



UNDETERRED AND
(SOMEWHAT)
SUCCESSFUL - HOW
CANADIAN FIRMS
MITIGATE
INNOVATION
BARRIERS TO REMAIN
INNOVATIVE?

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Undeterred and (somewhat) successful – How Canadian firms mitigate innovation barriers to remain innovative?¹

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Abstract / Résumé

This paper disentangles the actions that firms took to mitigate financial and nonfinancial innovation barriers and offers a first assessment of the role of government support programs for innovation related activities in relation with these perceived innovation obstacles. Our results show that firms that face financial constraints cannot completely overcome these innovation barriers. When not financially constrained however, firms that choose to be undeterred by the obstacles they face and takes successful measures or use government programs are either equally or more innovative than firms that do not face such innovation obstacles. Firms that have used government assistance programs have a greater propensity to innovate than those that did not use any government support.

Ce document distingue les mesures prises par les entreprises pour atténuer les obstacles financiers et non financiers à l'innovation et propose une première évaluation du rôle des programmes de soutien public aux activités liées à l'innovation en relation avec ces obstacles perçus à l'innovation. Nos résultats montrent que les entreprises confrontées à des contraintes financières ne peuvent pas surmonter complètement ces obstacles à l'innovation. Toutefois, lorsqu'elles ne sont pas confrontées à des contraintes financières, les entreprises qui choisissent de ne pas se laisser décourager par les obstacles auxquels elles sont confrontées et qui prennent des mesures efficaces ou utilisent des programmes gouvernementaux sont tout aussi innovantes, voire plus, que les entreprises qui ne sont pas confrontées à de tels obstacles à l'innovation. Les entreprises qui ont eu recours à des programmes d'aide publique ont une plus grande propension à innover que celles qui n'ont bénéficié d'aucune aide publique.

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Keywords/ Mots-clés: Obstacles to innovation, government incentives, innovation performance, mitigating innovation barriers / Obstacles à l'innovation, incitations gouvernementales, performance de l'innovation, atténuation des obstacles à l'innovation

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1 Introduction

This study is a glass half-full story. We build on the outstanding work of numbers of colleagues who have studied the relationship between numerous barriers to innovation, and innovation activities (from R&D expenditures to innovation outcomes). Instead of focusing on their negative impact, we address how firms use different tools at their disposal, including government support programs, to overcome these barriers and innovate. There lies the originality of the paper.

Innovation is a well-known key driver of productivity gains, economic growth and enhanced living standards (see Commission européenne; Jenkins et al., 2011; OECD, 2017; STIC, 2013). Building and supporting an innovative business sector is therefore part of the Canadian government's key objectives (for Canada's inclusive innovation agenda, see ISED, 2016). In this regard, previous analyses and reports have led to a broad diagnostic: Canada's subpar innovation performance (Nicholson, 2016) has been attributed to a low demand for innovation by Canadian businesses (CCA, 2009), but since then, this low performance has been rather perceived as a paradox (CCA, 2018; The Conference Board of Canada, 2013) for which a single culprit is difficult to pinpoint. Governments have identified a problem, want to do more to help but are unsure how and whether their programs have an impact. More research is therefore needed to elucidate the reasons for this low propensity to perform innovation activities and role of government in redressing the balance. In addition, the pre-COVID-19 period may bear little resemblance with what comes after the pandemic is under control and we strive to rebuild our economies with unprecedented financial constraints.

Since innovation surveys have started to more systematically include questions on innovation obstacles, numerous descriptive and empirical articles have focused on the impact of obstacles impeding firms' propensity to innovate. The relationship between innovative output and factors hampering innovation activities has generated an important literature (Arundel, 1997; Baldwin & Lin, 2002; Blanchard, Huiban, Musolesi, & Sevestre, 2013; D'Este, Iammarino, Savona, & von Tunzelmann, 2012; Garnsey & Wright, 1990; Gartner & Naiman, 1980; González, Jordi, & Pazó, 2005; Knight, 1987, 1989; Linsteadt, 1978; Lööf & Heshmati, 2006; McIntyre, 1982; Mohnen, Palm, van der Loeff, & Tiwari,

2008; Mohnen & Rosa, 2002; Mohr, 1969; Sapolsky, 1967; Savignac, 2008; Steffle, 1985). Among the types of obstacles investigated, financial constraints have been cited repeatedly as some of the most important barriers to innovation, and as a result have been extensively studied (Canepa & Stoneman, 2008; Hall, 2002; Hottenrott & Peters, 2011; Mancusi & Vezzulli, 2014; Savignac, 2008; Tiwari, Mohnen, Palm, & van der Loeff, 2008). In the empirical literature however, the effect of such constraints on innovation appears at first to be not conclusive. Non-significant or positive and significant coefficients are often associated with the variable “obstacles” (Mohnen et al., 2008), i.e. the more firms faced obstacles, the more innovative they were. This positive relationship paradox has been interpreted in the literature as an indication of how successfully firms can overcome these obstacles (Baldwin & Lin, 2002; Tourigny & Le, 2004).

Savignac (2008) alternatively argued that this unexpected positive relationship between firm’s performance and the probability to face obstacles (from financial constraints in her case) to innovation results from the combination of two sources of bias: first, the endogeneity of obstacles due to unobserved factors affecting both obstacles and the propensity to innovate; second, the inclusion of firms that have no intention to innovate (i.e. jointly estimate obstacles and the propensity to innovate). The first bias can be accounted for by using appropriate econometric technique while the second potential bias can be eliminated by sampling only firms that “wished” to innovate (even if they effectively did not innovate). When one properly accounts for endogeneity and appropriately use sample selection, the impact of obstacles on the probability of introducing innovations yields the expected negative sign. Blanchard et al. (2013) provided an elaborate means by which to select firms that are willing to innovate. They suggest distinguishing firms that innovate and firms that want to but fail to innovate, from firms that are discouraged from trying to innovation and firms that simply do not want to innovate. One would neither expect that obstacles to innovation have the same impact on all these types of firms, nor that government support contributes to alleviating these obstacles in the same way. Alternative methods for appropriate sample selection are also suggested by a number of scholars (D’Este et al., 2012; García-Quevedo, Pellegrino, & Savona, 2016; Mancusi & Vezzulli, 2010; Pellegrino & Savona, 2017; Segarra-Blasco & Arauzo-Carod, 2008).

When faced with innovation barriers, firms may choose to do nothing and maybe renounce on innovating altogether, what D'Este et al. (2012) refer to as 'detering' barriers to innovation. Otherwise, firms may choose to act to try to overcome or mitigate these obstacles. These actions may be a success and allow firms to surmount the barriers to innovation, or they may fail. While in the former case, firms would appear 'undeterred' and successful in overcoming innovation barriers, in the latter case, the end result may be that firms are deterred by the perceived barriers, having failed to overcome them, but at least they tried.

Some of the actions taken by firms are likely to involve the use of government support programs for innovation related activities. Most of the literature has examined whether government programs, mainly direct subsidies and R&D tax credits (Bronzini & Piselli, 2016; Cappelen, Raknerud, & Rybalka, 2012; Guan & Yam, 2015; Guo, Guo, & Jiang, 2016; Szczygielski, Grabowski, Pamukcu, & Tandogan, 2017; Yang, Huang, & Hou, 2012) or related to human capital (Amara, D'Este, Landry, & Doloreux, 2016; Szczygielski et al., 2017), influence the ability of a firm to innovate (from R&D intensity, patents and number of innovations). But no research to date has examined the dual role of government programs in helping a firm overcome obstacles to innovation and in helping the firm to innovate. Furthermore, solutions to surmount barriers to innovation that exclude government programs (whether successful or not), have not been addressed by the literature, let alone in conjunction with government programs. There is no a priori on which type of constraint impaired most Canadian firm's propensity to innovate or the effect of using government support programs and their ability to alleviate firm's obstacles to innovation (or to affect firm performance). A second objective of our research therefore consists in evaluating the differentiated role of government support (compared to other non-government related measures) in its ability to help firms overcoming innovation obstacles, in addition to contributing directly to increase their propensity to innovate.

This research is therefore a direct contribution to the ongoing literature that relates firm's perceived barriers to their propensity to innovate, by adding the success, or not, of the measures taken by these firms to overcome these obstacles, in addition to information about whether government innovation support programs were used or not. To our knowledge, this is the first study to address this question in such details.

The remainder of this paper is organised as follows. The next section presents the theoretical framework of the study, first exploring the different types of innovation obstacles and then how firms try to overcome them. Section 3 follows with details of the three databases used, a description of measures constructed for the study (i.e. the dependent and independent variables), and the methodology. The subsequent section describes the descriptive statistics of the sample. Section 5 then analyses the regressions results. Finally, the last section discusses the implications of the results and concludes.

2 Innovation barriers and mitigating measures

Mohnen and Röller (2005) suggested that firms involved in different phases of the innovation process, the probability of becoming an innovator, and the intensity of innovation, suffer from different constraints. For “wannabe” innovators, it is important to remove a number of obstacles at the same time because they are mostly substitutable to one another. For instance, innovators would innovate more if they had an easier access to finance and a better access to skilled labour. None of these obstacles are indeed independent of one another. A number of scholars (Baldwin & Lin, 2002; Galia & Legros, 2004; Mohnen & Röller, 2005; Mohnen & Rosa, 2002) have shown that obstacles can be grouped into coherent categories and that the resulting categories are often complementary to each other. Segarra-Blasco, Garcia-Quevedo, and Teruel-Carrizosa (2008) considered three categories: cost/financial, knowledge, and market barriers. D'Este et al. (2012) and Pellegrino and Savona (2017) added regulation factors to these three groups of innovation barriers.

In addition, the literature falls into three broad categories: the publications that examine the effect specific barriers on the propensity to engage in innovation activities; those that focus on innovation impact; and finally the studies that reverse the dependent and independent variables to examine the influence of innovation on the perception of the importance of these obstacles. The next subsection addresses the four families of obstacles to innovation in turn, highlighting the results of each strand of the literature.

2.1 Four families of innovation barriers

Financial constraints

Contrarily to scholars who have studied the impact of cash flow on R&D investment (Bond, Harhoff, & Van Reenen, 2005; Bontempi, 2016; Cincera, Ravet, & Veugelers, 2016; Harhoff, 1998; Himmelberg & Petersen, 1994; Hottenrott, Hall, & Czarnitzki, 2016) and used balance sheet information for this purpose, another strand of the literature, on which this paper focuses, utilises the family of ‘innovation surveys’ that directly measure the perception of firms regarding whether, or to what degree, they are financially constrained. Amongst financial constraints, the lack of financing sources is the most commonly reported by firms (Savignac, 2008), other dimensions such as excessive perceived economic/financial risks, direct innovation costs being too high, cost of finance, lack of appropriate sources of finance (D'Este et al., 2012; Iammarino, Sanna-Randaccio, & Savona, 2009; Pellegrino & Savona, 2017), lack of internal funds, lack of external funds, high cost of innovation (Segarra-Blasco et al., 2008) are also considered.

According to D'Este et al. (2012), the impact of the number of innovation activities performed by firms on the perception of facing cost-related barriers to innovation (excessive perceived economic risks, direct innovation costs too high, cost of finance, availability of finance) follows a U-shaped curve. Firms that do not perform any innovative activities are more likely to perceive financial constraints (or cost-related barriers) as important than firms that perform a small number of innovation activities (1-2) – the ‘detering’ part of the curve. At the other end of the spectrum, it is the firms that perform the most innovative activities that also report financial constraints as important (3-4, and 5-7 activities, the latter exhibiting more than double the impact) – the ‘revealing’ part of the curve.

Tiwari et al. (2008) found that firms’ R&D activities (measured by R&D intensity) are hampered by financial constraints. Others showed that financial constraints contribute to prematurely stopping, seriously slowing down, substantially delay or postpone innovative activities (Canepa & Stoneman, 2003, 2008; Mohnen et al., 2008) and reduce the propensity to innovate (Pellegrino & Savona, 2017; Savignac, 2008). High innovation costs and financial constraints were the two most important hampering factors for

innovative firms in the UK (Stockdale, 2002). There is a notable exception in the literature, Galia and Legros (2004) did not corroborate the importance of the lack of appropriate source of finance for postponed innovation projects, nor for abandoned projects (it was the least frequent obstacle mentioned).

Tourigny and Le (2004) found the same proportion of firms (25-30%) in low-, medium- and high-technology sectors identified ‘lack of financing’ as an impediment to innovation, but it was not the main impediment (‘high cost’ of innovation, the ‘inability to devote staff on an on-going basis’ and the ‘lack of skilled personnel’ came first). Canepa and Stoneman (2008) however noticed that the perception that these financial constraints have hampered innovation to be much more severe for firms in the high-tech sectors.

Tiwari et al. (2008) noted that when firms face other barriers to innovation, such as market uncertainty, regulation inflexibilities and organisational rigidities, the impact of the financial constrained were lessened (but remain predominant), but as other scholars do, they treat these non-financial barriers as control variables (Blanchard et al., 2013; Mancusi & Vezzulli, 2010). In addition, the probability of being financially constrained while deciding to venture into innovation activities are also likely to be dependent on common elements. Mohnen et al. (2008) suggested that financial constraints have a moderating effect on the other types of impediments: when financial constraints are perceived as constraining, other types of obstacles have a lesser impact on the realisation of innovative projects. When faced with either internal or external financial constraints, firms will abandon projects during the conception phase, but not (or less) during the execution phase. This somewhat echoes D’Este’s ‘detering’ barriers mentioned above.

Knowledge obstacles

This group of innovation barriers generally refers to skills shortages, a limited access to information about markets and technologies, and the difficulty to finding collaborators. Facing strong knowledge-related barriers such as organisational rigidities, lack of qualified personnel, lack of information on technology or on markets, delay innovation projects, hamper a firm’s will to innovate (Amara et al., 2016; Canepa & Stoneman, 2003; Segarra-Blasco et al., 2008) in addition to increasing the probability of abandoning a project during the conception phase (García-Quevedo, Segarra-Blasco, & Teruel, 2018).

Turning the regression around, Iammarino et al. (2009) also showed that firms having introduced at least one product or process innovation perceive individual knowledge barriers related to the lack of skilled personnel, information on technology and on markets as important or very important. In the same vein, D'Este et al. (2012) showed that firms engage in more numerous innovation activities (3-4 and 5-7 such activities) are more likely to report knowledge barriers to innovation (a dummy for lack of qualified personnel, lack of information on technology, lack of information on markets), while lower level of innovators do not. Consequently, the authors would qualify knowledge barriers to innovation as weak 'detering' obstacles, but as strong 'revealing' or 'learning' obstacles.

Mohnen et al. (2008) however chose not to include barriers such as the costs being too high, shortage of personnel, shortage of knowledge and organisational rigidities in their analysis because they thought that these are somewhat related to financial constraints. Hottenrott and Peters (2011) considered the lack of qualified personnel as an "innovation capability" issue. They found that firms that are in the top 20% of the share of highly qualified personnel or of expenditures on training per employee were more likely to perceive strong financial constraints.

Market or demand obstacles

The lack of demand, uncertainty of demand, lack of customer responsiveness, intensity of competition or a market dominated by established enterprises were identified by various scholars as factors that hamper the will of firms to venture into investing in R&D (García-Quevedo et al., 2016; Tiwari et al., 2008), their propensity to innovate (Amara et al., 2016; Canepa & Stoneman, 2003; Segarra-Blasco et al., 2008). In a nutshell, firms that face uncertain demand for innovative goods or services are less likely to be innovative (Pellegrino & Savona, 2017). Mohnen et al. (2008) suggested that the hampering effect of these market constraints is reinforced by being financially constrained, i.e. these barriers have an exacerbating effect for firms also facing financial constraints on the propensity to abandon, prematurely stop, seriously slow down or delay, and not start innovative projects.

