coordination, information sharing, and performance in collaborative initiatives, which increases the expected value of forming a strategic alliance. (Muscio, A. (2007), Flatten et al (2011)). Delving into the innovation literature uncovers compelling evidence that innovation efforts go beyond just generating novel knowledge, but they also play a crucial role in enhancing a firm's absorptive capacity. As Cohen and Levinthal (1989) point out, '*...while R&D obviously generates innovations, it also develops the firm's ability to identify, assimilate, and exploit knowledge from the environment, what we call a firm's learning or absorptive capacity.*' In fact, R&D serves a dual role, not only creating new knowledge but also bolstering a firm's ability to effectively leverage existing information, as Muscio, A. (2007) highlights.

This article builds upon this concept and relates it to the literature that studies the impact of public support on innovation activities; more precisely, to the part of the innovation policy literature that has examined the impact of public support on input additionality (Zúñiga-Vicente et al. (2014)). Grounding on this literature we argue that to the extent to which public support for innovation increases firm innovation effort, this additional innovation effort will improve the firm's capabilities to identify attractive partners and to manage a collaboration agreement, as the literature on (potential) absorptive capacity suggests. These enhanced collaborative capabilities will increase the likelihood of non-technological collaboration producing a positive causal relationship between public support for innovation and the formation non-technological strategic alliances.

The certification effect. The first and most crucial step in the decision to participate in a strategic alliance is to choose the right partner. This is not an easy task as information problems abound, making it challenging to assess the capabilities of alternative cooperation partners to collaborate effectively. In this paper we claim that receiving public support for an innovation project can operate as a signal of these unobservable capabilities, increasing therefore the likelihood that the granted firm will cooperate with external corporate partners. Bianchi et al. (2019) argued that public innovation subsidies can act as a "stamp of approval" that facilitates technological strategic alliances. We extend this claim by arguing that public support can also be a signal of the firm capabilities as a collaboration partner for non-technological collaboration agreements for the following reasons. First, receiving public support for innovation proves that the firm has been able to successfully go through a formal application procedure, supervised by a public agency that made the decision of choosing such firm as a promising target to allocate the public support. We

knowledge or markets. In these exploratory activities, the emphasis is on recognizing and assimilating new knowledge (potential absorptive capacity) rather than exploiting it (realized absorptive capacity). The focus is on expanding the firm's knowledge base and exploring new opportunities, rather than immediate application or commercialization. Nonetheless, it's important to note that potential and realized absorptive capacity are interconnected and mutually reinforcing throughout time.

claim that the public agency decision to assign public resources to support innovation activities to a specific firm, can work as a signal of the reliability and trustworthiness of such firm. As trust and confidence between alliance partners are important aspects to contribute to the survival of strategic alliances, we claim that firms receiving public support for innovation would be more likely to be perceived as reliable and trustworthy and thus as attractive partners for non-technological cooperation agreements. Moreover, having received support for innovation indicates that the firm allocates internal resources to undertake innovation activities reflecting commitment to the development of new products and productivity. Thus, public support received to undertake innovation can work a signal of the innovative capabilities of the firm which are a key determinant of its long- term survival. As strategic alliances often involve significant investment in resources, time and effort, choosing a partner with stronger innovation capabilities reduces the risk of partner failure and of early termination of the alliance. In sum, we argue that receiving public support can be a signal of relevant firm capabilities that could foretell better success in the formation of a non-technological cooperation agreement turning the granted firm into a more attractive partner for non-technological strategic alliances.

These theoretical arguments offer novel insights into the potential benefits and limitations of public support for innovation in influencing strategic alliance formation, specifically in the realm of non-technological alliances. We depart away from the conventional literature that focuses on public support for innovation solely in the context of cooperative R&D or other technological collaborations (Bianchi et al. (2019); Chapman, G. et al. (2018); Busom, I. and Fernández-Ribas, A. (2008) and instead pave the way for a fresh and relevant perspective that argues that public support for innovation can also incentivize non-technological alliances. In the next section we develop a theoretical model that takes into account both the absorptive capacity and certification effect as the channels through which public support for innovation may affect non-technological cooperation.

3 Model setup

This section outlines our baseline theory, which allows us to rationalize our results. We focus on the optimal decisions for a single firm.

Timing of events. The sequence of events in the model is as follows. In stage 0, we assume that firms decide to invest in innovation or not; this is captured by the indicator $q \in \{0, 1\}$ which is 1 if a firm decides to invest in innovation.

If a firm invests in innovation ($q = 1$) then, at time 1, it decides whether or not to apply for public support for the innovation project, i.e., $d \in \{0, 1\}$.

If the firm applies, in $t = 2$, a public agency evaluates the project and decides whether it will provide public support. If the decision is positive, the public agency decides how much support it will provide.

After this stage, the firm decides how much to invest in innovation, I .

In the last stage of the game, after profits due to innovation are realized, the firm decides whether or not to undertake cooperation agreements, $c \in \{0, 1\}$ which is 1 if a firm chooses to cooperate with another firm.

Before continuing, it is useful to discuss the sequence of the game. One might wonder why the decision to innovate could precede the decision to cooperate. In this article, we focus on non-technological strategic alliances, and in this sense, we consider that the timing of events is aligned with the natural progression of events in real-world business dynamics. It reflects the sequential nature of resource allocation, strategic considerations, and risk assessment that firms typically undertake when pursuing innovation and collaboration. That is, firms can allocate resources accordingly and focus on building their internal innovation capabilities. Only after securing the necessary resources and developing innovative solutions can firms effectively engage in cooperation to leverage and expand their innovation efforts through the non-technological cooperation agreements that we study in this article, i.e., joint marketing, distribution, or purchasing agreements.

3.1 Cooperation decision

Let z denotes the "output of innovation" and K the cooperation cost. A firm undertakes a cooperation agreement if $\Pi(z) \geq K(d)$. Therefore, the cooperation decision

$$c = \mathcal{I}[\Pi(z) - K(d) \geq 0]. \quad (1)$$

z is defined as $z = \alpha_0 f(I)$ where α_0 is the baseline firm's characteristics and I is the level of firm innovation efforts. Furthermore, the cooperation cost, $K(d)$, depends on whether a firm applies for public support ($d \in \{0, 1\}$).

We will assume that $K(d = 1) < K(d = 0)$, consistent with previously mentioned evidence that innovation reduces the costs of cooperation.

Thus, the cooperation decision (1) involves two key dimensions, reported in Section 2. Namely, the absorptive capacity effect summarized in z and the certification effect reported in lower cooperation costs for those who have received public sector support. Thus z may enable firms to recognize the relevance and significance of external knowledge in relation to their existing knowledge and strategic goals and facilitate the application of external knowledge to collaborative initiatives. $K(d = 1) < K(d = 0)$ summarizes the idea that firms that would receive public support could be signaling their ability to cooperate effectively with other firms. That is, the public support a firm receives serves as a certification, indicating the type of partner it's likely to be.

