UNIVERSITY OF ALBERTA
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Department of Economics

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Determinants of Locational Patenting Behavior of Canadian Firms

Andrew Eckert
University of Alberta

Corinne Langinier
University of Alberta

Long Zhao
University of Alberta

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Andrew Eckert, Corinne Langinier and Long Zhao †

Department of Economics, University of Alberta

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Abstract Using a unique data set combining Canadian and U.S patent data with firm level data, we analyze Canadian firms' locational patenting decisions during the period 2000-2008. We find first that Canadian firms' propensity to patent increases in firm size and research and development intensity, but decreases in firm age and profitability. Second, the likelihood of patenting in both the U.S. and Canada is associated with past patenting experience, firm size, profitability and patent scope. While manufacturing firms in export intensive industries are more likely to patent in both countries, firms in Foreign Direct Investment intensive industries are more likely to patent domestically. Finally, Canadian Intellectual Property Office's role as an International Search Authority under the Patent Cooperation Treaty (PCT) is associated with an increase in the use of PCT by Canadian firms.

Keywords: Canadian firms, locational patenting behavior

JEL Codes: O12, O34

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†Address: Andrew Eckert *aeckert@ualberta.ca*; Corinne Langinier *langinie@ualberta.ca*; Long Zhao *lzhao3@ualberta.ca*.

1 Introduction

Innovators make several decisions at different stages of the innovation and patenting process. At the outset, a firm decides whether to innovate. Once an innovation has been discovered, the innovator must decide whether to patent it or not. When a patenting decision has been made, the innovator decides where to patent its innovation. Patent rights are defined by national laws; a patent granted in one country cannot protect the innovation in another country. This requires firms to decide on the geographical coverage of patent protection for their innovations. While the decision to patent has been widely studied in the literature, locational patenting decisions have received little attention at the firm level.

The purpose of this paper is to empirically examine firms' decisions to apply for patents at home or abroad, focusing on the case of Canadian firms. Canadian firms have applied more frequently for patents in the U.S. than in Canada during the period 2000-2012 (Greenspon and Rodigues, 2017). While patent applications by Canadian firms at the United States Patent and Trademark Office (USPTO) keep increasing, those at the Canadian Intellectual Property Office (CIPO) have decreased. Additionally, CIPO is known to be an office of second filing as firms tend to apply for patents elsewhere before filing with CIPO.

The motives behind Canadian firms' locational patenting decisions have potentially important policy implications. If locational patenting decisions are determined by firm level characteristics such as age and size, then if increasing domestic patenting is a policy objective, it may be best achieved by targeting firms with certain characteristics. Likewise, if the decision not to patent at home is caused by the design of the patent system, then policy intervention to increase domestic patenting could focus on patent rules and procedures. Finally, if the key determinant of domestic patenting is the industrial environment, policy changes should focus on improving business opportunities.

Existing studies on locational patenting decisions have been limited due to legal obligations and confidentiality issues that prevent researchers from merging patent data with firm level data. We overcome this hurdle for Canadian firms' locational patenting in Canada and the U.S. under arrangements with Statistics Canada that maintain legal confidentiality requirements. As well, while previous studies have used surveys of selected firms, our analysis makes use of patent data directly from USPTO and CIPO for all Canadian firms.

We use panel data for Canadian firms over the period 2000-2008 to estimate models of the decisions to patent, and if so where, in order to examine how these decisions are associated with firm and industry characteristics and patent system design. Overall, our results suggest that regarding firm level characteristics, the decisions to patent are significantly associated with firm age, firm size, profitability, and research and development (R&D) intensity. For instance, our findings indicate that older firms are less likely to patent, and that if they do, they are less likely than younger firms to patent only domestically. Our findings also suggest that the likelihood of only applying for patents abroad is mainly associated with past patenting experience, R&D intensity, firm size, and patent scope. Additionally, regarding industrial level characteristics we show that manufacturing firms in export intensive sectors are more likely to patent in Canada as well as in the U.S., whereas firms in Foreign Direct Investment (FDI) intensive sectors are less likely to patent in both patent offices.

Our analysis so far is restricted to Canadian firms' patenting in Canada and the U.S. However, we can get some understanding of the decision of Canadian firms to apply for patents outside of Canada and the U.S. by considering their use of the Patent Cooperation Treaty (PCT). PCT is an international treaty contracted by more than 150 countries aiming to facilitate firms' patenting in several countries. According to World Intellectual Property Office (WIPO) statistics, 8% of patent applications at USPTO by Canadian applicants were made through PCT , while this ratio was 63% at the European Patent Office (EPO), 78% at the Australia Patent Office, 75% at the National Intellectual Property Administration in China, and 81% at the Japan Patent Office during 2004-2008. This suggests that the use of PCT is linked to patent applications by Canadian firms to countries other than the U.S. and Canada. Our findings suggest that the use of PCT by Canadian firms is mainly connected with firm age, patenting experience, profitability, patent scope and firm size. Notably, CIPO's role as an International Search Authority (ISA) is associated with an increase in PCT applications by Canadian firms; however, after CIPO became an ISA, Canadian firms have been less likely to patent at both offices.

The rest of the paper is organized as follows. In Section 2, a brief survey of the literature is provided, with a focus on why and where firms patent, and on Canadian firms' patenting behavior. Section 3 focuses on the econometric framework whereas Section 4 describes the data sources, the construction of variables, and summary statistics. Section 5 presents the empirical findings. Section 6 carries out robustness checks and Section 7 concludes.

2 Literature

This paper contributes to three strands of the patent literature. First, our study is related to the literature on incentives to patent.[1] Empirical studies using surveys (Levin et al., 1987; Cohen et al., 2000; Sichelman and Graham, 2008; Graham et al., 2009) find that firms patent to prevent copying, obtain licensing revenue, increase negotiation position, and avoid lawsuits. Empirical evidence also suggests that patents are used to avoid expensive imitation costs (Mansfield et al., 1981), to distort rival firms' decisions in R&D activities (Kortum and Lerner, 1999; Palangkaraya et al., 2008), to reduce the possibility of being held up by external patent owners (Hall and Ziedonis, 2001) and to increase the value of innovation (Arora et al., 2008).

In addition, patenting has shown significant impacts on firm performance. Among others, Balasubramanian and Sivadasan (2011) find that the patent stock of U.S. firms is positively associated with firm growth. Using data on West Germany during the period 1953-1988, Lanjouw (1998) concludes that patenting increases returns to firms' R&D expenditure by

[1]Theoretical models have been proposed to understand why firms patent. For instance, Horstmann et al. (1985) argue that innovating firms possess private information about the profitability of their innovation and their decisions to patent can influence rivals' behavior. Langinier (2005) suggests that when the leader in a patent race has more information about the improvability of an innovation, he can choose to patent strategically. In the context of sequential innovations, Bessen and Maskin (2009) argue that patents can be used to block potential rivals in their subsequent research.

about 10%. In the case of France, Schankerman (1998) finds that the returns to R&D generated from patents can be as high as 25%. Ortiz-Villajos and Sotoca (2018) find that British manufacturing firms' survival is positively associated with the number of their patent applications. However, the impact of patents on the rate of innovation seems to be limited (Cohen, 2010), with the exception of pharmaceutical and chemical industries (Cohen et al., 2000; Mansfield, 1986).

Second, our study is related to the literature on firms' locational patenting behavior. Much of this empirical literature focuses on the role of exporting and the importance of patenting in jurisdictions where the innovation will be used or sold. For example, Palangkaraya et al. (2017) find that whether a firm gets patents in a foreign country affects its decision to trade patentable goods. While Bosworth (1984) finds a strong correlation between patenting and FDI, Dosi et al. (1990), Licht and Zoz (2000), and Yang and Kuo (2008) conclude that cross-country patenting is positively associated with trade flows. As well, the decision of where to patent is related to innovation costs (Eaton and Kortum, 1996) and the sizes of innovators' economies and distance (Sláma, 1981).

The literature also suggests that the decision of where to patent an innovation depends in part on its quality, as not all innovations are worth multiple patent applications (Jaffe and Lerner, 2011). In a study of nine agricultural biotechnology firms in the U.S., Chan (2010) finds that the major determinants of the decisions to patent abroad include the quality of innovations and the firms' valuation of incremental revenue from extra geographical coverage.

In addition, the literature suggests that locational patenting decisions may be influenced by the perceived quality of patent protection in different jurisdictions. Cohen et al. (2002) find that while patents are perceived to be effective in Japan, U.S. firms perceive patents to be less effective. Furthermore, when firms consider applying for patents abroad, the target country's ability to defend the patent's claims and rights is assessed before applying (Lemley and Shapiro, 2005). Yang and Kuo (2008) and Park (1999) show that a country with strong Intellectual Property Rights (IPRs) protection tends to receive more patent applications from foreign inventors.

Finally, our study has a particular focus on Canadian firms' patenting behavior. Only a few empirical studies have been conducted on the patenting behavior of Canadian firms. As is the case for the broader patent literature, most of this research has focused on why firms patent and the characteristics of firms that patent. In general, Canadian firms are less likely to view patents as effective instruments to protect their innovations, and are less likely to patent their innovations, than firms in other countries (Baldwin et al., 1999; Trajtenberg, 2000; Nikzad, 2013). In particular, Nikzad (2015) finds that Canadian small and medium size firms are less likely to apply for patents than comparable-sized firms in other countries.

Some empirical analysis documents the extent to which Canadian firms apply for patents at home versus abroad. Using data on a survey of innovation in Canadian manufacturing by Statistics Canada in 1999, Hanel (2005) finds that 65.8% of Canadian manufacturing firms apply for patents both in Canada and the U.S., 9.8% apply only in the U.S., 19.3% apply only in Canada, and 5.1% apply elsewhere. During the period from 1990 to 2008, Canadian applications account for only 13% of total applications at CIPO (Nikzad, 2011) and in 2010, domestic patent applications represented less than 15% of all patent applications in Canada, while the U.S. was the destination of 50% of Canadian applications (Nikzad, 2013). Similarly, Trajtenberg (2000) shows that less than half of Canadian patents are owned by Canadian applicants. However, the underlying explanations for these observations are rarely addressed in the patenting literature.

