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An Empirical Analysis

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Contact: Gustavo Crespi, gcrespi@iadb.org.

The Role of Obstacles to Innovation on Innovative Activities: an Empirical Analysis*

Andrés Zahler†, Daniel Goya‡ and Matías Caamaño§

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Abstract

We study the effect of different types of barriers to innovation (financial, demand, knowledge, market, cooperation, and regulatory barriers) on firm level innovation inputs and outputs. Using a pooled sample of three Chilean innovation surveys, based on an instrumental variables approach, we find that the probability of generating innovation outcomes is significantly reduced by demand and financial barriers. Regarding inputs for innovation, we find a clear negative relationship between financial and demand obstacles and the propensity to incur (non-R&D) innovation expenditures, but not with its intensity. We also provide evidence of heterogeneous effects across sectors, finding that knowledge obstacles are relevant for manufacturing and market structure obstacles for services, while demand and financial obstacles appear to matter across the board.

Keywords: Financial and non-financial barriers to innovation, sectoral heterogeneity in innovation barriers, potential innovators, instrumental variables.

JEL codes: D22, O31, O32.

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†School of Economics and Business, Diego Portales University, andres.zahler@udp.cl.
‡School of Business and Economics, Pontificia Universidad Católica de Valparaíso, daniel.goya@pucv.cl.
§Universidad Finis Terrae, mcaamanoc@uft.edu.

1 Introduction

Several micro-level studies have found that innovation has a positive impact on productivity at the firm level (see for example Janz et al., 2003; Mansury and Love, 2008; Crespi et al., 2017). Innovation could thus be the key to overcome the problem of stagnant productivity levels that has become one of Latin America's most pressing challenges for development (Pagés, 2010; Grazzi et al., 2016). Stagnant productivity has been a reality both in countries with a low growth record and countries with better outcomes, such as Mexico or Chile, and more recently Colombia and Peru. These economies have enacted, some for many years, active innovation policies with the goal of addressing market failures and expanding productivity at the firm, sector and country levels. However, despite these increasing efforts, both financial and institutional, rates of innovation and productivity levels have remained low.

What could be stopping firms from innovating more? It could be that the scale of government support is still relatively low in the presence of multiple market failures. But it could also be the result of a lack of understanding, and thus ineffective addressing, of the barriers firms face to innovate. In order to answer this question from an empirical perspective, we need to analyze data and assess the impact of obstacles on innovation. Despite the fact that surveys have asked questions about obstacles for innovation for more than twenty years in several countries, the analysis of their impact on innovation activity is relatively recent, partly due to the fact that surveys tend to show a positive correlation between innovation and obstacles. Recent literature has addressed this issue by restricting the sample analyzed to firms "interested" in innovating (Savignac, 2008; D'Este et al., 2012). However, most analyses have focused on the role of financial obstacles (e.g. Savignac, 2008 or Álvarez and Crespi, 2015, for Chile), which is the most obvious obstacle that emerges from a market-failure understanding of innovative activity. Only very recently the relative role of different obstacles has emerged, partly motivated by the broader set of issues considered by the systems/evolutionary approach to innovation policy.[1] For example, the systems approach to innovation emphasizes interactions and technological capabilities related to cooperation and knowledge barriers, which are not issues that follow directly from thinking about market failures.

In this paper we build upon this literature to explore the effect of innovation obstacles on a range of innovation inputs and outputs at the firm level for the case of Chile. We analyze innovation and R&D expenditure as inputs. As for outcomes, we look at dummies for innovation, technological (product and process) innovation, and non-technological (market and organizational) innovation. Chilean data has the advantage of the quality associated to the accumulated experience, as the country has undertaken 10 rounds of innovation surveys. These surveys include questions about different barriers to innovation, and analyze most economic sectors. In this study we use the three latest available rounds (7th, 8th and 9th innovation surveys). Although they are not panel surveys, it is possible to connect triads of surveys to build a panel, which we use for our analysis.

Our work expands the literature in three ways. First, we disaggregate what are usually grouped together as "market" obstacles into two categories: *demand* and *market structure* obstacles, which we argue capture different dimensions of innovation barriers (lack or uncertainty of demand for new products on the one hand, and a market dominated by a few established firms on the other, which is more related to traditional barriers to entry). Second, we decompose the data to analyze the differential impact of different obstacles across different sectors and firm types to provide a more detailed analysis of heterogeneous effects. Third, we implement alternative econometric strategies, including an instrumental variables approach and fixed effects

[1] See for instance Pellegrino and Savona (2017), Coad et al. (2016), and the early contribution by Galia and Legros (2004).

estimations, to make a stronger case on the causality of our results.

Our results consistently show that, together with financial constraints, demand obstacles are the most important barriers firms face to innovate. Our instrumental variables estimates indicate that facing demand constraints lowers the probability of innovating by between 15 and 28 percentage points, depending on the instrument used, and financial obstacles lower it between 17 and 23 percentage points. The effect of demand and financial barriers on the propensity to spend on (non-R&D) innovation activities is 13 and 15 percentage points, respectively. Considering potentially innovative firms,[2] these coefficients imply that financial and demand barriers on their own roughly halve the propensities to innovate or to spend on innovation, an economically significant effect. The rest of the obstacles appear to be irrelevant for the whole sample for instrumental variables and fixed-effects estimates. This is consistent with findings by Galia et al. (2012) and Pellegrino and Savona (2017).

We also analyze sectoral subsamples to understand if there are heterogeneous effects and if our results are explained by some sectors in particular. We find that demand and financial obstacles are relevant across the board, albeit with heterogeneous magnitudes, and other barriers appear to be sector-specific. Manufacturing is the only sector where knowledge obstacles are relevant, and market structure obstacles, which are significant for the regular regressions for the whole sample, appear only relevant for the services sector. We obtain similar results for innovation inputs. We also find that the coefficients for the mining sector are particularly high.

We complement this analysis with qualitative research based on in-depth interviews with firms' managers (see Zahler et al., 2019), which we use to corroborate the main findings and to dig deeper in their interpretation, in particular regarding possible hypotheses on what could be driving demand obstacles, and mechanisms used to ease barriers. The qualitative analysis performed confirms the importance of both financial and particularly demand obstacles. Firms usually required internal or external (usually government) financial support to engage in innovation activities. However, they consistently declared that the most binding constraint, once finance was not a huge issue, was finding buyers for their new products. Most of the firms interviewed were suppliers of goods and services for other firms, so our insights on demand barriers apply to this group.[3] Most current and potential clients are very conservative in their buying decisions. This seems to be particularly marked in the mining sector. Also, when collaboration with customers was required to develop a new product or lower the risk of the innovative process, they were usually unwilling to share this risk, and preferred waiting until the leaders of the respective industry tried the product. Managers interviewed interpreted this lack of demand as coming mostly from a strong preference for low-risk and short-run results. The interviews also motivated us to separate demand obstacles from market structure obstacles, as explained before.

As part of this qualitative analysis we found that financial obstacles, although ubiquitous, were not very difficult to resolve. However, demand obstacles were the final and most difficult hurdle for successful innovation. Motivated by this recurrent fact, we also test in this paper whether the key obstacles (demand and financial) are binding in preventing innovation. We test if firms with no financial (or demand) obstacles face the highlighted demand (or financial) obstacles more, or other obstacles appear relevant. We find that when firms do not face one of these obstacles, the rest of the obstacles expand their relevance, particularly the other key obstacle (finance when demand is absent and vice versa). However, when the demand or financial obstacle is *present*, the relevance of other obstacles is reduced or disappears, including the other key

[2] We define this concept in Section 2.2.

[3] According to the Central Bank, intermediate consumption represents roughly half of Chile's GDP. Unfortunately, our data does not allow us to differentiate between firms selling to final consumers or to other firms.

obstacle. This suggests that, when active, each of them dominate the difficulties faced by firms that attempt to innovate.

The paper builds on several strands of related literature on economics of innovation at the firm level. First, it is part of the extensive empirical literature on determinants of innovation, which uses innovation surveys. There is a vast amount of research done for developed and developing economies seeking to understand the determinants of innovation activity and its effect on firm level outcomes. Relevant examples of this are Crespi and Zuniga (2012); Griffith et al. (2006); Benavente (2006); Zahler et al. (2014); Álvarez et al. (2010). Specifically we complement the empirical papers that analyze characteristics and conditions that inhibit or negatively affect firm level innovation activity. As mentioned earlier, this latter literature is recent, because innovation surveys gave counterintuitive relations between obstacles and innovation. This puzzle was resolved by Savignac (2008) and D'Este et al. (2008) by restricting survey samples to potentially innovative firms, where the declaration of obstacles effectively reflected actual challenges to pursue innovation. We use their same procedure to eliminate selection bias, and show that it exists. Papers have then analyzed mostly the role of financial obstacles. For Chile, Álvarez and Crespi (2015) use data from 2007 and study the role of financial constraints. They find a significant negative effect of financial obstacles on innovation output.[4] They also disaggregate by sector. Crespi et al. (2016) use data from 2009 to explore whether different groups of barriers to innovation have a different relationship with innovation, however only for the services sector. We will build on those studies methodologically, using instrumental variables and fixed effects, expanding their application in the dimensions previously mentioned.

Álvarez and Crespi (2015) and Pellegrino and Savona (2017) are the closest to our paper, since they correspondingly analyze obstacles in Chile and compare the relevance of different categories of obstacles. We expand the analysis in Álvarez and Crespi (2015) to all possible barriers. We analyze obstacles in a very similar logic to Pellegrino and Savona (2017), however, we provide a different definition of our most important object of analysis: demand obstacles. Additionally, we use instrumental variables strategies and panel data to give a causal explanation of our results, and we provide an in-depth analysis of the potential heterogeneity of these effects. Although with a different definition, we find similar relevance of demand obstacles as Pellegrino and Savona (2017). Our work is also related to recent work, mostly in developed economies, that analyzes demand obstacles, and the relation between different obstacles and innovation. García-Quevedo et al. (2016) establish that one of the main problems in undertaking R&D is the interest of clients for potential new products (lack of demand). They also identify lack of demand and demand uncertainty as two distinct issues (we analyze them together, though, as demand side obstacles). Also, even though we do not test for complementarities among obstacles, we analyze obstacles in the presence and absence of particular ones. Galia and Legros (2004) do this more formally, studying the complementarities of obstacles on innovation, analyzing how they affect the probability of postponing or abandoning innovation projects. We build on their logic to analyze the relations between the pervasive obstacles and the rest of them.