The decision to engage in cooperation, as expressed in equation (1), encompasses two important factors discussed in Section 2. These factors are the absorptive capacity effect, and the certification effect, which leads to lower cooperation costs for firms that have received public sector support. The absorptive capacity effect is captured by the variable z which represents a firm's ability to recognize the importance and relevance of

external knowledge in relation to its existing knowledge and strategic objectives. A higher value of z indicates that a firm possesses a greater capacity to understand and utilize external knowledge in collaborative endeavors. On the other hand, the certification effect is reflected in the inequality $K(d = 1) < K(d = 0)$, and suggests that firms receiving public support are signaling their proficiency in cooperating effectively with other firms. In this context, the public support received by a firm acts as a certification, indicating the firm's potential as a collaborative partner and reducing costs related to asymmetric information. Combining these two dimensions, firms with higher absorptive capacity, denoted by a larger z value, are more likely to comprehend and apply external knowledge in collaborative initiatives. Additionally, firms that have received public support, which it acts as a signal, it is expected that they will be good partners for collaborative endeavors with other firms. In summary, in the cooperation decision intervene two factors, namely, the absorptive capacity effect, which enables firms to leverage external knowledge, and the certification effect, where public support acts as a signal of a firm's cooperative capabilities that reduces information problems.

3.2 Innovation technology

When a firm invests in innovation, their profits will ultimately depend on the amount invested, I . The innovation technology implies the following expected discounted profits:

$$\Pi = \alpha^{1-\gamma} \left(\frac{I^\gamma + 1}{\gamma} \right) - I - F_I \quad (2)$$

where $\alpha \geq 0$ is a measure of productivity of innovation and γ a parameter of the concavity of profits in innovation effort I , and F_I is a fixed cost necessary to innovate (unless otherwise specified, all variables are firm specific).

3.3 Innovation efforts

Since the firm may receive public support (s) to undertake its innovation activity the firm problem is:

$$\max_I \Pi(I, s) = \alpha^{1-\gamma} \left(\frac{I^\gamma + 1}{\gamma} \right) - (1-s)I - F_I$$

Since the firm problem is concave in I , the FOC

$$I^*(s) := \arg \max \Pi(I, s) = \alpha(1-s)^{\frac{1}{\gamma-1}} \quad (3)$$

We assume that $\gamma < 1$.

The profit value function

$$\Pi^*(I^*(s), s) = \frac{(1-\gamma)}{\gamma} \alpha_0 (1-s)^{\frac{\gamma}{\gamma-1}} + \frac{\alpha_0^{(1-\gamma)}}{\gamma} - F_I$$

Then, given s the firm's participation constraint is

$$I^{**}(s) = \mathcal{I}[\Pi^*(I^*(s), s) \geq 0] I^*(s) \quad (4)$$

Assuming α depends on observed and unobserved characteristics, $\alpha := \exp X\beta + \epsilon$ and taking the natural log of both side of I^* yields the following familiar expression for the log of innovation:

$$\ln I^* = X\beta + \frac{1}{\gamma-1} \ln(1-s) + \epsilon$$

3.4 Public support

By assuming an economy with two firms, the public agency problem is

$$\max_s U(I(s), s) = I(s_1)^{\rho_1} I(s_2)^{\rho_2}$$

subject to

$$\sum_{i=1}^2 s_i I(s_i) \leq \bar{B}.$$

where ρ_i for $i = 1, 2$ is a spillover parameter that takes into account possible externalities from the firm's innovation efforts to the public agency. The problem is subject to the public agency budget constraint, i.e. the total public support allocated amongst firms should be less or equal than the total public budget.

The FOC in the constrained problem is:

$$\rho_1 \left(\bar{B}(1-s_1)^{\frac{1}{1-\gamma}} - s_1 \alpha_0 \right) = \rho_2 \alpha_0 (1-\gamma + \gamma s_1) \quad (5)$$

When, for example, $\gamma = 0$, the explicit form of optimal subsidy is:

$$s_1^* = \frac{\rho_1 \bar{B} - \rho_2 \alpha_0}{\rho_1 (\bar{B} - \alpha_0)}$$

Before studying the application stage, it is useful to observe the following:

1. Given the values of parameters (F_I, α, γ) , from the firm's investment constraint, the

level of subsidy necessary to invest is

$$\hat{s} = 1 - \left(\frac{\alpha_0(1-\gamma)}{F_I\gamma - \alpha_0^{1-\gamma}} \right)^{\frac{1-\gamma}{\gamma}} \quad (6)$$

2. Depending on F_I , the firm's investment constraint never/sometimes/always binds. That is:

(a) The firm always invests in innovation, even if $s = 0$ when the cost F_I is sufficiently low; that is when

$$F_I < \underline{F} := \frac{\alpha_0(1-\gamma) + \alpha_0^{1-\gamma}}{\gamma} \quad (7)$$

(b) The firm never invests in innovation, even if it gets some maximum level of subsidy \bar{s} , when F_I is sufficiently high. That is, when

$$F_I > \bar{F} := \frac{(1-\gamma)}{\gamma} \frac{\alpha_0}{(1-\bar{s})^{\frac{\gamma}{1-\gamma}}} + \frac{\alpha_0^{1-\gamma}}{\gamma} \quad (8)$$

(c) When the cost $F_I \in (\underline{F}, \bar{F}]$ the firm will invest only if it gets \hat{s} .

3.5 Application for public support decision

If the firm does not apply for public support

$$\Pi^{NS} = \Pi(I^*(0), 0) \quad (9)$$

If the firm does apply for public support

$$\Pi^S = E[\Pi(I^*(s), s)] - D, \quad (10)$$

where D is the application cost. Then, the firm's optimal application decision is expressed as:

$$d = \mathcal{I}[(\Pi^S - \Pi^{NS}) \geq 0] \quad (11)$$

We will see that the optimal application decision will depend on whether $F_I < \underline{F}$, $F_I > \bar{F}$, or $F_I \in (\underline{F}, \bar{F}]$.

