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ORIGINAL PAPER

Entrepreneurial traits and firm innovation

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Abstract Entrepreneurial behavior is widely considered to be influenced by the interaction between skills and motivation. And because entrepreneurial behavior is viewed as a causal determinant of firm performance, given the context in which the venture is embedded, factors determining entrepreneurial behavior are expected to influence firm performance. The research questions explored in this paper are: *Do entrepreneurial traits have a direct effect on firm innovation?* and if so, *Is there a specific entrepreneurial profile that makes firms more innovative?* I use a representative survey of firms from Chile to examine whether owners' skills and motivations affect firm innovation. The survey collects information on both firm and owner characteristics, which allows us to put the entrepreneur back into the analysis of the determinants of firm innovation, a dimension that the related literature does not generally focus on. The survey also allows us to analyze the incidence of innovation in micro and small firms, which have been traditionally overlooked in the study of innovation, despite the fact that they represent the majority of firms in developing countries. The results from a probit model suggest that entrepreneurial traits are important in explaining firm innovation propensity, so any attempt to understand firm innovation should also take the characteristics of the entrepreneur into consideration. Furthermore, different entrepreneurial profiles are related to different firm innovation propensities, providing new evidence on the sources of firm heterogeneity. These results confirm the idea that not all entrepreneurs are the same and that some have particular traits that greatly affect the innovating performance of their ventures.

Keywords Innovation · Entrepreneurship · Entrepreneurial traits

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1 Introduction

This paper analyzes the relationship between traits of entrepreneurs and firm innovation. Entrepreneurial behavior is widely considered to be influenced by the interaction between skills and motivations. And because entrepreneurial behavior is viewed as a causal determinant of firm performance, given the context in which the firm is embedded, variables that affect behavior will indirectly affect the performance caused by that behavior. Hence entrepreneurial traits, like motivations and skills, are expected to exert influence over firm performance, particularly in terms of a firm's innovative performance. Therefore, the research questions addressed in this paper are: *Do entrepreneurial motivations and skills have a direct effect on firm innovation propensity?* and if so, *Is there a specific entrepreneurial profile that makes firms more innovative?*.

There is a wide range of literature dealing with the factors that determine firm innovation. Organizational, environmental, and entrepreneurial traits are among the factors usually covered in this literature. This paper puts emphasis on the third category, for which there is relatively less empirical evidence available due to data limitations. In fact, research that relies on innovation surveys based on the Oslo Manual guidelines fails to control for entrepreneurial traits when analyzing the determinants of firm innovation, as this type of information is not collected in these surveys. However, a relatively recent survey on Chilean firms collected valuable information on both firm and owner characteristics, opening a window of opportunity to put the entrepreneur back into the analysis of firm innovation.

To answer these research questions, I use the second wave of the Longitudinal Survey on Chilean Firms (ELE), which collects information about a representative sample of firms categorized by economic activity and sector for the year 2009. This database also contains information about the characteristics of the firm owner; therefore, it is possible to analyze the relationship between entrepreneurial traits and firm innovation, controlling for firm characteristics.

My results show that entrepreneurs who attain high levels of education and are intrinsically motivated manage firms that are more likely to introduce innovations (even after controlling for usual firm characteristics), although education seems to matter more than motivation. This suggests that any attempt to understand what makes firms go innovative needs to take into consideration the person behind the decision-making process: the entrepreneur.

This paper contributes to the research field of entrepreneurship by providing novel empirical evidence on the link between entrepreneurial traits and firm innovation. The findings regarding this link allows to broaden the understanding regarding the sources of entrepreneurial heterogeneity. Furthermore, the investigation focuses on the national context of Chile, a relatively under-investigated developing country in Latin America as far as these issues are concerned. The findings derived from this paper provide interesting insights to policymakers as

adequate education policies may indirectly induce an increase in the population of innovative firms.

2 Conceptual framework

The population of entrepreneurs is highly heterogeneous in nature, and thus there are a wide variety of entrepreneurs co-existing within the same environment. A fundamental implication of this fact is that different types of entrepreneurs are expected to contribute differently to economic development (Quatraro and Vivarelli 2014). In particular, entrepreneurs pursuing ventures that have the potential to be innovative and achieve high growth rates, in terms of sales and job creation, are expected to generate a larger economic impact than those who remain small and local.

This paper focuses on innovative entrepreneurs, those elusive characters among the continuum of individuals that compose the population of entrepreneurs. The question is: *who* are these elusive pioneers that have the potential to impact economic development through the innovative businesses they pursue?

Joseph Schumpeter described the profile of this special character back in the early 20th century. In his early work, Schumpeter viewed economic development as a result that emerged from a process of creative destruction triggered by 'the entrepreneur' through the introduction of new combinations of means of production (Schumpeter 1934). The entrepreneurial function consists of 'carrying out new combinations', which appear 'discontinuously in time in groups or swarns'. These new combinations are embodied in new firms that emerge alongside the old ones, which are eventually eliminated through competition. The fact that these new businesses appear *en masse*, in the words of Schumpeter, provokes a substantial increase in the purchasing power of this group, explaining the process by which individuals and families rise and fall economically and socially.

The Schumpeterian entrepreneur is, according to the author, a special type of person in terms of his conduct. Doing something different and new, or carrying out innovations, involves high levels of uncertainty, as the decisions to be made do not rely on ordinary routines based on widespread knowledge and habits. Alternatively, the Schumpeterian entrepreneur goes against these ordinary routines and fixed patterns of thinking, fighting the forces of habit that rise up against the one who wants to do something new. Facing this requires a special conduct, a specific type of psyche. First, the individual must have willpower to work on a new combination, believing in it as a real possibility and not merely day-dream; this requires a mental freedom that is by nature peculiar. Second, the reaction of the social environment against one who wishes to do something new can be very strong, especially in the early stages of the project. Successfully dealing with this opposition is a special kind of task that requires a special kind of conduct. Third, leadership is a trait that when mixed with the appearance of new possibilities, brings up the nature or conduct of the entrepreneur. In this sense, the entrepreneurial function is not to *find* or *create* new possibilities, but to actually *set them into motion*. It is the capacity to execute one's ideas that makes one an entrepreneur rather than just a creative person.

Schumpeter goes even further defining the underlying motives that explain the conduct of entrepreneurs from a psychological point of view. First, they share the dream and will to found a private kingdom; this feeling is especially strong in people who have no other chance of achieving social distinction. Second, they share a will to conquer, an impulse to fight and to prove themselves superior to others—to succeed for the sake of success rather than the economic reward. They see profit not as an end in itself, but as an index of success. And third, they share the joy of creating, of getting things done. The entrepreneur seeks out difficulties and changes, finding delight in the venture itself.