Finally, we base our construction of instrumental variables on the strategy used by Cassiman and Veugelers (2002) and Chun and Mun (2012). They use industry averages of sources of information to innovate as instruments of individual values of these sources, since they tend to be simultaneous with their variable of interest: cooperation for innovation. We face a similar problem in our analysis, and thus we also use averages, albeit at a different level of aggregation and for a different variable.

The paper is organized as follows. Section 2 describes the database and the main variables of analysis.

[4] A similar result is found by Savignac (2008) and Mohnen et al. (2008).

Table 1: Basic innovation survey information.

Innovation Survey	7th	8th	9th
Period Covered	2009-2010	2011-2012	2013-2014
Classification of Sectors	ISIC Rev.3	Same as 7th	Same as 7th
Sectors Covered	A,B,C,D,E,F,G,H,I,J,K,N,O	Same as 7th	Same as 7th
Number of observations (unweighted)	3,604	4,537	5,398
Number of observations (weighted)	94,012	144,840	130,166
Minimum firm size	Sales above UF2,400	Same as 7th	Same as 7th

Section 3 provides descriptive statistics that motivate the problems analyzed and the econometric analysis. Section 4 shows the econometric methodology used and the main results of the paper, as well as robustness checks using a small panel. In this section we also provide an heterogeneity analysis and test the relationships between key obstacles (demand and financial) and other obstacles in preventing innovation. Section 5 discusses our results in light of the qualitative analysis. Finally, Section 6 summarizes our findings and discusses policy implications.

2 Data and definition of variables

Our main source of data is the Innovation Survey carried every two years by the Chilean National Institute of Statistics (INE) and the Chilean Ministry of Economy. Ten rounds have been undertaken, covering the period 1994-2014. We use the 7th, 8th and 9th rounds of the innovation survey to expand the sample size as much as possible while keeping methodological consistency, specifically regarding the definition of innovation obstacles[5]. Table 1 provides a basic description of each of these surveys.

We were also able to build a panel from the 7th, 8th and 9th surveys, as we were able to obtain a set of identifiers from INE for the set of firms that were surveyed in these waves. We use this panel to support our main findings through the use of firm level fixed effects. The sample is small (a balanced panel of 769 firms) and is biased towards larger firms. The reason for this is that the surveys were not intended to be used as panel data. The Chilean innovation surveys use a different random sample for each wave, but nevertheless, some firms are repeated across surveys, either because they belong to sectors or groups where all firms are forced to be surveyed (mining, utilities, firms with over 2% of a sector's sales), or by pure chance. Table 2 shows basic characteristics of the panel as well as the full pooled sample as comparison in the same table.

2.1 Definition of barriers

The list of barriers to innovation had changes during the older waves of the innovation survey, but it remained constant over the surveys that we use (waves 7 through 9). When firms are surveyed, a list of barriers to innovative activity is presented, allowing respondents to indicate as many barriers as they believe are relevant on a scale of 1 (non-important) to 4 (very important). We group these barriers under different categories and, for the sake of this paper, we consider that a barrier category is present if a firm declared that any of the barriers under that category had a "high importance". Table 3 shows each obstacle as it appears on the survey, the category in which it was listed in the survey and the category under which it is classified

[5]The 10th round was not ready when we did our research.

Table 2: Data description, by sector.

Sector	Panel		Pooled cross section			
			Unweighted		Weighted	
	Frequency	%	Frequency	%	Frequency	%
A - Agriculture, hunting and forestry	28	3.7	787	5.8	40,877	11.1
B - Fishing	27	3.5	349	2.6	2,802	0.8
C - Mining and quarrying	36	4.7	163	1.2	163	0.0
D - Manufacturing	252	32.9	3,501	25.9	12,046	3.3
E - Electricity, gas and water supply	72	9.4	338	2.5	338	0.1
F - Construction	42	5.5	1,053	7.8	43,724	11.9
G - Wholesale and retail trade; repairs	82	10.7	1,768	13.1	124,345	33.7
H - Hotels and restaurants	30	3.9	664	4.9	18,356	5.0
I - Transport, storage and communications	29	3.8	1,154	8.5	42,247	11.5
J - Financial intermediation	37	4.8	506	3.7	10,448	2.8
K - Real estate, renting and business	56	7.3	2,099	15.5	53,370	14.5
N - Health and social work	34	4.4	609	4.5	14,584	4.0
O - Other community, social services	42	5.5	548	4.1	5,717	1.6
Total	767	100	13,539	100	369,017	100

in this paper. We define six categories of obstacles: financial, knowledge, cooperation, market, demand and regulatory.

Comparing categories in the survey with our paper, we recategorized obstacle 7 as cooperation since it clearly asks a question on this aspect of innovation. We also created different *market structure* and *demand* categories, leaving only obstacle 8 as a market structure obstacle, and categorizing obstacles 9 and 10 as "demand" obstacles. We made this distinction because we consider the underlying questions to aim at two fundamentally different issues: the question that we classify as a "market" barrier is related to market structure and dominance, while the questions that we classify as "demand" barriers indicate a perceived important commercialization risk related to demand uncertainty or lack of demand. Although both categories are related, we believe they reflect different issues affecting innovation decisions. Market structure obstacles are related to the fact that there is low competition and high barriers to entry, but they are not driven by demand, but by competitors. Demand obstacles on the other hand are directly related to the risk of not finding buyers or the uncertainty about it. We were motivated to make this differentiation based on the findings of our qualitative analysis. When interpreting the results, we stress that "demand" does not necessarily refer to final consumers. Many of the firms surveyed are intermediate suppliers, and our interviews suggest that it is other firm's as buyers that are associated with feeble demand for innovation, although unfortunately we have no data that would enable us to dig deeper into this issue.[6,7] Obstacle 11 was categorized as "regulation" since it is the only (unfortunately not very accurate) question that asks directly about regulatory issues generating problems for innovation. Finally, we excluded obstacle 12 from the analysis. We do not consider it a real obstacle to innovation, given the way it is asked ("*no need due to*

[6]We differ in this aspect from Pellegrino and Savona (2017) and others who consider market and demand factors as a unique "demand" category. We differ also from García-Quevedo et al. (2016), who look at demand level and demand uncertainty as different barriers (and consider all other barriers only as an additional control).

[7]A small fraction of firms declared a high importance of the obstacle "no need due to lack of demand" and at the same time innovated, which might reflect a contradiction since the obstacle is defined as innovation not being necessary. We kept this question in the analysis since it might reflect a timing issue (they may have innovated in the first year covered by the survey, and at the time of answering consider that there is no further need).

Table 3: Survey questions on obstacles and categories we define.

Obstacle #	Question	Survey category	Paper category
1	*Lack of own funds*	Costs	Financial
2	*Lack of external funding*	Costs	Financial
3	*High costs of innovation*	Costs	Financial
4	*Lack of qualified personnel*	Knowledge	Knowledge
5	*Lack of information about technology*	Knowledge	Knowledge
6	*Lack of information about markets*	Knowledge	Knowledge
7	*Difficulty in finding partners for innovation*	Knowledge	Cooperation
8	*Market dominated by established firms*	Market	Market
9	*Uncertainty about demand for innovative goods and services*	Market	Demand
10	*No need because of lack of demand for innovation*	Other	Demand
11	*Regulatory difficulty*	Other	Regulatory
12	*Not needed because of previous innovations*	Other	Excluded

previous innovations"). That in our view is a decision more than an obstacle.[8]

2.2 Definition of the sample of "potentially innovative" firms

Next, we define the relevant sample of potentially innovative firms. As shown by D'Este et al. (2012) and Savignac (2008), one of the reasons why the analysis of barriers was not developed before in the innovation empirical literature was because using the full sample produced counterintuitive results. They show that using a sample of firms that intend to innovate, this counterintuitive result was reversed and it was possible to assess in a better way the role of obstacles. Firms that made an effort to innovate or appear to declare some interest in the topic by declaring the existence of obstacles, be it that they innovated or not, are included in the estimations. Following this logic we will define a subsample of "potentially innovative" firms as those that fulfill at least one of the following requirements:

- They innovated in product or process.
- They spent money on activities related to innovation (R&D,[9] machinery, training, licensing, etc.).
- They declared at least one barrier as of high importance.

With these conditions, Table 4 shows how the full sample changes to a "potentially innovative firm" sample. We exclude 3,375 observations as non-innovative firms.

Table 5 shows descriptive statistics for potentially innovative and non-potentially innovative firms. A simple comparison of potentially innovative firms with the rest of the sample does not reveal important differences, something we did not expect. Both groups have similar firm size (although slightly larger for the potentially innovative group, in employees), slightly higher proportion of exporting firms and similar firm age. These firm characteristics will be used as controls in our econometric analysis.

[8] We checked including this barrier as a new category in the regressions, and there were no relevant changes in the parameter estimates.

[9] Either internal or external.

Table 4: Construction of the sample of potentially innovative firms.

			Spends on innovation	N	Declares some barrier to innovation as very high	N	Potentially innovative sample
			Yes	2,746	Yes	2,008	Included
					No	738	Included
	Yes	3,312					
			No	566	Yes	390	Included
					No	176	Included
Technological innovation							
			Yes	1,039	Yes	755	Included
					No	284	Included
	No	10,227					
			No	9,188	Yes	5,813	Included
					No	3,375	Excluded

Table 5: Basic descriptive statistics (using sampling weights).