When $F_I < \underline{F}$, the firm will invest even if $s = 0$. Nonetheless, given the budget \bar{B} and firm's baseline productivity α_0 , the amount that a firm will actually receive will depend on the spillover ratio. Following 5, when

$$\frac{\rho_1}{\rho_2} < \underline{\varrho} := \frac{\alpha_0(1-\gamma)}{\bar{B}} \quad (12)$$

the optimal subsidy will be $s_1^* = 0$. On the other hand, let denotes \bar{s} be the maximum level of subsidy that implies threshold for the maximum level of the spillover ratio:

$$\frac{\rho_1}{\rho_2} > \bar{\varrho} := \frac{\alpha_0(1 - \gamma + \gamma\bar{s})}{\bar{B}(1 - \bar{s})^{\frac{1}{1-\gamma}} - \bar{s}\alpha_0} \quad (13)$$

Therefore, $E[\Pi(I^*(s), s)]$ is

$$\Phi(\underline{\varrho})\Pi(I^*(0), 0) + \int_{\underline{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \phi(\varrho) d\varrho + (1 - \Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s}) \quad (14)$$

and the optimal application decision for sufficiently low cost $F_I < \underline{F}$ will be one if the following condition holds

$$\int_{\underline{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \phi(\varrho) d\varrho + (1 - \Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s}) - (1 - \Phi(\underline{\varrho}))\Pi(I^*(0), 0) \geq D \quad (15)$$

When $F_I \in (\underline{F}, \bar{F}]$, a firm invests in innovation only if it gets the subsidy \hat{s} . In turn, \hat{s} will be optimal for the public agency if the ratio of spillover is $\hat{\varrho} := \frac{\alpha_0(1-\gamma)+\gamma\hat{s}}{\bar{B}(1-\hat{s})^{\frac{1}{1-\gamma}}}$.

Thus, if $\frac{\rho_1}{\rho_2} < \hat{\varrho}$ the optimal subsidy that satisfies (5) implies $s^* \prec s^\wedge$ and the firm does not invest in innovation. Thus, $\Pi(I^*(s_1^*), s_1^*) < 0 \forall s_1^* \in [0, s^\wedge)$. Then $I^*(s_1^*) = 0$, and $\Pi(I^*(s_1^*), s_1^*) = \Pi(0, 0) \forall s_1^* \in [0, s^\wedge)$. In contrast, when $\varrho > \hat{\varrho}$, given (5), the optimal subsidy $s_1^* > \hat{s}_1$, and the firm always invests in innovation.

Therefore,

$$E[\Pi(I^*(s), s)] = \int_{\hat{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \phi(\varrho) d\varrho + (1 - \Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s}) + \Phi(\hat{\varrho})\Pi(0, 0) \quad (16)$$

and the optimal application decision becomes one if the following condition holds:

$$\int_{\hat{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \phi(\varrho) d\varrho + (1 - \Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s}) - (1 - \Phi(\hat{\varrho}))\Pi(0, 0) \geq D \quad (17)$$

Finally, if $F_I > \bar{F}$, the cost are so high that the firm will never invest even if it would get $s = \bar{s}$.

3.6 Firm's innovation investment decision

If the firm does not invest in innovation

$$\Pi^{NI} = \Pi(0, 0) \quad (18)$$

If the firm does apply for public support

$$\Pi^I = (1 - d)\Pi^{NS} + d\Pi^S. \quad (19)$$

Then, the firm's optimal investment decision is expressed as:

$$q = \mathcal{I}[(\Pi^I - \Pi^{NI}) \geq 0] \quad (20)$$

For $F_I < \underline{F}$, the optimal innovation investment decision will be one if the following condition holds

$$\Pi(I^*(0), 0)[(1-d)+d\Phi(\underline{\varrho})]+d[\int_{\underline{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \phi(\varrho) d\varrho+(1-\Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s})]-D-\Pi(0, 0) \geq 0 \quad (21)$$

When $F_I \in (\underline{F}, \bar{F}]$, the optimal innovation investment decision will be one if the following condition holds

$$\int_{\underline{\varrho}}^{\bar{\varrho}} \Pi(I^*(s^*), s^*) \Phi(\varrho) d\varrho + (1 - \Phi(\bar{\varrho}))\Pi(I^*(\bar{s}), \bar{s}) - D - \Pi(0, 0) \geq 0 \quad (22)$$

If $F_I > \bar{F}$ then $q = 0$.

Proposition 1 Given the fixed-cost of innovation, F_I , and the spillover ratio $\varrho = \frac{\rho_1}{\rho_2}$, the equilibrium can be characterized as follows:

If the innovation cost are sufficiently low $F_I < \underline{F}$, then:

1. the firm always invests (even without subsidy), and
2. if (15) holds, the firm will apply for subsidy, $d = 1$, otherwise $d = 0$.
3. In the case that firm applies for public support, $d = 1$, the level of subsidy depends on ϱ ; that is:
 - (a) if $\varrho < \underline{\varrho}$, the optimal level of subsidy that satisfies (5) is $s^* = 0$, and the optimal innovation decision will be according to (3), $I^*(0)$. In such a case, the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(0), 0)] - K(d = 1)$.
 - (b) if $\varrho \in (\underline{\varrho}, \varrho^-)$, then the optimal level of subsidy that satisfies (5) is $s^* > 0$, and the optimal innovation decision will be according to (3), $I^*(s^*)$. In such a case, the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(s^*), s^*)] - K(d = 1)$.
 - (c) Finally, if $\varrho > \varrho^-$, then the optimal level of subsidy that satisfies (5) is $s^* = s^-$, and the optimal innovation decision will be according to (3), $I^*(s^-)$. In such a case, the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(\bar{s}), \bar{s})] - K(d = 1)$.
4. If $d = 0$, the optimal innovation decision will be according to (3), $I^*(0)$ and the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(0), 0)] - K(d = 0)$.

In the case that $F_I \in (\underline{F}, \bar{F}]$,

1. the firm requires at least \hat{s} to undertake any innovation project, otherwise $I^* = 0$.
2. Then, if (15) holds, the firm will apply for subsidy, $d = 1$, otherwise $d = 0$.
3. In the case that firm applies for public support, $d = 1$, the level of subsidy depends on ϱ ; that is:
 - (a) if $\varrho < \hat{\varrho}$, the optimal level of subsidy that satisfies (5) is $s^* < \hat{s}$. Then, the firm will not invest $I^* = 0$ and, in such a case, the optimal cooperation decision will be $c = \mathcal{I}[\Pi(0, 0)] - K(d = 1)$.
 - (b) if $\varrho \in (\hat{\varrho}, \varrho^-)$, then the optimal level of subsidy that satisfies (5) is $s^* > \hat{s}$ and the firm will invest in innovation according to (3), $I^*(s^*)$. In such a case, the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(s^*), s^*)] - K(d = 1)$.
 - (c) Finally, if $\varrho > \varrho^-$, then the optimal level of subsidy that satisfies (5) is $s^* = \bar{s}$, and the firm will invest in innovation according to (3), $I^*(\bar{s})$. In such a case,¹ the optimal cooperation decision will be $c = \mathcal{I}[\Pi(I(\bar{s}), \bar{s})] - K(d = 1)$.
4. If $d = 0$, the firm will not invest in innovation and the optimal cooperation decision will be $c = \mathcal{I}[\Pi(0, 0)] - K(d = 0)$.