The *entrepreneurial function* carried out by this character involves the creation of new things, or things that significantly differ from those the consumer is familiar with.[1] In this sense, innovation is a function carried out by the entrepreneur, and therefore the entrepreneurial function, as defined by Schumpeter, is interlinked to innovation. However, in spite of the fact that innovative entrepreneurs play a central role in socio-economic development, they have not received enough attention in innovation studies (Baumol 2010). And despite common roots in Schumpeterian ideas, entrepreneurship and innovation have evolved over time as two largely separate research fields (Landström et al. 2012). This paper aims at putting the entrepreneur back into the analysis of firm innovation. Next I discuss how the entrepreneur is expected to exert influence over the innovative performance of his business.

I follow the Enhanced Value Creation Performance (VCP) Model developed by Herron and Robinson (1993), in which entrepreneurial behavior is explained by the interaction of individual skills and motivations.[2] And because behavior is viewed as a causal determinant of performance, given the context in which the business is embedded, variables that affect behavior will also affect the performance caused by that behavior. Therefore, both entrepreneurial motivations and skills (captured through educational attainment) are expected to exert influence on firm performance.

This paper starts from the hypothesis that the motivation and skills of the entrepreneur have an influence over the organization, management, and performance of the firm; we expect that this is particularly true for smaller enterprises, where the owner of the firm is typically very close to day-to-day activities and directly influences the decision-making processes (Hausman 2005). Decisions made by entrepreneurs shape the startup and its growth, an influence that starts even before the founding itself and can extend through all stages of the startup's development (Wasserman 2012).[3] Thus, entrepreneurs' characteristics should be taken into account when analyzing factors that determine innovation at the firm

[1] See Schumpeter (1934) page 66 in Chapter 2 for a list of cases of innovations or new combinations.

[2] Personality traits also affect entrepreneurial behavior but in an indirect way as they are assumed to be mediated by motivation (Herron and Robinson 1993).

[3] In his book Wasserman (2012) analyzes the different dilemmas that entrepreneurs behind technology- and science-based startups face and the critical decisions they have to make, from the decision to found or not in the first place to the decision to exit the company. Each decision involves assessing different options and weighing trade-offs. And although there is no 'right decision', any early decision will surely influence the development of the startup in the future, in a very path-dependent fashion.

level. However, since performance is contingent upon the situational context in which the business is embedded, I also consider some contextual factors that are typically recognized in the literature as determinants of firm innovation.

As previously mentioned, even though innovation and entrepreneurship are closely linked, the latter is not a sufficient condition for the former in the sense that not all entrepreneurs are innovative, or some of them are more innovative than others (Szirmai et al. 2011; Reynolds et al. 2002). Furthermore, according to the Schumpeterian approach to entrepreneurship discussed earlier, certain attributes of the entrepreneur make them more innovative, and consequently their firms end up being innovative. Also, as the population of entrepreneurs is highly heterogeneous, we can expect that the motivations that drive them to pursue the creation of new ventures are also different. The question is whether different entrepreneurial motivations and skills have different effects on firm innovation propensity.

The recent empirical literature that has explored the relationship between firm innovation and the characteristics of the entrepreneur (see for example Hausman 2005; Marcati et al. 2008; de Mel et al. 2009; Pérez-Luño et al. 2010; Robson et al. 2012; Galasso and Simcoe 2011; Romero and Martínez-Román 2011; Gebreeyesus 2011) has found that individual traits do have an influence on innovation, even controlling for firm size and other firm characteristics. This is especially true for small firms, where the entrepreneur is typically closer to the decision-making process; consequently, his or her personality, motivations, skills, and behavior are expected to have a higher influence on the organization, management, and performance of the firm.

The relationship between innovation propensity and entrepreneurial personality and motivation has been tested empirically by de Mel et al. (2009), Pérez-Luño et al. (2010), Galasso and Simcoe (2011) and Romero and Martínez-Román (2011). Despite the fact that they test for different personality traits and motivations, they all find a significant influence on firm innovation. Romero and Martínez-Román (2011), for example, explore how different motivations to start a business affect the probability of introducing innovations in Andalusian small firms. They distinguish between intrinsically, extrinsically, and necessity-driven entrepreneurs. Intrinsic motivation is considered to be more related to the need for success and professional development; extrinsic motivation is considered to be driven by economic reward and material achievement; and necessity motivation is associated with those people pushed to entrepreneurship by unemployment situations or dissatisfaction with their previous work. Their main findings show that both intrinsically and extrinsically motivated entrepreneurs have a higher probability of introducing innovations, while necessity-motivated entrepreneurs are less innovative. Furthermore, Pérez-Luño et al. (2010) explored the relationship between personality traits and innovation generation and adoption. Using a sample of innovative Spanish firms, they found that proactivity and risk taking influence the number of innovations generated and the extent to which firms favor generation over adoption. Finally, de Mel et al. (2009) show using a sample of micro, small and medium urban firms in Sri Lanka that impatient entrepreneurs are more likely to innovate, although no significant effect was found for risk-seeking behavior.

In addition to personality traits, other characteristics of the entrepreneur have been found to have a significant influence on firm innovation. First, variations in experience may explain why entrepreneurs differ in their innovativeness (Ucbasaran et al. 2009; Robson et al. 2012). More experienced entrepreneurs, measured for example through prior business ownership experience or proportion of failed businesses over total number of businesses owned, may have developed the tacit knowledge and expertise required to recognize good opportunities. Entrepreneurs that have developed a business expertise have the ability to put together seemingly unrelated information that cannot be properly grasped by novice entrepreneurs, and they might be able to identify (and potentially successfully implement) more innovative opportunities. Despite this initial positive relationship, there might be a point in which experience becomes path-dependent and lock-in effects take place. Ucbasaran et al. (2009) argues that path dependency on prior experience might introduce biases in the entrepreneur's decision-making process: they may assume they know more than they do, infer too much from limited information, become constrained by the familiar, and so on. So at some point when the entrepreneur faces difficulties finding new opportunities and eventually their innovativeness is affected by this path-dependency on prior experience, the firm will become less innovative as well. Using a sample of entrepreneurs from Great Britain,the results of Ucbasaran et al. (2009) show that in fact there is an inverted U-shape relationship between prior business ownership experience and opportunity identification. But the innovativeness of the last opportunity found does not decrease with experience, suggesting that experience is positively related to innovativeness, an idea which is also supported by Robson et al. (2012) using a sample of firms from Ghana.