3 Econometric Framework

This section presents the econometric framework we use to address Canadian firms' decisions to patent, their locational patenting behavior and their use of PCT applications.

3.1 Canadian Firms' Decisions to Patent

When a firm has discovered an innovation, it has to decide whether to apply for a patent. For the empirical analyses, we define $Patent\_us_{ijpt}$ as the number of patent applications by firm i that belongs to industry j and operates in province p in year t at USPTO, and $Patent\_ca_{ijpt}$ at CIPO.[2] Consequently, $Patenting_{ijpt}$ can be constructed as follows

$$Patenting_{ijpt} = \begin{cases} 0 & \text{if } Patent\_us_{ijpt} = 0 \text{ and } Patent\_ca_{ijpt} = 0, \\ 1 & \text{if } \max(Patent\_us_{ijpt}, Patent\_ca_{ijpt}) > 0. \end{cases}$$

To decide whether to patent, the firm will evaluate the net benefit from patenting. Let an underlying latent variable $Patenting^*_{ijpt}$ denote the net benefit between the choice to patent and not to patent for firm i that belongs to industry j and operates in province p in year t. The observable variable $Patenting_{ijpt}$ as defined is associated with this latent variable in the following way,

$$Patenting_{ijpt} = \begin{cases} 1 & \text{if } Patenting^*_{ijpt} > 0, \\ 0 & \text{Otherwise.} \end{cases}$$

For each firm i, $i = 1, ..., N$ in year t, $t = 2000, ..., 2008$, the latent variable is determined by an independent variable vector X_{ijpt} such that

$$Patenting^*_{ijpt} = X_{ijpt}\alpha + \delta_j + \delta_p + \delta_t + \varepsilon_{ijpt},$$

where α is a parameter vector, δ_j, δ_p, and δ_t are the industry, province and year fixed effects, and ε_{ijpt} is an error term following the logistic distribution.

[2] As described later, we only consider patent applications that are ultimately granted because we only have access to USPTO data that have information on granted applications.

3.2 Decisions on Where to Patent

Our data are restricted to patenting by Canadian firms in Canada and the U.S. For this reason, our main empirical analysis of patenting location focuses on whether a Canadian firm patents in either Canada, the U.S., or both, without considering patenting in other countries. This can be justified by the fact that Canada and the U.S. are the destinations of the majority of Canadian applications; according to WIPO statistics, 74% of patent applications by Canadian firms went to one of these two countries during the period 2000-2008. Our approach to analyzing indirectly the decision of firms to apply for patents outside of Canada and the U.S., through the use of the PCT, will be discussed in Section 3.3 below. For the subsequent analysis, we define Canadian firms' locational patenting decisions, $App\_location_{ijpt}$ for firm i at year t as

$$App\_location_{ijpt} = \begin{cases} 1 & \text{if } Patent\_us_{ijpt} = 0 \text{ and } Patent\_ca_{ijpt} > 0, \\ 2 & \text{if } Patent\_us_{ijpt} > 0 \text{ and } Patent\_ca_{ijpt} = 0, \\ 3 & \text{if } Patent\_us_{ijpt} > 0 \text{ and } Patent\_ca_{ijpt} > 0, \end{cases}$$

where a value of 1, 2, and 3 means that at time t, firm i patents only at CIPO, only at USPTO, and at both USPTO and CIPO, respectively.

The latent variable $App\_location^*_{ijpt,k}$ denote firm i's profit associated with the kth choice, $k = 1, 2, 3$, at time t, where $k = 1$ refers to patenting at CIPO only, $k = 2$ to USPTO only, and $k = 3$ to both. The observable variable $App\_location_{ijpt}$ is determined as $App\_location_{ijpt} = k$ if $App\_location^*_{ijpt,k} = max(App\_location^*_{ijpt,1}, App\_location^*_{ijpt,2}, App\_location^*_{ijpt,3})$.

Given this setup, we assume that the latent variable $App\_location^*_{ijpt,k}$ is connected with the independent variables Z_{ijpt} in the following manner

$$\forall k \in (1, 2, 3) : App\_location^*_{ijpt,k} = Z_{ijpt}\beta_k + \delta_j + \delta_p + \delta_t + \mu_{ijpt,k},$$

where β_k is the coefficient vector that will be estimated and $\mu_{ijpt,k}$ is the error term capturing unobserved variation. Because of our definition of $App\_location_{ijpt}$, our dependent variable has three discrete outcomes: patent in Canada only, the U.S. only or both. Our analysis employs a Multinomial Logistic Regression model due to Chamberlain (1980). As shown in Maddala (1986), if $\mu_{ijpt,k}$ follows the type-1 extreme value distribution with density $f(\mu_{ijpt,k}) = exp(-\mu_{ijpt,k} - exp(-\mu_{ijpt,k}))$, the probability that firm i chooses the baseline patenting location (CIPO only) is

$$\Pr\left(App\_location_{ijpt} = 1 | Z_{ijpt}\right) = \frac{1}{1 + \sum_{k=2}^{k=K} e^{Z_{ijpt}\beta_k + \delta_j + \delta_p + \delta_t}}.$$

The probabilities of choosing the other two patenting locations (USPTO only and both CIPO and USPTO) are given by

$$\Pr\left(App\_location_{ijpt} = k | Z_{ijpt}\right) = \frac{e^{Z_{ijpt}\beta_k + \delta_j + \delta_p + \delta_t}}{1 + \sum_{k=2}^{k=K} e^{Z_{ijpt}\beta_k + \delta_j + \delta_p + \delta_t}}, \text{for } k = 2, 3.$$

This implies that we can compute the log-odds as follows

$$ln \frac{\Pr\left(App\_location_{ijpt} = k | Z_{ijpt}\right)}{\Pr\left(App\_location_{ijpt} = 1 | Z_{ijpt}\right)} = Z_{ijpt}\beta_k + \delta_j + \delta_p + \delta_t, \text{for } k = 2, 3.$$

Our objective is to empirically estimate β_k. The explanatory covariates Z_{ijpt} include all variables in X_{ijpt} and include variables measuring patenting experience and patent scope.

3.3 Canadian Firms' Use of PCT Filing

PCT is a multilateral treaty that includes more than 150 countries and is administered by WIPO to facilitate multinational patenting. Through PCT, a patent applicant is enabled to seek patent protection for his innovation in multiple countries. A PCT application first goes through a search and examination process by an ISA in an international phase, which will result in an International Search Report (ISR) on the potential patentability of the innovation. Upon receiving the ISR, the applicant decides whether to continue his patent applications at individual patent offices in an national phase.

Thus, applicants use PCT in order to facilitate patenting in foreign countries. As mentioned, Canadian firms appear to file patent applications in countries other than Canada and the U.S. through PCT. By investigating Canadian firms' use of PCT, we gain some insights about Canadian firms' patenting decisions outside of Canada and the U.S. To simplify notation, from now on, we omit jp and only keep it. We denote PCT_num_{it} as the number of applications filed through PCT and $Direct\_num_{it}$ the number of direct applications for firm i in year t. Similarly, we construct three filing choices,

$$PCT\_location_{it} = \begin{cases} 1 & \text{if } PCT\_num_{it} > 0 \text{ and } Direct\_num_{it} = 0, \\ 2 & \text{if } PCT\_num_{it} = 0 \text{ and } Direct\_num_{it} > 0, \\ 3 & \text{if } PCT\_num_{it} > 0 \text{ and } Direct\_num_{it} > 0, \end{cases}$$

where a value of 1, 2, and 3 indicates that in year t, firm i files PCT applications only, direct applications only, and both PCT and direct applications, respectively. With this definition, we will use a similar multinomial Logit model as described in Section 3.2. As we do not have information on whether a USPTO patent application was filed through PCT, we focus on CIPO data to investigate Canadian use of PCT program.

4 Data, Variable Construction, and Summary Statistics

We use data on Canadian firms' patenting activities in Canada and the U.S. as well as data on firm level and industry level characteristics. While patent data are from USPTO and CIPO, other data are obtained from Industry Canada and Statistics Canada. In the following sections, we present in detail the data sources and variable construction.

4.1 Data and Sample Construction

This study makes use of firm level panel data on Canadian firms over the period 2000-2008. Our data set merges information on firm characteristics with data on their patenting behavior. Data on Canadian firms come from the National Accounts Longitudinal Microdata File (NALMF), maintained by Statistics Canada. NALMF provides information on firms' business activities such as employment, locations where they operate, revenue, and total assets. Firm level variables are then linked to patent data from CIPO and USPTO.[3]

Patent data include information regarding application dates and grant dates. Our main sample contains 2,501 firms that obtained a total of 13,084 patents during the sample period (5,527 from CIPO and 7,557 from USPTO). Information on patent technological classifications used to construct patent scope as a proxy for the quality of patents was obtained using the EPO Worldwide Patent Statistical Database (PATSTAT) (Squicciarini et al., 2013). Data to measure business opportunities were obtained from Industry Canada for export and Statistics Canada for direct investment in the U.S. by industry.

Since USPTO data only report granted patents, for each firm we count the number of patent applications filed in each country during a given year that were eventually granted. As the application year better captures when the innovation has been discovered (Griliches et al., 1986), our analysis is based on application years. After an application is submitted, it will be examined automatically at USPTO. In contrast, to be examined at CIPO, an applicant needs to submit a request for examination. An examination request can be submitted within five years of filing. To adjust for this difference, for USPTO patent data, we count the number of patents granted by 2011 and for CIPO patent data, we count the number of patents granted by 2014. After 2008, the number of patent applications declined sharply due to truncation issues. In our regression analyses, we use data for the period 2000-2008.

[3]The NALMF dataset only contains data on Canadian firms. Therefore, we do not make use of data on patents applied for or held by individuals and universities. Overall, this restriction removes approximately 20 percent of observations in the patent level data set.

4.2 Variable Construction

In this subsection, we describe how the variables are constructed. We identify factors at the firm and industry level, with a special attention to business opportunity measures. Definitions of all variables are summarized in Table 1.