Finally, when the cost of innovation is high enough, $F_I > \bar{F}$, the firm will not invest in innovation, and the optimal cooperation decision will be $c = \mathcal{I}[\Pi(0, 0)] - K(d = 0)$.

4 Data and variables definitions

We use publicly available Uruguayan data from the Business Innovation Survey (BIS), which is jointly conducted by the National Institute of Statistics (INE) and the National Agency for Innovation and Research (ANII). This survey is specially designed to provide detailed information on a firm's innovation activities, with measures that characterize the innovation process.

Our dataset comprises three waves of the BIS conducted between 2007 and 2015 and covers all firms with 50 or more employees and a representative sample of smaller firms with at least ten employees. Within this rich dataset, we are particularly interested in the sources of public funding for innovation activities and the cooperation agreements held by firms.

While the survey is conducted every three years, some variables are reported yearly, and in other cases, firms are asked to report averages for the given wave. By exploiting the panel structure of the surveys, our analysis leverages a sample of 1,342 firms and 4,026 observations to test the main hypotheses of the current article. We describe below the main variables of interest.

Cooperation agreements. The BIS collects information on five different kinds of cooperation agreements (and a residual category) held by firms. All surveyed firms must answer these questions regardless of whether they have undertaken any innovation activity.

Firms must indicate whether they have entered into cooperation agreements with other firms during the wave period.

According to the BIS, a cooperation agreement is an explicit agreement, formal or informal, between two or more independent firms, by which joining or sharing part of their capabilities and resources, firms establish a certain degree of interrelation in order to increase their competitive advantages.

From the survey, we are not able to distinguish among partners; we are only able to know that the partners are *other firms* that may operate in horizontally and/or vertically related markets.

Information about cooperation agreements includes (a) commercialization-marketing agreements, (b) agreements to purchase raw materials or inputs, (c) agreements to purchase technology, (d) agreements for joint technology development, (e) agreements to train employees, and (f) other minors categories.

In this study, we focus on non-technological cooperation agreements only, then this variable takes a value of 1 if the firm reports having an agreement in at least the category (a), (b), (e), and (f).

Table 1 suggests that between 13% and 14% of firms held a cooperation agreement with other firms in any category, between 12% and 14% are non-technological agreements, while the most common agreement is related to the commercialization-marketing agreement, at around 8%, followed by agreements to purchase of raw materials or inputs at around 5%, across all three waves.

Public support. Those firms undertaking innovation activities must report whether they received public support to finance their innovation activities in the wave period. The main mechanisms implemented in Uruguay to support firms' innovation activities are: (a) partial direct subsidies (matching grants), and (b) tax incentives. Based on this information, we construct a binary measure of public support ("Public Support"). The variable takes a value of 1 if the firm reports receiving public support to undertake innovation activities. Table 1 shows that between 6.6% and 11.6% of the surveyed firms got financial support to undertake innovation activities between 2007 and 2015, an average of 8.1% across the three waves. To qualify as a potential beneficiary from these sources of funds firms are not required to hold or to enter into any cooperation agreement with other firms.

Table 2 presents the distribution of non-technological cooperation agreements among firms that have received public support for innovation and those that have not. The data highlights a contrast between the two groups, with a much larger share of supported firms engaging in such agreements. For instance, in the 2007-2009 period, 34.83% of supported firms established non-technological cooperation agreements, while only 11.65% of unsupported firms did so.

In our empirical exercise, we will use the lag of this variable.

Control variables. As controls in our analysis, we include the following variables at the firm level: (a) firm size measured as the logarithm of the mean number of employees in

each wave ("Employees"), (b) firm's ratio of exports to sales ("Export share"), (c) firm's age in years ("Age"), (d) firm's technological gap measured as the difference between firm's labor productivity and the labor productivity of the leading firm in its sector ("Technology gap"), and (e) the ratio of the number of professionals and technicians in the firm to its mean number of employees in each wave ("White-collar share").

Table 1: Descriptive Statistics

VARIABLES	(2007-2009)	(2010-2012)	(2013-2015)
	Mean	Mean	Mean
Cooperation	0.141	0.136	0.131
<i>Non-technological</i>	<i>0.132</i>	<i>0.140</i>	<i>0.122</i>
Commercialization	0.088	0.083	0.082
Purchase of Input	0.050	0.062	0.056
Training Employees	0.053	0.057	0.068
Others	0.027	0.026	0.007
<i>Technological</i>	<i>0.057</i>	<i>0.065</i>	<i>0.069</i>
Purchase of Technology	0.035	0.0505	0.048
Technology Development	0.038	0.044	0.049
Public Support	0.066	0.102	0.116
Employees	154	165	183
Export share	11.919	11.568	11.244
Age	24.637	26.087	28.823
Technology Gap	0.651	0.644	0.700
White Collar Share	0.177	0.187	0.168
% of innovative firms in the sector	0.437	0.370	0.420
Share Sect. Public Supp.	0.013	0.003	0.007
Innov. Exp (thousands USD)	705.209	226.001	343.135
Observations	1,342	1,342	1,342

Source: Business Innovation Survey 2007–2009, 2010–2012, 2013–2015.

Innov. Exp is in constant prices of December 2021 from Uruguayan Peso to USD dollars 30/12/21 BCU price.

Table 2: Non-technological Cooperation Agreements of Firms. According to Beneficiary Status (percentages)

	2007 - 2009	2010-2012	2013-2015
	Percent	Percent	Percent
Public Support	34.83%	23.36%	29.49%
No Public Support	11.65%	12.95%	9.95%
Total	177	188	164

Source: Business Innovation Survey 2007–2009, 2010–2012, 2013–2015.

5 Reduced form analysis

In this section, we focus on reduced form analysis of the variables of interest. This section presents two reduced-form approaches taken in the paper to recover a causal effect of interest via reduced-form methods. The first one is centered around the notion that self-selection can be explained by some unobserved fixed characteristic of firms. The second builds over the first one and relaxes the notion that the only source of endogeneity is time-invariant and firm-specific.