Estimating the factors associated with innovation barriers as the dependent variable, Iammarino et al. (2009) found that only the less innovative firms perceive the lack of

clients' responsiveness as an important impediment to innovative activities. The authors interpret this results as a " 'Schmooklerian' framework, according to which the decision to invest in innovation is somewhat 'demand-led' " (ibid: p. 94). Both D'Este et al. (2012), and García-Quevedo et al. (2018) found a strong deterring effect, and a weak 'revealing' or 'learning' effect of such market barriers on innovation associated with the perception that the market is dominated by established enterprises, or that there is uncertain demand for innovative goods/services.

Regulation obstacles

The fear of not fulfilling regulations or standards is associated with projects being delayed, being abolished or not even starting (Canepa & Stoneman, 2003). Moreover, firms that perceive important obstacles to innovation stemming from the need to meet EU/UK Government regulations are less likely to be innovators (Pellegrino & Savona, 2017).

Iammarino et al. (2009) noticed that innovative firms are more likely to perceive insufficient flexibility of regulation and normative standards as factor hampering innovation. Such regulatory barriers are only having a weak 'detering' effect on innovation, but a strong 'revealing' effect as only firms that perform a large number of innovation activities (5-7) perceive as important barriers to innovation the need to meet UK government or EU regulations (D'Este et al., 2012). Mohnen et al. (2008) and Coad, Pellegrino, and Savona (2016) incidentally found regulatory barriers to be minor compared to other obstacles to innovation.

2.2 Overcoming barriers to innovation

Instead of abandoning innovative activities or projects, and failing to innovate, a number of firms actually take measures to mitigate, or overcome, these barriers to innovation. Most articles surveyed in the sections above provide extensive practical and policy recommendations to help firms and government mitigate the perceived and actual innovation obstacles that firms encounter along the innovation path. Firms that have benefited from financial government support programs (R&D tax credits, R&D grants, government VC support) generally report facing obstacles to innovation in greater proportion than firms that have used non-financial government support; for instance

technology support and assistance programs, information and Internet series, training support (Tourigny and Le, 2004). The authors indeed showed that only firms that face innovation obstacles (with the exception of a lack of financing) will seek government support to alleviate these impediments. The vast number of government programs available in Canada covers a wide array of activities, ranging from loan for young entrepreneurs to expert business advice².

A number of literature reviews have been written on government innovation support programs, from Pavitt and Walker (1976), to Jaumotte and Pain (2005), (Becker, 2015), Petrin (2018), Bloom, Van Reenen, and Williams (2019), Jugend, Fiorini, Armellini, and Ferrari (2020), to mention a few. While a large number of studies measure the impact of public support on innovation, in general focusing on government tax credits and subsidies (Bérubé & Mohnen, 2009; Czarnitzki & Bento, 2012; Lokshin & Mohnen, 2012), very little evidence exists regarding whether government support actually helps alleviate innovation obstacles for firms to successfully innovate. For instance, Falk (2007), reported that cost-constrained firms that benefit from government support endeavour into larger innovation projects than they would if they did not benefit from such a scheme. Segarra-Blasco et al. (2008) examined whether various innovation programs are associated with families of innovation barriers. The authors examined: grants for R&D, credit support for R&D, grants for cooperative R&D projects, technological support centers, improved university–firm relations (grants to subcontract R&D to universities), seed fund and concept capital fund, grant for incorporating researchers and technical employees. All are related to cost-based obstacles to innovation. The authors did not however test whether benefitting from any of those support programs helped firms overcome innovation barriers and innovate.

To our knowledge, no study actually measures whether, how and for what purpose firms use such a wide range of support programs, whether they are perceived as successful or not, or their impact on innovation. As Hall, Moncada-Paternò-Castello, Montresor, and Vezzani (2016) highlighted, “there is relatively little knowledge about what makes an

² The website of Innovation, Science and Economic Development (ISED) Canada lists nearly a thousand programs available to businesses in Canada: https://innovation.ised-isde.canada.ca/s/list-liste?language=en_CA&token=a0B0b00000Oyq1FEAR

organisation innovate, which conditions favour the rise of such organisations and whether certain socio-economic environments and policies can support their development in both manufacturing and service industries” (ibid: p. 193). The authors further stress the usefulness of investigating “the costs and benefits for both firms and governments of putting in place different mechanisms for attenuating financing constraints in research and innovation activities” (ibid: p. 192). This paper answers this call for further research and there lies its originality.

3 Data and methodology

Data from three Statistics Canada databases were combined to achieve our objectives: The Surveys of Innovation and Business Strategy (SIBS 2009 and 2012), the General Index of Financial Information³ (GIFI 2009 and 2012) and the Research and Development in Canadian Industry database⁴ (RDCI 2009 and 2012). These surveys were chosen because they capture firms’ perceptions relatively closely after the last important financial crisis of 2008. The Surveys of Innovation and Business Strategy are based on a stratified random sample (size, region, and sector)⁵ drawn from the October 2009 and 2012

³ More information on GIFI can be found at: <https://www.canada.ca/en/revenue-agency/services/forms-publications/publications/rc4088/general-index-financial-information-gifi.html>

⁴ The database constitutes a census of the largest R&D performers (those that cover about two-thirds of the R&D expenditures) and a stratified random sample (within each industrial category) of the mid-size R&D performers. The smallest R&D performers are not sampled. More details on RDCI 2009 and 2012 data and methodology can be found at:

<https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=58560>
<https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=134818>.

⁵ The three strata are categorised as follow:

- Three size classes based on number of employees per enterprise: Small enterprises (20 to 99 employees); Medium-sized enterprises (100 to 249 employees); and Large enterprises (more than 249 employees). Note that the sample of Large enterprises to be surveyed was a census.
- Fourteen sectors based on the North American Industry Classification System (NAICS) Canada 2007: Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying, and Oil and Gas Extraction; Utilities; Construction; Manufacturing; Wholesale Trade; Retail Trade; Transportation and Warehousing; Information and Cultural Industries; Finance and Insurance; Real Estate and Rental and Leasing; Professional, Scientific and Technical Services; Management of Companies and Enterprises; Administrative and Support, Waste Management and Remediation Services.
- Thirteen provinces and territories.

versions of Statistics Canada’s Business Register. The resulting sample for both SIBS 2009 and 2012 is representative of the population of Canadian firms of more than 20 employees.

As in Blanchard et al. (2013), this research proposes to adopt Savignac’s (2008) beliefs on potential sources of bias and endorse the view that not all firms are necessarily willing to innovate. In some cases, innovating may not be necessary or even desirable for a firm to be successful. For example, some firms are aware that the public’s reaction to innovation (i.e. change) can be negative and are thus not willing to innovate. Including those non-innovative firms into the sample would certainly introduce a bias as they would never report coming across obstacles to innovation in any case and, as a result, firms facing obstacles would be more likely to innovate. As a consequence, the identification of firms potentially willing to innovate or conversely of firms that are not actively pursuing any innovation-related business strategy is critical.

In selecting our sample of innovative firms, we draw inspiration from Savignac (2008), and Pellegrino and Savona (2017), who built on D’Este et al. (2012) innovators and “wannabe” innovators, to select the “relevant sample of potential innovators” (ibid: p. 511). Their method is based on filtering out the firms that are not willing to engage in innovation activities, for reasons other than facing innovation obstacles. Doing so, reduces the sample size from 8,731 observations (7,445 groups or unique firms) to 6,784 observations (5,894 groups). This assumes that a firm is involved in innovation if it has innovated (introduced new or significantly improved products –goods and services– or processes) or if it has encountered obstacles to innovation. Adding to the sample the firms that have actually spent on R&D increases our final sample to 7,092 observations (6,085 groups). Table 1 summarises the selection process of the final sample.⁶

More details on SIBS 2009 and 2012 data and methodology can be found at:
<http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=60670>
<http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=137295>.

⁶ During the course of the research, we have also tested samples that include firms with a strategic focus on introducing new or significantly improved products (product innovation), processes (process innovation), marketing practices or methods (marketing innovations) and new and significantly improved management practices or change to their organizational structure (organizational innovation), with and without firms that have R&D expenditures (in the past and current years), even if they did not innovate or faced obstacles. While the strategic focus on innovation proved too vague a concept to select the sample, R&D spenders provided a better and more specific selection of firms. These results are available from the authors in an unpublished appendix.

Table 1 Sample selection

Samples	All	Final sample	
Who is included in the target population		+ Product & process innovators	+ Faced any obstacle to innovation
			+ Performed R&D
Nb observations	8,731	6,784	7,092
Nb of firms	7,445	5,894	6,085
Innovators ($Y_i=1$)			70.8%
Nb excluded	0	1,947	1,639

3.1 Analytical Framework

Because of the various types of obstacles encountered by firms, this study considers multiple empirical specifications. As in Savignac (2008), we followed Crépon et al. (1998) and define a univariate probit model. In this model, the decision to undertake innovative activities depends on ‘traditional’ determinants based on existing literature as firm size, market share, technology environment, and sectoral dummies controlling for the type of industry. We improved the measure of the technology environment in those ‘traditional’ determinants by using an advanced technology indicator instead of a Likert scale as in Savignac (2008). Likert scale often represents more the perception of the respondent than the actual technology market firms’ are evolving in. Firms using advanced technology are more likely to evolve in a strong innovative market.

We also included ‘breaking new ground’ determinants that could influence the decision to undertake innovative activities like firm’s strategic focus with respect to its goods and services. For example, it is possible that firms for which long-term strategy focuses on low-price would be less prone to undertake innovative activity than firms with a focus on good or service positioning. More details on these ‘ground breaking’ variables and controls can be found in section 3.3 (independent variables) and 3.4 (control variables).

As in Savignac (2008), we defined Y_{1i}^* the latent variable underlying this probit as:

Model 1

$$Y_{1i}^* = X_{1i}\beta_1 + Y_{2i}\gamma_1 + \varepsilon_i \quad (1)$$

Where the latent variable Y_{1i}^* represents the expected return of firm's innovative projects. Since we are interested in the decision to engage in innovative activities⁷, the first simple univariate probit model looks at the decision to perform innovative activities ($Y_{1i} = 1$ if the firm i has innovative activities and 0 if not) that depends on 'traditional' and new determinants of the decision to innovate (X_{1i}) which includes the existence of obstacles⁸ as well as an indicator of financial constraints (Y_{2i}) which is also an obstacle. We separate the financial constraint obstacle from the other obstacles for presentation simplicity and because this constraint will be considered as endogenous in a subsequent model while other obstacles will not. Clearly undertaking innovation activities might have a direct impact on a firm's finances but not necessarily on competition policies or market size for example.

Firm i has four state possibilities for each obstacle:

1. The firm faced obstacles to innovation but no measures were taken to overcome these specific obstacles;
2. The firm faced obstacles to innovation and the measures that it took to overcome these obstacles where measures unsuccessful;
3. The firm faced obstacles to innovation and the measures that it took to overcome these obstacles where measures successful;
4. The firm did not face this particular obstacle to innovation (reference category).

As stated in Savignac (2008), the probability to perform innovative activities when facing specific constraints, such as internal and external financing, are likely to both be affected by common elements of unobservable heterogeneity. In other words, the decision to engage in innovative activities and the way to finance this new investment are probably simultaneously determined. Consequently (and following Savignac 2008), the decision to

⁷ Innovative activities are characterized by firms that introduced new (or significantly) improved innovations, whether they are product, process, marketing or management practices innovations.

⁸ Market size, lack of skills, collaboration difficulties, uncertainty and risk, regulations, IP protection, competition policies.

innovate and the likelihood to face financial constraints is modeled as simultaneous equations. The latent variable model accounting for this relation is defined as follow:

Model 2

$$Y_{1i}^* = X_{1i}\beta_1 + Y_{2i}\gamma_1 + \varepsilon_{1i} \quad (2)$$

$$Y_{2i}^* = X_{2i}\beta_2 + Y_{1i}\gamma_2 + \varepsilon_{2i} \quad (3)$$

Where Y_{1i}^* and Y_{2i}^* represent, respectively, the (unobserved) expected return of the innovative projects and the severity of financial constraints⁹. As mentioned above, X_{1i} accounts for the traditional and new determinants of innovation while X_{2i} are explanatory factors of the financial risk associated with the investment (from balance sheets) such as the localisation of the head office, profits (or loss), debt to equity ratio. Even if we know the innovative and financial status of firms, as mentioned in Savignac (2008), “such a model is inconsistent and some restrictions are needed on the coefficients to be logically consistent”. However, a bivariate probit model can be estimated after identification by setting $\gamma_2=0$. Model 2 then becomes¹⁰:

Model 2 (with restrictions)

$$Y_{1i}^* = X_{1i}\beta_1 + Y_{2i}\gamma_1 + \varepsilon_{1i} \quad (2')$$

$$Y_{2i}^* = X_{2i}\beta_2 + \varepsilon_{2i} \quad (3')$$

We also postulate that the error terms are independently and identically distributed as bivariate normal and as in Savignac (2008), we need “no additional restrictions on the parameters to achieve identification of this bivariate probit model with endogenous dummy regressor”. The likelihood of the bivariate probit is not modified by the endogenous aspect of Y_2 in the first equation, so the probability of undertaking innovation activities or of facing financial constraints is given by the value of the normal cumulative distribution function, as in a standard bivariate probit model without endogeneity¹¹.

⁹ Internal and external financial constraint were both considered separately and combined.

¹⁰ For identification purposes, it is necessary to adopt the standard normalization of the variance of the errors (Savignac 2008).

¹¹ See Savignac (2008) to have more details on the econometric conditions of this model.

For both models¹², government support was tested to assess whether firms that faced obstacles to innovation and used specific government programs to try to alleviate these obstacles were more prone to innovate. Unfortunately, the survey does not match specifically the programs used by firms to overcome which obstacles. Finally, the use of specific government programs were investigated individually to assess their contribution to the propensity of firms to innovate¹³. We had initially planned to investigate each government program in relation with each type of obstacle, but that proved impossible as the sample size for most program-obstacle combinations was too small to be representative.

3.2 Dependent variables

The dependent variable (*dInnov*) will simply reflect the propensity of a firm to innovate¹⁴. It takes the value 1 if, during the past three years¹⁵, the firm has introduced new or significantly improved products (goods or services) or processes¹⁶.

3.3 Independent variables

Four groups of variables will be considered as independent variables in our regression analysis: obstacles to innovation, the success or not of the measures taken and whether government programs were used or not to overcome these obstacles, the specific government programs used to support innovation (that may also have contributed to alleviate innovation obstacles), and the financial constraints variables (in Model 1).

Nine different obstacles to innovation were identified by the surveyed firms, two of which are related to financing: *obsifin* captures the lack of funds within the firm and *obsefin* captures the lack of funds from outside firm sources. Similarly to García-Quevedo et al.

¹² Although the role of specific government programs were estimated using both the probit (Model 1) and biprobit (Model 2) specifications, for the sake of brevity, only the biprobit results are presented in the paper. The probit results are available from the authors upon request.

¹³ Again, both probit and biprobit models were estimated, and only the biprobit regression results will be presented in the paper.

¹⁴ The SIBS questionnaire does distinguish the degree of innovativeness (firm-, country- or world-first).

¹⁵ SIBS 2009 covers the years 2007 to 2009, and SIBS 2012 covers the years 2010 to 2012.