Insert **Table 1: Definition of Variables**

Characteristics of Firms

Patent Scope: No consensus has been reached in the patent literature on how to measure the quality of a patented innovation. Due to data limitations, we adopt Squicciarini et al. (2013)'s approach to measure firms' innovation quality based on 'patent scope', which corresponds to the number of International Patent Classification (IPC) codes listed in a patent description by patent offices. IPC is a hierarchical system for the classification of patents according to the different areas of technology to which they pertain. Our first measure ($average\ patent\ scope_{it}$) is the average scope of patents filed by firm i in year t. The second measure ($maximum\ patent\ scope_{it}$) is the maximum number of 4-digit IPC classes into which one of the firm i's patents falls in year t. As IPC assignment at USPTO and CIPO may be different, we weight our patent scope measures by the average number of patent scopes at each patent office annually.

Patenting Experience: Patenting experience is expected to influence patenting decisions in two ways. First, firms with more patenting experience are more likely to be innovative and have more innovations to patent. Second, experienced firms have accumulated valuable knowledge of the patent system (patentability, application filing, etc.) where they have been patenting. As a result, firms are more likely to patent in a location where they have experience. To measure patenting experience at each of CIPO and USPTO, we use the variables $experience\ at\ CIPO_{it}$ and $experience\ at\ USPTO_{it}$, which count the total number of patents applied at each office during the past five years. We expect that greater experience at

CIPO (respectively, USPTO) will more likely induce a firm to patent at CIPO (respectively, USPTO).

Firm Age: We measure firm age by the natural logarithm of the number of years since its establishment in year t, $log(firm\ age+1)_{it}$. Firm age has been related to firms' patenting (Balasubramanian and Lee, 2008; Kotha et al., 2011; Coad, 2018). However, its effect on firms' locational patenting is not explored in the literature. We investigate the potential effect of firm age on locational patenting in our empirical analysis.[4]

Firm Size: Firm size is an important factor in patenting behavior. While the literature has widely found that large firms are more likely to have patentable innovations and to patent, the effect of firm size on locational patenting decisions has been rarely discussed. We measure firm size by the logarithm of total number of employees $log(employee)_{it}$ and the logarithm of total assets $log(total\ assets)_{it}$. As large firms are more likely to have business activities across countries, we expect that large firms are more likely to patent in both Canada and the U.S.[5]

Country of Control: The ownership structure of a firm is related to firms' locational patenting (Baldwin, 1997). To differentiate Canadian-owned firms from firms owned by foreign entities, we create a dummy $Canadian\ control_{it}$. This variable equals 1 if a firm is registered in Canada and owned by a Canadian entity; it equals 0 if a firm is registered in Canada but is owned by a foreign entity.

R&D Intensities: We measure firms' R&D intensity as a ratio between total R&D expenses and total assets, $R\&D\ intensity_{it}$. We expect that R&D intensive firms are more likely to use patents to protect their innovations as patenting is positively related to R&D expenditure (Lerner and Zhu, 2007). As patenting in multiple countries makes it possible to appropriate extra revenue from innovations, we expect that an increase in R&D expenditure

[4]We have explored if the effect of firm age is monotonic by including a squared term in the regressions. It turns out that the squared term is not significant. In what follows, we keep firm age in its logarithm form.

[5]We have explored if the effect of firm size is monotonic by including a squared term in the regressions. It turns out that the squared term is not significant. In what follows, we keep firm size in its logarithm form.

would increase firms' decisions to patent in both countries.[6]

Profitability: We measure $profitability_{it}$ as the ratio between gross profit and total assets. The effects of profitability and market power on the incentives to patent are ambiguous in the literature.

Financial Constraints: As small firms are more likely to face financial constraints, both CIPO and USPTO have different fee structures for small firms. Specifically, application fees for small firms are half of these for large firms at CIPO and USPTO. To control for the impact of such a constraint, ideally we should look at cash flow of a firm. However, because we do not have data on cash flow, we use the $debt\ ratio_{it}$ between total liabilities to total assets as a proxy, which allows us to mitigate the potential correlation between firm size and firm liabilities. A large debt ratio might imply heavy financial burdens, leading to firms' reluctance to patent or to patent in multiple locations.[7]

Industrial Characteristics

Business Opportunities: As discussed in the literature review, incentives to patent in a country are linked to business opportunities in that country. We construct two measures of business opportunities at industry level. We only focus at industry level as we do not have data on exports and FDI at the firm level. Our first business opportunity measure, $log(industrial\ export)_{it}$, is the natural logarithm of annual exports of Canadian products to the U.S. of firm i's 3-digit North American Industry Classification System (NAICS) industry. It is a proxy for the demand for Canadian products in the U.S. as exporting involves production in Canada but selling products in the U.S. To protect innovations embedded in these exporting products, we expect that Canadian firms in export intensive industries might be more likely to patent in both countries.

For our second business opportunity measure, we consider $log(industrial\ FDI)_{it}$, which

[6]The logarithm of R&D expenditure is also used to indicate R&D intensity. As the results are consistent, in all regressions, we use the current definition.

[7]The ratio of total current liability and total current assets is alternatively used. The results will remain, so we use the current definition in all regressions.

is the natural logarithm of the annual FDI in the U.S. of firm i's 3-digit NAICS industry. This measure captures Canadian firms' business prospects in the U.S. As production through FDI will take place in the U.S., we expect that Canadian firms in FDI intensive industries are more likely to patent in the U.S.

Industry Concentration: We measure industry concentration through a Herfindahl-Hirschman Index (HHI_{it}) at the 3-digit NAICS level. The predicted effect of industrial concentration on the incentives to patent is ambiguous. On the one hand, monopoly power brings profits to firms; in order to maintain their monopolistic position and avoid losing monopoly power to innovating entrants, firms might have incentives to patent (Gilbert and Newbery, 1982). This implies that firms in a concentrated industry might be more likely to patent. On the other hand, in a monopolistic market, firms may have less incentive to innovate for two reasons. First, the marginal gains from innovations in a competitive market are larger than in a monopolistic market. Second, if a monopoly firm introduces a new innovation, it may displace part of its existing monopoly rents (Arrow, 1962; Cohen, 2010).

Policy Changes at CIPO

In July 2004, CIPO became the ISA for PCT applications filed by Canadian firms at CIPO.[8] This new service was expected to reduce the costs of obtaining foreign patents for Canadian firms; meanwhile, improved information technology infrastructure and increased examination capacity may also have encouraged Canadian firms to submit more patent applications at CIPO (Paquet and Roy, 2005). In addition, Canadian applicants might be in contact with the same examiner during the international and national phases.[9] This could make it easier for Canadian firms to obtain patents through the PCT program.

On the one hand, firms that have been patenting at CIPO might be aware of changes

[8]CIPO's application to be an ISA was approved by WIPO in 2002 but started its service as an ISA in July 2004.

[9]Archived Joint Liaison Committee – Meeting #126, https://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr03542.html. Last assessed January 18, 2019.

in the patent system and, thus, be more likely to respond to CIPO's role as an ISA than firms that have never patented at CIPO. On the other hand, if lawyers are drafting patent applications for their clients, they will be well aware of the changes at CIPO. In the latter case, firms patenting at CIPO may not necessarily have a different response from firms that have never patented at CIPO. In this paper, we investigate whether CIPO's role as an ISA has an impact on firms' patenting at CIPO. To do so, we compare two group of firms. The first group contains firms that have applied for at least one patent at CIPO during the period 1995-2003; the second group contains firms that did not apply for any patent during the same period. We generate a dummy variable, $CIPO\_2004_{it}$, which equals 1 for the first group and 0 for the second group. We also generate a dummy variable, ISA_{it}, which equals 1 for years after 2004. In our analyses, we include the interaction term, $isaxcipo_{it}$, which is the product of $CIPO\_2004_{it}$ and ISA_{it}. This interaction term allows us to investigate if firms patenting at CIPO react to CIPO's role as an ISA differently from those that did not patent at CIPO.

4.3 Locational Patenting Patterns and Summary Statistics

Table 2 shows the distribution of patenting decisions by industry and location, where "CIPO" represents *App_location* = 1, "USPTO" represents *App_location* = 2 and "Both" represents *App_location* = 3. Panel A represents the frequencies of patenting locations by industry over the sample period. For each industry, we display the frequencies of each of these three locational patenting choices: CIPO only, USPTO only, and both. Industries with less than 10 observations are combined as "Other industries". For instance, in the construction industry, 41 observations (patenting firm-year) correspond to firms that patented at CIPO only, 37 at USPTO only and 14 at both CIPO and USPTO over the sample period.[10] Firms in most industries choose to patent at USPTO only and then at CIPO only, except for firms in the construction industry and the mining, quarrying, and oil and gas extraction industry

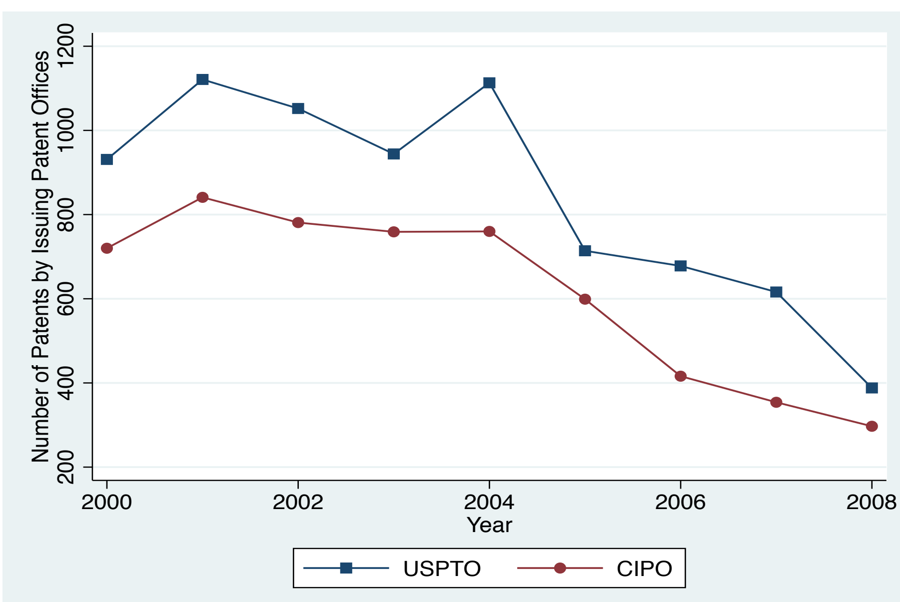
[10]Note that it could the same firm in different years.

who are more likely to patent at CIPO only. Only a small fraction of firms choose to patent at both USPTO and CIPO.