		Non-potentially innovative	Potentially innovative
Observations		103,644	265,375
		28.1%	71.9%
Sales (CH$million)	mean	3,522	3,224
	median	193	186
	min	0.1	1.1
	max	6,474,701	14,600,000
Employment	mean	34	43
	median	6	8.5
	min	0.5	0.5
	max	29,356	65,699
Export propensity	mean	0.053	0.064
	median	0	0
	min	0	0
	max	1	1
Age	mean	14.4	14.9
	median	13	12
	min	0	0
	max	270	268

3 Descriptive analysis

We first provide descriptive statistics regarding the main variables of interest: obstacles and some innovation outputs. Table 6 provides a first overview of the main variables, disaggregated at a 1 digit level. We show means and standard deviation across sectoral categories. When we disaggregate by sector we observe an important heterogeneity, both in the rate of innovation and the percentage of firms declaring obstacles. For each column, we colored in blue the 3 sectors with the highest propensities to innovate and the lowest perception of each obstacle, and in red the 3 sectors that are in the opposite end. Looking columnwise, we observe that the sectoral highest levels of innovation more than double the lowest levels. Mining (C), utilities (E) and manufacturing (D) are the most innovative, whereas transport, storage and communications (I), fishing (B), and wholesale and retail trade (G) are the least. This heterogeneity is also present in obstacles. Sectors with high perception of obstacles more than double those with low average perception. Second, some obstacles are more ubiquitous than others. Financial obstacles are the most declared by far (50% on average across sectors). Knowledge, demand and market barriers are also common.[10] Regulation is the least mentioned barrier. When looking across sectors, some interesting patterns arise. Some sectors appear to be less constrained to innovation for most barriers and others more constrained. The table shows that mining has consistently a relatively low declaration of obstacles. Something similar happens with electricity, gas and water companies (utilities). This also coincides with the fact that these companies tend to be large and permanently included in the innovation survey. These two sectors are among those with the highest propensities to innovate. Sector J (financial intermediation) also tends to have lower propensity to declare obstacles across the different categories, however, it is not across those with more innovation. On the contrary, fishing (B), construction (F) and retail (G) tend to show higher propensities to declare barriers across categories. This motivates us to investigate sectoral heterogeneity in our estimations.

Table 7 shows the correlation between different barriers. All of them are positively correlated, although

[10] Financial, knowledge and demand obstacles include two or more questions.

Table 6: Descriptive statistics, pooled cross section, 7^{th}-9^{th} innovation surveys.

		% of firms that declare obstacle of high importance								
Sector	Innovates	Financial	Knowledge	Market	Cooperation	Regulation	Demand	Mean	Std Dev	# obs
A	0.223	0.57	0.42	0.36	0.28	0.15	0.36	0.36	0.14	40,877
B	0.154	0.64	0.52	0.47	0.37	0.26	0.51	0.46	0.13	2,802
C	0.374	0.34	0.23	0.16	0.12	0.09	0.18	0.19	0.09	163
D	0.303	0.60	0.40	0.32	0.28	0.13	0.37	0.35	0.15	12,046
E	0.334	0.31	0.14	0.14	0.12	0.15	0.20	0.18	0.07	338
F	0.193	0.59	0.39	0.43	0.28	0.14	0.39	0.37	0.15	43,724
G	0.193	0.57	0.41	0.40	0.31	0.16	0.37	0.37	0.13	124,345
H	0.205	0.58	0.45	0.30	0.30	0.15	0.31	0.35	0.15	18,356
I	0.131	0.55	0.38	0.36	0.29	0.13	0.37	0.35	0.14	42,247
J	0.213	0.31	0.17	0.25	0.17	0.13	0.17	0.20	0.07	10,449
K	0.253	0.50	0.32	0.25	0.24	0.09	0.32	0.29	0.13	53,370
N	0.236	0.47	0.27	0.24	0.19	0.09	0.26	0.25	0.12	14,584
O	0.227	0.52	0.32	0.20	0.23	0.11	0.29	0.28	0.14	5,717
Mean	0.23	0.50	0.34	0.30	0.24	0.14	0.32			
Std Dev	0.07	0.11	0.11	0.10	0.07	0.04	0.10			

Notes: For each column, the 3 sectors with the highest propensities to innovate and the 3 sectors with the lowest perception of each obstacle are in blue, and in red the 3 sectors that are in the opposite end. The means and standard deviations are calculated for each row and column in the table, not for the original sample.

Table 7: Correlations between barriers.

	Financial	Knowledge	Market	Cooperation	Regulation	Demand
Financial	1					
Knowledge	0.4544	1				
Market	0.4546	0.3886	1			
Cooperation	0.4224	0.4859	0.415	1		
Regulation	0.2931	0.3289	0.3717	0.396	1	
Demand	0.4152	0.4055	0.5588	0.4557	0.3978	1

the correlations are not high, indicating that they provide different information.

4 Econometric analysis

4.1 Estimation strategies

Our base set of specifications are linear regressions over the pooled cross section of innovation surveys (waves seven to nine). With this strategy we take advantage of a relatively large dataset as well as detailed and homogeneous questions on innovation inputs, outputs, obstacles and several covariates. The obvious disadvantage is that there is no simple way to control for the endogeneity of the measures of obstacles. The case for endogeneity is based on the argument that firms that innovate have more information on what obstacles they face. Also, firms that innovated probably had to overcome different obstacles and this might affect the perception they have of them.

To tackle endogeneity we employ an instrumental variables approach. We instrument each barrier category at the firm level using sector-region-period averages of the same obstacle. We use a similar strategy to that of Veugelers and Cassiman (2005) and Chun and Mun (2012), as we explain below in section 4.3.

As a complementary methodology, we use a balanced panel we built using the 7th, 8th and 9th surveys. The panel nature of the data allows us to control for time-invariant unobserved heterogeneity (i.e. constant unobserved firm characteristics), dealing with an important degree of the endogeneity that is present in the pooled cross sections used in much of this literature.

As previously explained, we restrict the sample used in our estimations to "potentially innovative firms". We define these as those that i) declared technological innovations during the period; or ii) incurred any expenditure on R&D (whether internal or external) or innovation-related activities; or iii) faced at least one barrier with high intensity[11]. As explained by D'Este et al. (2012) and Savignac (2008), the reason for this restriction is that only firms interested in innovating effectively and purposefully report barriers and perform innovative activities. In fact, the literature consistently shows that only when the "relevant" sample of firms that are interested in innovation are considered, a negative relationship between innovation and barriers emerges (e.g. Savignac, 2008; Pellegrino and Savona, 2017; Álvarez and Crespi, 2015). Our data shows the same pattern.

Finally, all results presented in the paper use linear models, even though some dependent variables are binary or censored. We focus on linear models due to their robustness and the fact that they do not require any distributional assumption on the unobserved. They also allow for more flexibility, for instance using firm level fixed effects without the incidental parameters problem.[12]

4.2 Pooled innovation surveys

First, we present results for a linear model pooling the three innovation surveys (waves seven to nine), where we regress a variety of outcomes on dummies for the six categories of barriers, and some basic controls (survey and sector dummies, an exporting dummy, log employment and firm age), as shown in Equation 1.[13]

$$y_{i,t} = \alpha + \mathbf{x}'_{i,t}\beta + \mathbf{z}'_{i,t}\gamma + \lambda_t + \lambda_r + \lambda_s + u_{i,t} \tag{1}$$

Where $y_{i,t}$ is a measure of innovation inputs or outputs, λ_t represents time dummies, λ_r the region dummies, λ_s the sector dummies, $\mathbf{x}_{i,t}$ is a vector including the barrier dummies for firm i in year t and $\mathbf{z}_{i,t}$ is a vector of firm-level controls. We are interested in the vector β, with the coefficients that represent the relationship between the barriers and the outcomes. All of the regressions use the surveys' sampling weights.[14] Standard errors are clustered at the sector-region level.

Tables 8 and 9 present results for innovation inputs and outputs. The left panel in each table shows the results using the full sample, and the right panel restricting it to *potentially innovative* firms (the "relevant sample"). For inputs, we analyze an R&D expenditure dummy,[15] a dummy for (non-R&D) spending on innovation, and a measure of its intensity, the (log) expenditure on innovation per employee. For innovation

[11] We also estimated the specifications of this section, expanding the group of potentially innovative firms, including also medium perception of obstacles. Results are very similar.

[12] Unreported results using nonlinear models (i.e. Probit and Heckman models, depending on the variables) produce essentially the same results.

[13] The definition of each innovation barrier dummy and covariates can be found in Appendix A. Table 5 provides descriptive statistics of the covariates.

[14] These weights are required for the estimates to be consistent for the population regression function, given that the sample is not random (see Angrist and Pischke [2008] for an econometric justification and Instituto Nacional de Estadísticas [2015] for the sampling methodology used for the survey).

[15] R&D is not included in the innovation expenditure variable because this type of expenditure was asked in different ways in each survey wave. For this reason it was impossible to include the R&D expenditure level consistently through the three waves analyzed.

Table 8: Expenditure, pooled sample

	Full sample			Relevant sample		
	R&D dummy	Innovation exp. dummy	ln(Innov. exp. /employment)	R&D dummy	Innovation exp. dummy	ln(Innov. exp. /employment)
Financial	0.0347**	0.0808***	-0.0145	-0.0135	-0.0945***	-0.0145
	(0.026)	(0.000)	(0.923)	(0.269)	(0.000)	(0.923)
Knowledge	-0.00937	0.0334*	-0.401**	-0.0245**	-0.0253	-0.401**
	(0.391)	(0.100)	(0.022)	(0.047)	(0.209)	(0.022)
Market	-0.0183*	-0.0302**	-0.102	-0.0249**	-0.0632***	-0.102
	(0.068)	(0.042)	(0.611)	(0.028)	(0.000)	(0.611)
Regulatory	0.00142	-0.0315	0.00605	0.00823	-0.00760	0.00605
	(0.929)	(0.279)	(0.979)	(0.621)	(0.798)	(0.979)
Demand	0.00785	-0.0379	-0.00371	-0.00507	-0.0851***	-0.00371
	(0.527)	(0.118)	(0.983)	(0.745)	(0.004)	(0.983)
Cooperation	-0.0178	-0.0328	0.0145	-0.0191	-0.0350	0.0145
	(0.184)	(0.179)	(0.910)	(0.151)	(0.146)	(0.910)
N	13516	13516	3569	10150	10150	3569
Adj. R-Squared	0.054	0.071	0.215	0.072	0.113	0.215
Joint barriers	0.029	0.000	0.082	0.001	0.000	0.082

Notes. Innovation survey data, waves 7, 8 and 9. Firm level pooled OLS regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Joint barriers is an F-test of the joint significance of the barrier dummies. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

outputs we look at any type of innovation and disaggregate it by technological and non-technological innovation. Only the coefficients for the dummies indicating if a firm observed a barrier (financial, knowledge, market, regulatory, demand and cooperation barriers) are reported.