5.1 Chamberlain-Mundlak approach to unobserved effects models

The underlying identification logic is following Mundlak (1978) and Chamberlain (1982). We claim that the unobserved effects are exogenous from the treatment once we control for firm-specific unobservable which are modeled as time-averages of observable characteristics (\bar{X}_i). Let \tilde{s}_{it} be a variable that is 1 when s_i is bigger than 0 and 0 otherwise. If we specify $E(c_{it}|\tilde{s}_{it}, X_{it}, \bar{X}_i)$ parametrically as a logit, the sign of the coefficient on \tilde{s}_{it} can be interpreted as the sign of the average causal effect. The main identification assumption disposing of the parametric distribution is that $E(c_{it}|\tilde{s}_{it}, X_{it}, \bar{X}_i) = E(c_{it}|X_{it}, \bar{X}_i)$. The structural system of equations for firm i at time t is:

$$\begin{aligned} c_{it} &= 1(\alpha_0 + \alpha_1 \tilde{s}_{it} + \alpha_2 X_{it} + v_i - u_{it} > 0) \\ &= 1(\alpha_0 + \alpha_1 \tilde{s}_{it} + \alpha_2 X_{it} + E(v_i|X_{it}, \tilde{s}_i, \bar{X}_i) - w_i - u_{it} > 0) \\ E(v_i|X_{it}, \tilde{s}_{it}, \bar{X}_i) &= \beta_0 + \beta_1 \bar{X}_i \end{aligned}$$

Where, as noted before, c_{it} is cooperation, \tilde{s}_{it} is receiving public support, X_{it} is a vector of firm-level exogenous control variables, v_i is a firm's fixed effect, $w_i + u_{it}$ is an error term with logistic distribution independent of everything, \bar{X}_i is the time average of the vector of firm-level controls. Note \tilde{s}_{it} might not be independent of v_i , even conditional on X_{it} . By substitution, we get:

$$c_{it} = 1(\tilde{\alpha}_0 + \alpha_1 \tilde{s}_{it} + \alpha_2 X_{it} + \beta_1 \bar{X}_i - w_i - u_{it} > 0)$$

After using the fact that $w_i + u_{it}$ is logistic and independent of X and \tilde{s} once controlled for \bar{X} :

$$\Gamma(\tilde{\alpha}_0 + \alpha_1 \tilde{s}_{it} + \alpha_2 X_{it} + \beta_1 \bar{X}_i) = P(Y_{it} = 1|X_{it}, \tilde{s}_{it}, \bar{X}_i)$$

This equation is estimable by Maximum Likelihood. Note $\tilde{\alpha}_0 = \alpha_0 + \beta_0$. Recall $P(Y_{it} = 1|X_{it}, \tilde{s}_{it}, \bar{X}_i) = E(Y_{it}|X_{it}, \tilde{s}_{it}, \bar{X}_i)$.

5.2 Bivariate probit model

The previous analysis relies on controlling properly for the endogeneity which we assume to be an individual preference parameter v_i , which we can model as a function of observed characteristics. Such a strategy might be questioned since self-selection might not be properly controlled with the average characteristics of observable. In light of that possibility, we complement the analysis with an instrumental variables analysis. In particular, since the setting implies a treatment variable that is binary, i.e. where there is unobserved heterogeneity present, *2SLS* would provide an estimate for the local average treatment effect as noted by Imbens and Angrist (1994). To obtain estimates of the average treatment effect, we follow Ashford and Sowden (1970), Heckman (1978) and use a bivariate probit model, a widely used framework. The bivariate probit model provides enough structure to point-identify traditional parameters of interest such as the average treatment effect (ATE), and its counterparts for the treated (ATT) and untreated (ATU) groups.

We propose a set of instrumental variables to identify the causal effects of public support for innovation on the decision of firms in the context of *non-technological* strategic alliances. Specifically, we propose two instrument variables: (i) Share Sect. Public Supp, which is the percentage of the total amount of public funding available for a given sector at a given time, and (ii) % of innovative firms in a sector, which is the percentage of innovative firms in a given sector at a given year.

The justification for using Share Sect. Public Supp as an instrument variable is based on the idea that variations in the amount of innovation financing available create exogenous shocks that affect the total number of potential beneficiary projects, but do not impact the strategic cooperation decision. An increase in the overall budget available for the innovation funding program will affect the decision about how many projects will receive the grant, but the choice (and ability) to perform any type of valorization activities, such as cooperation with other firms, remains an independent decision.

The percentage of innovative firms in a sector, on the other hand, captures sectoral innovation opportunities, which are shaped by structural factors such as the level of technological advancement and the innovative dynamics in the sector. As such, this variable can be considered exogenous of the firm's decision to form *non-technological* strategic alliances such as commercialization agreements or agreements to purchase inputs, which we examine in this study. Furthermore, innovation opportunities are closely related to the firm's decision to seek public support for innovation. Thus, the greater the innovation opportunities in an economic sector, the more likely a firm is to ask for public funding for innovation to take advantage of these opportunities.

In this context, consider the following extension of the previous model but accounting for the endogenous choice of D_{it} :

$$\begin{aligned} c_{it} &= 1(\alpha_0 + \alpha_1 \tilde{s}_{it} + \alpha_2 X_{it} + \alpha_3 \bar{X}_i + v_{it} > 0) \\ \tilde{s}_{it} &= 1(\gamma_0 + \gamma_1 \bar{B}_{jt} + \gamma_2 X_{it} + \gamma_3 \bar{X}_i + e_{it} > 0) \end{aligned}$$

Where \bar{B}_{jt} is the percentage of the amount of public support for the sector j at time t to whom firm i belongs. v_{it}, e_{it} are distributed jointly standard normal. \bar{B}_{jt} is independent of e_{it}, v_{it} .

Once again, the system can be estimated by Maximum Likelihood.

5.3 Mediation analysis

In the previous section, we identified the causal connection between public support for innovation and non-technological cooperation. In this section, we explain the mechanisms through which public support for innovation affects the firm's decision to cooperate. As we hypothesized in the theoretical model these mechanisms are: the absorptive capacity effect and the certification effect.

The mediation is checked via the following procedure:

1. Run an instrumental variable regression of cooperation on public support, using as instrumental variables the sectorial funds for innovation and the percentage of innovators in the sector.
2. Run an instrumental variable regression of innovation on public support, using as instrumental variables the sectorial funds for innovation and the percentage of innovators in the sector.
3. Run an instrumental variable regression of cooperation on innovation, using as instrumental variables the sectorial funds for innovation and the percentage of innovators in the sector.
4. Run an instrumental variable regression of cooperation on innovation and public support, using as instrumental variables the sectorial funds for innovation and the percentage of innovators in the sector.

The purpose of Steps 1-3 is to establish that zero-order relationships among the variables exist. If one or more of these relationships are non-significant, researchers usually conclude that mediation is not possible or likely. Assuming there are significant relationships from Steps 1 through 3, one proceeds to Step 4. In the Step 4 model, some form of mediation is supported if the effect of innovation remains significant after controlling for public support. If public support is no longer significant when innovation is controlled for, the finding supports full mediation. If public support is still significant (i.e., both public support and innovation significantly predict cooperation), the finding supports partial mediation. We acknowledge that the mediation effect identified is of a local nature since we are using linear instrumental variable models and interpreting the identified effects as *LATE* (Imbens and Angrist, 1994).