Insert **Table 2: Distribution of Patenting Decisions by Industry and Location**

To understand the patenting intensity in each industry by different patenting locations, Table 2 Panel B calculates the number of patents corresponding to each incidence in Panel A. For instance, consider again the construction industry, 45 CIPO patents have been granted to the 41 observations (patenting firm-year) of Panel A. Panel B shows that firms that apply for patents at both USPTO and CIPO file the largest fraction of total patent applications. Another pattern is that patents are largely concentrated in the manufacturing industry and the industry providing professional, scientific and technical services, even though these two industries show a rather different locational patenting behavior. Manufacturing firms patent intensively in both countries, whereas firms providing professional, scientific and technical services patent more at USPTO only. These differences might be due to the fact that business methods are more likely to be patented at USPTO. In contrast, firms in the mining, quarrying, and oil and gas extraction industry patent more widely at CIPO only. The remaining categories do not show evident differences across these three patenting locations.

Figure 1: Total Number of Patents Granted at Patent Offices to Canadian Firms



To visualize the trend of locational patenting over time, Figure 1 plots the number of granted patents by USPTO and CIPO during 2000-2008. It shows that Canadian firms are granted more U.S. patents than Canadian patents; on average the number of U.S. patents granted to Canadian firms is 1.4 times that of Canadian patents. In our sample, we focus on application dates of granted patents and therefore as granting decisions take patent offices a few years to complete,the declining in late years is caused by the truncation issue.[11]

Figure 2 plots the number of firms that apply for patents at CIPO only, USPTO only and both offices during the period 2000-2008. This figure shows that over time, more Canadian firms apply for patents at USPTO than at CIPO. The number of firms patenting in both countries has declined after 2004, while the number of firms that patent at CIPO only has increased in 2005 before declining after 2005. Meanwhile, the number of firms patenting at USPTO only experienced a slight decrease in 2005 and a moderate increase in 2006 and then started to decline after 2006. Overall, in terms of the number of firms, USPTO was the patenting choice for the largest fraction of Canadian firms.

Figure 2: Distribution of Patenting Firms by Patenting Locations

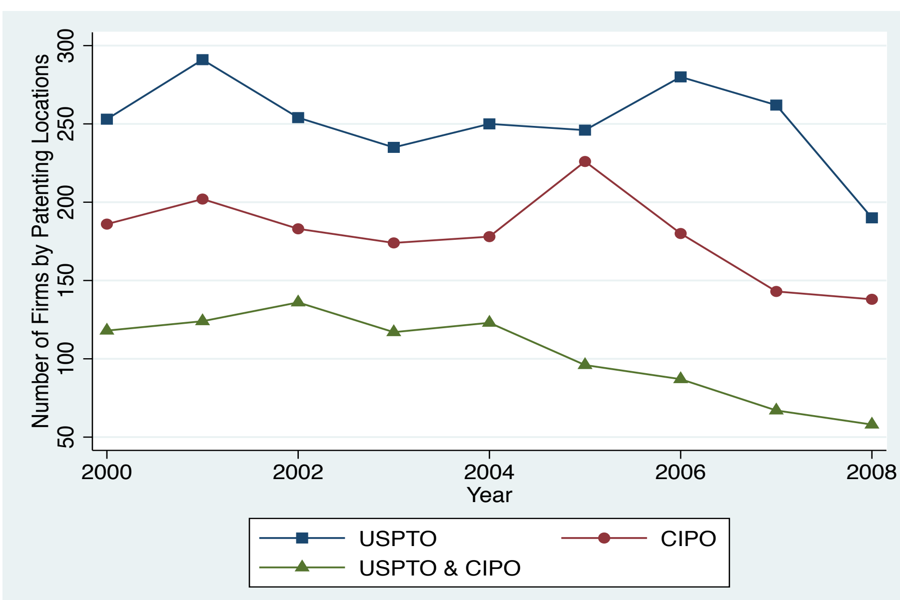


Table 3 provides summary statistics to compare non-patenting firms and patenting firms.

[11]We carry out a robustness check in the subsequent section regarding the truncation issue.

Even though the data set from NALMF contains data on all Canadian firms, only a small fraction of them are patenting (roughly 0.1%). The numbers indicate that compared with non-patenting firms, patenting firms are older, larger, and are in more concentrated industries. Patenting firms spend more on R&D, and on average they have a lower profitability than non-patenting firms. There is no substantial difference in debt ratio between patenting and non-patenting firms.

Insert **Table 3: Summary Statistics for Non-patenting Firms and Patenting Firms**

5 Results

This section summarizes the key findings from the empirical estimation of our econometric models. For each regression, we tested for the presence of multicollinearity using the Variance Inflation Factors (VIF). For all reported specifications, the VIF scores are below 5, suggesting that there are no strong correlations among the independent variables that may bias our estimations. As our data are highly unbalanced, with over 50% of firms appearing only once, serial correlation should not be a concern. In addition, we carried out the score test proposed by Gourieroux et al. (1985) and no serial correlation was detected in our models.

We explore several factors that may be related to Canadian firms' patenting behavior. Among these factors, firms' profitability and debt ratios may be affected by unobservable factors. For example, the province of Ontario has a strong relationship with the U.S. in the auto industry. Changes in the economic conditions of the U.S. will likely have a more sizable impact on firms' profitability in the auto industry than firms in other sectors of other provinces. We include industry fixed effects, year fixed effects, and province fixed effects to mitigate the endogeneity concern.

Our analysis starts with Canadian firms' decisions to patent. Then, we study Canadian firms' locational patenting choices. We end our empirical analysis with a focus on Canadian firms' use of PCT, with a particular attention on CIPO's role as an ISA. As shown in Table 2 Panel B, about 58% of patents were applied by manufacturing firms. In addition, manufacturing firms are more likely to export to foreign countries. As a robustness check, we compare the results using the whole sample and the sub-sample of manufacturing industries. All the regressions control for the industry fixed effects, the province fixed effects and the year fixed effects.[12]

5.1 Canadian Firms' Decisions to Patent

Table 4 Panel A reports estimates of the factors affecting firms' patenting decisions using the whole sample. Our results suggest that newly established firms, large firms, and Canadian controlled firms are more likely to protect their innovations with patents. Likewise, while profitable firms are reluctant to patent, firms with intensive R&D are inclined to patent. The coefficient of the dummy variable *isaxcipo* is negative and statistically significant, suggesting that Canadian firms that have been patenting at CIPO are less responsive to CIPO's role as an ISA than those that have never patented at CIPO. This suggests that CIPO's role as an ISA is associated with an increase in the propensity of Canadian firms to patent.

Insert **Table 4: Regressions on Canadian Firms' Decisions to Patent**

Table 4 Panel B reports the estimates focusing on manufacturing industries, where we have included two more variables (industrial export and FDI) in our regression analysis to capture the potential effects of business opportunities. Overall, results of manufacturing industries are consistent with those of the whole sample. One difference is that the coefficient of *isaxcipo* becomes insignificant. Firms in manufacturing industries have intensively patented in both countries, so they may not be responding to CIPO's role as an ISA. In

[12] As the number of observations in the provinces Newfoundland and Labrador (NL), Prince Edward Island (PE), Yukon (YT) and Nunavut (NU) is very small, we exclude observations in these provinces. In the empirical analysis, we control for two digits NAICS fixed effects. However, as a few industries have a very small number of observations, we combine a few industries according to their similarities. In particular, we combine NAICS 44 and 45 together to represent retail trade, NAICS 48 and 49 to represent transportation and warehousing and NAICS 61 and 62 to represent educational and other social assistance services.

addition, the probability of a firm deciding to patent is positively associated with the industrial export of the manufacturing sector, whereas firms in FDI intensive sectors do not show a preference for patenting.

Results in Table 4 are based on all firms with available information. One concern is that the fraction of patenting firms is very small. There might be two reasons for a firm to have no patents. On one hand, the firm does not do any R&D and has no innovation to patent. On the other hand, the firm might have done R&D, but might have decided not to patent. The first situation may result in an overestimation of firms' decisions to not patent. In order to mitigate such a potential problem, we re-estimate Canadian firms' decisions to patent by considering firms that have patented or have done some R&D during our study period (we call those firms innovating firms).

With this treatment, the number of observations is reduced from 3,998,293 to 230,444 for the whole sample, and from 322,747 to 80,521 for the manufacturing industries as shown in Table 5. This suggests that only a very small fraction of Canadian firms reported that they were doing R&D or applied for patents during our study period. Table 5 also suggests that our findings are not sensitive to how many non-patenting firms are included in our sample. While the results are consistent, the only exception is the impact of the industrial export. This suggests that for R&D intensive firms, the impact of R&D may dominate the impact of industrial export.

Insert **Table 5: Regressions on Decisions to Patent by Canadian Innovating Firms**

5.2 Canadian Firms' Locational Patenting Decisions

5.2.1 Individual Patenting Locations

Table 6 presents the average marginal effects of multinomial Logistic regression models for firms' locational patenting choices. Overall, firm characteristics such as firm age, country of control, patenting experience, profitability, R&D intensity, patent scope, firm size, industrial export, FDI as well as CIPO's role as an ISA are significant factors affecting Canadian firms' locational patenting behavior.