Table 8 examines inputs to the innovation process: the propensity to invest in innovation activities, the propensity to invest in R&D, as well as the intensity of investment in innovation activities.

The first thing that becomes apparent is that when estimating using the full sample, around half of the estimated coefficients show a positive relationship between barriers and innovation, and some of them are significant. However, when we restrict the sample to potentially innovative firms, all coefficients become negative and many are significant. This is fully consistent with the received literature and confirms that this pattern, which had been described for financial barriers in Chile by Álvarez and Crespi (2015), also holds for every other obstacle category. As reported in the last row, in all cases the barriers are jointly significant, except for innovation expenditure intensity.

For the binary variable indicating whether a firm conducts R&D, knowledge and market barriers are significantly negative, with similar magnitudes. It is interesting that knowledge appears to be relevant only for the propensity to invest in R&D, and not for the propensity to invest in other innovation activities. This makes sense since more advanced knowledge is required for R&D than for other innovation expenditures, and this knowledge is more difficult to get access to. For a dummy indicating that a firm incurs non-R&D innovation expenditures, the estimates are significantly negative for financial, market and demand barriers. Financial barriers show the largest coefficients, followed closely by demand obstacles. When comparing the coefficients of R&D to non-R&D expenditure dummies, the latter are larger than the former, something explained at least in part by the lower propensity to spend on R&D (around 12% of the firms, vis-à-vis

Table 9: Innovation, pooled sample

	Full sample			Relevant sample		
	Innovates	Technological innovation	Non-technological innovation	Innovates	Technological innovation	Non-technological innovation
Financial	0.0751***	0.0430**	0.0504***	-0.113***	-0.129***	-0.0689***
	(0.000)	(0.043)	(0.000)	(0.000)	(0.000)	(0.001)
Knowledge	0.0788***	0.0609***	0.0479***	0.0161	0.00332	0.00892
	(0.000)	(0.000)	(0.003)	(0.437)	(0.824)	(0.577)
Market	-0.0611**	-0.0451*	-0.0448**	-0.0965***	-0.0782***	-0.0658***
	(0.014)	(0.087)	(0.010)	(0.000)	(0.003)	(0.001)
Regulatory	-0.0576***	-0.0511**	-0.0289*	-0.0310	-0.0273	-0.0120
	(0.008)	(0.020)	(0.084)	(0.144)	(0.192)	(0.448)
Demand	-0.0485**	-0.0295	-0.0445*	-0.100***	-0.0764***	-0.0763***
	(0.039)	(0.189)	(0.065)	(0.001)	(0.005)	(0.006)
Cooperation	-0.0208	0.00517	-0.00829	-0.0218	0.00493	-0.00970
	(0.364)	(0.772)	(0.698)	(0.319)	(0.776)	(0.646)
N	13516	13516	13516	10150	10150	10150
Adj. R-Squared	0.091	0.063	0.082	0.137	0.106	0.112
Joint barriers	0.000	0.001	0.000	0.000	0.000	0.000

Notes. Innovation survey data, waves 7, 8 and 9. Firm level pooled OLS regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Joint barriers is an F-test of the joint significance of the barrier dummies. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

26% for non-R&D innovative expenditures), meaning that in relative terms the impact is comparable on both propensities. As for the intensity of innovation expenditures (conditional on spending), only knowledge barriers are significant, suggesting that once a firm decided to spend on these activities, the only barrier that matters to determine the intensity of expenditure is whether they have the knowledge required for the issues at hand.[16]

There is no clear pattern for the relationship between barriers and innovation inputs, however, it is interesting to note that for the decision to invest in innovative activities (which for the Chilean case is much more prevalent than R&D expenditure), demand barriers matter just as much as financial ones. The relevance of financial barriers could be expected, given that they are directly connected with expenditure. But the fact that demand obstacles are just as important is an interesting finding and suggests that firms that face uncertain demand change their innovation investment decisions, which happen way before the moment they actually have to go to the market. This result is consistent with the findings by Pellegrino and Savona (2017) with United Kingdom data.

Table 9 shows the results for the relationship between innovation outputs and obstacles. As for the inputs, and consistent with the literature, coefficient estimates change signs when the relevant sample is used. For the three innovation categories, only three obstacles seem to be relevant: financial, demand and market structure conditions. In other words, money requirements to produce the innovation, demand to buy it, and a market with relatively low entry costs. In terms of significance, results are similar for the three outcomes, but the coefficients are larger for technological than for non-technological innovation. Financial barriers have

[16] In an unreported estimation of a Heckman selection model (type II Tobit), we find similar results, i.e. for the sample of potentially innovative firms, financial, market and demand barriers are significant for the decision to invest and, conditional on spending, only the marginal effect of knowledge barriers is significant.

the highest impact on the propensity to innovate (between 7 and 13 percentage points), followed by demand barriers (between 8 and 10 percentage points). The next in magnitude are market barriers, with similar coefficients to demand obstacles, albeit slightly smaller.

Summarizing, restricting the sample to potentially innovative firms eliminates positive coefficients for all barriers, turning them negative and significant in some cases for innovation inputs and innovation outputs. For innovation outputs, financial, demand and market obstacles appear to be the most important. For innovation inputs, knowledge obstacles appear to be important, which is interesting because it is expected that capabilities are mostly required in the investment phase of a new product, service or process.

4.3 Instrumental variables

Firms that engage in innovation activities are the ones that experience actual problems in the process of investing, improving, and producing innovation. Thus, innovation efforts and the observation of barriers happen simultaneously. In order to assess the possibility that the previous estimations were affected by endogeneity, we provide estimations using instrumental variables.

For our definition of instrumental variables we adapted their use in papers that analyze the determinants of cooperation for innovation. In particular, Cassiman and Veugelers (2002) and Chun and Mun (2012). These papers use industry averages as instruments for individual firm dummies of the use of different sources of information to innovate.

We propose a definition of instrumental variables using averages of each of the obstacle variables over region-sector-survey groups. With this we pretend to capture the exogenous component of these barriers, determined by market/demand and technology characteristics, which one can argue vary by sector, geographical location and time, but which have common traits within each group. We assume that each of these averages picks up the effects of unobserved industry-specific attributes that contribute to that endogenous firm-specific variable (instrumental variable relevance condition). This approach also assumes that the average perception of obstacles of the firms in the region-sector-survey will not influence the decision to innovate or spend on innovation of a given firm beyond its effect through the barrier, and that individual firms do not influence regional-sectoral-survey averages (the exogeneity condition).[17] Cassiman and Veugelers (2002) use as individual measures a rescaled (0-1) of the mean scores of severity of each obstacle category, and thus simply calculate the average across each industry. Since our measure of obstacles is activated if any obstacle in that category has a high perception, we calculate averages to construct instruments as the sector-region-survey averages of each obstacle category dummy. However, we also follow the paper's methodology and build a second instrument using the average *intensity* with which each obstacle is perceived over the sector-region-survey, ranging from zero (not important) to three (very important).[18] Finally, since we use sampling weights in our estimations, we calculated these averages using the corresponding weights, and considering only the sample of potentially innovative firms. The formal definition of the dummy instrument is:

$$dummy\_IV^k_{s,r,t} \equiv \sum_{i \in \Xi_{s,r,t}} \frac{d^k_{i,s,r,t}}{n\left(\Xi_{s,r,t}\right)}$$

Where $d^k_{s,r,t}$ is a dummy that takes the value 1 if firm i in sector s in region r at time t declares that barrier

[17] To check the robustness of the latter assumption, we calculated the instrument dropping sectors with a small number of firms (less than 5), and results hold.

[18] In the innovation survey, the questions take a value from 1 to 4, but where 1 is very important and 4 is not important, we inverted the scale and started it from zero.

k is an important obstacle for innovation (k can be *financial*, *knowledge*, *market*, *regulatory*, *demand* or *cooperation*). $n(\Xi_{s,r,t})$ is the cardinality of $\Xi_{s,r,t}$, which is the set of all potentially innovative firms in sector s in region r at time t. The full set of instruments includes $dummy\_IV_{s,r,t}^{financial}$; $dummy\_IV_{s,r,t}^{knowledge}$; $dummy\_IV_{s,r,t}^{market}$; $dummy\_IV_{s,r,t}^{regulatory}$; $dummy\_IV_{s,r,t}^{demand}$ and $dummy\_IV_{s,r,t}^{cooperation}$.

And the intensity instrument is built as

$$intensity\ IV_{s,r,t}^{k} \equiv \sum_{i \in \Xi_{s,r,t}} \frac{int_{i,s,r,t}^{k}}{n(\Xi_{s,r,t})}$$

Where $int_{i,s,r,t}^{k}$ captures the intensity (between 0 and 3, 0 being not relevant and 3 being very relevant) with which barrier k is declared as an obstacle by firm i in sector s in region r at time t, where k can be each of the six types of obstacles.

We present results for the probability of innovating and for the probability of spending on innovation (the only innovation input variable with strong results in pooled cross section estimates). Tables 10 and 11 compare non-instrumented results for the whole sample and potentially innovative firms (from Tables 9 and 8), with instrumental variables estimates using each of the sets of instruments defined above.

Table 10 shows results for the probability of innovating in any type of innovation. When instrumenting, only the financial and demand obstacles remain significant, and both coefficients increase in size, both having a larger negative impact on the probability of innovating. The instruments do not appear to be weak, as shown by the F tests reported. Comparing both instrumental variables regressions, depending on the instrument we use, we observe that either demand obstacles (using intensity averages) or financial obstacles (using dummy averages of high importance) appear to have the highest impact. We do not have enough evidence to support one over another with these regressions, but this gives us evidence that both issues are clearly the most important issues deterring firms from innovating.

Market structure barriers, which are strongly significant for innovation outcomes in the original regressions, are not significant anymore.

