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Innovation Activities and Export Performance of Canadian Small and Medium-Sized Agri-Food Firms *

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Abstract

Canadian small and medium-sized firms face two major challenges, namely, that of innovation in supporting their growth and improving their competitiveness and that of access to international markets. The objective of this study is to analyze the impact of research and Development (R&D) investment on the export performance of Canadian agri-food companies and on that of related sectors, namely, the textile and clothing sector and the manufacture of leather goods and similar products. We used impact assessment methods to analyze the effects of firms' innovation activities on their export performance. First, we analyzed explanatory factors for R&D expenses; second, we analyzed the impact of R&D on extensive (market access) and intensive (trade value) margins of trade. In doing so, we used Statistics Canada's National Accounts Longitudinal Microdata File (NALMF) for 2010 to 2015, which is coupled with the Trade by Exporter Characteristics (TEC) database. The size of firms and their support from the Canadian government affect their propensity to invest in R&D, the value of R&D expenses and their intensity, as measured from the ratio of R&D to sales of goods and services. Overall, our results show that investment in R&D has a positive impact on the export performance of agri-food SMEs.

Keywords: Research and Development, Agri-Food, Small and Medium-Sized Firm, Extensive Margin of International Trade, Intensive Margin of International Trade

JEL Codes: F14, Q16, Q17

Résumé

Les petites et moyennes entreprises (PME) canadiennes font face à deux grands enjeux soit celui de l'innovation afin notamment de soutenir leur croissance et améliorer leur compétitivité et celui de l'accès aux marchés internationaux. Le présent projet de recherche a pour objectif d'analyser l'impact des investissements en recherche et développement (R&D) sur les performances à l'exportation des entreprises agroalimentaires canadiennes et de celles de secteurs connexes soit les industries du textile et des vêtements et de la fabrication de produits du cuir et produits analogues. Les méthodes d'évaluation d'impact seront utilisées pour analyser les effets des activités d'innovation des entreprises sur leurs performances à l'exportation. Dans un premier temps, les facteurs explicatifs des investissements en R&D sont analysé. Puis nous analysons les effets des investissements en R&D sur les marges extensive (accès aux marchés) et intensive (valeur du commerce). Nous utilisons le Fichier de micro données longitudinales des comptes nationaux (NALMF) de Statistique Canada pour la période de 2010 à 2015 qui est couplé au fichier du programme de Commerce selon les caractéristiques des exportateurs (TEC). La taille des entreprises et l'appui du gouvernement canadien sont déterminants dans la probabilité d'investir dans la R&D ainsi que le montant de ces investissements et son intensité mesurée par le ratio du montant investit sur les ventes totales de biens et services des PME agroalimentaires.

Mots clés : Recherche et développement, Agroalimentaire, Petites et moyennes entreprises, Marge extensive du commerce international, Marge intensive du commerce international

Codes JEL : F14, Q16, Q17

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1 Introduction and background

Manufacturing is one of the most important sectors of the Canadian economy. In October 2018, Statistics Canada reported that approximately 203 billion dollars of the country's GDP originates from manufacturing, contributing more than 10%.[1] During the same period, GDP from food amounted to 27.58 billion dollars, representing 13.56% of the manufacturing sector's GDP. From October 2010 to October 2018, the GDP of the food processing industry increased by 22%. As indicated in Table 1, this growth of GDP mainly came from the *Grain and oilseed milling* [3112][2], *Animal food manufacturing* [3111], *Bakeries and tortilla manufacturing* [3118] and *Fruit and vegetable preservation and specialty food manufacturing* [3114] sectors.

Table 1. Evolution of the share and growth of different food processing sub-industries (NAICS classification) using monthly data

	October 2010		**October 2018**		**Growth**
	GDP ($\$10^6$)	Share	GDP ($\$10^6$)	Share	From 2010 to 2018
Food manufacturing [311]	22 611		27 586		22.00%
Animal food manufacturing [3111]	1 161	5.13%	1 552	5.63%	33.68%
Grain and oilseed milling [3112]	1 683	7.44%	2 581	9.36%	53.36%
Sugar and confectionery product manufacturing [3113]	1 300	5.75%	1 391	5.04%	7.00%
Fruit and vegetable preservation and specialty food manufacturing [3114]	2 091	9.25%	2 522	9.14%	20.61%
Dairy product manufacturing [3115]	3 019	13.35%	3 151	11.42%	4.37%
Meat product manufacturing [3116]	5 784	25.58%	6 007	21.78%	3.86%
Seafood product preparation and packaging [3117]	1 136	5.02%	1 028	3.73%	-9.51%
Bakeries and tortilla manufacturing [3118]	3 606	15.95%	4 591	16.64%	27.32%
Other food manufacturing [3119]	2 831	12.52%	4 763	17.27%	68.24%

GDP: Seasonally adjusted at annual rates and Chained (2012) dollars. Source: Statistic Canada (Table 36-10-0434-01)

[1] Statistics Canada, Table 36-10-0434-01.