Table 6 Panel A reports results based on the whole sample. First, the estimates imply that on average with one percent increase in firm age, the probability of a firm patenting at CIPO only will decrease by 1.41%. However, from the marginal effects, we have no further evidence on whether these firms tend to patent at USPTO only or patent in both countries. As well, firms with innovations of broader patent scope are less likely to apply for patents in the U.S. only. Instead, these firms have a strong incentive to patent in both countries.

Second, the more patents a firm has obtained at USPTO (respectively, CIPO), the more likely the firm will patent only at USPTO (respectively, CIPO) and the less likely it will patent only at CIPO (respectively, USPTO). This suggests that Canadian firms may stick to their locational patenting decisions. In other words, firms that have been intensively patenting at one patent office are less likely to stop applying at this office. Moreover, the patenting experience may also reflect the fact that those firms had business activities in the past. Nonetheless, patenting experience at either patent office increases firms' likelihood to patent in both countries.

Third, firms with intensive investment in R&D tend to patent at USPTO only rather than at CIPO only. However, there is no evidence to indicate whether these firms are more likely to patent in both countries. This may suggest that firms with intensive R&D are more likely to produce or sell in larger markets, the U.S. market or the U.S. and Canadian markets rather than the Canadian market only. Moreover, the coefficients of *isaxcipo* are significantly positive for decisions to patent in Canada only, but significantly negative for the decisions to patent at both offices. This would suggest that CIPO's role as an ISA might have encouraged Canadian firms to apply for more patents at CIPO, which in turn may have reduced firms' patenting at USPTO.

Furthermore, our results also suggest that one percent increase in firm size increases the probability of a firm patenting at CIPO only by 2.41% but decreases the probability of a firm patenting at USPTO only by 2.12%. Although we expect that large firms are more likely to patent in both countries, we do not find evidence to support this argument. However, our finding is consistent with Hanel (2005) who finds that large firms are less likely to patent in both countries. This suggests that large firms operating in Canada depend on CIPO to protect their innovations (Paquet and Roy, 2005).

Insert **Table 6: Multinomial Locational Choice Regressions**

Table 6 Panel B reports results for manufacturing industries. While the results are consistent with those in Panel A, a few differences are worth noting. First, the results suggest that older manufacturing firms tend to patent in both countries rather than in Canada only. Second, firms in FDI intensive industries are more likely to patent at CIPO only and less likely to patent in both countries, whereas firms in export intensive industries are less likely to patent at USPTO only and more likely to patent in both countries. Furthermore, profitability and Canadian control are not significantly associated with locational patenting choices of manufacturing firms. As well, firms debt ratio and industrial concentration do not have significant impacts on locational patenting decisions for the whole sample and manufacturing firms.

5.2.2 Patenting Abroad Against Patenting at Home

One advantage of multinomial Logit regression models is that it allows us to compare individual choices to a baseline choice. This comparison can be realized by calculating the relative risk ratio of multinomial Logit regressions. If the relative risk ratio of a variable for an individual choice is larger than 1, it means that its impact on this individual choice is larger than that on the baseline choice. Table 7 reports the relative risk ratio of the multinomial Logit model with patenting at CIPO only as the baseline choice.

Results in Table 7 indicate what factors are associated with Canadian firms' patenting at home but not abroad. In particular, the first columns of Panel A and B report the corresponding relative risk ratio for the multinomial Logit regressions in Table 6. The other columns report results with alternative measures of firm size and patent scope. The results show that our findings are robust to alternative measures of these two variables.[13]

The results suggest that with reference to patenting at CIPO only, Canadian firms' decisions to patent in the U.S. are significantly affected by their patenting experience and R&D intensity. Likewise, compared with domestic patenting, large firms are less likely to patent in the U.S. only or patent in both countries. This could suggest that thanks to large production scale, these firms might produce at lower costs than their rivals. As a result, even if they only patent at CIPO, their competitors cannot compete with them due to a lack of scale efficiency. However, production scale is out of the scope of this study and we cannot confirm if scale efficiency is the actual reason.

In addition, our results suggest that as a firm operates on the market longer, or if it has innovations of broader patent scope, it is more likely to patent in both countries. Regarding the potential impacts of CIPO's role as an ISA, for firms that have been patenting at CIPO before 2004, they are less likely to patent in both countries. The estimates suggest that after 2004, the odds of a Canadian firm patenting in both countries is 57.20% of that in Canada only. Moreover, our results suggest that these firms seemed to be indifferent between patenting at CIPO only and USPTO only after CIPO became an ISA.

Insert **Table 7: Relative Risk Ratio of Multinomial Logit Regressions**

Panel B summarizes the findings for manufacturing industries. As the impacts of most of the variables are consistent, unlike the previous analysis we only focus on the impacts of industrial FDI and export. Our results suggest that firms in FDI intensive industries are less likely to patent in both countries. However, the relative risk ratios suggest that Canadian firms have no strong preference for patenting at CIPO only or at USPTO only. This may reflect the fact that firms patent their innovations in Canada first before going to

[13]We have run regressions by excluding the largest 5% and 10% of firms in our sample and results are consistent with current findings. In other words, our findings are not driven by extremely large firms.

the U.S. through FDI or they patent their FDI products directly at USPTO. As our data is highly unbalanced and we cannot keep track of the same innovation at CIPO and USPTO, we cannot confirm this finding. Besides, if a Canadian firm uses FDI, it may have a U.S. subsidiary and if patents are filed by these subsidiaries, we may underestimate the patenting of the firms in the U.S. In other words, with our data we cannot observe patenting in the U.S. by FDI subsidiaries.

5.3 Canadian Firms' PCT Use

5.3.1 Canadian Firms' Patent Filing Strategies

This section focuses on how Canadian firms are using PCT for patent applications. Specifically, we investigate how firms make decisions to file their patent applications: PCT applications only, direct applications only, or both PCT and direct applications. While a PCT application at CIPO may not ultimately go to a foreign patent office, to some extent it suggests the applicant's intention to do so. Consequently, a firm's use of PCT may indicate that it might intend to apply for a foreign patent in the future. Table 8 reports the average marginal effects of multinomial Logit models for Canadian firms' filing strategies. Panel A uses the whole sample and Panel B focuses on manufacturing sectors. The results for manufacturing industries are in general consistent with the findings from the whole sample.

First, we find that older firms, Canadian controlled firms, profitable firms, and firms with greater experience at CIPO are less likely to file PCT applications only. Likewise, firms with broad patent scope, large debt ratio, and high R&D intensity are more likely to file PCT applications. The coefficient of *isaxcipo* is significantly positive, suggesting that CIPO's role as an ISA might have induced firms to use more PCT applications.

Second, regarding Canadian firms' decisions to file direct applications only, our results suggest that while firm age, Canadian ownership, profitability show positive impacts, the effects of R&D intensity, patent scope, firm size and CIPO's role as an ISA are negative. Except for firm size, the effects of other variables on the decisions to file PCT applications only are different from the effects on the decision to file direct applications only.

Finally, we consider the case of using both PCT and direct applications together. Older firms are less likely to use both channels to apply for patents, whereas experienced and large firms are more likely to use both. While debt burdens do not have a strong effect on firms' choice of direct applications only, it suggests a strong negative impact on the choice of filing through both channels. Additionally, we find that firms in FDI intensity industries are more likely to use both PCT and direct applications or PCT applications only. Conversely, no significant impacts of export are found.

Insert **Table 8: Multinomial Logit Regressions on Canadian Firms Use of PCT**

5.3.2 PCT Applications versus Direct Applications

To compare individual choices to a baseline choice, Table 9 reports the relative risk ratio of multinomial Logit models in Table 8. In this analysis, we compare PCT applications only and both PCT and direct applications with direct applications.

First, compared to direct applications only, large firms are more likely to file both PCT and direct applications. In Section 5.2, we found that large firms are less likely to patent at USPTO only. This suggests that Canadian firms probably do not apply for USPTO patents through PCT at CIPO. In other words, PCT may be used by Canadian firms to apply for CIPO patents or patents in countries other than Canada and the U.S.

Second, older and profitable firms, and Canadian controlled firms are more likely to file direct applications than PCT applications. Firms with greater patenting experience are more likely to file PCT and direct applications. Nonetheless, firms with higher debt ratio seem to be less likely to use both application channels. Instead, they are more likely to use direct applications only rather than PCT applications.

Third, as firms devote more resources to R&D, they are more likely to have patentable innovations. Our results suggest that compared with direct applications only, R&D intensive firms are more likely to patent through PCT applications. Furthermore, they do not even consider using both PCT and direct applications together.

Moreover, our results suggest that after CIPO became an ISA, Canadian firms who have been patenting at CIPO are more likely to file PCT applications than direct applications. This further suggests that Canadian firms are responsive to CIPO's new role as an ISA and take advantage of changes in the patent system. Besides, firms with broad patent scope are more likely to patent through PCT applications with potential consideration to patent in multiple countries.

In the case of manufacturing industries, our finding indicates that firms in FDI intensive industries are more likely to use PCT applications or PCT and direct applications together. However, firms in export intensive industries do not show a strong preference for the use of PCT or direct applications.

Insert **Table 9: Relative Risk Ratio of Multinomial Logit Regressions for PCT**

6 Robustness

For all multinomial Logit regressions, we carry out corresponding Logit regressions by combining either two of these three locational choices. Estimations from binary dependent variables are consistent with the previous analysis so we do not report results from the Logit models. As there is a time lag between application date to grant date, it is possible that firms in our sample have more patent applications than the number of patents used in our analysis. In this section, we carry out a set of robustness checking regressions to investigate whether our findings are sensitive to the number of patents included in our sample.

First, we only have data from USPTO on patents that are granted by 2011. Although we have data on non-granted patents from CIPO, our analysis is based on granted patents from CIPO. To investigate if including only granted patents affects our analysis, we add data on non-granted CIPO patents. The results are reported in the first column of Table 10. Our results based on only granted CIPO patents are highly consistent with those based on all

CIPO patents. The results suggest that our findings are not sensitive to how many patents a firm holds in one location. As long as the firm has more than one patent in a location, our analysis will not be affected.