Table 11 shows comparative results for the probability of spending on innovation. Again the instrumental variables estimates show that financial and demand obstacles are significant and have larger magnitudes than before, but only when instrumenting using the dummy averages. When using intensity averages as instruments, no obstacles are significant.

4.4 Heterogeneity

In the descriptive section, we showed that there appears to be an important degree of sectoral heterogeneity in innovativeness, and in the perception of obstacles. Primary sectors like mining, and services, like utilities and financial services, have the lowest perception of obstacles and some of the highest propensities to innovate. On the other hand, fishing and wholesale and retail trade are on the opposite end in both respects. We want to find evidence on whether the relationships found in the previous sections are driven by these sectors or others. Also, since financial and demand barriers appear to be the most pervasive, we present some evidence on how the relationship between obtacles and innovation variables changes when financial or demand barriers are present or absent.[19]

[19] All results presented here are based on the pooled cross section of innovation surveys and on the sample of potentially innovative firms.

Table 10: Impact of barriers on innovation dummy

	Not instrumented		Instrumented (pot. innovative)	
	Full sample	Potentially innovative	Dummy IV	Intensity IV
Financial	0.0751***	-0.113***	-0.231***	-0.169*
	(0.000)	(0.000)	(0.000)	(0.072)
Knowledge	0.0788***	0.0161	0.0816	0.144
	(0.000)	(0.437)	(0.162)	(0.158)
Market	-0.0611**	-0.0965***	-0.0636	0.0583
	(0.014)	(0.000)	(0.283)	(0.489)
Regulatory	-0.0576***	-0.0310	-0.0650	-0.172
	(0.008)	(0.144)	(0.313)	(0.124)
Demand	-0.0485**	-0.100***	-0.150**	-0.279***
	(0.039)	(0.001)	(0.015)	(0.001)
Cooperation	-0.0208	-0.0218	0.0866*	0.105
	(0.364)	(0.319)	(0.093)	(0.118)
N	13516	10150	10150	10150
Adj. R-Squared	0.091	0.137	0.087	0.031
Joint barriers	0.000	0.000	0.000	0.013
Underid p			0.000	0.000
Cragg Donald F			162.898	67.143
Kleibergen-Paap F			1149.253	23.249

Notes. Innovation survey data, waves 7, 8 and 9. Firm level instrumental variables regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Barrier dummies are instrumented by the average of each barrier over the firm's sector-region-survey (dummy instrument), or by a measure of intensity of the barrier over the firm's sector-region-survey (intensity instrument). Intensity goes from 0 (irrelevant) to 3 (high importance) and is averaged over all questions classified under each category. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Impact of barriers on innovation expenditure dummy

	Not instrumented		Instrumented (pot. innovative)	
	Full sample	Potentially innovative	Dummy IV	Intensity IV
Financial	0.0808***	-0.0945***	-0.146**	-0.0655
	(0.000)	(0.000)	(0.048)	(0.393)
Knowledge	0.0334*	-0.0253	0.0690	0.0667
	(0.100)	(0.209)	(0.217)	(0.520)
Market	-0.0302**	-0.0632***	-0.0767	-0.0314
	(0.042)	(0.000)	(0.175)	(0.675)
Regulatory	-0.0315	-0.00760	-0.0106	-0.0674
	(0.279)	(0.798)	(0.887)	(0.517)
Demand	-0.0379	-0.0851***	-0.126**	-0.143
	(0.118)	(0.004)	(0.021)	(0.128)
Cooperation	-0.0328	-0.0350	0.0372	0.0293
	(0.179)	(0.146)	(0.558)	(0.713)
N	13516	10150	10150	10150
Adj. R-Squared	0.071	0.113	0.063	0.061
Joint barriers	0.000	0.000	0.013	0.646
Underid p			0.000	0.000
Cragg Donald F			162.898	67.143
Kleibergen-Paap F			1149.253	23.249

Notes. Innovation survey data, waves 7, 8 and 9. Firm level instrumental variables regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Barrier dummies are instrumented by the average of each barrier over the firm's sector-region-survey (dummy instrument), or by a measure of intensity of the barrier over the firm's sector-region-survey (intensity instrument). Intensity goes from 0 (irrelevant) to 3 (high importance) and is averaged over all questions classified under each category. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4.1 Differences across sectors

We disaggregate our sample in four sectors:[20] non-mining primaries, mining,[21] manufacturing and services. Due to the nature of our instrument, we cannot use it for some of the sectors, so results in this section are based on simple OLS estimates. We focus on the dummies for innovation and for expenditure on innovation as dependent variables. Table 12 shows the results for innovation outcomes (any innovation). The non-mining primary sector innovation seems to be influenced only by financial obstacles. In the case of mining, financial obstacles (with double the impact compared with the rest of the primary sector) and demand obstacles have an important and similar impact, reducing the probability of innovation by up to 40 percentage points. In manufacturing again, finance and demand have the highest negative impact (15 and 10 percentage points, respectively), but also knowledge barriers appear relevant in this sector. Finally, for the services sector, again finance and demand are the most important obstacles, with coefficients of -0.10, although market structure obstacles also have a significant negative impact, with a similar coefficient. In sum, finance and demand matter across the board, while market barriers are only relevant for services and knowledge barriers for manufacturing.

Next, we analyze results for innovation inputs. The results for the probability of spending on innovation, seen in Table 13, are very similar to those of the probability of generating innovation outputs, with the important difference that now demand barriers are also relevant for the primary (non-mining) sector. The obstacles that appear significant are the same and the coefficients are very similar too.

Summarizing, the coefficients we observe in Table 9 for innovation outputs, particularly for demand and finance obstacles are not driven by any sector in particular. In three of the four sectors we analyzed, both demand and finance appear to be significant, although in mining the coefficients appear particularly large. The only exception is agriculture and fishing, where the coefficient for demand is almost significant at 10%. It is interesting that although mining has the highest rate of innovation and the lowest propensity to declare obstacles, as seen in Table 6, it faces the highest impact of some of those obstacles on innovation. As for the significant coefficient we observe for market structure obstacles, it seems to be driven by the services sector, although it is not significant when instrumenting. Finally, only in manufacturing do we observe knowledge obstacles being relevant, but this is not observed when we estimate using the whole sample. Appendix B presents the same regressions but without aggregating ISIC sections.

We discuss the policy implications of these results later on.

4.4.2 Heterogeneity in obstacles: "removing" barriers

We want to take the analysis of these barriers one step further, analyzing what happens with the rest of the perceived obstacles under the presence or absence of the most important barriers. Tables 14, 15 and 16 show this from different perspectives. Table 14 divides the sample between the firms that experience financial obstacles and those which do not. We look at the relevance of the rest of the obstacles for each group. Interestingly, when firms do not face financial obstacles, the effect of the rest of the obstacles is amplified. This is true both for innovation inputs and outputs. Demand obstacles have clearly the largest impact. When introducing a new product or process, also knowledge, market and cooperation obstacles become significant, when firms face no important financial obstacles. However, when financial obstacles are active (right panel),

[20] Each represents one or several first-level ISIC Sections.

[21] We separated mining because it is by far the most important export and because it has the highest rate of innovation and the lowest perception of obstacles.

Table 12: Barriers to innovation dummy, results across broad sectors

	Full sample	Broad sectors			
		Primary	Mining	Manufacturing	Services
Financial	-0.113***	-0.213**	-0.407***	-0.149***	-0.0999***
	(0.000)	(0.028)	(0.000)	(0.000)	(0.001)
Knowledge	0.0161	0.00102	-0.107	-0.0594**	0.0128
	(0.531)	(0.990)	(0.382)	(0.028)	(0.640)
Market	-0.0965***	-0.0848	0.112	0.00374	-0.104***
	(0.000)	(0.335)	(0.450)	(0.898)	(0.000)
Regulatory	-0.0310	0.0877	-0.0743	-0.0318	-0.0513*
	(0.281)	(0.431)	(0.658)	(0.356)	(0.091)
Demand	-0.100***	-0.0650	-0.355***	-0.0971***	-0.104***
	(0.000)	(0.439)	(0.008)	(0.001)	(0.000)
Cooperation	-0.0218	-0.0187	0.0599	-0.0337	-0.0150
	(0.385)	(0.804)	(0.730)	(0.248)	(0.582)
N	10150	880	118	2896	6256
Adj. R-Squared	0.137	0.196	0.297	0.163	0.140
Joint barriers	0.000	0.339	0.000	0.000	0.000

Notes. Innovation survey data, waves 7, 8 and 9. Firm level OLS regressions, classified by broad sectors. Determinants of innovation dummy by broad sector, only potentially innovative firms. Controlling for survey dummies, region dummies, sector dummies (when appropriate), exporter dummy, firm age and log employment. Robust standard errors (not enough clusters for valid cluster-robust inference). p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: Barriers to innovation expenditure dummy, results across broad sectors

	Full sample	Broad sectors			
		Primary	Mining	Manufacturing	Services
Financial	-0.0945***	-0.192*	-0.388***	-0.149***	-0.0785***
	(0.001)	(0.057)	(0.000)	(0.000)	(0.006)
Knowledge	-0.0253	-0.0469	-0.121	-0.0517**	-0.0303
	(0.303)	(0.569)	(0.313)	(0.042)	(0.245)
Market	-0.0632***	-0.000346	0.243*	-0.0351	-0.0712***
	(0.009)	(0.997)	(0.062)	(0.202)	(0.007)
Regulatory	-0.00760	0.154	-0.116	-0.00990	-0.0294
	(0.775)	(0.131)	(0.307)	(0.771)	(0.285)
Demand	-0.0851***	-0.178**	-0.397***	-0.105***	-0.0728***
	(0.000)	(0.018)	(0.004)	(0.000)	(0.004)
Cooperation	-0.0350	-0.0107	0.0650	-0.0215	-0.0355
	(0.140)	(0.884)	(0.670)	(0.444)	(0.165)
N	10150	880	118	2896	6256
Adj. R-Squared	0.113	0.150	0.416	0.158	0.116
Joint barriers	0.000	0.054	0.000	0.000	0.000

Notes. Innovation survey data, waves 7, 8 and 9. Firm level OLS regressions, classified by broad sectors. Determinants of innovation expenditure dummy by broad sector, only potentially innovative firms. Controlling for survey dummies, region dummies, sector dummies (when appropriate), exporter dummy, firm age and log employment. Robust standard errors (not enough clusters for valid cluster-robust inference). p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Effect of barriers depending on whether firms face financial barriers