Furthermore, former employee condition can be also considered as an experience that can directly impact one's ability to successfully run an innovative business; as an employee, they are likely to develop tacit knowledge about the industry and accumulate some relevant social capital that may prove useful in their own venture. Hellmann (2007) argues that employees of established companies turn out to be one of the most significant sources of entrepreneurship. He develops a theoretical model in which employees-turned-entrepreneurs might be the result of two situations. One he calls *stubborn equilibrium*; in this situation, the firm refuses to turn any employee's innovative idea into an intrapreneurship. The employee, faced with poor prospects of work in the company, finally decides to leave to implement his or her new idea through a new business. In the other situation, which he calls *entrepreneurial equilibrium*, the firm encourages the innovative ideas of its employees through start-ups (if the employee owns the intellectual property of the idea) or spin-offs (if the firm owns the IP). Athough it is not possible to differentiate these two situations using the data at hand, it is believed that the condition of being a prior employee in a given sector gives the entrepreneur a tacit knowledge about how a firm is organized and managed, ideas about unfulfilled needs and unexploited opportunities within the sector, and access to the network of suppliers and customers. Supporting this view, Romero and Martínez-Román (2011) find that the prior condition of employment is a major determinant of innovation in small Andalusian firms, irrespective of the sector in which the experience was obtained.

The educational background of the entrepreneur is an important source of skills, knowledge, networks, and problem-solving abilities, and it is considered a key aspect of entrepreneurial success. Furthermore, the literature finds that firms owned by more educated entrepreneurs have a higher likelihood of innovating (de Mel et al. 2009; Romero and Martínez-Román 2011).[4] However, Lazear (2005) argues that entrepreneurs are jacks-of-all-trades who may not excel in one skill, but are competent in many. This implies that individuals with balanced skills are more likely to become successful entrepreneurs. In line with this, higher educational levels are expected to be more conducive to innovation, but only to a certain point. For example, it is not assumed that having a doctoral degree is necessarily more conducive to entrepreneurship and innovative success than having a master's degree, since a PhD educates one to become an expert in a very specific area and probably might fail to develop the balanced skills that are required to manage a business.

As noted above, the research questions explored in this paper are: *Do entrepreneurial traits, particularly motivations and skills, have a direct effect on firm innovation propensity?* and if so, *Is there a specific entrepreneurial profile that makes firms more innovative?* The hypothesis is that intrinsically motivated entrepreneurs, or those who resemble the Schumpeterian entrepreneur described earlier, are more prone to pursue innovative businesses.

In the analysis I will also take into account firm characteristics. There is an extended literature, both theoretical and empirical, on the determinants of firm innovation.[5] A common finding in the literature is that *size* explains the propensity to innovate (although not necessarily the degree of innovation intensity). Size is assumed to capture access of firms to capabilities and resources required for innovation (financial, human, technical, and so on), so I expect that larger firms will have a higher propensity to innovate than smaller firms. *Sector dummies*, which capture the context in which the business is embedded, are also expected to affect firm innovation. In particular, these are expected to capture the differences in technological opportunities and market concentration. Age of the firm, R&D efforts, and exporting activities are also typically considered as factors that can affect firm innovation.

[4] The relationship between skill endowment and innovation has been analyzed in the literature suggesting complementarities between skill endowment and innovation (Leiponen 2005). The literature has focused typically on one direction of causality: the 'skill-biased' impact of innovation, where a larger availability of skilled workers induces investment in that technology that is more intensive in the use of that production factor that has become relatively more abundant (Acemoglu 1998). Therefore, the direction of technical change closely relates to the availability of technical skills. The complementarity between skills and technological innovation has also been empirically tested by Piva and Vivarelli (2009), who supply evidence for the role of skill endowment in increasing a firm's R&D investments. Their results suggest that there is a co-evolution of skills and technological innovation, but it should not be solely attributed to the skill-biased technological change discussed before. The link goes also in the opposite direction: an adequate *ex-ante* endowment of skills may accelerate R&D investment and so drive innovation *ex-post*. Their results have important implications from a policy point of view in the sense that successful education and training policies that increase the skill ratio may also act as indirect incentives to R&D investments.

[5] For a review on econometric evidence using Innovation Surveys, see Mairesse and Mohnen (2010).

3 Methodology

This paper focuses on how firm innovation propensity is related to entrepreneurial motivation and education, controlling for the usual explanatory variables that determine firm innovation propensity. Since motivation is expected to correlate with the error term through unobservable variables that may affect both the propensity of a firm to innovate and the motivation to start the business (i.e., personality traits), I estimate simultaneously two equations: one for entrepreneurial motivation and one for innovation propensity. The former equation involves estimating a multinomial probit while the latter one involves estimating a probit model.

3.1 The motivation equation

As discussed earlier, the population under study is of a heterogeneous nature, and therefore we can expect that the motivations driving entrepreneurs to launch new ventures can differ. Entrepreneurial motivation is modeled here as a function of a set of observable characteristics of the entrepreneur. Therefore, a vector $\mathbf{x}$ of individual characteristics is assumed to determine the motivation category for each individual. The dependent variable y captures the main reason that motivated individuals to start a business activity; thus it can take any value j where $j = 1, \ldots, 4$ in this paper. The probability that motivation j is chosen by an individual i is given by $p_{ij} = Pr[y_i = j|\mathbf{x}_i]$, with $j = 1, \ldots, 4$. The categorical nature of the dependent variable can be modeled through a multinomial probit (MNP).

As opposed to multinomial logit (MNL) models, MNP models allow for correlation across choices through the unobserved component, which requires us to work with normally distributed error terms. This means that in an m-choice multinomial model, utility of choice jth is given by $U_j = V_j + \varepsilon_j$ with $j = 1, 2, \ldots, m$, where the errors are assumed to be joint normally distributed, with $\varepsilon \sim \mathcal{N}[\boldsymbol{0}, \boldsymbol{\Sigma}]$ and the $m \times 1$ vector $\varepsilon = [\varepsilon_1 \ldots \varepsilon_2]'$. Allowing correlation across errors implies allowing some of the off-diagonal entries in the covariance matrix $\boldsymbol{\Sigma}$ to be nonzero. Restrictions on $\boldsymbol{\Sigma}$ are required to ensure identification, which implies considering the difference $U_j - U_1$ between the utility of alternative j and that of alternative 1 as a benchmark alternative.