6 Empirical findings

6.1 Main results

This section presents the findings from the identification strategies described before and offers a detailed analysis thereof.

Table 3 reports the results of the two models: first without the time-mean controls (column 1), and then including these additional controls (column 3). Marginal effects are reported in columns 2 and 4 respectively. The results show that public support for innovation has a positive and statistically significant effect on the probability to form a non-technological agreement. As reported in column 4, the average marginal effect of public support is 0.038, and this figure is statistically significant at the 5 percent level. These findings suggest that public support plays a crucial role in boosting the probability of forming a non-technological strategic alliance. Considering the baseline probability of establishing a non-technological cooperation agreement (i.e., 11.4% - see Table 1), the estimated effect is about 33%.

Furthermore, our analysis reveals that the likelihood of forming non-technological strategic alliances is significantly influenced by two key drivers: firm size (as measured by the number of employees), and the time-mean proportion of skilled employees (as indicated by the "White-collar share" variable). These findings align with the capability theory, which posits that absorptive capacity is a vital determinant of a firm's ability to form and benefit from such agreements.

Table 3: Non-technological Strategic Alliances

VARIABLES	(1) Simple Logit Model	(2) Marginal effects	(3) Chamberlain Logit Model	(4) Marginal effects
Public Support (t-1)	0.413*** (0.157)	0.040*** (0.015)	0.393** (0.159)	0.038** (0.015)
Employees	0.202*** (0.042)	0.019*** (0.004)	0.148* (0.079)	0.014* (0.008)
Export Share	0.004* (0.002)	0.000* (0.000)	0.002 (0.003)	0.000 (0.000)
Age	0.103 (0.076)	0.010 (0.007)	0.105 (0.169)	0.010 (0.016)
Technology Gap	0.178 (0.198)	0.017 (0.019)	-0.232 (0.304)	-0.022 (0.029)
White Collar Share	0.639 (0.451)	0.061 (0.043)	0.429 (0.412)	0.041 (0.039)
Avg. Employees			0.072 (0.091)	0.007 (0.009)
Avg. Export Share			0.003 (0.004)	0.000 (0.000)
Avg. Age			-0.009 (0.182)	-0.001 (0.017)
Avg. Technology Gap			0.703* (0.408)	0.067* (0.039)
Avg. White Collar Share			0.496*** (0.168)	0.047*** (0.016)
Constant	-3.710*** (0.396)	-4.072*** (0.431)		
Observations	3,814	3,814	3,814	3,814
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes

Note: This table presents the Logit and the Chamberlain Logit. Each column estimates the probability of forming non-technological cooperation agreement assuming that the unobserved component follows a logistic distribution. Column 1 reports the results from the model without the time-mean controls, and Column 3 reports the results with these additional controls.

Columns (2) and (4) are the respective marginal effects. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

While our initial results indicate a positive relationship between public support and cooperation, we acknowledge the possibility of unobservable factors that could affect both outcomes. To address this potential selection bias, we adopt the strategy described in the identification section. Specifically, we estimate a biprobit model (see Table 4) that controls for unobserved factors not captured by the Chamberlain approach. The results of our analysis suggest that the average marginal effect of public support on the likelihood of cooperation is 0.008, with a significance level of 1 percent. This implies that all else equal, and considering again the baseline probability of forming a cooperation agreement (i.e., 11.4%, Table 1), the estimated effect is +7% approximately. It is worth noting that this effect size is smaller than the one obtained from the Chamberlain logit model (see Table 3). This difference suggests that the Chamberlain model may have overestimated the effect of public support by failing to account for some self-selection bias.

Table 4: Non-technological Cooperation-Bivariate probit strategy

VARIABLES	(1) First Stage on public support	(2) Second Stage on cooperation
Public Support (t-1)		0.770*** (0.296)
% of innovative firms in the sector (t-1)	1.412*** (0.162)	
Share Sect. Public Supp. (t-1)	4.300*** (1.130)	
Constant	-1.973*** (0.084)	-2.241*** (0.214)
<i>Marginal effect</i>		
Public support (t-1)		0.008***
Observations		
Sector Dummies	3,814	3,814
Year Dummies	Yes	Yes
Chamberlain Controls	Yes	Yes
Other Controls in Table	Yes	Yes
3	Yes	Yes

Note: This table presents the Bivariate probit model estimates assuming that the unobservables follow a jointly standard normal distribution. Column 1 reports the results from the first stage, showing that the instruments are relevant. Column 2 reports the results for the outcome variable of interest. Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6.1.1 Non-technological cooperation and public support: innovation efforts as a mediator

In light of our previous results, next we investigate the underlying mechanisms through which the observed effect occurs. As outlined in Section 2, the literature suggests the existence of two potential mechanisms at play: the absorptive capacity effect and the certification effect. We conduct a mediation analysis (as described in Section 5.3) to shed light on these mechanisms and estimate their impact.

Specifically, and following our theoretical framework, we hypothesized that public support for innovation directly impacts the formation of collaboration agreements, acting as an approval stamp that signals the quality of potential partners. Additionally, we posited that public support for innovation indirectly impacts the formation of strategic alliances by stimulating the innovation financial efforts of firms, which, in turn, increases their potential absorptive capacity. This enhanced absorptive capacity then plays a crucial role in strengthening a firm's collaboration process.

Table 5 reports the empirical findings of our mediation test that assesses the direct and indirect effects of public support for innovation on cooperation.

We run four instrumental variable regression tests (columns 1 to 4, Table 5). As discussed in Section 5.2, we instrument public support for innovation by using as instruments the percentage of sectorial funds for innovation and the percentage of innovative firms in the sector. In order to instrument for innovation financial efforts, we adopt the percentage of innovative firms in a sector. We posit that this instrument satisfies the relevance condition,⁶ as it captures the level of technological dynamism within the sector. A highly innovative sector is likely to be characterized by rapid and intense technological change, thereby motivating firms to invest more in innovation to remain competitive. Furthermore, such sectors may also expose firms to technological spillovers and externalities, creating additional incentives for innovation investment.

Table 5: Mediation analysis

VARIABLES	(1)	(2)	(3)	(4)
	Coop STEP 1	Ln Innov. Exp (t-1) STEP 2	Coop STEP 3	Coop STEP 4
Public Support (t-1)	0.368*** (0.133)	40.013*** (4.570)		-0.212 (0.242)
Ln Innov. Exp (t-1)			0.011*** (0.003)	0.014*** (0.005)
Constant	-0.050 (0.040)	0.217 (1.390)	-0.045 (0.038)	-0.053 (0.040)
Observations	3,814	3,814	3,814	3,814
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The findings of our mediation analysis, presented in Table 5, reveal a number of key relationships between public support for innovation, innovation financial effort, and the likelihood of forming a strategic cooperation agreement. First, our results indicate that public support for innovation exerts a positive and statistically significant effect on both the probability of forming a cooperation agreement (Step 1) and the level of innovation financial effort (Step 2).