[2] North America Industrial Classification System (NAICS).

As indicated in Table 1, meat product manufacturing, bakeries and tortilla manufacturing, and dairy product manufacturing are the top three subindustries of the food processing industry in terms of GDP. However, shares of the first and third experienced a decline from 2010 to 2018. In Canada, from 2006 to 2014 food-manufacturing SMEs accounted for approximately 84% of establishments and for 17% of sales (FCC, 2014).

Table 2 presents the share and value of exports of the food processing subindustry. In 2017,[3] the value of Canadian's exports of processed food products was approximately $34 billion (current dollars).[4,5] *Grain and oilseed milling* [3112], *Meat product manufacturing* [3116] and *Seafood product preparation and packaging* [3117] were the top exporting food processing subindustries. However, the destination countries are not diversified. For most of the industries, the main destination of Canadian processed food products is the USA, and the top ten importing countries received more than 90% of Canadian exports of processed food products.

Figure 1 presents the share of GDP and exports by industry. *Meat product manufacturing* [3116], *Grain and oilseed milling* [3112] and *Seafood product preparation and packaging* [3117] exports are higher than corresponding contributions to the GDP of food manufacturing, indicating that they are the most heavily export-oriented industries.

[3] At the time of writing this report, GDP data for 2018 were not available.

[4] See Government of Canada. Trade Data Online. Available at https://www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home. Accessed June 19, 2018.

[5] For the same period, exports of the primary agricultural sector were valued at $14.7 billion. See https://www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home. Accessed June 21, 2018.

Table 2. Export value and share by industries (NAICS) in 2017

	Exports		**Share by destination**	
	Share	Value (x 10^6)	USA	Top 10 countries
Food manufacturing [311]	100.00%	33,930	71.39%	92.77%
Animal food manufacturing [3111]	3.39%	1,151	56.83%	80.14%
Grain and oilseed milling [3112]	21.35%	7,246	72.60%	98.28%
Sugar and confectionery product manufacturing [3113]	9.00%	3,053	94.42%	98.07%
Fruit and vegetable preservation and specialty food manufacturing [3114]	9.83%	3,334	83.32%	93.51%
Dairy product manufacturing [3115]	1.89%	641	57.45%	82.44%
Meat product manufacturing [3116]	22.51%	7,637	49.96%	95.07%
Seafood product preparation and packaging [3117]	13.84%	4,696	57.17%	90.51%
Bakeries and tortilla manufacturing [3118]	9.92%	3,365	96.78%	99.41%
Other food manufacturing [3119]	8.27%	2,807	89.82%	95.44%

Figure 1. Share of GDP and exports by industry (2017)