¹⁶ Processes range from methods of manufacturing or producing goods and services, logistics, delivery or distribution methods for their inputs, goods or services, to supporting activities for their processes, such as maintenance systems or operations for purchasing, accounting, or computing.

(2018), in addition to being tested as stand-alone variables, the latter obstacles (internal and external financing) were combined into a single financing obstacle, *obsfin*. Table 2 lists the dummy variables constructed for each of the obstacles to innovation encountered by firms. Each dummy variable takes the value 1 if the firm has encountered the specific obstacle, and 0 otherwise.¹⁷

Table 2 – List of dummy variables for the obstacles to innovation faced by firms

Variables	Obstacle to innovation related to...
Financial constraints	
<i>obsfin</i>	Internal financing
<i>obsefin</i>	External financing
<i>obsfin</i>	Internal or external financing
Knowledge-related obstacles	
<i>obskill</i>	Lack of skills within their firm
<i>obscolab</i>	Finding and reaching agreements with external collaborators
Demand- or market-related obstacles	
<i>obsmksize</i>	Market size
<i>obsrisk</i>	Uncertainty and risk
<i>obscompol</i>	Government competition policy
Regulation- and IP-related obstacles	
<i>obsregu</i>	Regulatory issues
<i>obsip</i>	Intellectual property protection

To test whether facing more obstacles have an impact on the propensity to innovate, we built an index of the obstacles faced by firms, *obsindex*, that corresponds to the sum of all nine obstacles (excluding *obsfin* which combines internal and external financing). For the simultaneously determined model (Model 2 using biprobit), indices of all obstacles other than financial were constructed: *obsothfin*, excluding both internal and external financing¹⁸.

¹⁷ During the course of the research, *obsothifin*, excluding internal financing, *obsothefin*, excluding external financing, were also tested but yield similar results to what is presented in the paper. In addition, we also constructed ordinal variables using the information provided about the measures taken to alleviate these obstacles and whether the measures were successful or not. Each ordinal variable takes the value 1 if no measures were taken by the firm, the value 2 if the firm took some measures to overcome these obstacles that unfortunately were not successful, the value 3 if the firm took some measures to overcome these obstacles and these were successful, and finally, the value 4 if the firm did not face obstacles to innovation. We will refer to these in a footnote in the results section.

¹⁸ The results were rather similar for all three groups of variables. As a consequence, only those using the combined internal and external financial constraints are presented in the paper.

The innovation barriers mentioned in the SIBS do not exactly match the categorisation generally used in the literature and replicated in the theoretical framework of the paper. For instance, there is no mention about the type of uncertainty or risk covered, whether it is related to succeeding in developing an innovation or whether it is the market uncertainties linked to its introduction on the market that are the focus, or both. Furthermore, the market size obstacle may refer to the fact that the market in which the firm is trying to introduce its innovation is dominated by incumbent firms, but it is not explicitly mentioned. An additional obstacle concerning government competition policy is also considered but not reported in other studies. Finally, obstacles related to intellectual property (IP) protection are also part of the suite of innovation barriers covered by the survey.

The main contribution of the paper stems from the next set of variables created to account for the measures taken by firms to mitigate innovation barriers, amongst which are non-descript government programs. To investigate whether they played a significant role in helping mitigating obstacles to innovation, we created 5 dummy variables using a bi-dimensional matrix addressing the measures taken and their success on one axis, and whether government programs were used on the other (see Table 3).

Table 3 – Creation of the dummy variables interacting facing obstacles, taking measures and the success of these measures with the use of government programs

		Used any government support program to overcome obstacle to innovation X	
		No	Yes
No measures taken		nmtX	N/A
The measures were taken by the firm to overcome these obstacles to innovation were...	...unsuccessful	nogovmtuX	govmtuX
	...successful	nogovmtsX	govmtsX

Note: X refers to the list of obstacles mentioned in the first column of Table 2.

To give an example of the five dummy variables described in Table 3 for internal financing: *nmtifin* takes the value 1 for firms that have faced internal financing obstacles to innovation, but did not take any measures to overcome them, and 0 otherwise; *nogovmtuifin* takes the value 1 if firms have faced internal financing obstacles to innovation, did take measures to overcome this financial obstacle, but to no avail, but did not use any government support program to overcome this financial obstacle, and 0

otherwise; *govmtuifin* takes the value 1 if firms have faced internal financing obstacles to innovation, did take measures to overcome this financial obstacle that were not successful, and used government support program(s) to overcome this financial obstacle, and 0 otherwise; *nogovmtsifin* takes the value 1 if firms have faced internal financing obstacles to innovation, did take measures to overcome this financial obstacle that were successful but did not use any government program to overcome this financial obstacle, and 0 otherwise; and finally, *govmtsifin* takes the value 1 if firms have faced internal financing obstacles to innovation, did take successful measures to overcome this financial obstacle, and used government support program(s) to overcome this financial obstacle, and 0 otherwise. The same set of obstacle-measures-government program dummy variables are built for each of the obstacles listed in Table 2.

The next group of independent variables explores specific government support programs (see Table 4). For each given government program, the firms had to indicate whether they have used the federal, provincial/territorial, and/or municipal government programs. If the firm ticked any of the three boxes, the dummy variable *govX*¹⁹ takes the value 1 and 0 otherwise²⁰. Two more indices were built to account for the number of government support programs used by the firm. The variable *govsupindex* simply counts the number of different programs used by the firm regardless of the level of government that provides the service.

¹⁹ X represents the name of the nine specific government programs listed in Table 4, as well as the other programs used, but not already specified in the questionnaire.

²⁰ We also built indices for each of the government programs. The index takes the value 1 if the firm only used a specific program, from one level of government, the value 2 if the firm used a specific program from any two levels of government, the value 3 if the firm used a specific program from all three levels of government, and 0 otherwise. The results however are not significantly different from those presented in the paper.

Table 4 – List of dummy for the nine government programs used by firms

Variables	Government support program used:
govtrain	Government training programs
govgrant	Government grants
govtxcr	Government tax credits
govproc	Government procurements
govhire	Government hiring program for recent graduates
govres	Access to government research facilities
govexp	Government export incentives and services
govinfo	Government information and technical assistance programs
govmktinfo	Government market information services
govoth	Other government program

The final group of independent variables (i.e., the X_{2i} in model 2) explores variables that may affect the firm in its ability to use internal funds or raise external funds for innovation purposes. The first variable selected is the natural logarithm of profit or loss [*profit*]. The more profits a firm generates, the more (internal) funds it can devote to further innovation activities, and the easier it may be to raise external financing for this purpose. The relationship with the financial obstacles should therefore be negative. The second variable relates mainly to the capacity of the firm to raise external funds: *debratio* measures the (natural logarithm of) debt to equity ratio. An excessive amount of debt compared to firm equity may seriously jeopardise a firm's capacity to borrow or raise external financing. We therefore expect a positive relationship with the financing obstacles²¹. The two remaining dummy variables correspond to whether a firm is a subsidiary of another Canadian company [*subs_headcan*], or a subsidiary of a foreign company [*subs_headforeign*]. We expect that subsidiaries face fewer financial constraints and thus that the relationship should be negative.

3.4 Control variables

In addition to the independent variables described above, a number of control variables were used in the regression model to account for other traditional factors that affect the propensity to innovate. Similarly to a number of studies that have found an effect of firm size on innovation (propensity, type, patterns, etc.), we include the natural

²¹ Both variables stem from the General Index of Financial Information (GIFI).

logarithm of the number of employees, *emp*, as a control variable (Acs & Audretsch, 1990; Cohen, 1995; Frenz & Ietto-Gillies, 2007; Tether, 2002). For instance, Roper, Du, and Love (2008) found that establishment size has an impact on process innovation, but not on product innovation. McGuirk, Lenihan, and Hart (2015) showed that the impact of firm size on the propensity to innovate is moderated by innovative human capital (training, willingness to change). Following Blundell, Griffith, and Van Reenen (1993, 1995) who showed that firms with a high market share are more innovative, we include the natural logarithm of the firm's market share, *marketsh*, and a dummy variable, *gainmark*, that takes the value 1 if the firm's gained market share for its highest selling good or service in its main market, and 0 otherwise.

Four variables related to firm strategy are added to the list of controls. First, we introduce a dummy variable, *flowprice*, that takes the value 1 if the firm's long-term strategy focuses on low-price and cost leadership (i.e. the mass market), and 0 otherwise. We anticipate this variable to be negatively associated with the propensity to innovate. A second control variable relates to the age of this long-term strategy, *agestrat*. Two more control variables account for the firm's strategic focus with respect to its goods and services, and to its operations and business activities. If the firm has a focus on introducing new or significantly improved goods and services regularly, *stratnewprod* takes the value 1, and 0 otherwise. Similarly, if the firm seeks mainly to introduce new or significantly improved business activities or processes to its operations, then, *stratnewproc* takes the value 1, and 0 otherwise. Rather than use a similarly constructed variable for the strategic focus toward organisational innovation²², we include a dummy variable, *neworgopen*, that takes the value 1 if the firm has introduced new methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or subcontracting, etc.), and 0 otherwise. This last variable addresses the extent to which a firm puts in place the organisational structure that allows collaboration, which is generally associated with innovative performance (Belderbos, Carree, Diederer, Lokshin, &

²² In other words, a dummy variable that takes the value 1 if the firm has a long-term focus that mainly seeks to introduce new or significantly improved management practices or changes to its organisational structure, and 0 otherwise.

Veugelers, 2004; Belderbos, Carree, & Lokshin, 2004; Belderbos, Carree, Lokshin, & Fernández Sastre, 2015; Duysters & Lokshin, 2011).

The international dimension of R&D performance may also play a role in the propensity to innovate. Rodríguez and Nieto (2016) suggested that both offshore R&D insourcing (overseas activities via foreign affiliates) and outsourcing (overseas activities performed by independent organisations) have a positive impact on innovation performance. To account for the importance of foreign partners and affiliates, we therefore introduce two more control variables: *outsourd* takes the value 1 if the firm has outsourced (contracted out) R&D to foreign independent organisations, and 0 otherwise; and *relocrd* takes the value 1 if the firm has performed or relocated R&D activities abroad, and 0 otherwise. R&D activities often result in the protection of the ensuing intellectual property –IP– (patents, copyrights, trademarks, etc.) prior to an innovation being implemented. Whilst patents are often used as a proxy for innovative performance, the SIBS do not record the number of patents or any other IP protection mechanisms used by the firm. To account for the presence of IP protection by the firm, we therefore add a dummy variable that takes the value 1 if the firm has intangible capital assets, *intcapital*, and 0 otherwise²³.

The adoption of new technologies²⁴, in particular advanced technologies, is likely to contribute to innovation: *techuse* is a dummy variable that takes the value 1 if the firm used

²³ The General Index of Financial Information (GIFI) of Statistics Canada reports the sum of all intangible capital assets for the enterprise or business entity. These assets include: Intangible assets (concessions, formulas, franchises, and organization costs); Goodwill; Quota; Licences; Incorporation costs (corporations only); Trademarks/patents; Customer lists; Rights; Research and development; Resource rights; Timber rights; Mining rights; Oil and gas rights. Although we estimated our regression models with the natural logarithm of the sum of all intangible capital assets, the results suffered from too strong a correlation between enterprise size and intangible capital assets. The equivalent dummy variable accounting for the presence or absence of these assets proved a suitable compromise.

²⁴ In the SIBS questionnaire, technology “is broadly defined to include the technical means and know-how required for the production of goods or services. It takes the form of equipment, materials, processes, blue prints and knowledge.” The types of advanced technologies related to process innovation comprise: advanced computerised design and engineering; advanced computerised processing, fabrication, and assembly technologies; advanced computerised inspection technologies; advanced communication technologies; advanced automated material handling technologies; and advanced information integration and control technologies. The types of advanced technologies that we would more closely associate with product innovation are: advanced biotechnologies/bioproductions; advanced nanotechnologies; and advanced green technologies. During the course of our research, we examined both sets of advanced technologies, i.e. either related to product or process innovation. Because of high correlation, both variables could not be used in the same regression and yielded similar results. In the end, we chose the more encompassing

any advanced technology (equipment or software) in 2009 or 2012 for each of the two surveys, and 0 otherwise.

Finally, we include a year dummy variable, *d2012*, to control for differences in the sample selection or in the economic conditions that firm faced in 2010-2012 compared to 2007-2009 (years covering the 2008 economic downturn). We also classify firms according to the well-known taxonomy of Pavitt (1984) that was adapted by Baldwin and Rafiquzzaman (1995) to which we have added a category to distinguish the knowledge-intensive business services (KIBS) firms from other service firms. Five sectoral dummy variables are thus created (see appendix A for a detailed list of the NAICS codes attributed to each variable): *inress* for resource-based industries; *inlab* for labour-intensive industries; *inscal* for scale-based industries; *inspec* for specification-based industries; *insci* for science-based industries; and *inserv_KIBS* for knowledge-intensive business services (the omitted dummy corresponds to the rest of the service industry). We divide the country into two regions and two provinces: *regon* represents firms in the province of Ontario (the omitted dummy variable); *regque* represents firms in the province of Québec; *regatl* is associated with the four Atlantic provinces (New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador); and *regwes* comprises of the western provinces (British Columbia, Alberta, Saskatchewan, and Manitoba) as well as the three Territories (Northwest Territories, Yukon, and Nunavut).

4 Descriptive statistics

Table 11 and Table 12 in Appendix B present the descriptive statistics and correlations between the main variables used in the paper. The obstacles to innovation most often encountered by firms are related to the risks and uncertainties of the innovation process (42.8%), the lack of skills (31.8%), and financial constraints (30.2%). At the other end of the spectrum, the low proportion of firms that did face IP related obstacles to innovation (only 5% of firms), and thus the high proportion of firms that did not. The same is true for obstacles to innovation related to finding and reaching agreements with external

variable. We also tested an index summing all the types of technologies used, but that index variables was too strongly correlated with firm size to remain in the regressions analysis.

collaborators (12.06% of firms) and to government competition policy (only 5.82% of firms faced such obstacles).

In general, less than 30% of firms did nothing when confronted with a given obstacle to innovation (see Table 5 – the exception is government competition policy). When firms did take action to alleviate these obstacles, they were unsuccessful part of the time. Unsuccessful outcomes were more often the case when firms faced obstacles related market size, finding and reaching agreements with external collaborators, uncertainty and risks, government competition policy, and internal financing. When faced with skills shortages, IP protection issues and external financing constraints, the actions firms took were more often unsuccessful. In proportion, far fewer firms use government programs to overcome innovation barriers than we first anticipated.

Table 5 – Proportion of firms that did nothing or took measures (successful or not, governmental or not) to overcome specific innovation obstacles

Obstacle	did nothing	Among the firms that faced obstacles – those that...			
		took unsuccessful measures	took successful measures		
obsifin	15.56%	44.05%	40.39%		
obsefin	9.55%	38.03%	52.42%		
obsfin	3.28%	47.17%	49.55%		
obsmktsize	28.09%	46.85%	25.06%		
obsskill	18.03%	35.99%	45.98%		
obscollab	9.47%	49.35%	41.18%		
obsrisk	29.35%	37.76%	32.88%		
obsregu	29.04%	43.76%	27.19%		
obsip	16.45%	27.64%	55.92%		
obscompol	43.62%	36.84%	19.54%		
		No government programs used	Government measures used	No government programs used	Government measures used
obsifin		38.53%	5.52%	33.26%	7.13%
obsefin		32.64%	5.39%	41.28%	11.15%
obsfin		40.54%	6.63%	38.12%	11.44%
obsmktsize		39.35%	7.50%	20.78%	4.28%
obsskill		33.40%	2.59%	40.36%	5.62%
obscollab		43.21%	6.14%	38.63%	2.55%
obsrisk		33.83%	3.93%	28.98%	3.90%
obsregu		38.78%	4.98%	25.22%	1.98%
obsip		C	C	51.87%	4.04%
obscompol		C	C	C	C

Note: The proportion of firms (mean of the dummy variable) that faced obstacles to innovation is provided in Table 11;

All proportions are calculated using the sampling weights.