Second, USPTO and CIPO differ in terms of their examination procedure, patentability and granting lag. In our data, some patents were granted within one year, whereas others were granted after more than 10 years. To test if our study is sensitive to the grant lags, we construct a data set by excluding patents with grant lags of more than five years, which is roughly one standard deviation above the average granting lags. The results, reported in the second column of Table 10, show that our findings are not sensitive to grant lags.

Third, we shorten our study sample by cutting data in 2000 and 2008. The results with data for the period 2001-2007 are reported in the third column of Table 10. The findings are consistent with our main findings.

As an additional robustness check, we re-estimate the model using lagged values of firm characteristics in the last column of Table 10. As our data is highly unbalanced with more than half of the firms that only appear once in our data set, our sample size will be reduced substantially with lagged terms. We make use of firms that appear at least twice to check if there are systematic differences. As shown in the last column of Table 10, a few variables become insignificant. This sub-sample represents firms that frequently patent. This indicates that for firms frequently using patents, they seem to consider fewer factors than those who patent less often.

Insert **Table 10: Regressions on Robustness Checking**

7 Conclusion

Locational patenting behavior at firm level has been rarely studied due to data limitation. Using firm level patent data for the 2000-2008 period, we document the effects of industry level factors that affect business opportunities and profitability, firm level factors such as firm age, firm size, and changes in patent system procedures and rules on locational patenting decisions. Our analysis is descriptive in nature. Thanks to a unique dataset at the firm level, we can analyze the determinants of locational patenting behavior of Canadian firms.

Overall, Canadian firms tend to be more likely to patent at the office with which they have past experience. Moreover, as a firm accumulates more patents both from CIPO and USPTO, it will probably patent at both USPTO and CIPO. Patent scope plays an important role in firms' decisions of where to patent. Our analysis suggests that Canadian firms with innovations of wider patent scope are more likely to patent in both countries. The longer a firm has operated in the market, the more likely it will patent in both countries. This finding might suggest that patent offices may consider providing younger firms preferential treatments to encourage them to innovate and patent.

We have studied firms' locational patenting decisions in manufacturing industries. When interaction with the U.S. economy is considered, R&D expenditure becomes an important consideration. The findings indicate that an increase in R&D expenditure is associated with an increase in a firm's decision to patent at USPTO only. Besides, large firms are reluctant to patent at USPTO only. Instead, our results indicate that large firms have a tendency to patent at CIPO only. Our findings are robust to different measures of firm size, total asset and total number of employees. Additionally, we find that manufacturing firms in export intensive industries are more likely to patent in both countries, firms in FDI intensive industries are more likely to patent domestically. However, limited by data availability, we cannot identify the impacts of firms' decision to export or use FDI. This can be a potentially important area to explore when data are available.

CIPO's role as an ISA has motivated Canadian firms to use PCT, which induced Canadian firms to patent at CIPO, although the evidence is weak. Possibly the intuition is that with CIPO's new role, it might be easier for Canadian firms to obtain patents through PCT. The focus of this paper is to investigate the factors influencing Canadian firms' locational patenting decisions, so we do not explore in details the potential impacts of CIPO's new role as an ISA. However, this issue deserves to be studied, especially as we find strong evidence that after CIPO became an ISA, Canadian firms sharply reduced their applications in both countries.

Finally, while our analysis helps understand how the locational patenting decisions are related to firm and industry characteristics and CIPO's role as an ISA, it has several limitations due to data availability. When data are available, some areas for future research could be explored. For instance, for a firm that has patented in multiple countries, it would be insightful to investigate where it patents a particular innovation, and where the innovation is patented first if multiple locations are chosen. It may be more accurate and informative to study the impact of patent quality at the patent level rather than at firm level. As well, if data are available, it would be interesting to explore the relationship between firms' decisions to export or use FDI and decisions to patent internationally. In addition, in this paper, we include a dummy variable to capture CIPO's role as an ISA. However, given the current data set, we cannot make causal inference on the impact of an ISA on patenting behavior. As ISA is an important policy initiative for collaboration among patent offices worldwide, it deserves to be investigated further.

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Table 1: Definition of Variables

Variables	Definition
Patenting Variables	
$Patent\_ca_{it}$	Count of granted patents filed by firm i at CIPO in year t
$Patent\_us_{it}$	Count of granted patents filed by firm i at USPTO in year t
PCT_num_{it}	Count of patent applications filed through PCT by firm i at CIPO in year t
$Direct\_num_{it}$	Count of patent applications directly filed at CIPO by firm i in year t
$Patenting_{it}$	Dummy variable, which equals 1 if firm i applies for patents at t
$App\_location_{it}$	Multinomial locational patenting: USPTO only, CIPO ony, and both
$PCT\_location_{it}$	Multinomial application filing choice: PCT only, Direct only, and both
Firm Characteristics	
$Canadian\ control_{it}$	Dummy variable that indicates if firm i is Canadian controlled
$log(employee)_{it}$	Natural logarithm of employees
$log(total\ assets)_{it}$	Natural logarithm of total assets
$experience\ at\ CIPO_{it}$	Number of patents filed at CIPO in the past 5 years
$experience\ at\ USPTO_{it}$	Number of patents filed at USPTO in the past 5 years
$R\&D\ intensity_{it}$	Ratio of R&D expenditure to the amount of tangible asset
$Debt\_ratio_{it}$	Ratio of total liabilities and total assets
$log(firm\ age+1)_{it}$	Number of years since the firm was established
$profitability_{it}$	Return on assets ratio defined as gross profits divided by total assets
$Average\ patent\ scope_{it}$	Average number of distinct 4-digit subclass of the International Patent Classification (IPC) of patents filed in year t
$maximum\ patent\ scope_{it}$	Maximum number of distinct 4-digit subclass of the International Patent Classification (IPC) of one of patents filed in year t, adjusted by average of year-industry patent scope at CIPO and USPTO
HHI_{it}	Herfindahl-Hirschman Index: sum of squared market share of each firm in the same industry. This index is multiplied by 100 to adjust for the magnitude of estimators
$log(industrial\ export)_{it}$	Canadian export to the U.S. in the 3-digit NAICS industry that firm i belongs to in year t, in millions of Canadian dollar
$log(industrial\ FDI)_{it}$	Canadian investment in the U.S. in the 3-digit NAICS industry that firm i belongs to in year t, in millions of Canadian dollar
Characteristics of CIPO	
$isaxcipo_{it}$	Dummy variable indicating firms that have been patenting at CIPO, for years after 2005

Table 2: Distribution of Patenting Decisions by Industry and Location

	Panel A: by frequencies				Panel B: by patents			
	CIPO	USPTO	Both	Total	CIPO	USPTO	Both	Total
Construction	41	37	14	92	45	40	43	128
	(45%)	(40%)	(15%)	(100%)	(35%)	(31%)	(34%)	(100%)
Manufacturing	839	993	501	2333	1625	2072	3893	7590
	(36%)	(43%)	(21%)	(100%)	(21%)	(27%)	(51%)	(100%)
Wholesale trade	129	172	61	362	185	234	244	663
	(36%)	(48%)	(17%)	(100%)	(28%)	(35%)	(37%)	(100%)
Information and cultural industries	37	68	16	121	78	111	86	275
	(31%)	(56%)	(13%)	(100%)	(28%)	(40%)	(31%)	(100%)
Mining, quarrying, and oil and gas extraction	76	66	61	203	598	102	257	957
	(37%)	(33%)	(30%)	(100%)	(62%)	(11%)	(27%)	(100%)
Professional, scientific and technical services	345	714	195	1254	501	1249	744	2494
	(28%)	(57%)	(16%)	(100%)	(20%)	(50%)	(30%)	(100%)
Health care, educational services and social assistance	33	58	18	109	49	183	77	309
	(30%)	(53%)	(17%)	(100%)	(16%)	(59%)	(25%)	(100%)
Administrative and support, waste management, remediation services	20	23	11	54	23	29	23	75
	(37%)	(43%)	(20%)	(100%)	(31%)	(39%)	(31%)	(100%)
Other industries	90	130	49	269	151	186	256	593
	(33%)	(48%)	(18%)	(100%)	(25%)	(31%)	(44%)	(100%)
Total	1610	2261	926	4797	3255	4206	5623	13084
	(34%)	(47%)	(19%)	(100%)	(25%)	(32%)	(43%)	(100%)

Notes: Numbers are aggregated over the period 2000-2008. Percentages are reported in parentheses. Industry classification follows the North American Industry Classification System (NAICS) Canada 2012.

Table 3: Summary Statistics for Non-patenting Firms and Patenting Firms

	Non-patenting Firms	Patenting Firms
log (firm age+1)	1.9763 (0.8413)	2.0094 (0.8323)
Canadian control	0.9949 (0.0711)	0.9742 (0.1587)
debt ratio	0.7495 (0.7090)	0.7895 (0.9508)
profitability	0.8757 (0.7647)	0.3977 (0.4666)
R&D intensity	0.0049 (0.0572)	0.1177 (0.2482)
HHI	1.4921 (3.7353)	1.7266 (2.9755)
log(total assets)	12.6546 (1.7286)	16.3242 (2.8163)
log(employee)	1.4426 (1.1766)	4.0012 (2.1575)
isaxcipo	0.0002 (0.0158)	0.1019 (0.3026)
experience at CIPO		2.7690 (15.1123)
experience at USPTO		4.3142 (15.0144)
average patent scope		1.0406 (0.5774)
maximum patent scope		1.1806 (0.7521)
No. of observations	3994818	4797

Standard deviations are in parentheses. HHI index is multiplied by 100 to adjust for the magnitude of estimators