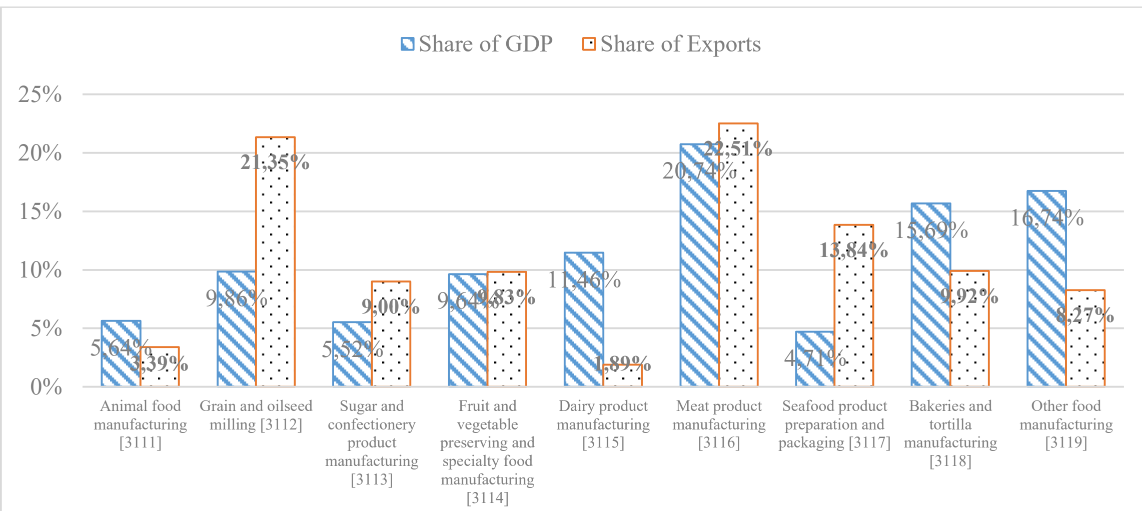
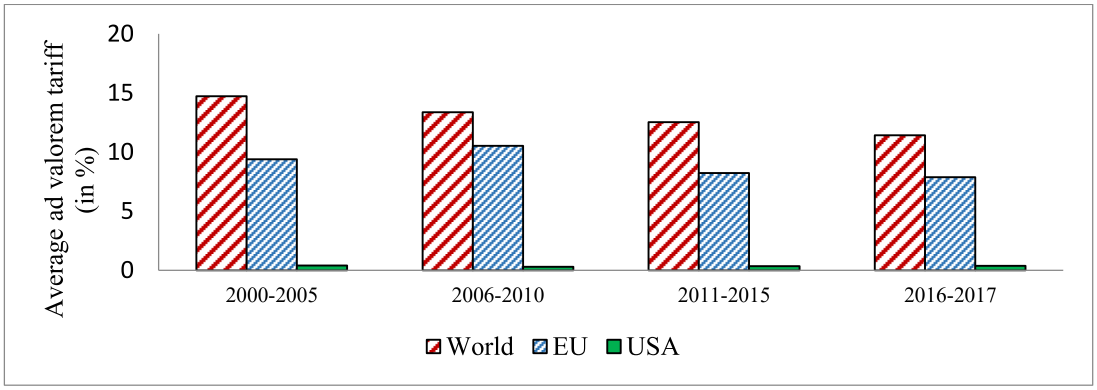


Table 2 shows that the United States (US) is the main destination of Canadian agri-food exports. Low trade costs including lower tariffs rates in place between the two countries due to NAFTA explain this situation. As shown in Figure 2, the ad valorem tariff between Canada and the US is set very low for agri-food products and tends towards zero.[6] This means that other challenges rather than trade costs are major issues faced by Canadian firms in the US market.

Figure 2. Average ad valorem tariffs applied to Canadian exports (Manufacture of food products and beverages; 2000-2017)



Even if some industries are dynamic, food-manufacturing firms such as other SMEs face two major challenges. The first relates to innovation that (i) supports the growth of businesses and improves their competitiveness, (ii) develops new products to meet the needs of consumers and (iii) develops specific products (certifications, allegations, etc.) with high value added.

The second major issue concerns access to international markets. Indeed, given the importance of international trade for the Canadian manufacturing sector,[7] SMEs need to establish business strategies or international standards to take advantage of export markets (MAPAQ, 2017;

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[6] Data on tariffs were collected using World Integrated Trade Solution (WITS) software (see http://wits.worldbank.org/wits/). The *ad valorem* applied tariff used in estimations is based on the value of the dutiable item and is expressed in percentage terms. Data on tariffs are those of International Standard Industrial Classification 15.

[7] In 2007-2009, according to Innovation, Science and Economic Development Canada, more than one third of all enterprises of the food manufacturing sector were involved in international activities. The percentage is more than 47% for the entire manufacturing sector (see https://www.ic.gc.ca/eic/site/eas-aes.nsf/eng/home, accessed March 26, 2019)

Cross, 2016). These issues are especially important for agri-food firms in view of their low contributions to manufacturing exports (Cross, 2016). The two issues mentioned above are closely related in that the goals and desired performance of Canadian agri-food firms on international markets could be achieved through investment in innovation activities. Statistics Canada estimates the share of research and development expenditures of food manufacturing revenues to be 0.4% for 2016. This is below the value for the manufacturing sector, which is estimated at 1.8% for the same year.[8]

Like many countries, Canada has placed innovation at the center of government action. Innovation, Science and Economic Development (ISED) Canada works "... *to enhance Canada's innovation performance, increase Canada's share of global trade and build a fair, efficient and competitive marketplace.*"[9] This objective reflects the importance that the government places on international trade and the interplay between innovation and firm performance. Supporting firm innovation can thus serve as a means of achieving this goal. It is therefore important to question the impact that innovation can have on firm performance. Recent discussions and the signing of a new economic agreement between Canada, the United States and Mexico raises new challenges for Canadian agri-food firms. Indeed, in the next few years Canadian companies will face the challenge of maintaining and/or increasing their market shares in the United States while diversifying exports to other markets.[10] Innovation through investment in R&D activities could serve as one of the most effective tools in facing

[8] Statistics Canada, Table 27-10-0358-01.