C Represent results that cannot be divulged because of confidentiality reasons, i.e. there are less than 10 observations in either one of the categories. In general, these correspond to proportions of less than 20% over all.

Unsurprisingly, the government programs that are most used by firms (see Table 11 in Appendix B) are the government tax credits (34.4% of firms – represented mostly by the scientific research and experimental development – SR&ED – *govtxcr*) and government

grants (22.9% of firms – *govgrant*). The latter are closely followed by training programs (19.7% of firms – *govtrain*), which are somewhat complementary to the programs targeted at the hiring of recent graduates (10.2% – *govhire*) in terms of improving human capital within the organisation. In contrast, very few firms use government support programs for procurement, access to government research facilities, export incentives, and market information services.

Remarkably, the types of government programs used by the firms when faced with different obstacles to innovation, is extremely stable across all types of obstacles (see Table 6). Furthermore, the firms that encounter any innovation challenges are more likely to make use of different government programs, as highlighted by the fact that all the proportions listed in Table 6 are greater than the general means (converted into proportions) of the same government programs listed in Appendix B (in Table 11). For instance, while 34.4% of firms have used tax credits, 58.5% of firms that have faced internal finance obstacles to innovation have used such government programs. Similar results are observed for all categories of government support.

The column on the right of each obstacle (Δ) shows the difference between the proportion of firms that faced a specific obstacle to innovation and the proportion of firms that did not, for each category of government program. As an example, 7.12% more firms used government grants when faced with internal finance obstacles than when not challenged by such obstacles. In comparison, the difference between firms that have used government tax credits is much lower in general (and much more widespread either way). The reader will also notice the high number of confidential values reported in the table (replaced by the letter C). These correspond to the categories of obstacles with a low proportion of firms facing such innovation obstacles: IP-related, finding and reaching agreements with external collaborators and government competition policy. We anticipate that the lack of a critical mass for these innovation obstacles will impact some of the regression results.

Table 6 – Proportion of firms that faced specific obstacles to innovation (compared to those that did not) and used particular government programs

	obsifin	Δ	obsefin	Δ	obsfin	Δ	obsmktsize	Δ	obsskill	Δ
govtrain	25.59%	4.28%	26.28%	4.52%	25.41%	4.22%	27.35%	5.92%	26.60%	5.54%
govgrant	34.35%	7.12%	35.34%	7.31%	34.27%	7.34%	33.06%	4.41%	32.93%	4.76%
govtxcr	58.47%	1.93%	58.71%	1.94%	58.41%	1.93%	58.63%	1.85%	59.57%	3.43%
govproc	7.76%	0.94%	8.09%	1.22%	7.70%	0.90%	7.23%	0.13%	8.60%	2.11%
govhire	14.60%	3.93%	15.21%	4.12%	14.64%	4.20%	14.59%	3.35%	14.85%	4.12%
govres	9.77%	4.14%	10.29%	4.18%	9.51%	3.93%	10.66%	4.68%	8.23%	1.74%
govexp	11.79%	3.89%	13.59%	5.61%	11.61%	3.81%	11.29%	2.68%	11.47%	3.26%
govinfo	10.44%	3.75%	10.94%	3.82%	10.20%	3.55%	10.79%	3.64%	10.41%	3.53%
govmktinfo	10.61%	3.14%	11.00%	3.16%	10.69%	3.42%	10.28%	2.25%	9.85%	1.90%
govoth	5.08%	1.15%	4.79%	0.61%	4.87%	0.87%	4.82%	0.65%	4.07%	-0.35%
	obscollab	Δ	obsrisk	Δ	obsregu	Δ	obsip	Δ	obscompol	Δ
govtrain	27.93%	5.72%	24.92%	3.96%	24.81%	2.66%	24.47%	1.89%	23.45%	0.75%
govgrant	34.98%	5.92%	31.72%	3.82%	32.55%	3.76%	35.89%	6.86%	31.72%	2.24%
govtxcr	57.66%	0.51%	59.18%	3.62%	54.82%	-3.05%	69.82%	13.82%	52.87%	-4.60%
govproc	C	C	7.90%	1.39%	9.07%	2.49%	C	C	13.56%	6.85%
govhire	16.82%	5.33%	13.26%	2.32%	13.58%	2.05%	15.17%	3.49%	C	C
govres	C	C	8.59%	2.85%	10.28%	4.19%	C	C	C	C
govexp	C	C	10.44%	2.24%	10.34%	1.46%	C	C	C	C
govinfo	C	C	9.69%	3.15%	11.61%	4.70%	C	C	C	C
govmktinfo	C	C	10.09%	2.84%	11.55%	3.88%	C	C	13.10%	4.87%
govoth	C	C	4.95%	1.16%	C	C	C	C	C	C

Notes: All proportions are calculated using the sampling weights.

The proportion of firms (mean of the dummy variable) that faced obstacles to innovation or used giver government program is provided in Table 11;

Δ Represents the difference between the proportion of firms that faced a specific obstacle to innovation and the proportion of firms that did not, for each category of government program;

C Represent results that cannot be divulged because of confidentiality reasons, i.e. there are less than 10 observations in either one of the categories. In general, these correspond to proportions of less than 20% over all.

The average firm employs 115 employees and has generated profits of about 8.7 million\$. More than 16% are subsidiaries of other firms with a head office either in Canada (10.2%) or in a foreign country (6.0%). Overall, 26.7% of firms hold intangible capital, and 45.3% use advanced technologies (from computerized design and engineering to information and control technologies). Only 11.3% have a focus on low price and cost leadership. In other words, the main focus of most firms (88.7%) is on good or service positioning rather than on low price. That does not necessarily imply that all firms have a long-term strategic focus on new products (24.1% of firms only) or on new processes (41.4% of firms). In fact, among the firms of our final sample, 70.8% have innovated (introduced a new or significantly improved product or process) during the three years covered by each survey (2007 to 2009 for SIBS 2009, and from 2010 to 2012 for SIBS 2012).

5 Regressions results

Table 7 present the regression results model 2 which accounts for the fact that facing financial obstacles to innovation and the propensity to innovate are simultaneously determined²⁵. Firms that face financial obstacles to innovation are less likely to be innovative, hence supporting cost-based obstacles as having a deterring effect on innovation (D’Este, Iammarino, Savona, & von Tunzelmann, 2012). Adding an index of all other obstacles to innovation (see columns O_i and O_im in Table 7) does not change the relationship between financial obstacles and innovation propensity.

[Place Table 7 about here]

Furthermore, firms that have taken measures to surmount these financial obstacles, whether successful or not (*mtufin* and *mtsfin* respectively), are more likely to innovate than if they had done nothing, but these are not enough to overcome the hampering effect of these barriers (see columns O_m to O_10 in Table 7). Not surprisingly, the successful measures [*mtsfin*] have about double the impact of unsuccessful measures [*mtufin*] taken by the firm to partially mitigate financial obstacles to innovation. These firms chose to be somewhat undeterred by financial constraints and tried to maintain a path towards innovation, not all succeeding though as the cumulative effect of the obstacles remain negative. Before exploring in greater details the interaction between the success of the measures taken and the government programs used or not, let us briefly examine the other non-financial constraints.

With the exception of innovation obstacles related to finding and reaching agreements with external collaborators (O_6), and competition policy (O_10), both non-significant, in general, the impact of innovation obstacles on the propensity to innovate is negative (similar results are obtained from Model 1 presented in Appendix C – Regression analysis – Model 1

Table 13 in Appendix C). The coefficients of obstacles related to lack of skills (O_5), risks and uncertainties (O_7) are negative and significant but a weaker level of significance

²⁵ We investigated using internal, external and both financial constraints as the financial variable. All the results are similar, i.e. the same signs and level of significance are obtained for the different models. The results reported in the paper therefor include both internal and external financial constraints combined.

is measured for market size (O_4), and regulation (O_8). For these demand or market- and regulation-related obstacles, the deterring effect appears to dominate. Obstacles to innovation related to IP protection-related obstacles (O_9) are positive and significant^{26,27}.

The latter therefore appears as a ‘revealing’ effect. In addition to the lower proportion of firms that have faced IP-related innovation obstacles, we suspect that the choice of our sample maybe at play here; i.e. firms that do not patent are not likely to face IP-related innovation obstacles. As a consequence, we may be measuring the fact that firms that patent and are innovative are also more likely to face IP-related issues than firms that do not patent. We believe that if we had been able to select firms that have patents within the sample, we would have been able to obtain the expected negative coefficient here.

Finally, all financial variables are significant and give the anticipated signs (equation 3’): Being a subsidiary of a Canadian [*subs_headcan*] or a foreign company [*subs_headforeign*] have a negative impact on facing financial obstacles; Generating larger profits [*profit*] implies less financial constraint; and having a larger debt to equity ratio [*debratio*], because it is more likely to hinder the capacity of the firm to further borrow, has a positive relationship with financial obstacles.

5.1 Firm taking matters in their own hands

Let us now turn to the core of the paper which specifically explores the fact that firms do not stay idle when faced with innovation obstacles by using a cross between the success of the measures taken and the fact that firm used government programs or not (as in Table

²⁶ During the course of the analysis, we also used ordinal variables to measure how successful firms were in overcoming innovation barriers. For all types of obstacles, with the exception of IP protection related obstacles, firms that take successful measures to overcome these obstacles are more prone to innovate. Firms that have not faced obstacles to innovation (4), or that have successfully overcome market size, skills, risks, or regulation obstacles (3) were more innovative (if they not also faced financial constraints). These results point towards most of the categories of obstacles falling into the ‘detering’ category with the exception of collaboration-, and competition policy-related obstacles for which we cannot conclude, and IP protection that seem to once again fall into the ‘revealing’ group. This way of constructing the variables does not however allow to separate both types of barriers according to D’Este et al. (2012) or to replicate their U-shaped results. Their categorisation is more an inspiration or an additional lens through which to see our results. These results are therefore not included in the paper, but are available from the authors in an unpublished appendix.

²⁷ The lack of a critical mass for IP-, collaboration-, and competition policy-related innovation obstacles influences the level of significance of our results.

3). In each of the regressions presented in Table 8, five mutually exclusive dummy variables are added to the regression and compared to not facing a particular obstacle to innovation (the omitted dummy variable)²⁸. Whilst taking successful measures to overcome financial obstacles is better than not having faced these obstacles, using government programs, regardless of whether the measures taken were successful or not, only partially alleviates the financial constraints (see column SG_3). Most firms (nearly 97%) do not wait to be overburdened by financial obstacles to innovation to use government programs; they are part of their routine and of the bundle of programs they use, but they are not yet enough to be a complete game changer. Before addressing to the specific government programs used, let us first examine each obstacle and the measures taken in turn.

[Place Table 8 about here]

In general, not taking any measure to overcome these non-financial obstacles to innovation is the worst strategy (almost all *nmt...* variables yield negative and significant coefficients). Not using government programs and taking unsuccessful measures is almost as bad (almost all *nogovmtu...* variables have negative and significant coefficients). In contrast, when either the measures are successful or government programs are used, the impact differs according to the type of obstacle faced. In other words, if the firm does nothing or is unsuccessful at what it tries to mitigate innovation obstacles, then it is hampered by these barriers. Cost/financial constraints nevertheless remain a deterring factor.

For both financial and market size obstacles (see columns SG_3 and SG_4), we observe a clear improvement between not using government programs but taking successful measures to overcome innovation barriers and using government programs (with an additional improvement compared to not facing market size obstacles when the measures taken are successful). Government grants and tax credits are intuitively the most obvious innovation support programs that should help firms mitigate their financial

²⁸ The same regressions were performed for Model 1 and by and large yield similar results for each of the obstacles. These results are available upon request from the authors.

constraints. These however are not enough to bring the firm on par with their counterparts that do not face such financial constraints.

Table 5 indeed showed that a rather small proportion of firms that took measures to overcome barriers to innovation actually reported to have used government programs for that purpose: 6.63% and 11.44% of firms that faced financial constraints for which the measures taken were unsuccessful and successful, respectively. Although Table 6 showed that it is relatively difficult to disentangle which government program is used for what reason, the fact that among the firms that obtained government grants, there is more than a 7% gap between the firms that faced financial constraints (internal or external) and those that did not is an indication that firms do not perceive this to be the primary goal of the program. Comparing Table 5 and Table 6 suggests that firms do not associate the use of government programs to being specifically targeted at helping them mitigate obstacles to innovation, but to serve a much broader innovation-related role. Our regression results however show that in this particular case, their perception may underrate the positive impact of such programs in regard to their mitigation effect.

For the market size obstacles to innovation, the third most important program used relates to training. As Iammarino et al. (2009) argued, better learning leads to higher competences and increased market shares. These skills may well be acquired via government training programs. More than 27% of firms that faced such barriers used innovation support government programs (see Table 6), yet only 4.28% of firms that took measures to overcome innovation barriers reported to have successfully benefited from such government programs (and 7.5% of firms report the measures to be unsuccessful). Again, the perception among firms is that the programs are not necessarily used for the sole purpose of alleviating innovation obstacles.

For lack of skills- and regulatory issues-related obstacles, taking successful measures or using government programs effectively helps the firms that faced these obstacles bring their performance to the same level as those that do not encounter such skills shortages (*nogovmtskill*, *govmtuskill* and *govmtskill*, are all non-significant in column SG_5) or face regulatory issues (*nogovmtsregu*, *govmturegu* and *govmtsregu*, are all non-significant in column SG_8), providing they do not also face financial constraints. In other words, no

significant advantage accrues from taking measures to overcome innovation obstacles, or using government support programs for innovation-related activities. These actions taken do not contribute to increasing their propensity to innovate above and beyond that of firms that do not face such obstacles and are not also financially constrained. Understandably, regulation is very sector specific, and not all firms would likely encounter such challenges. We unfortunately lack the sample size for testing the different regulated sectors (or even as a group) to be able to adequately investigate this particular effect.

Regarding the obstacles related to the difficulty to find and reach collaboration agreements, it appears that the successful measures taken that are non-governmental in nature allow the firm to stand out (only *nogovmtscollab* is significant in SG_6). In other words, government programs do not appear to contribute to helping firms find and reach agreements with external collaborators for the purpose of innovating, i.e. they do not improve the likelihood of innovating above that of not facing these obstacles. It is however important to highlight the small proportion of firms that have reported this type of obstacle (12.1%), and the fact that matchmaking is often a task devolved to innovation intermediaries, i.e. not an activity that firms would normally identify as government-led.

Compared to firms that do not face innovation obstacles related to risks and uncertainty (column SG_7), enterprises that took successful measures other than using government programs have a greater likelihood of innovating. Moreover, those that employed unsuccessful measures but were somewhat 'saved' by government programs were more prone to innovate. The lack of significance of *govmtscollab* is most probably due to the fact that very few firms used government programs and took successful measures to overcome risks-related obstacles to innovation (about 2.55% of our sample of firms – see Table 5 above). Similar results are obtained for firms that faced IP protection-related (column SG_9) and government competition policy obstacles to innovation (column SG_10), for the same reasons (lack of a critical mass of firms that used government programs and took successful measures to mitigate these types of innovation obstacles).