	No financial barriers			Financial barriers		
	Innovates	R&D dummy	Innovation exp. dummy	Innovates	R&D dummy	Innovation exp. dummy
Knowledge	-0.144***	-0.0541***	-0.174***	0.0627***	-0.0166	0.00937
	(0.000)	(0.000)	(0.000)	(0.006)	(0.313)	(0.671)
Market	-0.184***	-0.0488**	-0.196***	-0.0808***	-0.0195*	-0.0291*
	(0.000)	(0.020)	(0.000)	(0.006)	(0.095)	(0.086)
Regulatory	0.0168	0.0278	-0.0393	-0.0698***	-0.00433	-0.0343
	(0.837)	(0.605)	(0.462)	(0.002)	(0.776)	(0.260)
Demand	-0.355***	-0.0793**	-0.292***	-0.0356	0.0142	-0.0340
	(0.000)	(0.018)	(0.000)	(0.248)	(0.262)	(0.210)
Cooperation	-0.0954**	0.00643	-0.101**	-0.0351	-0.0308**	-0.0484*
	(0.024)	(0.804)	(0.011)	(0.151)	(0.030)	(0.094)
N	3389	3389	3389	6761	6761	6761
Adj. R-Squared	0.281	0.110	0.265	0.109	0.064	0.081

Notes. Innovation survey data, waves 7, 8 and 9. Firm level OLS regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Only potentially innovative firms. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

most of the coefficients that were significant become insignificant or reduce their magnitude. Most notably, demand obstacles become insignificant for the three dependent variables. Out of the four barriers that were negative and significant for innovation outputs when there were no financial barriers, only market obstacles remain significant. Regulatory obstacles appear relevant and were not before, and knowledge barriers have a puzzling positive coefficient. For the expenditure variables, all estimates become relatively small. In other words, when firms face financial barriers, not much else seems to matter, notably not demand. But when they lift them, it is only then that other obstacles, especially demand (and others which were not significant before) appear.

Table 15 shows how active obstacles appear to be in the presence or absence of demand obstacles. When demand obstacles are not active, finance appears to be the strongest deterrent to innovation, together with market structure and cooperation. For the probability of spending on innovation activities, results are very similar, with coefficients being a little smaller. Finally for spending on R&D, knowledge barriers are also significant, something that could be explained by the fact that R&D activities are in general more knowledge intensive than other innovation activities. However, when demand obstacles become active we observe that, besides regulatory obstacles, all barriers–including financial ones–become insignificant. One interpretation of this could be that demand obstacles dominate other ones, where in the presence of it, the other obstacles become irrelevant.

Finally, Table 16 shows the results when neither demand nor financial obstacles are active (left panel). This again increases the significance and the magnitude of the coefficients of the impact of the remaining obstacles when they are present (only regulatory obstacles remain insignificant). When either demand and/or finance obstacles are present, the other key obstacle becomes insignificant (except for one weakly positive coefficient). It is interesting to note that throughout the three exercises the other key obstacle is never significant when the other obstacle is active. The rest of the obstacles either loose significance or become smaller.

Table 15: Effect of barriers depending on whether firms face demand barriers

	No demand barriers			Demand barriers		
	Innovates	R&D dummy	Innovation exp. dummy	Innovates	R&D dummy	Innovation exp. dummy
Financial	-0.217***	-0.0419***	-0.193***	0.0325	0.0272	0.0538*
	(0.000)	(0.003)	(0.000)	(0.332)	(0.204)	(0.053)
Knowledge	-0.0222	-0.0379**	-0.0417	0.0580**	-0.0114	-0.0133
	(0.551)	(0.010)	(0.242)	(0.024)	(0.496)	(0.640)
Market	-0.171***	-0.0468***	-0.135***	-0.0596	-0.0167	-0.0205
	(0.000)	(0.001)	(0.000)	(0.199)	(0.277)	(0.388)
Regulatory	-0.00129	0.0234	0.0183	-0.0818***	-0.0120	-0.0496
	(0.984)	(0.291)	(0.692)	(0.002)	(0.543)	(0.163)
Cooperation	-0.112***	-0.0304**	-0.106***	0.0118	-0.0235	-0.0123
	(0.001)	(0.021)	(0.004)	(0.687)	(0.200)	(0.646)
N	5939	5939	5939	4211	4211	4211
Adj. R-Squared	0.175	0.098	0.146	0.100	0.060	0.074

Notes. Innovation survey data, waves 7, 8 and 9. Firm level OLS regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Only potentially innovative firms. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 16: Effect of barriers depending on whether firms face demand and financial barriers

	No demand or financial barriers			Demand or financial barriers		
	Innovates	R&D dummy	Innovation exp. dummy	Innovates	R&D dummy	Innovation exp. dummy
Knowledge	-0.316***	-0.101***	-0.302***	0.0607***	-0.0171	0.00535
	(0.000)	(0.000)	(0.000)	(0.004)	(0.278)	(0.794)
Market	-0.424***	-0.0777***	-0.383***	-0.0735***	-0.0312***	-0.0349**
	(0.000)	(0.006)	(0.000)	(0.004)	(0.009)	(0.018)
Regulatory	-0.128	-0.0360	-0.194***	-0.0609***	0.00143	-0.0286
	(0.461)	(0.532)	(0.006)	(0.010)	(0.930)	(0.349)
Cooperation	-0.218***	-0.0150	-0.205***	-0.0265	-0.0250*	-0.0414
	(0.000)	(0.695)	(0.000)	(0.241)	(0.057)	(0.137)
Financial				0.0491	0.0296	0.0598**
				(0.114)	(0.160)	(0.026)
Demand				-0.0492	0.0136	-0.0381
				(0.103)	(0.285)	(0.149)
N	2292	2292	2292	7858	7858	7858
Adj. R-Squared	0.370	0.111	0.315	0.092	0.042	0.071

Notes. Innovation survey data, waves 7, 8 and 9. Firm level OLS regressions controlling for survey, region and sector dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Only potentially innovative firms. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 17: Innovation, fixed-effects on available panel

	Full sample			Relevant sample		
	Innovates	Technological innovation	Non-technological innovation	Innovates	Technological innovation	Non-technological innovation
Financial	0.0718**	0.0581**	0.0534*	-0.0581*	-0.0571	-0.0278
	(0.014)	(0.046)	(0.055)	(0.090)	(0.107)	(0.418)
Knowledge	0.0397	0.0578*	0.0220	-0.00682	0.0139	-0.00926
	(0.184)	(0.055)	(0.443)	(0.837)	(0.685)	(0.774)
Market	-0.0201	0.0124	-0.0299	-0.0605	-0.0102	-0.0508
	(0.558)	(0.711)	(0.341)	(0.118)	(0.787)	(0.151)
Regulatory	-0.00221	0.0256	0.0291	-0.0279	0.00345	0.0104
	(0.952)	(0.475)	(0.415)	(0.484)	(0.929)	(0.786)
Demand	-0.0132	-0.0507*	0.0137	-0.0592*	-0.0888***	-0.0162
	(0.639)	(0.070)	(0.609)	(0.066)	(0.008)	(0.597)
Cooperation	-0.0262	-0.0184	0.00734	-0.0399	-0.0355	-0.00731
	(0.431)	(0.579)	(0.817)	(0.261)	(0.332)	(0.831)
N	2270	2270	2270	1730	1730	1730
Adj. R-Squared	0.081	0.067	0.060	0.107	0.076	0.072
Joint barriers	0.120	0.023	0.167	0.004	0.029	0.603

Notes. Innovation survey data, waves 7, 8 and 9. Firm level fixed effects regressions. Controlling for firm, region and survey dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Joint barriers is an F-test of the joint significance of the barrier dummies. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

These tables confirm the relevance of financial and demand obstacles. They seem to dominate others and, when present, they seem binding and decrease the relevance of other obstacles, making the other key obstacle (demand if finance active or finance when demand is active) insignificant, reducing generally the significance and size of the coefficients of the rest of the obstacles. When neither are active, market, knowledge and cooperation become negative and significant.

4.5 Fixed-effects regressions for available panels

In this section we use a small balanced panel we built from the three innovation surveys with the help of the Ministry of Economics and INE to control for firm-level fixed effects to check the robustness of our results.

We use the subsample of innovation survey respondents that were surveyed for the innovation survey waves 7, 8 and 9. As explained in Section 2, this panel is not representative of the population of firms, as it is biased towards large firms and some sectors, such as mining and manufacturing, which are overrepresented, leaving most of the services sector underrepresented.

Tables 17 and 18 replicate Tables 9 and 8, respectively, with the sole differences of controlling for *firm* fixed effects instead of *sector* fixed effects, and clustering the standard errors at the firm level.[22]

As in Tables 8 and 9, most estimates change signs when restricting the sample. However, the only obstacles that remain significant when using fixed effects are, just like under instrumental variables estimation, demand and financial obstacles, only at the 10% level, and with very similar coefficients to each other. When we decompose the innovation propensity into technological and non-technological innovation, demand obstacles

[22] With this panel we cannot use survey weights. This means that the estimates are not comparable to those in the previous sections.