[9] See http://www.ic.gc.ca/eic/site/icgc.nsf/eng/home . Accessed June 30, 2018.

[10] In addition, see the mandate letter from the Minister of International Trade Diversification at https://pm.gc.ca/eng/minister-international-trade-diversification-mandate-letter-august-28-2018. Accessed January 31, 2019.

this challenge. However, studies that address the interplay between innovation and Canadian agri-food firm performance are almost nonexistent[11] even though this sector, given its peculiarity, has always been treated differently when negotiating trade agreements.

This study aims to fill this gap by focusing on the specific case of agri-food firms (food manufacturing and beverage and tobacco product manufacturing) and on the textile and clothing (textiles, textile factories and clothing manufacturing) and leather and allied product manufacturing industries, which are both listed under NAICS code 31. This study is methodologically innovative in that it uses difference-in-difference methods (see Hirano and Imbens, 2004) to analyze the effects of R&D on firms' export performance. This approach allows us, for the analysis of the export performance of SMEs, to measure the true causal effect of firms' innovation status.

The rest of the paper is organized as follows. Section 2 presents a discussion on innovation and on its interplays with firm performance, and section 3 presents the empirical approach used. The data employed are presented in section 4, while the estimation results are presented and described in section 5. Section 6 concludes.

2 Innovation and firm performance: a review of the literature

Innovation is a major challenge facing modern economies. The seminal work of Schumpeter (1934) suggests that innovation is central to economic development. In all areas of the economy, it constitutes an important element of a firm's development.

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[11] Most studies focus on the manufacturing sector alone. Examples include Baldwin, Dar-Brodeur and Yan (2016) and Therrien and Hanel (2010).

2.1 Definition and forms of innovation

An analysis of firm innovation activities requires using a clear definition of what innovation is. In the literature, several definitions of innovation exist. These definitions vary not only between disciplines but also within disciplines. In a literature review on the subject, Baregheh, Rowley and Sambrook (2009) identified sixty definitions developed in seven disciplines between 1934 and 2008. These definitions highlight the multidisciplinary nature of innovation. In the present study, we focus on the definitions most recently developed in economics without losing sight of the contributions of previous definitions or of other disciplines to understanding the phenomenon of innovation.

For Chen, Zhu and Yuan Xie (2004), “innovation refers to the introduction of a new combination of the essential factors of production into the production system. It involves the new product, the new technology, the new market, the new material and the new combination.” This definition refers to tools used and to the purpose of innovation. The Oslo Manual defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD/Eurostat, 2005; Bloch, 2007). This conception of innovation, even if it obscures the process of implementing innovation while devoting itself to its purpose, allows one to distinguish between different forms of innovation. Thus, innovation within a company can take four main forms: product innovation, process innovation, organizational innovation, and marketing innovation.

Whatever the form of innovation, the literature classifies it into two types by degree: incremental and radical innovation. Incremental innovation builds on existing knowledge and skills to improve progressively a production process or the aesthetic and functional qualities of a product. On the other hand, radical innovation develops a set of knowledge and capabilities that can render existing innovative capabilities of a company obsolete. The result of this form of innovation is the introduction of new production processes or products into the market (Tran, 2008). Radical innovation presents more growth opportunities for companies but is subject to uncertainty. This uncertainty is present during not only the implementation of a new invention but also in terms of its market potential. The size of the market, receptivity to the new product or service, and the need to undertake a series of complementary innovations are all issues related to the success of innovation but that are also subject to uncertainty (Rosenberg, 1994). This makes radical innovation less popular than incremental innovation, which is less risky.

Crossan and Apaydin (2010) used (i) Upper Echelon Theory, (ii) the Resource-Based View and Dynamic Capabilities and (iii) Process Theory to describe processes of innovation that occur within a firm. They also suggest that "five managerial levers, i.e., mission, goals, and strategy; structure and systems; resource allocation; organizational learning and knowledge management tools; and organizational culture enable core innovation processes" Crossan and Apaydin (2010: 1172).