Let us finally address the IP protection obstacles to innovation. As before, the results remain counterintuitive: Firms that have faced such obstacles and have not used government programs, or when they have and the measures taken to alleviate these

obstacles were unsuccessful (whether or not they are related to these particular government programs) are significantly more likely to innovate than firms that do not face such IP protection challenges. Once again, the sample of firms that have faced such innovation obstacles is small (5%), our results are therefore tainted by the lack of a critical mass. As mentioned above, the data at our disposal does not include information about firms that either protect their IP, have specific strategies in this regard or are even considering it. Without this information in our sample, we therefore cannot assess the influence of measures, governmental or else, taken to mitigate IP protection-related innovation obstacles.

5.2 Government programs

The reader will recall that specific government programs cannot be matched with using such programs to overcome particular innovation obstacles. These were two separate questions in the SIBS. In addition, estimating separate regressions for each subsample of firms that have encountered a particular obstacle do not provide robust results that we can trust, i.e. the critical mass is too small and likely provide anecdotal evidence. We can nevertheless propose avenues for further investigation by comparing the content of the matrix of obstacles and government programs used (see Table 6 above) with the results of another set of regressions focused on specific types of government support programs to innovation-related activities.

For instance, we expect that government programs related to training [*govtrain*] and to hiring recent graduates [*govhire*] may contribute to solving some of the issues related to skills mentioned by the firms surveyed. We hinted to that in the previous section as well. Both dummy variables are indeed positively associated with a higher propensity to innovate (see columns Gov_A and Gov_E in Table 9). Yet, the results presented above did not show that firms that use government programs innovate more than firms that do not face skills-related obstacles to innovation.

[Place Table 9 about here]

Both government grants [*govgrant*] and tax credits [*govtxcr*] (in columns Gov_B and Gov_C of Table 9) have been extensively studied in the literature and have demonstrated

a clear impact on the propensity to innovate, while only partially mitigating financial constraints. These programs are used across the entire spectrum of the economy and are difficult to disentangle from other more specific programs used. We would therefore expect a wide impact from these programs. In addition, firms do not wait to encounter obstacles to innovation to make use of these programs, they are very much part, and sometimes the foundation, of the innovation landscape. Research suggests that the Canadian firms that have shown the best performance over time have often benefitted from SR&ED tax credits as well as other forms of direct support (Bérubé & Mohnen, 2009; Bérubé & Therrien, 2016).

A type of government program that has relatively recently been suggested as a way to accelerate the adoption and diffusion of innovation (Appelt & Galindo-Rueda, 2016; Edler & Yeow, 2016) is public procurement [*govproc*]. It was rarely used by firms in 2009 and 2012, and its influence on the propensity to innovate is not significant (see column Gov_D). It is possible that in responding to the survey, firms do not distinguish traditional public procurement from that destined to ‘beta test’ new technologies with the government as a prime user of such innovation. With better information about the latter, we suspect that the future SIBS surveys will most probably pick the anticipated positive effect of public procurement on the propensity to innovate. Stojčić, Srhoj, and Coad (2020) found that public procurement and funding to support innovation actually fulfill their goals and contribute to greater innovation and output.

Access to government research facilities [*govres*] has a strong positive impact on the propensity to innovate (column Gov_F). The majority of these research facilities fall under the umbrella of the National Research Council of Canada (NRC), whose mandate is to “undertake, assist or promote scientific and industrial research”²⁹. Although the data used for this study by and large predates the National Research Council (NRC) “business approach” that transformed the organisation into a Research and Technology Organisation (RTO)³⁰, the move towards an organisation that provides “technology and industry support

²⁹ National Research Council Act (R.S.C., 1985, c. N-15) - Act current to 2019-01-30 and last amended on 2018-12-13.

³⁰ National Research Council Strategy 2013-2018 - https://www.nrc-cnrc.gc.ca/obj/doc/reports.../NRC_Strategy_2013_2018_e.pdf

for industrial innovation and growth” was already part of the organisation’s DNA in the mid-2000. This category also includes governmental and paragonmental facilities such as the *Institut de recherche d’Hydro-Québec* (IREQ) that specialises high voltage research, mechanics and thermomechanics, network simulations, and works on developing new materials for electric vehicle batteries³¹, the *Centre de recherche industrielle du Québec* (CRIQ) that covers a vast number research areas, from aerospace to wood products, *Institut National d’Optique* (INO) focusing on optics and photonics solutions to problems ranging from biomedical to advanced manufacturing, the Ontario Centers of Excellence (OCE) to support the commercialisation of university research, industry-university collaborations and the development and adoption of emerging technologies, and so on.

Despite the fact that very few firms use government export incentives and services [*govexp*] (4.07% – see Table 11), those that do gain innovation advantage from this use of government resources (see column Gov_G in Table 9). We presume here that firms that export or at least have the intention of exporting are using such government programs. Aghion, Bergeaud, Lequien, and Melitz (2018) showed that firms that export also patent more (their proxy for measuring how innovative is the firm), but only if their initial level of productivity is high. Firms with low productivity (and lower market share) suffer from the increased competition that comes with playing on the international market. Other scholars argued that the increase was nonetheless conducive to innovation (Narula & Zanfei, 2003; Pellegrino & Savona, 2017).

Contrarily to the Survey of Innovation and Business Strategy (SIBS) used by Statistics Canada, the Community Innovation Survey (CIS) lists as a barrier to innovation the lack of information on technology and on markets. SIBS addresses this lack of information from the point of view of government programs. The survey includes a question on whether firms used government information and technical assistance programs [*govinfo*] as well as government market information services [*govmktinfo*]. Using both

³¹ The Natural Science and Engineering Research Council of Canada (NSERC) classifies IREQ as an industrial laboratory, although according to past directors of the institute, it has all the characteristics of a government laboratory. In formation on other research centres can be found at the following sites: <http://www.hydroquebec.com/innovation/en/>; <https://www.criq.qc.ca/en/industries.html>; <https://www.ino.ca/en/>; <https://www.occ-ontario.org/>.

types of programs yields positive and significant results on the innovation propensity, although the effect is weakly significant for the latter (see column Gov_I in Table 9). In contrast to what is generally portrayed in the literature (Amara et al., 2016; Pellegrino & Savona, 2017; Segarra-Blasco et al., 2008), in the SIBS survey, information on technology or on markets is not explored as an obstacle (measured by the perception of the lack of information), but rather as a government innovation support program to help firms accessing information as part of their innovation activities.

5.3 Control variables

Before concluding the paper, let us briefly address the control variables. Three variables are systematically non-significant throughout all models: firm size [*emp*], the age of the strategy [*agestrat*], and R&D relocation [*relocrd*]. The size of the firm does not influence the propensity of a firm to innovate. Considering the lack of consensus on the impact of firm size in the literature, this is not surprising. Nonetheless, the fact that only firms with 20 employees and more are surveyed in SIBS may provide part of the explanation as the very small firms are missing from the sample. Another reason stems from the fact that both process and product innovation are amalgamated into a single variable. Roper et al. (2008) found that size only impacted process innovation. When tested separately, our estimations for product and process innovations did not yield different results. The age of the strategy does not appear to make a difference either. Depending on sectors, innovation may appear sooner or later, so we expect that the sectoral dummies are correcting for this. In addition, strategies are not set in stone, but adapted and fine-tuned as time goes by, which may explain the lack of significance. Finally, relocating R&D activities from Canada to another country [*relocrd*] has no influence on the propensity of the firm to innovate. The few firms (less than 1% of the sample) that have done so are neither more innovative, nor less innovative than the firms that have not. In comparison, firms that outsource R&D activities to other entities [*outsourd*] are also slightly more likely to be innovative. It is therefore possible that the advantages from locating R&D activities abroad take longer to generate innovation compared to outsourcing R&D to already existing facilities. The effect is weak in any case.

All other control variables yield significant coefficients. If the firm has a long-term strategic focus on low price [*flowprice*] and cost leadership as opposed to a focus on good and service positioning, it is perfectly understandable that its propensity to innovate is lower. In contrast, if the firm has a strategic focus on introducing new or significantly improved goods or services [*stratnewprod*] or business activities or processes to its operations [*stratnewproc*], it is more likely to be innovative. Similarly, firms that have introduced new methods of organising external relations with other firms or public institutions [*neworgopen*] are also more innovative. Another factor that is correlated with the propensity to innovate is the adoption of advanced technologies [*techuse*]. Innovative firms are clearly at the avant-garde in this regard.

In general, firms that have a higher market share [*marketsh*] and that have gained market share [*gainmark*] for their highest selling good or service are more innovative. Finally, although the intangible capital measure [*intcapital*] covers a wide range of assets, including patents and licenses, its impact is positive, but weakly significant. Regional dummy variables are included but not individually significant, the year dummy for 2012 and all sectoral dummy variables are all positive and significant (compared to the omitted service industry). The omitted year dummy variable is for 2009, a year after the financial crisis of 2008, when innovating may not have been as important as simply surviving.

6 Discussion and conclusion

This paper's contribution to the empirical literature on obstacles to innovation is two-fold: 1) it explores the influence of nature and success of the actions that firms took to mitigate financial and non-financial innovation barriers; and 2) it offers a first assessment of the role of government support programs for innovation related activities in relation with these perceived innovation obstacles.

The paper makes a novel contribution by exploring the impact of the success or failure of the measures taken by the firms to mitigate or overcome the innovation barriers in conjunction with government innovation support programs. Although the overall impact remains negative compared to not facing such cost-related barriers to innovation, compared to doing nothing when faced with financial constraints, firms that take measures, whether

successful or not, improve their propensity to innovate, and when successful, the impact is much more important. Furthermore, our results highlight the positive impact of government programs destined to help firms partially mitigate their lack of funds problems. Programs such as R&D tax credits and subsidies are widely used, and have a demonstrated track record. Firms that have indeed used government innovation support programs to mitigate financial constraints are much more prone to be innovative, even more so than firms that turned to other successful measures but did not use government programs. Despite the low percentage of firms that report having managed to overcome barriers to innovation by using government programs, when the measures taken by the firms are successful, the impact on the likelihood of innovating is greater than when not using the programs. Our results suggest a reinforcing effect between the non-governmental and governmental tools at the disposal of firms that want to innovate despite the financial constraints encountered which remain a strong hampering effect.

Although the framework of our study is quite different from that of D'Este et al. (2012), let us analyse our results with their 'deterred' versus 'revealed' innovation barrier lens in mind. Firms that were not less successful at innovating when faced with financial/cost obstacles than those that did not encounter such problems are not really revealing anything by reporting such barriers. Their innovation level was hampered by financial constraints, but a very small proportion (about 3.3%) did not take any measures to try to mitigate them, hence the first part of the title of the paper introducing the fact that by their actions, firms may in fact be 'undeterred' by some obstacles that would otherwise be earmarked as deterring factors to innovate. Because so few firms do nothing when confronted with financial constraints, principally as a results of the numerous support programs at their disposal, we cannot classify these obstacles as pure deterring factors, despite the fact that the overall impact results in these firms having a reduced propensity to innovate compared to their counterparts not facing such cost-related barriers.

We find a similar story for firms that reported market-related obstacles to innovation. Doing nothing, or trying something but failing, evidently deterred firms from innovating altogether; i.e. the end result is much worse than if firms did not face such market-related obstacles in the first place. Similarly to the firms that encountered financial constraints, those that took measures to overcome market size-related innovation obstacles did much

better, and even more so if they used government programs. For this type of barrier to innovation, our results are in agreement with D'Este et al. (2012) and Mohnen et al. (2008) who showed them to have a strong hampering effect on innovation. That said, once firms decide to not be hindered by market-size obstacles, and either use government programs or take measures that are successful, then they are on the path towards a greater propensity to innovate, providing they do not also face financial constraints. Obstacles related to risk and uncertainty trigger the same behaviour from the firms in our sample. The other innovation barriers, when there is enough critical mass to justify the results, perform more or less as a relative 'detering' effects (for instance lack of skills and regulation), as no government programs or measures taken by firms seem to improve their capacity to innovate more than firms that did not face such barriers.

The final part of the paper turned to specific families of government programs and showed them all to have a significant association with an increased likelihood of innovating, with the exception of public procurement (not significant). This is likely due to the fact that firms may not be able to disentangle 'ordinary' public procurement from the programs aimed at 'beta-testing' new technologies by the state.

Although we cannot directly link each given family of government support programs with the fact that firms used them to overcome specific obstacles to innovation, we can guess some obvious matches. While some government support programs for innovation related activities are rather narrowly focused, such as hiring programs for recent graduates and training programs, others like R&D tax credits and subsidies have a much broader scope of impacts. The former are intuitively destined to helping firms mitigate innovation barriers related to lack of skills. Although widely used by firms that face financial constraints, the latter is only perceived by few as helping them mitigate these innovation barriers. More research is required to elucidate why firms accurately perceive that despite using these programs, financial constraints still hamper innovation.

Statistics Canada showed great flair in adapting the traditional CIS questionnaire to add questions about whether firms took measures to overcome barriers to innovation and whether any government programs were used for that purpose. Further improvements to these questionnaires are warranted to be able to properly answer the call for more detailed

research on “what makes an organisation innovate” (Hall et al., 2016), what actions they take to surmount the barriers that hamper their capacity to do so and the different mechanisms (innovation policies and support programs) they use which make a difference. Instead of the traditional section highlighting the limitations of our study, which are mainly related to sample size and sample selection, we prefer to present them as recommendations to improve future research.

Our first recommendation would be to substantially increase the number of firms surveyed to provide enough critical mass in most of the categories listed in Table 5 and Table 6. One of the limitation of the study is that once we distinguish firms that innovate from those that do not in these subcategories, the measured probability of innovating is affected (it is almost always positive but non-significant) by the number of firms being seriously reduced in some of these subcategories.

Second, further research is required to adequately identify firms that are potential innovators. We hinted towards the fact that a drawback of our study is that we probably not capture all potentially innovative firms by not including those that may have patented in the past or have other strategic means to protect their intellectual property. An obvious fix consists in matching patent databases with innovation surveys, but this is not enough if the latter does not also explore all types of IP protection mechanisms. Although this is a promising line of inquiries for future research, those that will venture on that path need to proceed with caution to account for the fact that there are many reasons other than to innovate that may explain why a firm patents, or protect its IP. Patent strategic barriers, thickets, trolls spring to mind. We suggest that only the highest quality of patents, those related to the core of the innovative activities of the firm, or filed in countries close to the main export markets of the firm be considered. Our recommendation would therefore to add questions in innovation surveys regarding the use of IP protection mechanisms.

Third, one of the main downside is the fact that the survey used does not allow to match specific suites of government programs with the obstacles they contributed to mitigating or overcoming. While this can be partially remedied by careful matching between the survey and the different federal programs for which an office of national statistics such as Statistics Canada has access to, collecting data from the provinces and at

the municipal level may prove more complex, if at all possible, to implement. Furthermore, we are still uninformed as to why some firms decide to do something to overcome these obstacles in the first place, about the types of measures that firms have taken to try or successfully mitigate the obstacles to innovation that they faced, and who helps them navigate through the wide spectrum of these government programs. Our study cannot shed light into the matter. This in itself would require detailed questionnaires and most probably in depth interviews. That said, this form of innovation surveys doubled with business strategies has a promising future to disentangle the role of government innovation support programs from other types of measures that the firms may take to mitigate innovation barriers.