Estimation of MNP models is preferably done by maximum likelihood and requires calculation of $(m - 1)$-fold integrals, making it more challenging than the estimation of a MNL model. Cameron and Trivedi (2005) assert that a trivariate normal integral is the limit for numerical methods, limiting standard numerical integration methods to a four-choice MNP model (Cameron and Trivedi 2005, p. 518), hence the four motivation categories considered in the motivation equation.

3.2 The innovation equation

Innovation propensity is modeled through a binary variable y_i that captures whether or not the firm i introduced an innovation in 2009. The observed binary outcome y_i can be interpreted as the result of a latent process through which the firm evaluates

its decision to innovate. Let y_i^* be a continuous unobservable variable that depends on a vector of covariates $\mathbf{x_i}$ and a normally distributed error term u_i. The vector of covariates $\mathbf{x_i}$ include firm characteristics w_i, entrepreneurial motivations m_i as previously modeled in Sect. 3.1, and the education level s_i of the owner or partner of the firm.

$$\begin{aligned} y_i^* &= \mathbf{x_i}'\boldsymbol{\beta} + u_i \\ y_i^* &= m_i'\beta^m + s_i'\beta^s + w_i'\beta^w + u_i \end{aligned} \tag{1}$$

And although y_i^* is not observable, we do observe if the firm innovated:

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \rightarrow \text{the firm introduced an innovation in 2009} \\ 0 & \text{if } y_i^* \leq 0 \rightarrow \text{otherwise} \end{cases} \tag{2}$$

The probability that a firm i innovates is then given by

$$\begin{aligned} p_i = Pr[y_i = 1|\mathbf{x}] &= Pr[\mathbf{x_i}'\boldsymbol{\beta} + u_i > 0|\mathbf{x}] \\ &= Pr[-u_i < \mathbf{x_i}'\boldsymbol{\beta}|\mathbf{x}] \\ &= \Phi(\mathbf{x}'\beta)) \end{aligned} \tag{3}$$

where $\Phi(\mathbf{x}'\beta)$ is the standard normal cumulative distribution function that defines a probit model.

An important remark is that in Eq. (1) the error term u_i embodies all unobservable factors that determine the propensity that a firm introduces an innovation. Since in this paper firm innovation propensity is modeled as a function of the characteristics of the owner or partner that manages the business, it is expected that u_i may include unobservable factors that affect both m_i and y_i^*. The consequence of this expected correlation between m_i and u_i is that the estimator for β^m will be biased and inconsistent. To address this, the motivation and innovation equations are estimated simultaneously through maximum likelihood, taking into account the full covariance structure to obtain more efficient estimators (Roodman 2011). This is done using the Stata command [**cmp**] developed by Roodman (2011).

4 Data

4.1 The longitudinal enterprise survey

This paper uses the second wave of the Longitudinal Enterprise Survey, ELE 2011, which collects information for the year 2009. The targeted population are formal firms that perform a productive, commercial, or service activity within territorial boundaries of Chile and whose sales in 2009 were at least UF800.[6] The status of formality is given by the enrollment of the firm in the administrative records of the

[6] The Unidad de Fomento (UF) is an accounting unit that is adjusted periodically by the inflation rate. The average value of the UF in December of 2009 was $20,989.80 Chilean pesos according to the Tax Office website, or €29. Meaning that the sample included firms whose sales were higher than €23k approximately.

Tax Office (SII) and therefore are subject to tax payment. The sample to be surveyed was obtained from the National Statistics Office Directory of Firms, which is based on the administrative records of the SII and other internal directories of the INE.

The ELE 2011 survey was designed using a stratified probabilistic sampling procedure with no replacement. Two strata were considered: economic activity (12 sectors) and size category (5 sales categories). The primary sampling unit is firms; large firms within each stratum were compulsorily included in the sample, while the rest were chosen through random sampling (INE 2011).[7] The sample totals 7062 firms (representing 2.83 % of the national population of firms) and is representative of economic activity (ISIC Rev. 3 at one digit level) and size as measured through sales.[8]

Through 5 modules, the survey collects the following information: Module 1: Finances and accounting; Module 2: Commercialization; Module 3: General management; Module 4: Human resources; and Module 5: Information technologies. In particular, Module 3 gathers information about the characteristics of the firm's general manager and owner such as age, gender, highest level of education attained, main motivation to start the business, sources of funding for launching the start-up, prior business ownership experience, former employee condition, attitude toward employee condition, and attitude towards business failure, among other characteristics.

Relying on the information obtained from Module 3, this paper uses the subsample of firms in the ELE 2011 for which there is available information on the characteristics of the entrepreneur behind the business. The operational definition of *entrepreneur* in this paper includes owners or partners who perform as general managers in the firm, as these figures are expected to exert the highest influence on the decision-making process. In addition to being general managers, firm owners and partners considered in this paper include only those who work full time in the business (meaning that those with full- or part-time jobs as employees are left out of the analysis) and who are 17 years or older when they started their business.

It is important to remark that even though a small panel can be created of those firms included in both the first and the second wave of the ELE Survey (30 % of the observations in ELE 2011 can be found in ELE 2009), the firms that appear in both waves are mainly large ones, which are left out of our discussion of this study given that the influence of the entrepreneur's traits over firm decisions is expected to decrease with size.[9] That is, in large firms the decision-making process is typically shared between more people, like the board of directors, and therefore the direct influence of the owner of the firm may be diluted. Therefore, the small panel sample resulting from merging both waves of the ELE was not useful for the purposes of this paper.

[7] Large firms were censed, meaning a total of 326 firms compulsory included in the sample.

[8] In Chile firm size is measured through yearly sales. The different size categories and their sales levels measured in euros of 2009 are the following: Micro 1: <23k; Micro 2: €23k–€69k; Small 1: €69k–€158k; Small 2: €158k–€792k; Medium: €792k–€3167k; Large: >€3167k.

[9] Large firms are compulsorily included in the sample of both waves.

Limitations of the cross-sectional dataset used in this paper include the impossibility of controlling for both unobservable heterogeneities and observable ones such as the firm's innovative background i.e., whether the firm introduced innovations before 2009 or not. The latter prevents us from distinguishing between novice and habitual innovators. A further limitation of the database relates to the fact that the survey does not collect information on the number of innovations introduced or the share of innovations in sales, which would allow us to study the effect of entrepreneurial motivations on innovation intensity.