Table 4: Regressions on Canadian Firms' Decisions to Patent

This table reports average marginal effects of Logit models. The dependent variable is the dummy variable $patenting_{it}$. Panel A reports results using the whole sample of firms in all industries. Results in Panel B are restricted to firms in manufacturing industries. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	Panel A: All industries	Panel B: Manufacturing
log(firm age+1)	-0.4187***	-0.3276***
	(0.0320)	(0.0549)
Canadian control	0.5132***	0.4205**
	(0.1420)	(0.1827)
debt ratio	0.0236	0.0778
	(0.0291)	(0.0573)
profitability	-0.9581***	-0.7106***
	(0.0488)	(0.1010)
R&D intensity	1.8295***	1.7582***
	(0.0782)	(0.1651)
isaxcipo	-0.2130**	-0.1439
	(0.1063)	(0.1583)
HHI	0.0060	0.0085***
	(0.0011)	(0.0027)
log(employee)	1.0823***	1.1260***
	(0.0190)	(0.0329)
log(industrial FDI)		0.0520
		(0.0410)
log(industrial export)		0.2348***
		(0.0580)
No. of observations	3998293	322747
No. of firms	859923	65476

Table 5: Regressions on Decisions to Patent by Canadian Innovating Firms

This table reports average marginal effects of Logit models. The dependent variable is the dummy variable $patenting_{it}$. Panel A reports results using the whole sample of firms in all industries that have done R&D. Results in Panel B are restricted to firms in manufacturing industries that have done R&D. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	Panel A: All industries	Panel B: Manufacturing
log (firm age+1)	-0.3158***	-0.3286***
	(0.0437)	(0.0654)
Canadian control	0.3383**	0.1254
	(0.1551)	(0.1953)
debt ratio	-0.0137	0.0578
	(0.0324)	(0.0650)
profitability	-0.9825***	-0.6008***
	(0.0646)	(0.1202)
R&D intensity	0.5186***	0.8924***
	(0.1006)	(0.1898)
isaxcipo	-0.4550***	-0.1147
	(0.1125)	(0.1710)
HHI	0.0034	0.1366***
	(0.0156)	(0.0310)
log (employee)	0.7002***	0.8822***
	(0.0258)	(0.0395)
log(industrial FDI)		-0.0241
		(0.0483)
log(industrial export)		0.0968
		(0.0710)
No. of observations	230444	80521
No. of firms	39179	16003

Table 6: Multinomial Locational Choice Regressions

This table reports average marginal effects of multinomial Logit regressions. The dependent variable is $app\_location_{it}$. Panel A reports results using the whole sample of firms in all industries. Results in Panel B are restricted to firms in manufacturing industries. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	Panel A: All industries			Panel B: Manufacturing		
app_location	1: USPTO only	2:CIPO only	3: Both	1: USPTO only	2:CIPO only	3: Both
log (firm age+1)	0.0042	-0.0141*	0.0099	-0.0042	-0.0295**	0.0337***
	(0.0090)	(0.0081)	(0.0075)	(0.0134)	(0.0122)	(0.0120)
Canadian control	-0.0357	-0.0518	0.0876**	-0.0887	0.0235	0.0652
	(0.0468)	(0.0422)	(0.0446)	(0.0556)	(0.0557)	(0.0509)
experience at CIPO	-0.1011***	0.0707***	0.0304***	-0.1009***	0.0817***	0.0191***
	(0.0050)	(0.0044)	(0.0024)	(0.0067)	(0.0065)	(0.0036)
experience at USPTO	0.1004***	-0.1314***	0.0311***	0.0931***	-0.1282***	0.0351***
	(0.0041)	(0.0053)	(0.0018)	(0.0054)	(0.0072)	(0.0027)
debt ratio	-0.0032	0.0055	-0.0023	-0.0122	0.0091	0.0030
	(0.0071)	(0.0066)	(0.0059)	(0.0141)	(0.0126)	(0.0119)
profitability	-0.0113	-0.0126	0.0239**	-0.0247	0.0045	0.0202
	(0.0136)	(0.0127)	(0.0109)	(0.0261)	(0.0246)	(0.0221)
R&D intensity	0.0946***	-0.0755***	-0.0191	0.1787**	-0.1938***	0.0151
	(0.0294)	(0.0283)	(0.0266)	(0.0747)	(0.0743)	(0.0705)
isaxcipo	-0.0148	0.0596**	-0.0448**	0.0330	0.0200	-0.0531*
	(0.0289)	(0.0280)	(0.0216)	(0.0393)	(0.0388)	(0.0306)
HHI	0.0033	-0.0029	-0.0005	0.0082	-0.0067	-0.0015
	(0.0029)	(0.0029)	(0.0023)	(0.0061)	(0.0057)	(0.0050)
average patent scope	-0.0540***	-0.0004	0.0544***	-0.0793***	0.0162	0.0631***
	(0.0108)	(0.0100)	(0.0079)	(0.0180)	(0.0161)	(0.0134)
log (employee)	-0.0212***	0.0241***	-0.0029	-0.0219***	0.0223***	-0.0004
	(0.0040)	(0.0036)	(0.0031)	(0.0060)	(0.0057)	(0.0050)
log(industrial FDI)				0.0116	0.0183**	-0.0300***
				(0.0099)	(0.0092)	(0.0081)
log(industrial export)				-0.0236*	-0.0002	0.0238**
				(0.0127)	(0.0116)	(0.0106)
No. of observations		4797			2086	
No. of firms		2501			1094	
Pseudo R-Squared		0.2492			0.2939	

Table 7: Relative Risk Ratio of Multinomial Logit Regressions

This table reports Relative Risk Ratio of multinomial Logit regressions. The dependent variable is $app\_location_{it}$ for each column. Panel A reports results using the whole sample of firms in all industries. Panel B is restricted to firms in manufacturing industries. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	Panel A: All industries			Panel B: Manufacturing		
Baseline: CIPO only	USPTO only	USPTO only	USPTO only	USPTO only	USPTO only	USPTO only
log (firm age+1)	1.0759	1.0356	1.0767	1.1325	1.0890	1.1345
Canadian control	1.1394	1.1772	1.1454	0.6864	0.6921	0.6975
experience at CIPO	0.5566***	0.5539***	0.5559***	0.5048***	0.5011***	0.5070***
experience at USPTO	2.3414***	2.3386***	2.3421***	2.4014***	2.4054***	2.4069***
debt ratio	0.9676	0.9504	0.9665	0.9239	0.9064	0.9214
profitability	1.0249	0.9509	1.0269	0.9092	0.8429	0.9095
R&D intensity	1.8030***	1.6472***	1.8044***	4.2129***	4.2373***	4.1866***
isaxcipo	0.7393	0.7386	0.7394	1.0063	0.9971	0.9844
HHI	1.0218	1.0229	1.0214	1.0577	1.0529	1.0568
average patent scope	0.8646**	0.8808*		0.7304***	0.7480**	
log (employee)	0.8488***		0.8503***	0.8440***		0.8482***
log(total assets)		0.8936***			0.8868***	
maximum patent scope			0.9084			0.7965**
log(industrial FDI)				0.9512	0.9671	0.9530
log(industrial export)				0.9322	0.9294	0.9301
constant	1.1818	4.5224***	1.1254	6.6466*	24.2751***	5.8176*
	Both	Both	Both	Both	Both	Both
log (firm age+1)	1.1360*	1.1280*	1.1412*	1.4204***	1.4105***	1.4195***
Canadian control	2.2418**	2.2392**	2.2638**	1.3565	1.3068	1.4210
experience at CIPO	0.8966***	0.8955***	0.8914***	0.7725***	0.7706***	0.7698***
experience at USPTO	2.1883***	2.1904***	2.1790***	2.2677***	2.2750***	2.2634***
debt ratio	0.9610	0.9396	0.9618	0.9771	0.9502	0.9834
profitibility	1.2384**	1.1221	1.2428**	1.1131	0.9925	1.1151
R&D intensity	1.2284	1.0953	1.2309	2.7065	2.4311	2.6423
isaxcipo	0.5720***	0.5742**	0.5762**	0.6504	0.6545	0.6524
HHI	1.0095	1.0157	1.0087	1.0222	1.0267	1.0217
average patent scope	1.4354***	1.4600***		1.3845**	1.4061**	
log (employee)	0.8822***		0.8767***	0.8989**		0.8949**
log(total assets)		0.8927***			0.8974**	
maximum patent scope			1.4247***			1.3982**
log(industrial FDI)				0.7593***	0.7671***	0.7538***
log(industrial export)				1.1644	1.1642	1.1675
constant	0.2332***	1.0408	0.2283***	0.2344	0.9418	0.2293
No. of observations	4797	4797	4797	2086	2086	2086
No. of firms	2501	2501	2501	1094	1094	1094
Pseudo R-squared	0.2492	0.2483	0.2494	0.2939	0.2928	0.2941

Table 8: Multinomial Logit Regressions on Canadian Firms' Use of PCT

This table reports average marginal effects of multinomial Logit regressions for patent filing strategies. The dependent variable is $PCT\_location_{it}$. Panel A reports results using the whole sample of firms in all industries and results from Panel B are restricted to firms in manufacturing industries. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	Panel A: All industries			Panel B: Manufacturing		
pct_location	1: PCT only	2: Direct only	3: Both	1: PCT only	2: Direct only	3: Both
log (firm age+1)	-0.0147***	0.0246*	-0.0099*	-0.0379***	0.0404***	-0.0025
	(0.0077)	(0.0082)	(0.0051)	(0.0106)	(0.0124)	(0.0085)
Canadian control	-0.1012*	0.0580***	0.0431**	-0.0923	0.0642***	0.0280
	(0.0296)	(0.0331)	(0.0212)	(0.0354)	(0.0430)	(0.0270)
experience at CIPO	-0.0001*	-0.0009	0.0010***	-0.0004	-0.0001	0.0005***
	(0.0005)	(0.0005)	(0.0001)	(0.0006)	(0.0005)	(0.0002)
debt ratio	0.0000**	0.0129	-0.0129**	-0.0017**	0.0332	-0.0314**
	(0.0053)	(0.0062)	(0.0051)	(0.0104)	(0.0145)	(0.0136)
profitability	-0.1039***	0.1514***	-0.0475***	-0.0879***	0.1437***	-0.0557***
	(0.0127)	(0.0136)	(0.0108)	(0.0229)	(0.0268)	(0.0204)
R&D intensity	0.0777***	-0.0865***	0.0087	0.1370***	-0.1876***	0.0506
	(0.0221)	(0.0261)	(0.0174)	(0.0465)	(0.0639)	(0.0360)
HHI	0.0013	-0.0028	0.0016	0.0092**	-0.0126***	0.0034
	(0.0025)	(0.0026)	(0.0015)	(0.0049)	(0.0054)	(0.0032)
isaxcipo	0.0394***	-0.0848**	0.0454***	0.0281**	-0.0694	0.0414**
	(0.0180)	(0.0194)	(0.0112)	(0.0237)	(0.0274)	(0.0180)
average patent scope	0.1182***	-0.1484***	0.0303***	0.0876***	-0.1259***	0.0383***
	(0.0093)	(0.0102)	(0.0060)	(0.0135)	(0.0159)	(0.0102)
log (employee)	-0.0090**	-0.0080***	0.0170***	-0.0148	-0.0079***	0.0227***
	(0.0034)	(0.0035)	(0.0021)	(0.0046)	(0.0053)	(0.0034)
log(industrial FDI)				0.0133***	-0.0276	0.0143**
				(0.0084)	(0.0094)	(0.0061)
log(industrial export)				0.0068	-0.0050	-0.0019
				(0.0100)	(0.0111)	(0.0069)
No. of observations		6119			2619	
No. of firms		3539			1485	
Pseudo R-squared		0.1467			0.1218	