Policy implications of our work

‘The glass is half full’ because firms take measures to overcome some of the non-financial obstacles and often succeed if they not also face financial constraints, which remains the empty part of the glass. Sorting innovation support programs that successfully allow firms to truly overcome financial constraints that hamper innovation should be one of the primary goals. In general, our results show that firms that takes measures and/or use government programs to mitigate non-financial barriers succeed in obtaining the same likelihood of innovating than if they had not faced such non-financial obstacles. Their actions and the government programs they use therefore serve their purpose. In the post-pandemic period, when countries will have to reimburse the massive bailouts that have kept the economy afloat during the pandemic, we anticipate that governments will have to take harsh decisions in regard to the programs they maintain. It is therefore imperative that in the light of the results obtained in this study and in other similar research, the academic community investigates which programs work and how to improve those that partially reach their objectives, while studying the behaviour of firms when trying to innovate.

Our research also highlighted where the government programs or the firms’ actions did manage to improve their likelihood of innovating above and beyond that of firms that did not face such non-financial barriers. Further research is also required to understand why, and which programs specifically have such a result that surpasses expectations, how

complementary are some of the programs, and whether some are close substitutes. This maybe a way for governments to select which innovation support programs to expand.

Table 7 – Model 2 regression results

Equation (2')	(O_c)	(O_i)	(O_m)	(O_im)	(O_4)	(O_5)	(O_6)	(O_7)	(O_8)	(O_9)	(O_10)
ln(emp)	-0.0218 (0.0152)	-0.0221 (0.0152)	-0.0206 (0.0153)	-0.0209 (0.0154)	-0.0218 (0.0154)	-0.0216 (0.0153)	-0.0206 (0.0153)	-0.0201 (0.0154)	-0.0206 (0.0153)	-0.0221 (0.0154)	-0.0203 (0.0153)
flowprice	-0.1006* (0.0515)	-0.1013** (0.0516)	-0.1018** (0.0519)	-0.1027** (0.0520)	-0.1010* (0.0520)	-0.1054*** (0.0519)	-0.1018** (0.0519)	-0.1024** (0.0521)	-0.1013* (0.0519)	-0.1009* (0.0519)	-0.1022*** (0.0518)
ln(agestrat)	0.0011 (0.0268)	0.0012 (0.0268)	0.0032 (0.0269)	0.0033 (0.0269)	0.0039 (0.0269)	0.0031 (0.0269)	0.0032 (0.0269)	0.0021 (0.0269)	0.0039 (0.0269)	0.0039 (0.0270)	0.0033 (0.0268)
stratnewprod	0.3702*** (0.0451)	0.3723*** (0.0447)	0.3633*** (0.0445)	0.3654*** (0.0442)	0.3656*** (0.0443)	0.3633*** (0.0443)	0.3633*** (0.0445)	0.3628*** (0.0443)	0.3648*** (0.0444)	0.3595*** (0.0444)	0.3623*** (0.0445)
stratnewproc	0.2646*** (0.0384)	0.2682*** (0.0383)	0.2641*** (0.0384)	0.2680*** (0.0383)	0.2648*** (0.0383)	0.2699*** (0.0383)	0.2641*** (0.0384)	0.2667*** (0.0383)	0.2652*** (0.0383)	0.2637*** (0.0384)	0.2640*** (0.0383)
techuse	0.4404*** (0.0410)	0.4453*** (0.0404)	0.4323*** (0.0401)	0.4375*** (0.0396)	0.4339*** (0.0397)	0.4377*** (0.0397)	0.4323*** (0.0401)	0.4369*** (0.0397)	0.4337*** (0.0398)	0.4318*** (0.0398)	0.4317*** (0.0402)
neworgopen	0.4783*** (0.0552)	0.4907*** (0.0549)	0.4671*** (0.0542)	0.4810*** (0.0540)	0.4746*** (0.0541)	0.4743*** (0.0539)	0.4670*** (0.0541)	0.4777*** (0.0539)	0.4707*** (0.0541)	0.4634*** (0.0539)	0.4679*** (0.0543)
outsourd	0.1002* (0.0578)	0.1045* (0.0581)	0.0974* (0.0581)	0.1025* (0.0584)	0.0977* (0.0582)	0.1008* (0.0583)	0.0973* (0.0581)	0.0996* (0.0585)	0.1012* (0.0582)	0.0924 (0.0583)	0.0966* (0.0580)
relocrd	0.2112 (0.2411)	0.2110 (0.2415)	0.2397 (0.2418)	0.2398 (0.2421)	0.2445 (0.2418)	0.2319 (0.2425)	0.2398 (0.2417)	0.2605 (0.2415)	0.2362 (0.2423)	0.2487 (0.2426)	0.2345 (0.2414)
ln(marketsh)	0.0241* (0.0136)	0.0245* (0.0136)	0.0224 (0.0137)	0.0228* (0.0137)	0.0226* (0.0137)	0.0230* (0.0137)	0.0224 (0.0137)	0.0219 (0.0137)	0.0227* (0.0137)	0.0220 (0.0137)	0.0227* (0.0137)
gainmark	0.3373*** (0.0405)	0.3394*** (0.0403)	0.3327*** (0.0404)	0.3349*** (0.0402)	0.3332*** (0.0403)	0.3367*** (0.0403)	0.3326*** (0.0404)	0.3327*** (0.0403)	0.3334*** (0.0403)	0.3313*** (0.0403)	0.3314*** (0.0404)
intcapital	0.0795** (0.0377)	0.0793** (0.0377)	0.0783** (0.0378)	0.0780** (0.0379)	0.0773** (0.0379)	0.0768** (0.0379)	0.0784** (0.0379)	0.0780** (0.0380)	0.0807** (0.0379)	0.0749** (0.0380)	0.0772** (0.0378)
obsfin	-0.7113** (0.3155)	-0.6650** (0.2978)	-0.9291*** (0.2888)	-0.8865*** (0.2721)	-0.9048*** (0.2804)	-0.9094*** (0.2756)	-0.9293*** (0.2888)	-0.8766*** (0.2807)	-0.9184*** (0.2808)	-0.9255*** (0.2857)	-0.9368*** (0.2867)
obsothfin		-0.0307** (0.0126)		-0.0357*** (0.0129)							
mtufin			0.1985*** (0.0690)	0.2086*** (0.0696)	0.2065*** (0.0695)	0.2022*** (0.0692)	0.1985*** (0.0690)	0.2086*** (0.0696)	0.2030*** (0.0693)	0.2025*** (0.0691)	0.1986*** (0.0689)
mtsfm			0.3997*** (0.0750)	0.4128*** (0.0754)	0.4070*** (0.0753)	0.4077*** (0.0751)	0.3996*** (0.0750)	0.4021*** (0.0749)	0.4073*** (0.0752)	0.3965*** (0.0749)	0.4014*** (0.0751)
Mult. obstacles					...mktsize	...skills	...collab	...risk	...regu	...ip	...compol
obs...					-0.0804* (0.0446)	-0.1008** (0.0396)	0.0025 (0.0614)	-0.1106*** (0.0382)	-0.0820* (0.0422)	0.1935*** (0.0721)	-0.0964 (0.0691)
Constant	0.1613 (0.1788)	0.1874 (0.1711)	0.1397 (0.1727)	0.1707 (0.1654)	0.1499 (0.1692)	0.1540 (0.1677)	0.1395 (0.1728)	0.1690 (0.1684)	0.1552 (0.1694)	0.1349 (0.1720)	0.1492 (0.1717)
Equation (3')											
subs_headcan	-0.0859* (0.0490)	-0.0860* (0.0490)	-0.0875* (0.0490)	-0.0875* (0.0490)	-0.0876* (0.0490)	-0.0877* (0.0490)	-0.0875* (0.0490)	-0.0871* (0.0491)	-0.0873* (0.0490)	-0.0870* (0.0491)	-0.0873* (0.0490)
subs_headforeign	-0.1067***	-0.1069**	-0.1095**	-0.1096**	-0.1098**	-0.1091**	-0.1095**	-0.1098**	-0.1095**	-0.1095**	-0.1092**

Equation (2')	(O_c)	(O_i)	(O_m)	(O_im)	(O_4)	(O_5)	(O_6)	(O_7)	(O_8)	(O_9)	(O_10)
ln(profit)	(0.0439) -0.0119***	(0.0438) -0.0118***	(0.0435) -0.0119***	(0.0435) -0.0118***	(0.0435) -0.0118***	(0.0436) -0.0119***	(0.0435) -0.0119***	(0.0436) -0.0118***	(0.0436) -0.0118***	(0.0436) -0.0118***	(0.0435) -0.0119***
ln(debtratio)	(0.0028) 0.6231***	(0.0027) 0.6251***	(0.0028) 0.6244***	(0.0028) 0.6265***	(0.0028) 0.6259***	(0.0028) 0.6255***	(0.0028) 0.6244***	(0.0028) 0.6267***	(0.0028) 0.6255***	(0.0028) 0.6260***	(0.0028) 0.6240***
Constant	(0.0854) -0.4549***	(0.0839) -0.4566***	(0.0839) -0.4553***	(0.0826) -0.4571***	(0.0831) -0.4567***	(0.0831) -0.4559***	(0.0839) -0.4554***	(0.0830) -0.4575***	(0.0833) -0.4564***	(0.0833) -0.4569***	(0.0840) -0.4550***
athrho	(0.0616) 0.3915*	(0.0607) 0.3819*	(0.0612) 0.3751*	(0.0603) 0.3653*	(0.0607) 0.3642*	(0.0607) 0.3715*	(0.0612) 0.3751*	(0.0606) 0.3590*	(0.0607) 0.3712*	(0.0608) 0.3626*	(0.0611) 0.3839*
Number of observations	6896	6896	6896	6896	6896	6896	6896	6896	6896	6896	6896
Number of groups	5912	5912	5912	5912	5912	5912	5912	5912	5912	5912	5912
χ^2	971.72***	970.08***	997.52***	995.68***	993.00***	996.99***	997.85***	993.86***	994.99***	980.16***	1004.46***
Log likelihood	-7681.39	-7678.56	-7665.45	-7661.71	-7663.79	-7662.11	-7665.44	-7661.09	-7663.63	-7661.78	-7664.57
ρ	0.3727	0.3644	0.3584	0.3499	0.3489	0.3553	0.3584	0.3443	0.3550	0.3475	0.3661

Notes: ***, **, * indicate significance at the 1%, 5% and 10% levels respectively; Robust standard errors clustered at firm level in parentheses; Year dummy (2012), regional dummy variables, and sectoral dummy variables included in all regressions.

Table 8 – Model 2 regression results – dummy variables for the success (S) of the measures taken to overcome each innovation obstacle including whether government (G) programs were used

Equation (2')	(SG_3)	(SG_4)	(SG_5)	(SG_6)	(SG_7)	(SG_8)	(SG_9)	(SG_10)
ln(emp)	-0.0209 (0.0155)	-0.0217 (0.0152)	-0.0249 (0.0152)	-0.0224 (0.0152)	-0.0252* (0.0152)	-0.0236 (0.0153)	-0.0239 (0.0152)	-0.0218 (0.0152)
flowprice	-0.1057** (0.0521)	-0.1056** (0.0516)	-0.1029** (0.0516)	-0.0998* (0.0516)	-0.1027** (0.0518)	-0.1003* (0.0517)	-0.1004* (0.0516)	-0.1022** (0.0515)
ln(agestrat)	0.0056 (0.0270)	0.0023 (0.0268)	0.0033 (0.0268)	-0.0005 (0.0268)	0.0065 (0.0268)	0.0016 (0.0268)	0.0026 (0.0269)	0.0008 (0.0267)
stratnewprod	0.3559*** (0.0442)	0.3635*** (0.0448)	0.3631*** (0.0450)	0.3671*** (0.0450)	0.3599*** (0.0447)	0.3731*** (0.0445)	0.3667*** (0.0447)	0.3704*** (0.0453)
stratnewproc	0.2568*** (0.0383)	0.2545*** (0.0383)	0.2652*** (0.0385)	0.2646*** (0.0385)	0.2595*** (0.0384)	0.2633*** (0.0383)	0.2645*** (0.0384)	0.2628*** (0.0385)
techuse	0.4316*** (0.0396)	0.4338*** (0.0404)	0.4321*** (0.0409)	0.4367*** (0.0409)	0.4359*** (0.0404)	0.4394*** (0.0400)	0.4405*** (0.0403)	0.4414*** (0.0413)
neworgopen	0.4676*** (0.0538)	0.4746*** (0.0553)	0.4765*** (0.0551)	0.4717*** (0.0552)	0.4635*** (0.0545)	0.4748*** (0.0545)	0.4736*** (0.0546)	0.4801*** (0.0556)
outsourd	0.0927 (0.0585)	0.0973* (0.0579)	0.0932 (0.0581)	0.0956* (0.0579)	0.0899 (0.0584)	0.1064* (0.0582)	0.0958* (0.0582)	0.1008* (0.0577)
relocrd	0.2504 (0.2412)	0.2113 (0.2339)	0.2085 (0.2400)	0.2177 (0.2421)	0.2547 (0.2445)	0.2204 (0.2423)	0.2183 (0.2429)	0.2083 (0.2408)
ln(marketsh)	0.0230* (0.0138)	0.0212 (0.0136)	0.0254* (0.0137)	0.0242* (0.0136)	0.0221 (0.0137)	0.0240* (0.0136)	0.0238* (0.0137)	0.0237* (0.0136)
gainmark	0.3339***	0.3266***	0.3355***	0.3370***	0.3239***	0.3328***	0.3363***	0.3356***