The effective sample of firms managed by entrepreneurs that fall into the previous definition totals 3366. However, complete information on both firm and entrepreneurial characteristics is only available for 1714 firms. Estimation of the motivation equation (see Sect. 3) uses the total sample of entrepreneurs for which there is available information on their background characteristics (the 3366 observations), while the innovation equation relies on the subsample for which there is available information on firm characteristics (the 1714 observations).

4.2 Variables

4.2.1 The motivation equation

Four categories of motivation to start a business are considered in this paper. These were built using the answers that owners and partners provided when they were asked to pick and rank the three main motivations to start their current business activity from a list. I use the motivations that were ranked in the first position. This list includes the following seven reasons: (1) family tradition or inheritance; (2) could not find a waged job; (3) I was fired; (4) to complement family income; (5) I found an opportunity in the market; (6) I wanted to organize my own business; (7) other reason. Whenever entrepreneurs answered that the main reason was 'I wanted to organize my own business', a follow-up question was asked for their main reason for wanting this. This list includes the following reasons: (1) have more time flexibility; (2) make my own decisions/be my own boss; (3) have economic success; (4) I like assuming new challenges; (5) social commitment; (6) obtain the results of my work; (7) other reasons.

Using these two questions, four motivations were built: (1) Roles, (2) Necessity, (3) Extrinsic and (4) Intrinsic. The 'necessity' category was built by merging three reasons that are related to what the literature has defined as necessity-driven entrepreneurs (Reynolds et al. 2002). The 'extrinsic' category was built by merging two reasons that are related to external factors affecting motivation drive. As for the 'intrinsic' category, it was built by merging five reasons that are related to internal factors that resemble the Schumpeterian entrepreneurial profile described in Sect. 2. Table 1 below presents the reasons associated to each motivation category. The dependent variable in the motivation equation is hence of a categorical type and captures the main drive that the owner or partner of the firm had to start the business. The following characteristics of the owner or partner of the firm were considered to explain entrepreneurial motivations: living in the capital city, age,

Table 1 Entrepreneurial motivation categories

Main reason for starting the business	Main reason for wanting to organize your own business	Motivation category
(1) Family tradition or inheritance		Roles
(2) Could not find a paid-job		Necessity
(3) I was dismissed from a waged job		Necessity
(4) Complement family income		Necessity
(5) Found a market opportunity		Extrinsic
(6) I wanted to organize my own business		
	(6.1) Have more time flexibility	Intrinsic
	(6.2) Make my own decisions	Intrinsic
	(6.3) Achieve economic success	Extrinsic
	(6.4) I like to take on new challenges	Intrinsic
	(6.5) Social commitment	Intrinsic
	(6.6) Obtain results of my own work	Intrinsic

gender, education, prior professional experience, and prior business ownership experience.

4.2.2 The innovation equation

The dependent variable is of a binary type and captures firm innovation propensity. A broad indicator is built considering the implementation in 2009 of new or significantly improved (1) products (goods and services), (2) processes, (3) marketing methods and/or (4) organizational methods. However, since the effects of firms' and entrepreneurs' characteristics might differ by type of innovation, the analysis also considers a narrower version of the indicator. This implies including only product and process innovations, which are generally considered to be more technology-intensive (OECD 2005). Two dependent variables are therefore considered: overall innovation and technological innovation.

The explanatory variables included in the innovation equation include both entrepreneurial and firm traits. The literature based on innovation surveys has typically considered size, sector, market power, and R&D efforts as determinants of innovation propensity (Mairesse and Mohnen 2010). A common finding regarding *size* is that larger firms, measured either as the level of total sales or employment, are more likely to innovate. Firm innovation dynamics are also thought to depend on the available technological opportunities faced by the firm in the sector in which it performs, known in the literature as the Schumpeterian 'technology push' effect on innovation. This effect is typically captured through *sector* dummies. Regarding the effect that *market structure* has on innovation, the literature has included different variables, like the Herfindahl index of industry concentration. And despite the fact

that one may expect that dominant firms are more likely to be innovative because they have more to lose than newcomers by not innovating, the empirical evidence points toward mixed results. In contrast, *R&D* efforts, especially when performed on a continuous basis, are generally found to have a positive and significant effect on firms' innovation propensity. Firm *age* has also been included as a proxy of the accumulated knowledge, or tacit knowledge, that a firm has accomplished along its life cycle, although results are also mixed and the direction of the effect is a priori ambiguous. Highly skilled labor within the firm, on the other hand, has been considered a proxy of the *technical capabilities* a firm has to carry out innovations, and a positive effect is expected. *Export* status has also been considered a determinant of firm innovation, given that exposure to international competition requires keeping high standards, which could act as an incentive for firms to invest in technology and innovate in order to meet the more rigorous requirements of external clients and remain internationally competitive. And despite the fact that there may be a double causality between exports and innovation, because an innovative firm may be more prepared to compete in international markets, the empirical literature available for a small economy like Chile has found that the effect goes from export status to innovation.[10]

Therefore, the innovation equation includes entrepreneurial traits as explanatory variables, particularly *motivation* and *education*, and the following firm controls: firm size, exporting status, firm age, R&D engagement, skilled personnel, and economic sector according to ISIC Rev. 3 (see Table 2 for a description of the variables).

4.3 Descriptive statistics

The descriptive statistics were calculated considering expansion factors and are presented in Table 3. Regarding the characteristics of the owner, it can be observed that 33 % of the business owners in the sample under analysis reported that they were motivated to start their business by 'intrinsic' drivers, while 30 % of them engaged in business motivated by 'extrinsic' ones.[11] The rest were driven by 'roles' (21 %) and 'necessity' (16 %). This implies that the launch of the businesses under

[10] Alvarez and Robertson (2004) study the effect of the exposure to foreign markets over plant-level innovation in Chile and Mexico, distinguishing three mechanisms: exports, foreign investment, and trade in intermediate inputs. Taking into consideration the potential problem of bicausality between foreign exposure and innovation by measuring all control variables at the beginning of the period, their results for Chile show a positive relationship between exports and technological innovation. However, they find that the effect of exports is not linear, since the squared export term is negative and significant. This indicates that a higher ratio of exports to output increases the propensity to innovate, but at some level it decreases.This evidence may be consistent with the idea that plants more consolidated in the international markets require lower efforts in innovation to remain competitive than plants that are in the first steps of the exporter process (Alvarez and Robertson 2004). Furthermore, in a later paper, Alvarez and Garcia (2008) study whether innovation promotes exporting activities in Chilean manufacturing firms. They do not find evidence that product and process innovations affect the probability of exporting.