Innovation in Canadian food manufacturing

Tamini, Morin-Rivet and Koné (2018) conducted extensive interviews with the CEOs of Canadian exporting multinationals to analyze the determinants of investments, including those made in innovation. The authors met with CEOs of processed fruit, canned and frozen vegetable, meat, chocolate and nonchocolate confectionery companies. In the confectionery industries, the business model used mainly involves supplying products to retailers or to other processors (Business-to-Business). These include, for example, Unilever, Kraft, Costco and Wal-Mart. Product research and development are performed at the customer's request whereas "general" product innovations occurs at corporate headquarters. In the canned and frozen vegetables industry, there is little differentiation between products. Product innovations are rare because the return on investment is low and as consumer demand is more oriented towards fresh products. Process and managerial innovations are more important for this type of business because they provide a competitive advantage. In the fruit-processing sector, product innovations are important due to strong differentiation between products dictated by consumer demand. Process marketing, including packaging and managerial innovation, will then accompany products to provide companies with advantages in terms of competitiveness. Finally, Tamini et al. (2018) analyzed the case of the Canadian meat sector. The specificities of products relate to cuts or production methods, implying that process and managerial innovations for firms are competitive internationally. These results are in line with those of the 2009 Survey of Industry and Business Strategy (SIBS) conducted by Innovation, Science and Economic Development Canada.[12,13] The percentage of enterprises introducing process innovations is higher at 45% followed by the percentage introducing organizational and product innovations. We summarize this information in Table 3.

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[12] *Business Innovation and Strategy: A Canadian Perspective. Report based on the results of the survey of innovation and business strategy (SIBS)*. See https://www.ic.gc.ca/eic/site/eas-aes.nsf/eng/home. Accessed March 26, 2019.

[13] Surveys were also conducted in 2012 and 2017. However, the manufacturing sector (31-33) is not disaggregated and it is impossible to analyze the food manufacturing sector. See CANSIM Table 27-10-0120-01 for the results of the 2012 survey.

Table 3. Percentage of enterprises indicating they introduced organizational or marketing innovations in 2007–09

Product innovation				
	Goods	Services		
	36.50%	14.40%		
Process innovation				
	Methods of manufacturing or producing	Logistic, delivery or distribution methods	Supporting activities for processes	
	45%	17.70%	25.80%	
Organisationnel innovation				
	Business practices for organizing procedures	Methods of organizing work responsibilities procedures	Methods of organizing external relations	
	38.30%	35.50%	18.40%	
Marketing innovations				
	Aesthetic design of packaging	Methods or techniques for promotion	Methods for product placement	Methods of pricing
	30.80%	20.20%	16.30%	13.10%

Source: Survey of Industry and Business Strategy (SIBS) conducted by Innovation, Science and Economic Development Canada.[14]

The information presented in the 2009 Survey of Industry and Business Strategy (SIBS) is not disaggregated by the sizes of enterprises at the industry level. However, when considering the entire manufacturing sector, percentages are smaller for small enterprises than they are for medium-sized enterprises except in the case of service innovation. In addition, for most of the cases, percentages are smaller for food manufacturing.

[14] See at https://www.ic.gc.ca/eic/site/eas-aes.nsf/eng/home. Accessed March 26, 2019.

2.2 Factors determining innovation

Becheikh, Landry and Amara (2006) conducted a rich literature review on the determinants of innovation at the company level by analyzing studies conducted on the subject between 1993 and 2003. For the authors, internal factors and the economic context in which firms operate are key elements that encourage or discourage innovation. Specialization, internationalization, and the protection of the competitive advantages of firms as well as the flexibility of a firm's structure are among the factors that positively influence innovation. The size of firms measured based on sales or the number of employees is also considered as a factor of innovation (Brouillette, 2014b; Baldwin et al., 2016).[15] This fact is explained by the resource-based view and from the use of dynamic capabilities as a determinant of innovation (Crossan and Apaydin, 2010).

In focusing specifically on the strategic determinants of innovation in SMEs in the manufacturing sector in the Bas-Saint-Laurent region, Becheikh et al. (2006) show that strategic management influences both the propensity for SMEs to innovate and the novelty of such innovation. Strategic management has a stronger impact than traditional variables such as research and development and firm size. While strategic management seems to be key to the success of innovation, the guiding thread is likely the manager's previous professional experience and especially in R&D institutions such as universities and research centers (Romijn and Albaladejo, 2002; Brouillette, 2014b; Baldwin et al., 2016).