Equation (2')	(SG 3)	(SG 4)	(SG 5)	(SG 6)	(SG 7)	(SG 8)	(SG 9)	(SG 10)
intcapital	(0.0403) 0.0737*	(0.0403) 0.0771**	(0.0405) 0.0783**	(0.0405) 0.0740**	(0.0403) 0.0780**	(0.0403) 0.0787**	(0.0404) 0.0766**	(0.0406) 0.0790**
obsfin	(0.0381) -0.7885***	(0.0378) -0.7269**	(0.0377) -0.7073**	(0.0377) -0.7194**	(0.0379) -0.6891**	(0.0379) -0.6907**	(0.0379) -0.6994**	(0.0376) -0.7234**
Mult. obstacles and measures	...fin	...mktsize	...skills	...collab	...risk	...regu	...ip	...compol
nmt...		-0.3349*** (0.0776)	-0.3334*** (0.0717)	-0.3085** (0.1375)	-0.3268*** (0.0544)	-0.2188*** (0.0729)	-0.0845 (0.1445)	-0.1904* (0.1128)
nogovmtu...	-0.0398 (0.1149)	-0.1580*** (0.0611)	-0.1571*** (0.0590)	-0.1674* (0.0932)	-0.1554*** (0.0517)	-0.1181** (0.0582)	0.2556** (0.1250)	-0.0219 (0.1028)
nogovmts...	0.2472** (0.1205)	0.1893** (0.0957)	0.0860 (0.0624)	0.3135*** (0.1072)	0.1408** (0.0613)	0.1036 (0.0778)	0.2944*** (0.1086)	-0.0677 (0.1493)
govmtu...	0.5816*** (0.1495)	0.4452*** (0.1649)	0.0042 (0.1468)	0.3097 (0.2974)	0.3866*** (0.1371)	0.1785 (0.2250)	4.8320*** (0.3492)	5.4974*** (0.2252)
govmts...	0.3809*** (0.1455)	0.4858*** (0.1817)	0.1716 (0.1237)	0.4922 (0.3281)	0.1665 (0.1228)	0.3776 (0.2491)	0.3699 (0.4197)	-0.3937 (0.3911)
Constant	0.1400 (0.1682)	0.1958 (0.1704)	0.1844 (0.1750)	0.1659 (0.1779)	0.2035 (0.1708)	0.1863 (0.1704)	0.1494 (0.1762)	0.1720 (0.1786)
Equation (3')								
subs_headcan	-0.0871* (0.0491)	-0.0871* (0.0489)	-0.0855* (0.0490)	-0.0856* (0.0490)	-0.0856* (0.0490)	-0.0862* (0.0490)	-0.0855* (0.0491)	-0.0855* (0.0489)
subs_headforeign	-0.1108** (0.0435)	-0.1073** (0.0437)	-0.1063** (0.0439)	-0.1063** (0.0439)	-0.1074** (0.0437)	-0.1067** (0.0439)	-0.1069** (0.0439)	-0.1065** (0.0438)
ln(profit)	-0.0118*** (0.0028)	-0.0119*** (0.0027)	-0.0119*** (0.0028)	-0.0119*** (0.0027)	-0.0118*** (0.0027)	-0.0118*** (0.0027)	-0.0118*** (0.0028)	-0.0119*** (0.0028)
ln(debtratio)	0.6260*** (0.0827)	0.6238*** (0.0843)	0.6227*** (0.0850)	0.6232*** (0.0850)	0.6247*** (0.0837)	0.6259*** (0.0835)	0.6257*** (0.0840)	0.6221*** (0.0858)
Constant	-0.4566*** (0.0606)	-0.4551*** (0.0607)	-0.4543*** (0.0613)	-0.4554*** (0.0613)	-0.4562*** (0.0604)	-0.4571*** (0.0604)	-0.4573*** (0.0608)	-0.4539*** (0.0618)
athrho	0.3603* (0.1971)	0.4018* (0.2149)	0.3988* (0.2222)	0.3940* (0.2269)	0.3923* (0.2126)	0.3775* (0.2085)	0.3707* (0.2182)	0.4025* (0.2301)
Number of observations	6896	6896	6896	6896	6896	6896	6896	6896
Number of groups	5912	5912	5912	5912	5912	5912	5912	5912
χ^2	1013.36***	1005.01***	1001.70***	994.44***	1027.61***	974.76***	1833.05***	2124.68***
Log likelihood	-7645.83	-7655.91	-7664.00	-7670.80	-7645.86	-7672.27	-7674.30	-7677.33
ρ	0.3455	0.3815	0.3789	0.3748	0.3733	0.3605	0.3546	0.3821

Notes: ***, **, * indicate significance at the 1%, 5% and 10% levels respectively; Robust standard errors clustered at firm level in parentheses; Year dummy (2012), regional dummy variables, and sectoral dummy variables included in all regressions.

Table 9 – Model 2 regression results – government (Gov) programs were used

Equation (2')	(Gov_i)	(Gov_A)	(Gov_B)	(Gov_C)	(Gov_D)	(Gov_E)	(Gov_F)	(Gov_Gi)	(Gov_H)	(Gov_I)	(Gov_J)
ln(emp)	-0.0362**	-0.0237	-0.0265*	-0.0315**	-0.0228	-0.0236	-0.0268*	-0.0242	-0.0245	-0.0242	-0.0223

Equation (2')	(Gov I)	(Gov A)	(Gov B)	(Gov C)	(Gov D)	(Gov E)	(Gov F)	(Gov Gi)	(Gov H)	(Gov I)	(Gov J)
flowprice	(0.0154) -0.1013** (0.0514)	(0.0152) -0.1021** (0.0516)	(0.0152) -0.1071** (0.0516)	(0.0153) -0.1014** (0.0516)	(0.0153) -0.0998* (0.0517)	(0.0153) -0.1007* (0.0517)	(0.0153) -0.1047** (0.0516)	(0.0152) -0.0985* (0.0516)	(0.0153) -0.1020** (0.0517)	(0.0153) -0.0992* (0.0515)	(0.0153) -0.1011** (0.0515)
ln(agestrat)	0.0066 (0.0268)	0.0029 (0.0268)	0.0060 (0.0267)	0.0021 (0.0268)	0.0009 (0.0268)	0.0034 (0.0268)	0.0013 (0.0268)	0.0005 (0.0268)	0.0032 (0.0268)	0.0025 (0.0267)	0.0002 (0.0268)
stratnewprod	0.3568*** (0.0448)	0.3740*** (0.0447)	0.3654*** (0.0448)	0.3570*** (0.0450)	0.3721*** (0.0447)	0.3706*** (0.0444)	0.3672*** (0.0446)	0.3699*** (0.0447)	0.3704*** (0.0448)	0.3698*** (0.0450)	0.3729*** (0.0448)
stratnewproc	0.2581*** (0.0384)	0.2655*** (0.0383)	0.2604*** (0.0383)	0.2650*** (0.0385)	0.2683*** (0.0383)	0.2684*** (0.0383)	0.2660*** (0.0383)	0.2670*** (0.0383)	0.2669*** (0.0384)	0.2668*** (0.0384)	0.2673*** (0.0383)
techuse	0.4255*** (0.0407)	0.4426*** (0.0402)	0.4379*** (0.0407)	0.4331*** (0.0409)	0.4447*** (0.0404)	0.4410*** (0.0398)	0.4429*** (0.0404)	0.4431*** (0.0404)	0.4425*** (0.0406)	0.4415*** (0.0408)	0.4422*** (0.0404)
neworgopen	0.4755*** (0.0555)	0.4870*** (0.0549)	0.4831*** (0.0553)	0.4865*** (0.0555)	0.4896*** (0.0549)	0.4888*** (0.0545)	0.4864*** (0.0550)	0.4887*** (0.0550)	0.4873*** (0.0552)	0.4876*** (0.0554)	0.4909*** (0.0550)
outsourd	0.0864 (0.0583)	0.1022* (0.0582)	0.0978* (0.0581)	0.0970* (0.0582)	0.1027* (0.0581)	0.1065* (0.0582)	0.0940 (0.0580)	0.1023* (0.0581)	0.0978* (0.0582)	0.1011* (0.0580)	0.1045* (0.0580)
relocrd	0.2170 (0.2387)	0.2197 (0.2406)	0.1982 (0.2382)	0.2286 (0.2395)	0.2046 (0.2415)	0.2180 (0.2415)	0.2066 (0.2406)	0.2124 (0.2406)	0.2205 (0.2404)	0.2065 (0.2430)	0.2109 (0.2412)
ln(marketsh)	0.0251* (0.0136)	0.0247* (0.0137)	0.0256* (0.0136)	0.0258* (0.0137)	0.0243* (0.0136)	0.0234* (0.0136)	0.0240* (0.0136)	0.0250* (0.0136)	0.0248* (0.0136)	0.0247* (0.0136)	0.0244* (0.0136)
gainmark	0.3382*** (0.0405)	0.3401*** (0.0404)	0.3383*** (0.0404)	0.3428*** (0.0406)	0.3393*** (0.0403)	0.3384*** (0.0402)	0.3383*** (0.0404)	0.3371*** (0.0404)	0.3389*** (0.0404)	0.3389*** (0.0404)	0.3378*** (0.0404)
intcapital	0.0759** (0.0377)	0.0809** (0.0378)	0.0770** (0.0377)	0.0735* (0.0378)	0.0787** (0.0378)	0.0789** (0.0378)	0.0764** (0.0377)	0.0803** (0.0377)	0.0790** (0.0377)	0.0802** (0.0377)	0.0795** (0.0377)
obsfin	-0.7088** (0.2995)	-0.6645** (0.2959)	-0.6981** (0.2988)	-0.6709** (0.3144)	-0.6655** (0.2979)	-0.6639** (0.2834)	-0.6784** (0.2953)	-0.6763** (0.2970)	-0.6716** (0.3016)	-0.6854** (0.3066)	-0.6739** (0.2975)
obsothfin	-0.0364*** (0.0127)	-0.0323** (0.0127)	-0.0325** (0.0127)	-0.0313** (0.0127)	-0.0312** (0.0127)	-0.0314** (0.0126)	-0.0324** (0.0127)	-0.0316** (0.0127)	-0.0330*** (0.0127)	-0.0318** (0.0127)	-0.0307** (0.0126)
govsupindex	0.0731*** (0.0130)										
Mult. government prog.		...train	...grant	...txcr	...proc	...hire	...res	...exp	...info	...mktinfo	...oth
gov...		0.0929** (0.0438)	0.1653*** (0.0412)	0.1574*** (0.0374)	0.0673 (0.0708)	0.1535*** (0.0582)	0.2138*** (0.0794)	0.1375** (0.0673)	0.1916*** (0.0742)	0.1291* (0.0678)	0.2088** (0.0931)
Constant	0.2299 (0.1706)	0.1884 (0.1705)	0.2015 (0.1709)	0.1986 (0.1761)	0.1903 (0.1712)	0.1870 (0.1669)	0.2180 (0.1700)	0.2035 (0.1706)	0.1921 (0.1722)	0.1976 (0.1734)	0.1907 (0.1710)
Equation (3')											
subs_headcan	-0.0851* (0.0489)	-0.0859* (0.0490)	-0.0852* (0.0490)	-0.0862* (0.0490)	-0.0859* (0.0490)	-0.0863* (0.0490)	-0.0861* (0.0490)	-0.0856* (0.0490)	-0.0851* (0.0490)	-0.0857* (0.0489)	-0.0858* (0.0490)
subs_headforeign	-0.1088** (0.0435)	-0.1074** (0.0438)	-0.1077** (0.0437)	-0.1076** (0.0438)	-0.1071** (0.0438)	-0.1077** (0.0437)	-0.1065** (0.0438)	-0.1072** (0.0438)	-0.1071** (0.0438)	-0.1069** (0.0438)	-0.1068** (0.0438)
ln(profit)	-0.0119*** (0.0027)	-0.0118*** (0.0028)	-0.0119*** (0.0027)	-0.0118*** (0.0027)	-0.0118*** (0.0027)	-0.0118*** (0.0027)	-0.0119*** (0.0027)	-0.0119*** (0.0027)	-0.0118*** (0.0027)	-0.0119*** (0.0027)	-0.0118*** (0.0027)
ln(debtratio)	0.6227*** (0.0848)	0.6251*** (0.0838)	0.6234*** (0.0846)	0.6245*** (0.0848)	0.6251*** (0.0839)	0.6260*** (0.0830)	0.6244*** (0.0839)	0.6246*** (0.0840)	0.6246*** (0.0841)	0.6234*** (0.0848)	0.6249*** (0.0840)
Constant	-0.4550***	-0.4564***	-0.4555***	-0.4570***	-0.4567***	-0.4570***	-0.4556***	-0.4560***	-0.4563***	-0.4552***	-0.4564***

Equation (2')	(Gov i)	(Gov A)	(Gov B)	(Gov C)	(Gov D)	(Gov E)	(Gov F)	(Gov Gi)	(Gov H)	(Gov I)	(Gov J)
	(0.0608)	(0.0607)	(0.0608)	(0.0610)	(0.0606)	(0.0601)	(0.0607)	(0.0607)	(0.0608)	(0.0612)	(0.0606)
athrho	0.4055*	0.3807*	0.3998*	0.3862*	0.3825*	0.3776*	0.3886*	0.3883*	0.3856*	0.3955*	0.3878*
	(0.2167)	(0.2099)	(0.2150)	(0.2241)	(0.2116)	(0.2006)	(0.2108)	(0.2119)	(0.2148)	(0.2198)	(0.2121)
Number of observations	6896	6896	6896	6896	6896	6896	6896	6896	6896	6896	6896
Number of groups	5912	5912	5912	5912	5912	5912	5912	5912	5912	5912	5912
χ^2	1007.91***	971.63***	1002.18***	989.65***	968.72***	975.67***	972.37***	975.40***	974.09***	981.47***	979.42***
Log likelihood	-7660.96	-7676.27	-7670.21	-7669.62	-7678.10	-7675.05	-7674.62	-7676.37	-7674.81	-7676.62	-7676.05
ρ	0.3846	0.3633	0.3798	0.3681	0.3649	0.3606	0.3701	0.3699	0.3675	0.3761	0.3695

Notes: ***, **, * indicate significance at the 1%, 5% and 10% levels respectively; Robust standard errors clustered at firm level in parentheses; Year dummy (2012), regional dummy variables, and sectoral dummy variables included in all regressions.

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Appendix A – North American Industry Classification System

Table 10 – 2007 and 2012 NAICS codes

Variable	NAICS	Industry group
inress	311	Food manufacturing
	312	Beverage and tobacco product manufacturing
	321	Wood product manufacturing
	322	Paper manufacturing
	324	Petroleum and coal product manufacturing
	327	Non-metallic mineral product manufacturing
inlab	113	Forestry and logging
	313	Textile mills
	314	Textile product mills
	315	Clothing manufacturing
	316	Leather and allied product manufacturing
	332	Fabricated metal product manufacturing
	337	Furniture and related product manufacturing
inscal	339	Miscellaneous manufacturing
	323	Printing and related support activities
	325	Chemical manufacturing
	326	Plastics and rubber products manufacturing
	331	Primary metal manufacturing
	3361	Motor vehicle manufacturing
	3362	Motor vehicle body and trailer manufacturing
	3363	Motor vehicle parts manufacturing
	3365	Railroad rolling stock manufacturing
3366	Ship and boat building	
inspec	3369	Other transportation equipment manufacturing
	333	Machinery manufacturing
inisci	335	Electrical equipment, appliance and component manufacturing
	334	Computer and electronic product manufacturing
KIBS	3364	Aerospace product and parts manufacturing
	5413	Architectural, engineering and related services
	5414	Specialized design services
	5415	Computer systems design and related services
	5417	Scientific research and development services
	5411	Legal services
	5412	Accounting, tax preparation, bookkeeping and payroll services
	5416	Management, scientific and technical consulting services
	5418	Advertising, public relations, and related services
	5419	Other professional, scientific and technical services

Appendix B – Descriptive statistics and correlation matrix

Table 11 – Descriptive statistics

Variable	Mean	Std. Dev.	Variable	Mean	Std. Dev.
dlnnov	0.7078	(0.4548)			
			[Independent variables]		
obsindex	1.8564	(1.9450)	govsupindex	1.1610	(1.4595)
[dummy variables of obstacles and measures]			[dummy variables for government programs]		
obsifin	0.2783	(0.4482)	govtrain	0.1971	(0.3978)
obssefin	0.1787	(0.3831)	govgrant	0.2293	(0.4204)
obsfin	0.3072	(0.4614)	govtxcr	0.3444	(0.4752)
obsmktsize	0.2201	(0.4144)	govproc	0.0584	(0.2345)
obsskill	0.3177	(0.4656)	govhire	0.1019	(0.3026)
obscollab	0.1206	(0.3256)	govres	0.0365	(0.1876)
obsrisk	0.4284	(0.4949)	govexp	0.0407	(0.1975)
obsregu	0.2044	(0.4033)	govinfo	0.0760	(0.2650)
obsip	0.0500	(0.2180)	govmktinfo	0.0588	(0.2353)
obscompol	0.0582	(0.2342)	govoth	0.0179	(0.1324)
			[Control variables]		
emp	114.7150	(1172.1290)	regatl	0.0376	(0.1902)
flowprice	0.1134	(0.3170)	regque	0.2840	(0.4510)
agestrat	11.3983	(13.3964)	regont	0.3791	(0.4852)
stratnewprod	0.2410	(0.4277)	regwes	0.2968	(0.4569)
stratnewproc	0.4135	(0.4925)	regoth	0.0053	(0.0723)
techuse	0.4530	(0.4978)	inress	0.0572	(0.2323)
neworgopen	0.1980	(0.3985)	inlab	0.0709	(0.2567)
outsourd	0.0781	(0.2683)	inscal	0.0509	(0.2199)
relocrd	0.0016	(0.0401)	inspec	0.0320	(0.1759)
ln(marketsh)	2.9631	(1.3370)	insci	0.0123	(0.1102)
gainmark	0.3494	(0.4768)	inserv_KIBS	0.0882	(0.2836)
intcapital	0.2667	(0.4423)	d2012	0.4764	(0.4995)
			[Financial variables]		
profit*	8,676,606	(106,000,000)	subsidiary	0.1620	(0.3685)
debratio	2.2415	(8.2265)	subs_headcan	0.1019	(0.3026)
			subs_headforeign	0.0600	(0.2376)

Notes: Number of observations = 7,092. * Number of observations = 6,896.