[11] It is important to remark that a firm may share its ownership between several partners. Therefore, when talking about owners I refer to both sole owners and partners. I also refer to them summarily as entrepreneurs.

Table 2 List of variables

Var. name	Definition	Type
A. Motivation equation		
Dependent variable		
Motivation	Main reason to start the business:	Categorical (4)
Roles	Family tradition or inheritance of the business	
Necessity	Did not find a job, dismissal, or to complement family income	
Extrinsic	Found a market opportunity or achieve economic success (*base comparison category*)	
Intrinsic	Time flexibility, make own decisions, take on new challenges, social commitments, and obtain results of own work	
Independent variables		
Capital	1 if from capital Santiago	Binary
Age_started	Age of individual when started activity	Continuous
Male	1 if male	Binary
Education	Educational attainment:	Categorical (6)
Primary	1 if primary or less education	
Secondary	1 if secondary education (*base comparison category*)	
Technical	1 if technical education (CFT)	
Prof_institute	1 if professional education (IP)	
University	1 if university (bachelor) education	
Graduate	1 if graduate education	
Professional_exp	1 if prior professional experience	Binary
Business_exp	Number of business previously owned	Continuous
B. Innovation equation		
Dependent variable		
Innovator	1 if firm introduced any of the four types of innovation in 2009	Binary
Tech_inn	1 if firm introduced product and/or process innovations in 2009	Binary
Independent variables		
Motivation	Main reason of the entrepreneur to start the business (see above)	Categorical (4)
Education	Educational attainment of the entrepreneur (see above)	Categorical (6)
ln_size_emp	Firm size, measured as the total number of employees in 2009 (in logs)	Continuous
Micro	1 if firm is micro-sized, according to sales	Binary
Small	1 if firm is small-sized, according to sales	Binary
Medium	1 if firm is medium-sized, according to sales	Binary
d_export	1 if firm exported in 2009	Binary
Age_firm	Number of years since firm initiated formally activities in the tax office	Continuous
d_RD	1 if firm engaged in R&D activities (intra and/or extramural) in 2009	Binary
Skilled	Proportion of employees with tertiary or more education (in logs)	Continuous

Table 2 continued

Var. name	Definition	Type
Sector	Sector in which the firm performs its activities	Categorical (12)
Sector A	1 if sector A (Agriculture, hunting and forestry)	
Sector B	1 if sector B (Fishing)	
Sector C	1 if sector C (Mining and quarrying)	
Sector D	1 if sector D (Manufacturing) (*base comparison category*)	
Sector E	1 if sector E (Electricity, gas and water supply)	
Sector F	1 if sector F (Construction)	
Sector G	1 if sector G (Wholesale and retail trade)	
Sector H	1 if sector H (Hotels and restaurants)	
Sector I	1 if sector I (Transport, storage and communications)	
Sector J	1 if sector J (Financial intermediation)	
Sector K	1 if sector K (Real estate, renting and business activities)	
Sector O	1 if sector O (Other community, social and pers. serv. activ.)	

analysis was the result of a decision-making process determined by different underlying motivations.

In terms of gender, the data shows that firms under study are more prone to be owned and managed by men: only 25 % of firms are led by a woman. In terms of age, on average business owners started their business in their early 40s, which coincides with the upper bound of the free-choice period (between 25 and 40 years old) where entrepreneurship is more likely to take place according to Martin (1994).

In terms of education, 44 % of the population of business owners had reached only the secondary level, while another 30 % had earned a bachelor's degree. A quick look at the descriptive statistics suggests that two types of owners can be distinguished: those who have pursued more than the mandatory level of secondary education, which includes those with tertiary or higher education attainment (i.e., technical or professional institute and bachelor and graduate levels), totaling 45 %, and those who have attained secondary or lower education levels.

Regarding prior experience, half of the owners have worked as employees before. This is consistent with the life cycle of an individual who starts labor life in the mid-twenties as an employee and starts gaining progressive experience until he or she is faced to a triggering event conducive to entrepreneurship. In terms of prior business ownership experience, 52 % of owners have had a prior experience in entrepreneurship, with an average number of 2 prior businesses (or 1 if we consider also novice entrepreneurs that is, those who did not have prior business ownership experience). One may expect that this subset of the population may have acquired some tacit knowledge about how a businesses is managed and on how markets work. They may also have developed a social network that proves useful to the business.

Table 3 Descriptive statistics

Variable	Mean	SD	Min.	Max.	N
Roles	0.21	0.41	0	1	3366
Necessity	0.16	0.37	0	1	3366
Extrinsic	0.30	0.46	0	1	3366
Intrinsic	0.33	0.47	0	1	3366
RM	0.43	0.49	0	1	3366
Age_started	40.56	10.77	17	83	3366
Gender	0.75	0.43	0	1	3366
Primary_less	0.11	0.32	0	1	3366
Secondary	0.44	0.50	0	1	3366
CFT	0.04	0.19	0	1	3366
IP	0.09	0.28	0	1	3366
University	0.30	0.46	0	1	3366
Graduate	0.02	0.15	0	1	3366
Prior_employee	0.51	0.50	0	1	3366
Business_exp	1.1	1.87	0	85	3366
Innovator	0.53	0.50	0	1	1714
Tech_inn	0.38	0.49	0	1	1714
ln_size_emp	1.71	1.27	0	8.22	1714
Micro	0.42	0.49	0	1	1714
Small	0.49	0.50	0	1	1714
Medium	0.09	0.29	0	1	1714
d_export	0.04	0.20	0	1	1714
Age_firm	11.76	7.61	1	60	1714
d_RD	0.10	0.30	0	1	1714
Skilled	0.20	0.31	0	1	1714
Sector_A	0.12	0.32	0	1	1714
Sector_B	0.01	0.07	0	1	1714
Sector_C	0.01	0.08	0	1	1714
Sector_D	0.15	0.36	0	1	1714
Sector_E	0.00	0.01	0	1	1714
Sector_F	0.10	0.30	0	1	1714
Sector_G	0.29	0.46	0	1	1714
Sector_H	0.05	0.21	0	1	1714
Sector_I	0.09	0.29	0	1	1714
Sector_J	0.00	0.03	0	1	1714
Sector_K	0.15	0.36	0	1	1714
Sector_O	0.04	0.20	0	1	1714

When considering the subsample of 1714 observations for which complete information is available (on both firm and entrepreneurial characteristics), it can be observed that half of the businesses introduced an innovation in 2009, while 38 % introduced a technological innovation. The average age of the firm is 12 years old,

meaning the average firm in the sample does not fall under the category of young startups. A small proportion of them export (4 %), while 10 % have been engaged in R&D activities. The average share of high skilled labor on total employment is 20 %. The sample is composed of 42 % micro-sized, 49 % small-sized and 9 % medium-sized firms.[12] These proportions suggest a slight bias toward smaller firms, since the distribution of the national firm population by size in 2009, when leaving aside large firms, was: 7 % medium-sized, 24 % small-sized, and 70 % micro-sized firms.