The quality of the workforce is another important factor that shapes innovation (Romijn and Albaladejo, 2002; Chen and Huang, 2010). For Chen and Huang (2010), this relationship does

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[15] See evidence for the entire manufacturing sector in CANSIM Table 27-10-0120-01.

not appear to be linearly related. These authors suggest that there is an inverted U-shaped relationship between innovation and the density of the creative workforce as measured from the proportion of employees assigned to research. The positive effect is attributed to the sharing of knowledge and learning related to the formation of a collective knowledge structure. However, the new costs associated with coordination have a negative effect.

In addition to the internal factors that can influence firm innovation performance, certain external factors are very important to the success of innovation projects. One of these factors is the market structure. For Raider (1998), a competitive market serves as a source of innovation whereas for Batterink, Wubben and Omta (2006) and Fortuin, Batterink and Omta, (2007), successful innovative food processing companies have a strong market and customer orientation.

Firms' networks and clusters and the quality of the institutional environment also appear to be important external factors (Romijn and Albaladejo, 2002; McAdam et al., 2016; Geldes et al., 2017; De Martino and Magnotti, 2018). Industries that have adopted a high-quality management system support stronger innovation activities (Maistry, Hurreeram and Ramessur, 2017).

The results given in Tamini et al. (2018) show that government support is important for the innovation activities of agri-food firms. Direct public support to firms can be provided through subsidies or tax incentives (OECD, 2018; Becker, 2015), with the latter being the instrument most frequently used in Canada (OECD, 2018; Brouillette, 2014b). Dagenais, Mohnen and Therrien (2004) and Baghana and Mohnen (2009) show that tax incentives are efficient in encouraging R&D activities with stronger impact for small enterprises.[16] The 2012 Survey of Innovation and Business Strategy confirms this result. In total, 50.7% of all enterprises of the surveyed industries determined that government tax credits were the most central public programs used in support of their innovation activities followed by government grants at 17.1%.[17] However, through a natural experiment on British Columbia, Brouillette (2014b) shows that even if it is positive, the impact of tax incentives is nonsignificant, suggesting the demand for innovation of Canadian is inelastic. These results are for the Canadian manufacturing sector as a whole, and to our knowledge, there is currently no specific evidence for the food manufacturing.

2.3 Innovation and R&D activities and inputs

Several authors argue that R&D spending increases the capacity for countries or firms to innovate (Parthasarthy and Hammond, 2002; Parisi, Schiantarelli and Sembenelli, 2006; Ganotakis and Love, 2010; Dziallas and Blind, 2018) even when innovation involves a complex process involving more than R&D (Parisi and Sembenelli, 2006; Brouillette, 2014a).[18]

The literature also indicates that there are two channels between R&D and innovation (Crossan and Apaydin, 2010). The first channel highlights the contributions of R&D investments to the creation of new knowledge within an organization. The second concerns the increase in an

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[16] However, Baghana and Mohnen (2009) show that dead weight is lost from this mechanism.

[17] See https://www150.statcan.gc.ca/n1/daily-quotidien/140214/dq140214b-eng.pdf. Accessed March 29, 2019.

[18] Bilbao-Osorio and Rodríguez-Pose (2004) showed that R&D investments in the private sector generate more innovation than those of the public sector or for education in European Union countries. According to the authors, R&D performance in terms of innovation depends on the socioeconomic characteristics of regions such as initial wealth, the availability of skills and the presence of high technology sectors.

organization's absorptive capacity, but it requires that investments be directed to skills development within an organization. The development of these skills allows firms to use the knowledge present in their environment to create new knowledge or to improve existing knowledge. This close relationship between R&D and innovation (Crossan and Apaydin, 2010) justifies the use of R&D intensity and/or expenditures as a proxy for innovation in the majority of studies as mentioned in Dziallas and Blind's (2018) recent literature review. As the database used in the present study does not use a direct measure for innovation, the latter will be approximated from research and development expenditures. In doing so we follow Baldwin et al.'s (2016) work on the interplay between innovation and export-market participation in Canadian manufacturing.

2.4 Innovation and firm performance

The literature extensively analyzes the relationship between innovation and three particular forms of business performance: productivity, growth and performance in international markets. While most theoretical and empirical investigations reveal a positive relationship between innovation and these performance indicators, controversy remains on the nature of such causality. Mohnen and Hall (2013) conducted a literature review on the impact of product innovation on productivity. Most of the studies analyzed suggest that the intensity of product innovation significantly increases firm productivity. Foster et al. (2018) explain that this growth in productivity creates a gap between innovative and noninnovative firms, which in the end leads to exits from the market, thereby increasing average productivity growth in the industry. These analyses should be considered with caution because their results are shaped by productivity measures and estimation methods used (Gonzales-Rocha and Mendez-Guerra, 2018). In a sensitivity analysis, Lööf and Heshmati (2006) already drew attention to the use of the least squares method in estimating the effects of innovation on productivity. For these authors, this method presents the major disadvantage of not accounting for issues of selection and simultaneity.