Table 18: Expenditure, fixed effects on available panel

	Full sample			Relevant sample		
	R&D dummy	Innovation exp. dummy	ln(Innov. exp. /employment)	R&D dummy	Innovation exp. dummy	ln(Innov. exp. /employment)
Financial	0.0146	0.0819***	-0.262	-0.0394	-0.0344	-0.262
	(0.537)	(0.005)	(0.322)	(0.185)	(0.339)	(0.322)
Knowledge	0.0417	0.0577**	-0.316	0.0248	0.0185	-0.316
	(0.104)	(0.046)	(0.260)	(0.393)	(0.574)	(0.260)
Market	-0.0254	-0.0102	0.937***	-0.0420	-0.0492	0.937***
	(0.359)	(0.758)	(0.007)	(0.183)	(0.184)	(0.007)
Regulatory	0.0195	0.0339	-0.00753	0.00299	-0.00487	-0.00753
	(0.509)	(0.323)	(0.983)	(0.927)	(0.894)	(0.983)
Demand	0.00194	-0.0483*	-0.511**	-0.0108	-0.0966***	-0.511**
	(0.931)	(0.086)	(0.039)	(0.684)	(0.003)	(0.039)
Cooperation	0.0161	-0.0522	0.353	0.00738	-0.0560	0.353
	(0.558)	(0.115)	(0.326)	(0.809)	(0.126)	(0.326)
N	2270	2270	811	1730	1730	811
Adj. R-Squared	0.053	0.092	0.226	0.057	0.101	0.226
Joint barriers	0.305	0.003	0.033	0.543	0.001	0.033

Notes. Innovation survey data, waves 7, 8 and 9. Firm level fixed effects regressions. Controlling for firm, region and survey dummies, exporter dummy, firm age and log employment. Standard errors clustered at the region-sector level. Joint barriers is an F-test of the joint significance of the barrier dummies. p-values in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

are the only significant determinants for technological innovation, but no obstacles appear significant for non-technological innovation.

Looking at Table 18, with the results for innovation inputs as regression outcomes, demand barriers again stand out, being strongly significant for the non-R&D innovation expenditure dummy. It is also significant at the 5% level for the intensity of innovation expenditure, conditional on strictly positive spending.[23] In a puzzling result, market barriers are positive and significant. This might be related to higher spending on sectors with concentrated markets.

Overall, results with the limited panel sample that is available confirm the importance of demand barriers, which, together with financial obstacles, stood out as the most important barrier under instrumental variables estimation.

4.6 Demand obstacles and information about demand

A relevant question when analyzing demand obstacles is if this obstacle reflects effective lack of demand or lack of information about demand. One way of analyzing this issue is looking at whether firms that declare demand obstacles look for ways to overcome them. One way of doing this is acquiring information. Figure 1 shows scatter plots of the percentage of firms that declare demand obstacles as important, for different degrees of use of clients or competitors as sources of information for innovation. Both sources can potentially provide relevant information about demand for new products. The graphs shows a clear negative relationship (monotonic for clients), showing that firms that declare a higher importance of client or competitor information for innovation are reporting demand barriers to innovation in higher proportions.

[23] It is not straightforward to extend the Heckman model with fixed effects.

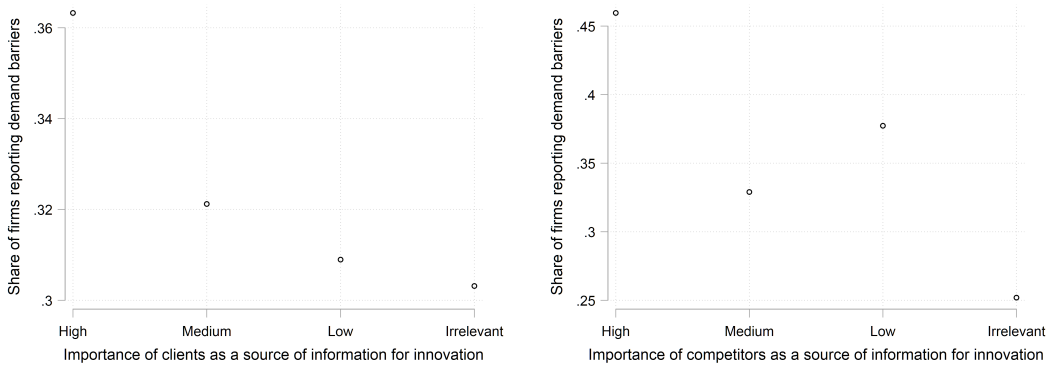

Figure 1: Demand barriers and sources of information for innovation.

This suggests that they tend to declare obstacles knowing if there is or is not demand. However, if true, the causality and underlying explanation of this could go in different directions.

One possibility is that firms that believe there could be no demand for their products have a higher incentive to look for information from clients or competitors. But it could also be the opposite. Firms that look for information might have a higher chance of verifying that there are actual demand problems. This is a natural area for further research to understand the underpinnings of these obstacles and how firms cope with them.

5 Discussion

Demand obstacles could be related to final consumers or to intermediate consumption by other firms that could buy innovations for their production processes.[24] Most of the firms that we interviewed in our complementary qualitative analysis are business-to-busines companies and argue that actual and potential clients seem very reluctant to even test new products, particularly if they have incurred large sunk costs to make current production processes work. Knowing that your customers are conservative in their buying decisions, particularly for untested products, could deter innovation from the beginning of the process. This could explain why we find in our paper that demand obstacles are significant for innovation inputs as well as outputs. From a buyer's perspective, the existence of technical risk when making changes in the productive processes is a fact, and from the perspective of the innovative supplier, it can be observed as a demand risk. Also, in some areas, where there is a dominant leader, many firms appear to wait for the leaders to adopt new technologies first, something that could be related to the significance of market structure barriers and how they could compound demand uncertainty.

There are other demand-related issues that were described as "cultural problems" by our interviewees: low degrees of confidence in the quality of innovative domestic suppliers; a tendency to value foreign alternatives as better regardless of actual quality; firms' short-sightedness and focus on short-term outcomes, which results in a lack of interest on the part of large firms in building long-term, win-win relationships with innovative suppliers; and a general attitude of larger firms to take advantage of their bargaining power vis-à-vis small- and medium-sized suppliers. It is interesting to relate these findings to the description of the issues faced by

[24] According to the National Accounts, intermediate consumption accounts for roughly half of Chilean GDP.

the Korean machine tools industry during its catch-up process, as described in Kim and Lee (2008). They argue that one of the main problems that small and mid-sized domestic firms had to face was "uncertain or unfair demand from user firms". They describe issues like a "wait and see" attitude towards using domestic products; a priori preference for foreign inputs; and requesting price discounts from domestic suppliers, even if their quality did not justify it. Even though Kim and Lee (2008) refer to the development of a specific and R&D intensive sector (machine tools), the similarities between the issues faced by those small and mid sized firms and by similar sized Chilean innovative firms that try to sell to large domestic firms are striking. While to an extent some characteristics of the Chilean culture might worsen these issues, the similarities between what has been observed in both countries suggest that these are more general, structural problems faced by smaller firms that try to sell to other firms in developing or middle income countries, where there is no tradition of domestic or innovative suppliers, and purchasing power is often concentrated in large conglomerates, which give them an upper hand in negotiations. For example, short-sightedness could be the result of limited management capabilities in developing countries (see Bloom and Van Reenen 2007, 2010, and the related literature).[25] If this was the case, demand barriers should be less important in countries with better management practices. In fact, while we find very similar effects for financial and demand barriers, a closely related paper on a developed country (Pellegrino and Savona, 2017) finds that the coefficients for demand barriers are smaller than those for financial barriers.[26] The uncertainty about the quality of domestic suppliers in the Korean case and of innovative products in the Chilean case could be the result of non-existent previous experience and reputation. As stressed by Foster et al. (2016), firms must go through a demand accumulation process where they build a customer base. This might create a vicious cycle of no demand because of not having a reputation, while a reputation cannot be built without having demand.

Financial barriers, although important, are fundamentally different from demand barriers: firms have more control over them. They can look for funds, join forces with other firms, and apply for public funds, of which firms in general have a positive opinion. It is much more difficult for them to get other firms to purchase their products or to collaborate with them to develop a new solution. Regarding cooperation with other firms, this was repeatedly mentioned as a solution not only to financial barriers, but also to knowledge and demand problems. Pooling different kinds of resources and working together with other firms is an important way to overcome barriers and innovate effectively.

6 Conclusions

This paper provides an in-depth empirical analysis of the negative effects of different obstacles to innovation activities in a middle income economy. Easing or removing obstacles might be necessary to unleash innovation at the firm level, particularly in countries like Chile, where levels of innovation and R&D are low despite subsidies promoting innovation having been in place for a long time.

We use an instrumental variables approach, as well as a small panel and fixed effects estimation, and find a strong and consistently large negative impact of demand and financial obstacles on innovation inputs (propensities to spend) and especially on innovation outputs (actual innovations). Particularly, lack of demand and uncertainty about it are pervasive enough as to affect not only the probability of introducing

[25] Policies to support firms' innovation management capabilities have been in place for several years. The problem of excessive focus on short-run outcomes however might be more general: firms need good management capabilities for their core processes before thinking about developing capabilities to manage innovation.

[26] Although, at least in one specification, this difference is not significant, the difference between the coefficients is important and consistent across specifications.

new products or services to the market, but the actual decision to invest in innovation. The significance of these relationships seems robust.

Depending on the instrument used, demand obstacles lower the probability of innovating by between 15 and 28 percentage points, and financial obstacles lower it between 17 and 23 percentage points. The effect of demand and financial barriers on the propensity to spend on (non-R&D) innovation activities are 13 and 15 percentage points, respectively. Considering the group of potentially innovative firms, this means that financial or demand barriers roughly halve the propensities to innovate or to spend on innovation.

Analyzing the primary sector, manufacturing and services separately, the coefficients for demand and financial obstacles are significant across the board, reinforcing the importance of these categories of barriers. The role played by financial and demand obstacles can also be observed when restricting estimations to firms that do or do not face them. When firms declare financial or demand obstacles, all other barriers tend to become insignificant. When they are absent, the significance of other obstacles–most of them insignificant for the whole sample–increases, suggesting that these two types of barriers are binding and only after lifting them might other obstacles become relevant.

We also find some sectorial heterogeneity. Knowledge barriers are significant for manufacturing for both inputs and outputs of innovation. The relevance of market structure obstacles, which appear significant in the non-instrumented full sample estimations, seems to be driven by the services sector.

The findings of this paper have important policy implications. Most policy instruments in Chile and Latin America correspond to financial support through matching grants or tax breaks, addressing and giving implicitly special importance to financial constraints for innovation as the main problem firms face. The relevance of demand obstacles points to an avenue of interesting and potentially complementary policies that could enhance innovation. One obvious alternative, which has received certain academic attention, is the role of public procurement policies for innovation (see for instance Edler and Georghiou, 2007, or Uyarra et al., 2014). Alternatively, insurance provided by a development bank (i.e. solving a missing market issue) could reduce the risk of testing new products for buyers.