5 Results

The results of the simultaneous estimation of the innovation and motivation equations show that the correlation between the error terms of both equations is not statistically significant at the usual levels.[13] This means that an unbiased and consistent estimator can be obtained directly by estimating the innovation equation. Therefore, the following discussion of results will rely on the probit estimation of the innovation equation.

Table 4 reports the average marginal effects after the probit estimation of the innovation equation, which give the magnitude of the average effect of each variable on the propensity of a firm to introduce an innovation (see list of variables in part B of Table 2). It is important to remark that the relationship between the regressors and the probability of innovating is nonlinear. The marginal effect for a continuous variable x_j is given by $\partial p/\partial x_j = \phi(x'\beta)\beta_j$ and for a dummy variable is $\partial p/\partial x_j = \Phi(x'\beta)_{(x_j=1)} - \Phi(x'\beta)_{(x_j=0)}$, interpreted as the change in the probability due to variable x_j going from value 0 to 1.

The results in column 1 of Table 4 show that, when compared to the base category of firms managed by 'extrinsically' motivated entrepreneurs, firms that are managed by 'intrinsically' motivated ones have, on average, a higher propensity to innovate of about 6 percentage points. The same holds for technological innovations (see column 2). No differences are observed between the base and the other motivation categories, roles and necessity.

The effect of intrinsically motivated entrepreneurs on firm innovation holds once the educational background of the entrepreneur has been controlled for. Recent evidence by Olivari (2016, Ch.3), suggests that higher educational attainment is related to the propensity to be an intrinsically-driven entrepreneur. So one may expect that due to the positive correlation between the two variables, one of them would not be significant in the innovation equation. This may happen if the effect of education over firm innovation propensity was only indirect through the effect it has on motivation. However, the fact that both education and intrinsic motivation have a positive and statistically significant effect over firm innovation means that education plays two roles in determining firm innovation: one is its effect over the type of motivation that drives an entrepreneur to pursue the launch of their business, and the

[12] Large firms are not included in the analysis, as explained in Sect. 4.1.

[13] Not reported here. Results of the error correlation can be provided upon request.

Table 4 Innovation equation: average marginal effects

Variables	(1) Innovator	(2) (se)	(3) Tech. Innovator	(4) (se)
Roles	−0.049	(0.033)	−0.046	(0.032)
Necessity	0.036	(0.044)	0.011	(0.044)
Intrinsic	0.058**	(0.029)	0.055*	(0.029)
Primary	−0.080	(0.054)	−0.051	(0.052)
Technical	−0.042	(0.065)	0.043	(0.064)
Prof_institute	−0.044	(0.043)	−0.008	(0.042)
University	0.083***	(0.031)	0.059**	(0.030)
Graduate	0.157**	(0.063)	0.108*	(0.065)
In_size_emp	0.017*	(0.010)	0.023**	(0.009)
d_export	0.024	(0.050)	0.090*	(0.047)
Age_firm	−0.003**	(0.002)	−0.001	(0.002)
d_RD	0.081**	(0.035)	0.131***	(0.034)
Skilled	0.018	(0.050)	0.015	(0.050)
Sector A	−0.047	(0.053)	−0.075	(0.054)
Sector B	−0.178***	(0.065)	−0.150**	(0.063)
Sector C	−0.110*	(0.059)	−0.105*	(0.058)
Sector E	−0.294	(0.279)	−0.229	(0.260)
Sector F	−0.155***	(0.047)	−0.155***	(0.046)
Sector G	−0.017	(0.043)	−0.040	(0.044)
Sector H	−0.019	(0.046)	−0.029	(0.047)
Sector I	−0.107**	(0.048)	−0.105**	(0.048)
Sector J	−0.030	(0.137)	−0.217*	(0.121)
Sector K	−0.113**	(0.049)	−0.114**	(0.048)
Sector O	−0.079	(0.058)	−0.043	(0.058)
Observations	1714		1714	

Standard errors in parentheses

Base motivation category: Extrinsic; Base education category: Secondary Base sector category: Manufacturing

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

other is the direct effect it has on the performance of the firm, in terms of the propensity to be innovative.

As discussed earlier, not all entrepreneurs are the same. They have different entrepreneurial motivations that, according to the results in this paper, ultimately affect the performance of the firms they manage. In fact, the results show that entrepreneurs who wanted to launch their businesses *pulled* by their need of autonomy and by their enjoyment of facing challenges and seeing the outcome of their own effort were more likely to run innovative businesses. This is consistent with the literature on personality traits, which argues that entrepreneurs are characterized by their need for achievement, self-efficacy, and internal locus of control.[14] This also coincides with the Schumpeterian profile of entrepreneurs, who have the will to conquer, the impulse to prove themselves superior to others, the drive to succeed for the sake of it and not for wealth, and who finds joy in creating

[14] See a review of personality traits of entrepreneurs in Rauch and Frese (2007) and Zhao et al. (2010).

and getting things done (see Sect. 2). All these characteristics are related to the motivations included in the intrinsic category studied in this paper.

Regarding the effect of education, the results show that higher levels of education have a positive effect on firm innovation propensity for both overall and technological innovations, although the effect is slightly larger for the former category. An interesting result is that having attained a graduate level (master's or PhD degree) doubles the effect of having a bachelor's degree in both models. For example, a business managed by an owner that has attained a bachelor's degree increases the probability that the firm introduces any innovation by 8 percentage points, while attaining a graduate level (master's or PhD) increases the probability of introducing an innovation by 16 percentage points.

Both entrepreneurial variables, education and motivation, have a statistically significant effect on firm innovation after controlling for firm characteristics, and their effects go in the expected direction. The positive effect of size is consistent with the literature, which suggests that larger firms are more prone to engage in innovation activities. R&D efforts also have the expected effect: engagement in R&D activities increases the propensity of firm innovation, especially for technological innovation (as expected), where the effect is almost doubled, reaching an increase in the probability of 13 percentage points. Firm age seems to have a negative effect on overall innovation propensity, although the magnitude of the effect is negligible. This goes in line with the empirical literature, where mixed effects are found.