One of the most frequently encountered issues noted in the recent literature concerns the relationship between firms' innovation activities and their performance in international markets. In the literature, the link between innovation and the export performance of firms is deemed positive. On the other hand, causality between the two variables remains a subject of debate in regard to international trade both empirically and theoretically. Indeed, for some authors, innovation shapes decision-making and export performance (Greenhalgh, Taylor and Wilson, 1994; Roper and Love, 2002; DiPietro and Anoruo, 2006).

An intuitive explanation for these results can be found from Melitz's (2003) heterogeneous firm model, in which firms differ in their productivity and whereby the most productive firms are those that are able to export. An innovation that translates into an improvement in a firm's productivity enhances its export capabilities. Cassiman, Golovko and Martínez-Ros (2010) demonstrated this with data from Spanish manufacturing firms. Other authors propose that the export activities of firms enhance their capacities to innovate (Blalock and Gertler, 2004; Salomon and Shaver, 2005; Lin and Lin, 2010). This phenomenon known as "learning by exporting" is rooted in the fact that exporting firms have access to a very broad range of knowledge through their network. This renders the innovation activities of these firms relatively easier to perform compared to those of firms that operate exclusively in local markets.

3 Methodological approach

3.1 Factors shaping the decision to invest in R&D and R&D expenses and intensity

We analyzed three different factors related to R&D activities. First, we analyzed the propensity to engage in R&D activities. Second, we analyzed the factors that shape R&D expenses. Third, we analyzed the intensity of R&D measured as the ratio of R&D expenses to total sales of goods and services by a firm.

3.1.1 Factors explaining the decision to invest in R&D activities

We analyzed the propensity to invest in R&D activities using a panel probit model. We assumed that at time *t*, firm *i* invests in R&D $\left(I_{it}=1\right)$ when its marginal profit i_{it}^{*} (latent variable not observed) from innovation activities is positive. Otherwise, a firm does not invest in R&D activities $\left(I_{it}=0\right)$. We framed this hypothesis as follows:

$$(1) \qquad I_{it}=\begin{cases}1 & if \quad i_{it}^{*}\geq 0\\ 0 & if \quad i_{it}^{*}<0\end{cases}$$

where $i_{it}^{*}=\mu_{i}+\mathbf{x}_{it}'\boldsymbol{\beta}+\varepsilon_{it}$, with $\mathbf{x}_{it}$ denoting variables that condition the latent variable, $\boldsymbol{\beta}$ denoting their corresponding coefficients, μ_{i} denoting a random coefficient that is distributed independent of the regressor and ε_{it} denoting the error term. We estimated the probability of a firm being innovative using a panel random effect probit model (Cameron and Trivedi, 2005) as follows:

$$(2) \qquad P_{it}\left(I_{it}=1\mid \mathbf{x}_{it}\right)=P_{it}\left(i_{it}^{*}>0\mid \mathbf{x}_{it}\right)=P_{it}\left(\mu_{i}+\mathbf{x}_{it}\boldsymbol{\beta}+\varepsilon_{it}>0\mid \mathbf{x}_{it}\right)$$

with $\mu_{i}\sim\left[\mu,\sigma_{\mu}^{2}\right]$ and $\varepsilon_{it}\sim\left[0,\sigma_{\varepsilon}^{2}\right]$.

A cross-sectional approach cannot satisfactorily take into account the fundamental issue of the persistence of firm behavior in terms of R&D spending. The use of the panel model allows us to take into account the fact that observations are repeated periodically for the same firm. Table 4 presents the variables used when estimating the propensity to invest in R&D. We selected variables based on the literature review presented in section 2.2 on factors explaining the propensity to innovate. In the estimation procedure, continuous variables are transformed in log form.