Second, the fact that we find that some obstacles are important for all sectors (demand and finance) and others only for specific ones (knowledge and market structure) points to policies that should be horizontal for the former and vertical for the latter. More research is needed to clarify these differences, but in principle, for example, policymakers could tackle potential problems of human capital that might reduce innovation in the manufacturing sector.

The results of this paper and its complementary qualitative analysis open some interesting questions for future research. What does it mean to have lack of demand and/or demand uncertainty as a constraint to innovation? What is the role of information about demand? Are the effects different if the buyers are final consumers or intermediate buyers? Do demand obstacles act differently on innovation inputs and outputs? Second, we need to dig deeper in the complementarity of obstacles. This has been advanced by papers like Galia and Legros (2004), but it is necessary to further understand how the presence or absence of particularly pervasive obstacles affect not only innovation itself, but the perception of other obstacles and their effects on innovation. Finally, the dynamics of these relations and the role of government policies in altering them is a natural avenue for future research. We were unable to exploit this in this paper due to the limitations of the panel, but disentangling these interactions through time can shed light on how policies should be implemented to be more effective in addressing these obstacles, as well as on questions related to the strategies used by firms to overcome barriers to innovation.

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A Dictionary of variables

B Sector level regressions[27]

The tables below present the same regressions discussed in the main text, but using the original ISIC sections, without aggregating them in broad sectors.

[27] The significance of the estimates should be interpreted carefully because of the differences in sample sizes.

Table 19: Dictionary of variables

Variable	Description	Type
Innovates	1 if the firm declares to have done any kind of innovation, 0 otherwise.	Dummy
Technological Innovation	1 if the firm declares to have done product or process innovation , 0 otherwise.	Dummy
Non-Technological Innovation	1 if the firm declares to have done marketing or organizational innovation, 0 otherwise.	Dummy
R&D Dummy	1 if the firm declared expenditure in R&D, 0 otherwise.	Dummy
Innov Expenditure Dummy or Spends in innovation activities	1 if the firm declared expenditure in innovation, excluding R&D, 0 otherwise.	Dummy
ln(Innovation exp. / Employment)	Ln of the ratio of innovation expenditure (in thousand pesos) over average empoyment for the two years covered by each survey.	Continuous
Employment	Average yearly number of employees over the two-year period covered in each survey.	Continuous
Exports	1 if the firm exported during the period of the survey, 0 otherwise.	Dummy
Age	Age of the firm in years.	Continuous
Sales	Average yearly sales over the two-year period covered in each survey, in pesos.	Continuous
Cooperates to innovate	1 if the firm declared any type of cooperation to innovate, 0 otherwise.	Dummy
Barriers (dummies)		
Financial	1 if firm faced Obstacle 1, 2 or 3 in high importance, 0 otherwise.	Dummy
Knowledge	1 if firm faced Obstacle 4, 5 or 6 in high importance, 0 otherwise.	Dummy
Cooperation	1 if firm faced Obstacle 7 in high importance, 0 otherwise.	Dummy
Regulation	1 if firm faced Obstacle 11 in high importance, 0 otherwise.	Dummy
Market	1 if firm faced Obstacle 8 in high importance, 0 otherwise.	Dummy
Demand	1 if firm faced Obstacle 9 or 10 in high importance, 0 otherwise.	Dummy
Barrier intensity		
Financial	Average of importance of obstacles 1, 2 and 3 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous
Knowledge	Average of importance of obstacles 4, 5 and 6 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous
Cooperation	Average of importance of obstacle 7 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous
Regulation	Average of importance of obstacle 11 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous
Market	Average of importance of obstacle 8 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous
Demand	Average of importance of obstacles 9 and 10 (0-not relevant, 1-low relevance, 2-medium relevance, 3-high relevance).	Continuous

See the list of barriers in Table 3 in the main text.

Table 20: Barriers on technological innovation dummy, results across sectors

	Financial	Knowledge	Market	Cooperation	Regulatory	Demand	N	R2
Agriculture, hunting and forestry	-0.285***	0.0821	-0.0102	0.00112	0.0183	-0.134	599	0.171
	(0.009)	(0.364)	(0.916)	(0.989)	(0.888)	(0.154)		
Fishing	0.131*	-0.120	-0.197***	-0.0249	0.159**	-0.193***	281	0.339
	(0.096)	(0.116)	(0.004)	(0.711)	(0.013)	(0.002)		
Mining and quarrying	-0.364***	-0.0331	0.0604	0.0446	-0.0990	-0.333***	118	0.415
	(0.000)	(0.779)	(0.647)	(0.798)	(0.568)	(0.006)		
Manufacturing	-0.156***	-0.0651***	-0.0202	-0.0106	-0.00901	-0.0861***	2896	0.157
	(0.000)	(0.009)	(0.453)	(0.697)	(0.789)	(0.001)		
Electricity, gas and water supply	-0.163**	-0.0530	-0.131*	0.00210	0.124	-0.158**	220	0.313
	(0.020)	(0.480)	(0.086)	(0.980)	(0.151)	(0.039)		
Construction	-0.154*	0.0543	-0.0144	-0.0626	-0.00197	-0.0533	793	0.152
	(0.075)	(0.373)	(0.819)	(0.382)	(0.982)	(0.493)		
Wholesale and retail trade; repairs	-0.0993*	0.0115	-0.153***	0.00446	-0.0572	0.00505	1258	0.158
	(0.072)	(0.808)	(0.008)	(0.929)	(0.236)	(0.921)		
Hotels and restaurants	0.000833	-0.00348	-0.141**	-0.00728	0.0312	-0.0608	469	0.173
	(0.990)	(0.961)	(0.025)	(0.916)	(0.629)	(0.330)		
Transport, storage and communications	-0.139	-0.0331	-0.0515	-0.0203	-0.0232	-0.0601	822	0.183
	(0.104)	(0.456)	(0.271)	(0.663)	(0.642)	(0.170)		
Financial intermediation	-0.0966	-0.00864	-0.178	-0.127	0.0983	-0.145	327	0.293
	(0.376)	(0.930)	(0.104)	(0.267)	(0.373)	(0.160)		
Real estate, renting and business activities	-0.0621	-0.0653	-0.0134	0.0307	-0.0831*	-0.164***	1506	0.130
	(0.196)	(0.129)	(0.745)	(0.495)	(0.073)	(0.000)		
Health and social work	-0.166**	-0.141**	-0.0272	0.0882	-0.0234	-0.173**	453	0.192
	(0.040)	(0.046)	(0.661)	(0.212)	(0.799)	(0.011)		
Other community, social and personal services	-0.198**	-0.0579	0.0170	-0.148*	0.0897	-0.250***	408	0.310
	(0.017)	(0.444)	(0.820)	(0.053)	(0.373)	(0.001)		

p-values in parentheses.

Determinants of technological innovation dummy by sector, only potentially innovative firms.

Controlling for survey dummies, region dummies, exporter dummy, firm age and log employment.

Robust standard errors (not enough clusters for valid cluster-robust inference).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 21: Barriers on innovation dummy, results across sectors

	Financial	Knowledge	Market	Cooperation	Regulatory	Demand	N	R2
Agriculture, hunting and forestry	-0.229**	0.0132	-0.0790	-0.0112	0.0600	-0.0574	599	0.228
	(0.030)	(0.882)	(0.422)	(0.893)	(0.635)	(0.549)		
Fishing	0.0433	-0.138*	-0.223***	-0.0628	0.179***	-0.168**	281	0.355
	(0.668)	(0.084)	(0.002)	(0.411)	(0.005)	(0.011)		
Mining and quarrying	-0.407***	-0.107	0.112	0.0599	-0.0743	-0.355***	118	0.436
	(0.000)	(0.382)	(0.450)	(0.730)	(0.658)	(0.008)		
Manufacturing	-0.149***	-0.0594**	0.00374	-0.0337	-0.0318	-0.0971***	2896	0.170
	(0.000)	(0.028)	(0.898)	(0.248)	(0.356)	(0.001)		
Electricity, gas and water supply	-0.191***	-0.0394	-0.113	-0.0371	0.121	-0.104	220	0.401
	(0.005)	(0.602)	(0.155)	(0.645)	(0.122)	(0.150)		
Construction	-0.140	0.174**	-0.109	-0.167**	-0.00797	-0.0911	793	0.232
	(0.114)	(0.029)	(0.156)	(0.045)	(0.928)	(0.288)		
Wholesale and retail trade; repairs	-0.0821	0.0242	-0.178***	-0.0161	-0.0671	-0.0181	1258	0.164
	(0.164)	(0.642)	(0.004)	(0.762)	(0.209)	(0.745)		
Hotels and restaurants	-0.0611	0.0468	-0.108	-0.101	0.0586	-0.102	469	0.182
	(0.462)	(0.549)	(0.157)	(0.204)	(0.420)	(0.152)		
Transport, storage and communications	-0.148*	-0.0318	-0.0460	-0.0311	0.0105	-0.0961**	822	0.212
	(0.083)	(0.488)	(0.349)	(0.512)	(0.853)	(0.040)		
Financial intermediation	-0.0277	0.0451	-0.299***	-0.103	0.0747	-0.0606	327	0.361
	(0.803)	(0.644)	(0.007)	(0.390)	(0.513)	(0.581)		
Real estate, renting and business activities	-0.0510	-0.0704	-0.00938	0.0250	-0.149***	-0.213***	1506	0.175
	(0.307)	(0.143)	(0.845)	(0.618)	(0.009)	(0.000)		
Health and social work	-0.206**	-0.102	-0.0759	0.0472	-0.0127	-0.187**	453	0.232
	(0.016)	(0.207)	(0.290)	(0.534)	(0.898)	(0.018)		
Other community, social and personal services	-0.152*	-0.0104	0.00363	-0.231***	0.0527	-0.253***	408	0.280
	(0.089)	(0.896)	(0.964)	(0.005)	(0.619)	(0.001)		

p-values in parentheses.

Determinants of innovation dummy by sector, only potentially innovative firms.

Controlling for survey dummies, region dummies, exporter dummy, firm age and log employment.

Robust standard errors (not enough clusters for valid cluster-robust inference).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.