A relevant question that emerges after the prior findings is: how much the probability that a firm innovates varies after fixing the characteristics of the entrepreneur? To examine this, an exercise was done using the estimated coefficients. Education and motivation were fixed to specific profiles, and then the predicted probability was calculated by letting firm characteristics vary. Afterwards, its density distribution was plotted.[15] The set of graphs in Fig. 1 show the variation in the probability of innovating due to firm characteristics for different entrepreneurial profiles.

The first graph in the upper left side of Fig. 1 shows that the probability distribution slightly shifts to the right for firms that are managed by intrinsically-driven entrepreneurs. The same pattern is observed when analyzing how the probability distributions change for different educational levels. The graph on the upper right side shows that for graduate entrepreneurs the probability of innovating is always higher than 50 %. When combining both education and motivation characteristics, we can see that no matter what size the firm is, what R&D profile it has, or which sector it performs in, if the owner has graduate education and is intrinsically motivated, the probability that the firm introduces an innovation (overall) is between 60 and 80 %. The next best profile involves and owner who is intrinsically motivated and has a

[15] The exercise was done as follows: First, the estimated coefficients $\hat{\beta}_j$ (not reported here) were retrieved after the probit estimation; second, the $\sum_i \hat{\beta}_j x_{ij}$ was calculated for each observation i after fixing the values of the motivation and education variables and letting the rest of the variables in Table 2 take the observed value; third, the nonlinear probability of innovating $p_i = Pr(y_i = 1) = \Phi \sum_i \hat{\beta}_j x_{ij}$ was calculated for each observation i; and fourth, the kernel density function was estimated for the predicted probabilities obtained in the previous step, using an Epanechnikov density function and the default bandwidth.

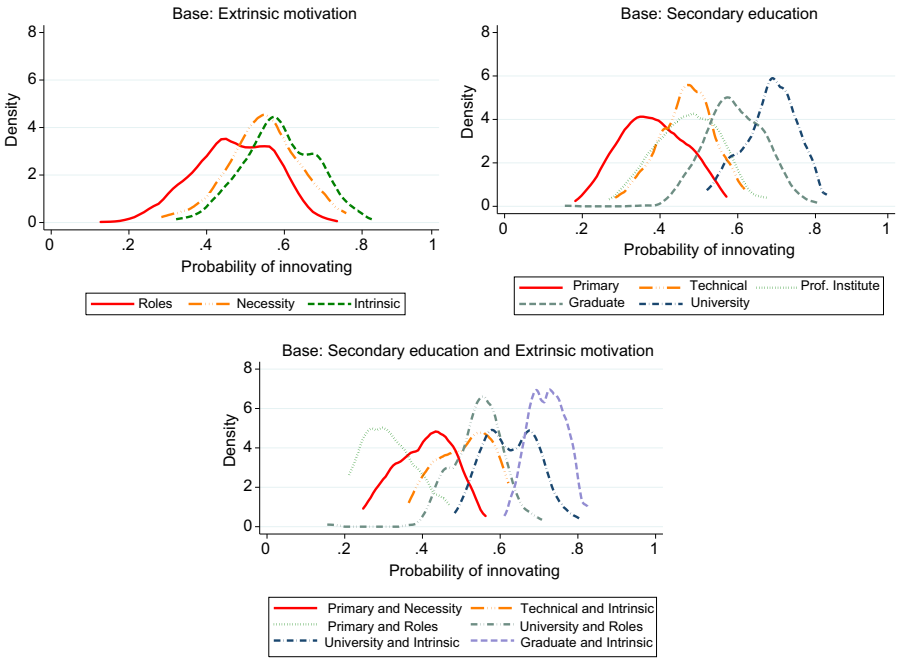

Fig. 1 Probability of innovating according to different entrepreneurial profiles

bachelor's degree. The least 'virtuous' one involves having low levels of education and pursuing a business because of family role models.

6 Concluding remarks

Understanding why firms go innovative requires that we take into consideration both the heterogeneous nature of the firm and of the entrepreneur behind the business. This is important when it comes to the design of effective policy instruments, as there is no 'one-size-fits-all' solution in a heterogeneous context like this.

To better understand what makes firms go innovative, we need to understand who is behind the decision making process: the entrepreneur. Entrepreneurs have different motivations for launching their businesses, which implies different individual behaviors and subsequent firm performances (in interaction with the context in which the firm is embedded).

The results of this research show that both entrepreneurial motivations and education attainment are important for explaining a firm's propensity to innovate (even after controlling for firm characteristics). In particular, different entrepreneurial motivations and educational backgrounds affect differently the likelihood that a firm will introduce an innovation. That is, different entrepreneurial profiles, as determined by their motivations and educational backgrounds, are related to different innovation propensities. This paper found that intrinsically motivated and

highly educated entrepreneurs are more prone to have businesses that innovate. These intrinsically motivated individuals resemble the Schumpeterian entrepreneur discussed in Sect. 2. Furthermore, in Chile, the Schumpeterian entrepreneurs behind innovative firms seem to be highly educated.

An interesting result is that having a graduate degree doubles the probability of innovating (16 percentage points) compared to having a bachelor's degree (8 percentage points). These results somehow go against Lazear's (2005) theory that entrepreneurs must be jacks-of-all-trades who need not excel in any one skill but be competent in many. Regardless, in a country like Chile, which exhibits high levels of inequality that determine the access to quality education, having a graduate degree may be a proxy for other unobservable factors that may be relevant to, or act as enablers of firm innovation, such as a better socioeconomic background and/or a larger, more diversified, and higher-quality social network. This relationship between education and the 'quality' of social networks, in terms of their influence on firm behavior and performance, has been addressed in Olivari (2016, Ch.5) using qualitative case studies.

This work still suffers from limitations owing to the cross-sectional nature of our data. First, endogeneity problems are always present in this setting, given that some variables are simultaneously determined. If suitable instruments are not available, solving endogeneity problems becomes very difficult, and we are left with inconsistent estimators. This is the main reason why other controls such as export status, certification, and other firm characteristics were not included (although the information is available). Furthermore, simultaneity issues make it difficult to make statements about directions of causality, so I am just able to identify relationships. Finally, with a cross-sectional dataset I am not able to study the dynamics of the firm, which is key to understanding firm behavior.

This study aims to make a contribution to the literature on determinants of firm innovation by enlarging the empirical evidence on the relationship between firm innovation propensity and entrepreneurial traits. It furthermore aims at contributing to the literature on Chilean innovative entrepreneurship, a country that is relatively less studied in the related literature.

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