Furthermore, we find that the level of innovation's financial effort has a positive and statistically significant impact on the probability of establishing a cooperation agreement (Step 3).

However when we jointly consider public support for innovation and the level of innovation's financial effort (Step 4), we find that only the latter variable has a significant effect on

⁶In Section 5.2, we discuss about the exogeneity condition for this instrument.

the probability of forming a cooperation agreement. This result suggests that innovation financial effort fully mediates the effect of public support on the likelihood of establishing a strategic alliance.

We interpret our results through the lens of capability theory, which posits that a firm's absorptive capacity is a key determinant of its ability to leverage external resources and knowledge. Our findings suggest that innovation's financial efforts strengthen a firm's potential absorptive capacity, which in turn enhances its ability to form strategic alliances. This result is in line with existing empirical literature on the role of absorptive capacity, see for example, Muscio, A. (2007), Flatten et al (2011). Overall, our findings underscore the importance of investing in innovation as a means of enhancing a firm's strategic capabilities and highlights the role of public support in facilitating such investments.

The absence of evidence for the certification effect in the empirical analysis could potentially be attributed to context-specific factors that could make this signal less relevant. For instance in contexts where there are less asymmetric information problems the certification effect could be less relevant or even not significant as it happens with our data.

6.2 Heterogeneous effects

While average effects can be informative, they may conceal important heterogeneity in the impact of public support for innovation on the likelihood to form a cooperation agreement. To shed light on this issue, we classify firms according to two distinct dimensions: size and skill composition of labor.

Our dataset is well-suited for examining the impact of firms' size on the study as it is a representative sample of small and large firms. To study the size effect, we split up the sample between two groups using a time-invariant variable that takes a value of 1 if the firm employs on average 50 or more employees (large and medium firms), and 0 otherwise (micro and small firms). As shown in Table 6, our findings suggest that public support for innovation has a positive and statistically significant effect on the probability to form a cooperation agreement only for large and medium-sized firms, highlighting the importance of firm size as a key determinant of the impact of public support on the probability to cooperate.

Next, to explore the effect of skill composition of labor, we divide the sample into two groups using a time-invariant variable that takes a value of 1 if the firm has, along all the periods, a percentage of skilled labor above the sectorial median, and 0 otherwise. Our results, presented in Table 8, suggest that public support for innovation has a positive and statistically significant impact on the likelihood of cooperation only for firms with a skilled workforce larger than the sectorial median, emphasizing the importance of workforce skills as a critical driver of absorptive capacity.

In order to distinguish the mechanisms underlying these results, we conduct the mediation analysis for each subgroup, the results of which are presented in Tables 7 and 9. As shown, the absorptive capacity effect is confirmed for the sub-samples of large and medium-sized

firms and firms with skilled work-forces above the sectorial median, respectively.

Overall, our findings suggest that the impact of public support for innovation on the likelihood of establishing a non-technological cooperation agreement is heterogeneous and contingent on firm size and skilled labor composition. More specifically we find that the positive effect of public support for innovation on the probability of participating in a non-technological strategic alliance is significant only for large and medium size firms and for the firms with a large share of qualified employees. These results suggest that in order to benefit from the absorptive capacity mechanism, firms need to have a certain level of resources and knowledge capabilities. This finding is consistent with the absorptive capacity literature (see Muscio, A. (2007)).

These insights have important implications for policymakers seeking to design effective innovation policies that cater to the specific needs of different types of firms.

Table 6: Heterogeneous effect by size

VARIABLES	Large and Medium firms		Small and Micro firms	
	(1) First Stage on public support	(2) Second Stage on cooperation	(3) First Stage on public support	(4) Second Stage on cooperation
Public Support (t-1)		0.753** (0.294)		-0.038 (1.021)
% of innovative firms in the sector (t-1)	1.174*** (0.207)		1.379*** (0.289)	
Share Sect. Public Supp. (t-1)	4.908*** (1.452)		0.988 (2.438)	
Constant	-1.674*** (0.108)	-2.708*** (0.326)	-2.259*** (0.145)	-2.397*** (0.394)
<i>Marginal effect</i>				
Public Support (t-1)		0.013***		-0.000
Observations	1,985	1,985	1,761	1,761
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table 3	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Mediation analysis for large and medium firms

VARIABLES	(1)	(2)	(3)	(4)
	Coop STEP 1	Ln Innov. Exp (t-1) STEP 2	Coop STEP 3	Coop STEP 4
Public Support (t-1)	0.778*** (0.301)	60.756*** (14.291)		-0.112 (0.284)
Ln Innov. Exp (t-1)			0.013*** (0.004)	0.015** (0.007)
Constant	-0.156* (0.081)	-1.055 (3.866)	-0.144** (0.067)	-0.140** (0.069)
Observations	1,985	1,985	1,985	1,985
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table	Yes	Yes	Yes	Yes

3 Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Heterogeneous effect by qualification

VARIABLES	High Qualification = 1		High Qualification = 0	
	(1)	(2)	(1)	(2)
	First Stage on public support	Second Stage on cooperation	First Stage on public support	Second Stage on cooperation
Public Support (t-1)		1.217*** (0.320)		-0.055 (0.545)
% of innovative firms in the sector (t-1)	1.304*** (0.259)		1.535*** (0.202)	
Share Sect. Public Supp. (t-1)	3.452* (1.785)		5.135*** (1.491)	
Constant	-1.845*** (0.131)	-1.796*** (0.294)	-2.106*** (0.106)	-2.786*** (0.318)
<i>Marginal effect</i>				
Public Support (t-1)		0.010***		-0.001
Observations	1,757	1,757	2,057	2,057
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table 3	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Mediation analysis for high qualification = 1

VARIABLES	(1) Coop STEP 1	(2) Ln Innov. Exp (t-1) STEP 2	(3) Coop STEP 3	(4) Coop STEP 4
Public Support (t-1) = 1	0.890*** (0.328)	47.554*** (10.539)		0.046 (0.452)
Ln Innov. Exp (t-1)			0.018*** (0.005)	0.018** (0.008)
Constant	0.096 (0.087)	2.597 (2.805)	0.046 (0.064)	0.050 (0.075)
Observations				
Sector Dummies	1,757	1,757	1,757	1,757
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table 3	Yes Yes	Yes Yes	Yes Yes	Yes Yes

Note: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6.3 Robustness checks

To provide additional evidence in support of our findings, we conducted a robustness exercise. This exercise is undertaken to address concerns regarding how to measure the certification or signaling effect. That is, the certification or signaling effect can be dependent on the amount of public support a firm receives, rather than the mere fact of receiving or not receiving public support itself. To investigate this possibility, we calculate the percentage of public support that each firm receives for innovation, as a proportion of its total innovation expenditure.