Table 9: Relative Risk Ratio of Multinomial Logit Regressions for PCT

This table reports Relative Risk Ratio of multinomial Logit regressions for patent filing strategies. The dependent variable is $PCT\_location_{it}$ for each column. The first column reports results using the whole sample of firms in all industries. Results in the second column are restricted to firms in manufacturing industries. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	All industries	Manufacturing
Baseline: Direct only	PCT only	PCT only
log (firm age+1)	0.8954**	0.7646***
Canadian control	0.5941***	0.5516**
experience at CIPO	1.0013	0.9983
debt ratio	0.9729	0.9362
profitability	0.4813***	0.4925***
R&D intensity	1.6319***	2.8335***
HHI	1.0111	1.0724**
isaxcipo	1.3994***	1.3054
average patent scope	2.1836***	1.9664***
log (employee)	0.9821	0.9377**
log(industrial FDI)		1.1242**
log(industrial export)		1.0453
constant	0.1825	0.3654
	Both	Both
log (firm age+1)	0.8372**	0.9065**
Canadian control	1.5196	1.2472
experience at CIPO	1.0144***	1.0058***
debt ratio	0.8267***	0.6521**
profitibility	0.3974***	0.4050***
R&D intensity	1.3435	2.5059*
HHI	1.0621	1.0638
isaxcipo	2.1224***	1.8349**
average patent scope	2.0115***	1.9490***
log (employee)	1.2604***	1.3242***
log(industrial FDI)		1.2410***
log(industrial export)		0.9866
constant	0.0222	0.0048***
No. of observations	6119	2619
No. of firms	3539	1485
Pseudo R-squared	0.1467	0.1218

Table 10: Regressions on Robustness Checking

This table reports average marginal effects of multinomial Logit models. The first column ("nongranted") uses data including non-granted patents. The second column ("subset") uses data on patents that were granted within 5 years. The third column ("short") uses data during the period 2001-2007. The fourth column ("lagged") use one year lagged independent variables. All regressions include 2 digits industry fixed effects, firms' operating province fixed effects and year fixed effects. Standard errors are in parentheses. *indicates significance at 10% level. **indicates significance at 5% level. ***indicates significance at 1% level.

	nongranted	subset	short	lagged
USPTO only				
log (firm age+1)	0.0063 (0.0061)	-0.0021 (0.0093)	0.0036 (0.0099)	0.0117 (0.0164)
Canadian control	-0.0342 (0.0289)	-0.0405 (0.0484)	-0.0536 (0.0569)	-0.1795 (0.1381)
experience at CIPO	-0.0420 (0.0024)***	-0.1079 (0.0060)***	-0.0919 (0.0053)***	-0.0456 (0.0040)***
experience at USPTO	0.0730 (0.0025)***	0.1014 (0.0044)***	0.0936 (0.0041)***	0.0388 (0.0028)***
debt ratio	-0.0020 (0.0044)	0.0008 (0.0075)	-0.0044 (0.0078)	-0.0010 (0.0146)
profitability	0.0121 (0.0088)	-0.0077 (0.0142)	0.0014 (0.0152)	0.0151 (0.0284)
R&D intensity	0.0291 (0.0167)*	0.0765 (0.0323)**	0.0827 (0.0310)***	0.0524 (0.0654)
isaxcipo	0.0311 (0.0176)*	-0.0185 (0.0319)	-0.0311 (0.0319)	-0.0022 (0.0491)
HHI	0.0009 (0.0018)	0.0061 (0.0032)*	0.0058 (0.0037)	0.0030 (0.0063)
average patent scope	-0.0333 (0.0079)***	-0.0568 (0.0113)***	-0.0497 (0.0123)***	-0.0178 (0.0199)
log(employee)	-0.0078 (0.0027)***	-0.0228 (0.0041)***	-0.0269 (0.0045)***	-0.0315 (0.0074)***
CIPO only				
log (firm age+1)	-0.0193 (0.0067)***	-0.0160 (0.0085)*	-0.0101 (0.0089)	-0.0464 (0.0138)***
Canadian control	-0.0425 (0.0345)	-0.0630 (0.0443)	-0.0435 (0.0517)	-0.0250 (0.1291)
experience at CIPO	0.0353 (0.0024)***	0.0759 (0.0051)***	0.0629 (0.0047)***	0.0313 (0.0033)***
experience at USPTO	-0.1275 (0.0037)***	-0.1294 (0.0056)***	-0.1228 (0.0054)***	-0.0505 (0.0038)***
debt ratio	0.0081 (0.0048)*	-0.0046 (0.0071)	0.0079 (0.0072)	-0.0042 (0.0126)
profitability	-0.0121 (0.0098)	-0.0169 (0.0134)	-0.0277 (0.0142)*	-0.0224 (0.0243)
R&D intensity	-0.0527 (0.0192)***	-0.0571 (0.0304)*	-0.0549 (0.0291)*	-0.0172 (0.0559)
isaxcipo	0.0091 (0.0201)	0.0521 (0.0310)*	0.0680 (0.0308)**	0.0611 (0.0438)
HHI	0.0003 (0.0020)	-0.0027 (0.0031)	-0.0049 (0.0036)	0.0009 (0.0052)
average patent scope	-0.0321 (0.0084)***	0.0121 (0.0105)	-0.0049 (0.0113)	0.0078 (0.0171)
log(employee)	0.0158 (0.0031)***	0.0226 (0.0038)***	0.0301 (0.0041)***	0.0176 (0.0064)***
Both				
log (firm age+1)	0.0131 (0.0058)**	0.0181 (0.0076)**	0.0065 (0.0082)	0.0348 (0.0153)**
Canadian control	0.0767 (0.0302)**	0.1034 (0.0458)**	0.0972 (0.0550)*	0.2045 (0.1569)
experience at CIPO	0.0067 (0.0013)***	0.0321 (0.0026)***	0.0290 (0.0026)***	0.0143 (0.0024)***
experience at USPTO	0.0545 (0.0019)***	0.0280 (0.0017)***	0.0292 (0.0018)***	0.0117 (0.0014)***
debt ratio	-0.0061 (0.0043)	0.0038 (0.0059)	-0.0035 (0.0067)	0.0052 (0.0134)
profitability	0.0000 (0.0087)	0.0246 (0.0109)**	0.0263 (0.0122)**	0.0073 (0.0258)
R&D intensity	0.0236 (0.0166)	-0.0194 (0.0280)	-0.0277 (0.0292)	-0.0352 (0.0674)
isaxcipo	-0.0402 (0.0149)***	-0.0336 (0.0214)	-0.0369 (0.0235)	-0.0588 (0.0447)
HHI	-0.0012 (0.0017)	-0.0034 (0.0027)	-0.0009 (0.0031)	-0.0039 (0.0051)
average patent scope	0.0654 (0.0064)***	0.0447 (0.0081)***	0.0547 (0.0091)***	0.0100 (0.0179)
log(employee)	-0.0080 (0.0026)***	0.0003 (0.0031)	-0.0032 (0.0035)	0.0139 (0.0064)***
No. of observations	7753	4448	3854	1546
No. of firms	4029	2385	2142	727
Pseudo R-squared	0.2247	0.2451	0.2529	0.2438

Appendix

Table A1: Correlation Coefficients of Key Variables for Patenting Firms

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 : log(firm age+1)	1												
2 : experience at CIPO	0.14	1											
3 : experience at USPTO	0.13	0.38	1										
4 : debt ratio	-0.19	-0.08	-0.11	1									
5 : profitability	0.01	-0.10	-0.13	0.00	1								
6 : R& D intensity	-0.30	-0.07	-0.05	0.38	0.04	1							
7 : HHI	0.03	0.14	0.14	-0.02	-0.13	0.08	1						
8 : average patent scope	-0.02	0.01	0.03	0.02	-0.05	0.02	0.05	1					
9 : maximum patent scope	0.04	0.20	0.27	-0.04	-0.10	-0.01	0.12	0.86	1				
10 : log(total assets)	0.32	0.34	0.35	-0.28	-0.40	-0.33	0.28	0.05	0.23	1			
11 : log(employee)	0.36	0.30	0.29	-0.23	-0.28	-0.32	0.24	0.00	0.16	0.92	1		
12: log(industrial FDI)	-0.01	0.08	0.11	0.00	-0.06	0.16	0.41	0.02	0.07	0.08	0.03	1	
13: log(industrial export)	0.03	0.06	0.10	-0.01	-0.10	-0.03	0.26	0.01	0.07	0.13	0.13	0.40	1

Table A1 provides the correlation coefficients of key independent variables for patenting firms that are used in the regression analyses. In general, these independent variables are not highly correlated. It is worth noting that the two measures of patent scope are highly correlated with a correlation coefficient of 0.845. As well, the two measures of firm size are also highly correlated with a correlation coefficient of 0.866.

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