Table 12 – Correlation table

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	
dlnnov	1													
obsindex	2	-0.1678 *	1											
obsmktsize	3	-0.1342 *	0.5518 *	1										
obsifin	4	-0.0944 *	0.6470 *	0.3186 *	1									
obsefin	5	-0.0696 *	0.6678 *	0.2631 *	0.5828 *	1								
obsfin	6	-0.0784 *	0.6632 *	0.3103 *	0.9325 *	0.7005 *	1							
obs skill	7	-0.0535 *	0.5699 *	0.1438 *	0.1999 *	0.2905 *	0.2253 *	1						
obs collab	8	-0.0660 *	0.6546 *	0.3425 *	0.3281 *	0.4002 *	0.3291 *	0.3217 *	1					
obsrisk	9	-0.2127 *	0.6549 *	0.2799 *	0.2959 *	0.2834 *	0.3138 *	0.3372 *	0.3124 *	1				
obsregu	10	-0.0930 *	0.5072 *	0.1266 *	0.1370 *	0.1777 *	0.1386 *	0.1797 *	0.2102 *	0.2814 *	1			
obsip	11	0.0554 *	0.4259 *	0.0831 *	0.2064 *	0.2331 *	0.1990 *	0.1456 *	0.2896 *	0.1719 *	0.2424 *	1		
obscompol	12	-0.1055 *	0.3015 *	0.1243 *	0.0358 *	0.0737 *	0.0362 *	0.0281 *	0.2265 *	0.0515 *	0.2434 *	0.2106 *	1	
obsotfin	13	-0.1733 *	0.9417 *	0.5583 *	0.3951 *	0.4405 *	0.4063 *	0.6109 *	0.6548 *	0.6950 *	0.5768 *	0.4352 *	0.3648 *	1
govsupindex	14	0.1397 *	0.0441 *	0.0081	0.0764 *	0.0481 *	0.0787 *	0.0368 *	0.0460 *	-0.0001	-0.0066	0.0419 *	-0.0372 *	0.0223
govtrain	15	0.0576 *	0.0652 *	0.0824 *	0.0764 *	0.0928 *	0.1086 *	0.0924 *	0.0495 *	0.0246 *	-0.0584 *	-0.0368 *	-0.0719 *	0.0384 *
govgrant	16	0.1408 *	-0.0447 *	-0.0507 *	0.0728 *	-0.0002	0.0590 *	-0.0583 *	-0.0027	-0.1013 *	-0.0281 *	0.0088	-0.0464 *	-0.0804 *
govtxcr	17	0.0942 *	0.0535 *	0.0219	0.0329 *	0.0249 *	0.0344 *	0.0636 *	-0.0069	0.0489 *	0.0036	0.0735 *	0.0073	0.0537 *
govproc	18	0.0129	0.0233 *	-0.0147	0.0340 *	0.0720 *	0.0290 *	0.0131	0.0293 *	-0.0375 *	0.0267 *	0.0096	-0.0054	0.0017
govhire	19	0.0855 *	-0.0417 *	-0.0459 *	-0.0356 *	-0.0116	-0.0375 *	-0.0111	0.0223	-0.0428 *	-0.0419 *	-0.0008	-0.0232	-0.0408 *
govres	20	0.0188	0.0950 *	0.1077 *	0.1152 *	0.0421 *	0.1128 *	-0.0038	0.0198	0.0797 *	0.0430 *	0.0579 *	-0.0070	0.0788 *
govexp	21	0.0414 *	0.0379 *	0.0171	0.0649 *	0.0420 *	0.0604 *	0.0108	-0.0096	0.0076	0.0024	0.0645 *	0.0034	0.0192
govinfo	22	0.0960 *	-0.0198	-0.0427 *	-0.0254 *	-0.0355 *	-0.0315 *	-0.0053	0.0473 *	-0.0156	0.0099	0.0118	-0.0320 *	-0.0090
govmktinfo	23	0.0402 *	0.0767 *	-0.0141	0.0357 *	0.0039	0.0377 *	0.0486 *	0.1073 *	0.0697 *	0.0776 *	0.0276 *	0.0348 *	0.0886 *
govoth	24	0.0113	0.0062	-0.0125	0.0117	0.0036	0.0103	0.0013	-0.0105	0.0184	0.0048	0.0143	-0.0032	0.0037
ln(emp)	25	0.0195	0.0140	0.0249 *	-0.0160	0.0399 *	-0.0340 *	-0.0527 *	0.0496 *	-0.0060	0.0420 *	0.0670 *	-0.0488 *	0.0128
flowprice	26	0.0480 *	0.0315 *	0.0744 *	-0.0129	0.0842 *	0.0348 *	-0.0294 *	0.0723 *	0.0186	-0.0257 *	-0.0495 *	0.0260 *	0.0234 *
ln(agestrat)	27	-0.0433 *	0.0456 *	0.0127	-0.0782 *	-0.0032	-0.0836 *	0.0948 *	0.0228	0.0188	0.0644 *	0.0556 *	0.0890 *	0.0842 *
stratnewprod	28	0.2573 *	0.1239 *	0.0178	0.0689 *	0.1054 *	0.0868 *	0.1007 *	0.0985 *	0.0492 *	0.0952 *	0.1334 *	-0.0364 *	0.1142 *
stratnewproc	29	0.1941 *	0.1180 *	0.0355 *	0.1499 *	0.0516 *	0.1325 *	0.0542 *	0.0622 *	-0.0068	0.1447 *	0.0996 *	0.0243 *	0.0960 *
techuse	30	0.1082 *	0.1910 *	0.0991 *	0.1552 *	0.1633 *	0.1834 *	0.0770 *	0.1333 *	0.1413 *	0.0683 *	0.1207 *	-0.0203	0.1611 *
neworgopen	31	0.1566 *	0.1223 *	0.1497 *	0.1185 *	0.1349 *	0.1038 *	0.0563 *	0.0760 *	0.0112	0.0346 *	0.0247 *	-0.0205	0.0895 *
outsourd	32	0.0475 *	0.0639 *	0.0416 *	0.0117	0.0037	0.0046	0.0656 *	0.1078 *	0.0407 *	0.0397 *	0.0224	-0.0268 *	0.0792 *
relocrd	33	0.0184	0.0201	0.0052	0.0211	0.0145	0.0180	0.0075	0.0048	0.0203	0.0101	0.0139	-0.0012	0.0162
ln(marketsh)	34	-0.0218	0.0115	0.0647 *	-0.0390 *	-0.0606 *	-0.0350 *	0.0554 *	0.0049	0.0407 *	-0.0022	0.0076	-0.0515 *	0.0425 *
gainmark	35	0.1951 *	-0.0378 *	-0.0579 *	0.0258 *	-0.0114	0.0075	0.0077	-0.0544 *	-0.0877 *	0.0080	0.0560 *	-0.0623 *	-0.0543 *
intcapital	36	0.0171	0.0209	-0.0576 *	0.0758 *	0.0734 *	0.0734 *	-0.0310 *	-0.0057	-0.0835 *	0.0372 *	0.1187 *	0.0817 *	-0.0145
ln(profit)	37	0.0060	-0.0557 *	-0.0669 *	0.0067	0.0154	0.0024	0.0315 *	-0.0675 *	-0.0499 *	-0.1005 *	0.0482 *	-0.1276 *	-0.0789 *
ln(debratio)	38	-0.1093 *	-0.0283 *	-0.0430 *	0.0840 *	-0.0345 *	0.0749 *	-0.0815 *	-0.0466 *	-0.0543 *	-0.0329 *	-0.0171	0.1510 *	-0.0535 *
subs_headcan	39	0.0934 *	-0.0329 *	-0.0215	-0.0381 *	-0.0381 *	-0.0396 *	-0.0019	0.0655 *	-0.0528 *	-0.0478 *	0.0264 *	-0.0181	-0.0218
subs_headforeign	40	0.0455 *	-0.0111	0.0226	0.0038	-0.0137	-0.0028	-0.0319 *	-0.0235 *	-0.0367 *	0.0055	0.0382 *	0.0114	-0.0122
Variable	14	15	16	17	18	19	20	21	22	23	24	25	26	

Appendix C – Regression analysis – Model 1

Table 13 – Model 1 regression results

Equation (1)	(O1_c)	(O1_i)	(O1_1)	(O1_2)	(O1_3)	(O1_4)	(O1_5)	(O1_6)	(O1_7)	(O1_8)	(O1_9)	(O1_10)
ln(emp)	-0.0156 (0.0155)	-0.0185 (0.0155)	-0.0180 (0.0155)	-0.0178 (0.0155)	-0.0187 (0.0155)	-0.0174 (0.0155)	-0.0174 (0.0155)	-0.0156 (0.0155)	-0.0162 (0.0155)	-0.0159 (0.0155)	-0.0166 (0.0155)	-0.0153 (0.0155)
flowprice	-0.1265** (0.0528)	-0.1232** (0.0529)	-0.1222** (0.0528)	-0.1240** (0.0528)	-0.1218** (0.0528)	-0.1247 ** (0.0529)	-0.1297** (0.0528)	-0.1261** (0.0528)	-0.1251** (0.0529)	-0.1250** (0.0528)	-0.1254** (0.0528)	-0.1268** (0.0528)
ln(agestrat)	0.0101 (0.0273)	0.0063 (0.0273)	0.0054 (0.0273)	0.0083 (0.0273)	0.0049 (0.0274)	0.0102 (0.0273)	0.0089 (0.0273)	0.0099 (0.0273)	0.0062 (0.0273)	0.0105 (0.0272)	0.0109 (0.0273)	0.0102 (0.0272)
stratnewprod	0.3859*** (0.0420)	0.3913*** (0.0422)	0.3893*** (0.0421)	0.3897*** (0.0420)	0.3905*** (0.0420)	0.3883 *** (0.0420)	0.3865*** (0.0421)	0.3860*** (0.0420)	0.3853*** (0.0421)	0.3877*** (0.0421)	0.3814*** (0.0420)	0.3858*** (0.0420)
stratnewproc	0.2693*** (0.0381)	0.2769*** (0.0382)	0.2735*** (0.0382)	0.2717*** (0.0382)	0.2739*** (0.0382)	0.2704 *** (0.0381)	0.2764*** (0.0382)	0.2695*** (0.0381)	0.2740*** (0.0382)	0.2709*** (0.0381)	0.2681*** (0.0381)	0.2698*** (0.0381)
techuse	0.4499*** (0.0364)	0.4575*** (0.0366)	0.4510*** (0.0365)	0.4524*** (0.0365)	0.4525*** (0.0365)	0.4513 *** (0.0364)	0.4566*** (0.0365)	0.4503*** (0.0364)	0.4562*** (0.0365)	0.4522*** (0.0365)	0.4483*** (0.0364)	0.4506*** (0.0364)
neworgopen	0.4803*** (0.0512)	0.5048*** (0.0513)	0.4894*** (0.0511)	0.4903*** (0.0511)	0.4904*** (0.0511)	0.4901 *** (0.0515)	0.4907*** (0.0514)	0.4819*** (0.0512)	0.4965*** (0.0513)	0.4850*** (0.0513)	0.4746*** (0.0513)	0.4834*** (0.0513)
outsourd	0.1139* (0.0592)	0.1214** (0.0594)	0.1168** (0.0592)	0.1153* (0.0592)	0.1176** (0.0593)	0.1142 * (0.0592)	0.1179** (0.0593)	0.1144* (0.0592)	0.1176** (0.0595)	0.1189** (0.0593)	0.1092* (0.0593)	0.1131* (0.0592)
relocrd	0.2051 (0.2500)	0.2230 (0.2496)	0.2276 (0.2491)	0.2145 (0.2492)	0.2263 (0.2491)	0.2124 (0.2495)	0.2011 (0.2508)	0.2050 (0.2500)	0.2408 (0.2487)	0.2021 (0.2507)	0.2094 (0.2504)	0.2004 (0.2501)
ln(marketsh)	0.0289** (0.0138)	0.0270* (0.0138)	0.0271** (0.0138)	0.0268* (0.0138)	0.0262* (0.0138)	0.0285 ** (0.0138)	0.0290** (0.0138)	0.0288** (0.0138)	0.0268* (0.0138)	0.0289** (0.0138)	0.0287** (0.0138)	0.0291** (0.0138)
gainmark	0.3422*** (0.0398)	0.3425*** (0.0398)	0.3399*** (0.0398)	0.3404*** (0.0398)	0.3401*** (0.0398)	0.3422 *** (0.0398)	0.3462*** (0.0398)	0.3424*** (0.0398)	0.3404*** (0.0398)	0.3429*** (0.0398)	0.3403*** (0.0398)	0.3415*** (0.0398)
intcapital	0.0730* (0.0379)	0.0741* (0.0380)	0.0747** (0.0380)	0.0736* (0.0379)	0.0748** (0.0380)	0.0718 * (0.0379)	0.0709* (0.0379)	0.0726* (0.0379)	0.0731* (0.0380)	0.0762** (0.0380)	0.0697* (0.0380)	0.0723* (0.0379)
obsindex		-0.0378*** (0.0088)										
Mult. obstacles			...ifin	...efin	...fin	...mktsize	...skills	...collab	...risk	...regu	...ip	...compol
obs...			-0.1080*** (0.0377)	-0.1102** (0.0433)	-0.1196*** (0.0370)	-0.0979** (0.0430)	-0.1159*** (0.0389)	-0.0268 (0.0610)	-0.1516*** (0.0361)	-0.0969** (0.0418)	0.1587** (0.0715)	-0.1203* (0.0698)
Constant	-0.1546 (0.1163)	-0.0522 (0.1186)	-0.0919 (0.1182)	-0.1091 (0.1177)	-0.0777 (0.1188)	-0.1229 (0.1170)	-0.1207 (0.1170)	-0.1507 (0.1164)	-0.0690 (0.1184)	-0.1259 (0.1168)	-0.1580 (0.1165)	-0.1459 (0.1164)
Nb obs.	7092	7092	7092	7092	7092	7092	7092	7092	7092	7092	7092	7092
Nb gr.	6085	6085	6085	6085	6085	6085	6085	6085	6085	6085	6085	6085
Pseudo R ²	0.1202	0.1223	0.1212	0.1210	0.1215	0.1208	0.1213	0.1202	0.1225	0.1208	0.1208	0.1205
χ ²	741.28***	754.00***	746.26***	751.93***	748.22***	744.51 ***	745.37***	741.73***	753.92***	742.65***	734.62***	744.98***
Log likelihood	-3340.14	-3332.13	-3336.11	-3337.00	-3335.00	-3337.65	-3335.73	-3340.05	-3331.39	-3337.63	-3337.67	-3338.80

Notes: ***, **, * indicate significance at the 1%, 5% and 10% levels respectively; Robust standard errors clustered at firm level in parentheses; Year dummy (2012), regional dummy variables, and sectoral dummy variables included in all regressions.