Our findings, as presented in Table 10, support again the claim that public support for innovation has a positive and statistically significant impact on the likelihood of establishing a non-technological alliance. Furthermore, we find again that this impact is entirely mediated by the firm's financial efforts in pursuing innovation, as shown in Table 10.

By conducting this robustness exercise, we bolster the validity of our research and provide a more nuanced understanding of the relationship between public support for innovation and the formation of non-technological alliances.

Table 10: Robustness check

VARIABLES	(1) Coop STEP 1	(2) Ln Innov. Exp (t-1) STEP 2	(3) Coop STEP 3	(4) Coop STEP 4
% of Public Supp. (t-1)	0.956** (0.373)	106.408*** (15.124)		-0.537 (0.617)
Ln Innov. Exp (t-1)			0.011*** (0.003)	0.014*** (0.005)
Constant	-0.074* (0.038)	-2.405 (1.558)	-0.045 (0.038)	-0.041 (0.039)
Observations	3,814	3,814	3,814	3,814
Sector Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Chamberlain Controls	Yes	Yes	Yes	Yes
Other Controls in Table 3	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

7 Conclusions

This paper studies the impact of public support for innovation on firm behavior. More precisely, we examine the relationship between public support for innovation and the formation of non-technological strategic alliances. Our empirical analysis provides evidence of a positive causal relationship between public support for innovation and the firms' likelihood of entering non-technological cooperation agreements. This finding suggests that public support for innovation can play an important role not only at stimulating firms to increase private innovation efforts (input additionality) but also at fostering non-technological cooperation among firms (behavioral additionality). Using Uruguayan data from 2007 to 2015, and controlling for endogeneity, we find that public support increases the likelihood of establishing non-technological agreements by 7% from the baseline probability.

Our theoretical framework hypothesized two mechanisms through which public support for innovation may impact the formation of non-technological strategic alliances: the absorptive capacity effect and the certification effect. The empirical results reported, provide support for the absorptive capacity mechanism and no support for the certification effect. Overall, our findings underscore the importance of investing in innovation as a key mechanism to enhance the firm capabilities to form strategic alliances and the role that public support for innovation can play to facilitate this process.

The absence of evidence for the certification effect could be due to context-specific factors that may turn this mechanism less relevant. For instance in contexts where asymmetric

information problems are less acute we would expect the certification effect to be weaker or even not significant. Future research could replicate this study in different contexts (for instance different industries or regions) to explore which context specific variables moderate the strength of the certification effect in order to provide a better understanding of this mechanism for alliance formation.

This study contributes both theoretically and empirically to the innovation policy evaluation literature by showing that public support for innovation can be an effective policy tool for fostering non-technological cooperation among firms, which can lead to improved efficiency and performance.

Our results have also important implications for policymakers and managers. By shedding light on the factors that influence the formation of non-technological cooperation agreements, our findings can inform the design of more effective innovation policies. The evidence provided in this paper suggest that public support is not only effective to stimulate private innovation expenditures but it can also encourage the formation of non-technological strategic alliances. Finally, managers can also use this results to better understand the conditions under which non-technological cooperation agreements are more likely to be formed and to guide their strategic decision-making.

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A Appendix: Proof Proposition 1

a. $F_I < F$

In this case, a firm always invests and the optimal cooperation decision will depend on s and d . From equation (4) the optimal decision at the investment decision stage, $I^*(s) = I^{**}(s) \forall (d, \varrho)$. Moreover, the public agency chooses $s \in [0, s^-]$ conditional on ϱ

and $d = 1$.

We want to prove that for each ϱ , there exists a function $s^*(\varrho)$.

This is true since $U(I^*(s), s)$ is continuous and concave, and the constraint is linear, equation (5) characterizes the $s^*(\varrho)$. Following equation (12), the optimal subsidy rate is:

$$s^*(\varrho) = 0 \quad \forall \varrho < \underline{\varrho}; \quad s^*(\varrho) = \bar{s} \quad \forall \varrho > \bar{\varrho}; \quad s^*(\varrho) = s^* \quad \forall \underline{\varrho} < \varrho < \bar{\varrho}.$$

If $d = 0$, then $s^*(\varrho) = 0 \quad \forall \varrho$.

Thus the best-response of public agency is a function $s^* = \{(0, 1) \times \varrho \rightarrow (0, s^{**}, \bar{s})\}$.

Then, the firm decides whether to apply or not given $\phi(\varrho)$, $s^*(\varrho)$, and $\pi^*(I^*(s^*))$. Since in a PBE the firm choices must maximize the profit and the firm belief must be consistent with the agency's strategy, $d^* = 1$ only if equation (15) holds and $d^* = 0$ otherwise. Moreover, the public agency best response to $d^* = 1$ is $s^* = \{0, s^*(\varrho), s^-\}$, and to $d^* = 0$ is $s^*(\varrho) = 0$. Thus we found a PBE that satisfies the criterion in Proposition 1.

b. $F_I \in (\underline{F}, \bar{F}]$

In this context, a firm will require at least \hat{s} to undertake any innovation project, otherwise $I^* = 0$. The optimal cooperation decision depends on s and d . If $s^*(\varrho) > \hat{s}$, the proof is identical to a). If $\varrho < \hat{\varrho}$ then $s^* < \hat{s}$ and given equation (6), $I^* = 0$, and from equation (5) this level of s^* satisfies the optimal condition from public agency.

When $F_I \in (\underline{F}, \bar{F})$ and $d = 1$ then $s^*(\varrho) = 0$ if $\varrho < \hat{\varrho}$. Moreover, $s^*(\varrho) = s^*$ if $\varrho \in (\hat{\varrho}, \bar{\varrho})$. Finally, $s^*(\varrho) = \bar{s}$ if $\varrho > \bar{\varrho}$. If $d = 0$, then $s^*(\varrho) = 0$.

The optimal agency decision is a function $s^* = \{(0, 1) \times \varrho \rightarrow (0, \hat{s}, s^*, \bar{s})\}$.

The firm decides d given $\phi(\varrho)$, $s^*(\varrho)$, and $\pi^*(I^*(s^*))$. Since in a PBE, the firm's decision choice must maximize the profit and the firm's belief must be consistent with the agency's strategy, $d^* = 1$ only if condition (17) holds, and $d^* = 0$ otherwise. Moreover, the agency's best response to $d^* = 1$ is $s^* = \{0, s^*(\varrho), \bar{s}\}$, and to $d^* = 0$ is $s^*(\varrho) = 0 \forall \varrho$.

c. $F_I > \bar{F}$

In such a case, the firm will not invest, public agency $s^*(\varrho) = 0$, and the optimal cooperation decision follows (1).