Table 4. Variables used in the model of the propensity to invest in R&D

Variables name	Variables description
Research and development	
sred_expenditures	Expenditures qualifying for the Scientific Research and Experimental Development (SR&ED) expenditure
sred_binary	=1 is sred_expenditures >0 and 0 otherwise
Sales and international activities	
trade_sales_goods_services	Trade sales of goods and services. Sum of all sales for corporations or partnerships.
Net_Foreign_Income	Sum of entries in net foreign non-business income earned in the year and net foreign business income earned in the year.
Net_Foreign_Income_binary	=1 if Net Foreign Income>0 and 0 otherwise.
Characteristics of the firm	
age of the firm	Age of the firm in year.
ilu	Sum of Individual Labour Units (ILUs) for enterprise.
Sales per ilu	trade_sales_goods_services per ilu. The sales values per workforce is introduced as a measure of firm productivity. It could also be an indicator of the intensity of labor in the industry, the sales per workforce being lower in industry intensive in labor.
Avgpay	Average payroll reported from PD7s. Calculated by taking the mean of all monthly payroll submissions (including 0s). It is introduced as a proxy of the quality of the workforce. We hypothesize that, all thing being equal, the average payroll is increasing in the quality of workforce.
total_tangible_assets	Total tangible capital assets en value.

Table 4. Variables used in the model of the propensity to invest in R&D (cont'd)

Variables name	**Variables description**
Government support	
subsidies_grants	Subsidies and grants. Government assistance and subsidy payments (for non-fishing corporations), federal, provincial, territorial, or municipal grants received.
sred_deducted_parti	Amount of SR&ED credit deducted from Part I tax. Introduced as a % of sred_expenses
rd_deduction	SR&ED deduction claimed for the year. Introduced as a % of sred_expenses.
Industries	
naics_311	=1 if naics code is 311 and 0 otherwise. Industry of reference.
naics_312	=1 if naics code is 312 and 0 otherwise.
naics_313	=1 if naics code is 313 and 0 otherwise.
naics_314	=1 if naics code is 314 and 0 otherwise.
naics_315	=1 if naics code is 315 and 0 otherwise.
naice_316	=1 if naics code is 316 and 0 otherwise.

3.1.2 Factors explaining R&D expenses and intensity

For R&D expenses and intensity, we estimated a panel linear regression model with two main features (Semykina and Wooldridge, 2013). First, based on the literature, we assumed that sales of goods and services, export status and sales per workforce could be endogenous (See section 2.4). We introduce sales values and sales per workforce as continuous variables and export status as a binary variable. However, because export status introduces convergence issues into the model, we remove this variable. Second, we correct for sample-sample selection due to the presence of "zeroes" in R&D expenses and because firms self-select in R&D activities (Aw, Roberts and Xu, 2011; Baldwin et al., 2014).

Specifically, we estimate the following model (Semykina and Wooldridge, 2013):

(3) $$rd_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + c_{1,i} + \zeta_{i,t}$$

where $t = 1,...,T$, $\mathbf{x}_{it}$ is a $1 \times K$ vector of explanatory variables including endogenous variables, $\boldsymbol{\beta}$ is a $K \times 1$ vector for the parameters, $c_{1,i}$ is the unobserved effect and ζ_i is the error term. We define z_i as a $1 \times L$ vector of instruments strictly exogenously conditional on $c_{1,i}$. In defining the selection indicator as $I = 1$ with a corresponding latent variable i^*, we obtain the following:

(4) $$i^*_{it} = \mathbf{z}_{it}\boldsymbol{\delta} + c_{2,i} + \xi_i$$

where $t = 1,...,T$, $c_{2,i}$ is the unobserved effect, and ξ_i is the error term. The selection indicator is as follows:

(5) $$I = 1\left[i^*_{it} > 0\right] = 1\left[\mathbf{z}_{it}\boldsymbol{\delta} + c_{2,i} + \xi_i > 0\right]$$

The estimation of the model is parametric and assumes the normality of errors in the selection equation and the linear conditional mean of the error in the primary equation (Wooldridge, 1995).[19] The adopted framework allows an R&D decision to depend on factors other than those related to R&D expenses within a panel dynamic setting. No existing article shares all of these characteristics when analyzing R&D.

Table 5 presents the variables used in estimating the models for investment in R&D and its intensity. They were selected based on the review of literature given in section 2.2.

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[19] We use the Stata code made available on Semykina's website (http://myweb.fsu.edu/asemykina/).

Table 5. Variables used in the model of investment in R&D (value and intensity)

Variables name	Variables description
Dependant variables (R&D)	
sred_expenditures	Expenditures qualifying for the Scientific Research and Experimental Development (SR&ED) expenditure
sred_intensity	Ratio of sred_expenditures and trade_sales_goods_services
sred_binary	=1 is sred_expenditures >0 and 0 otherwise
Explanatory variables of the expenses and the intensity	
trade_sales_goods_services	Trade sales of goods and services. Sum of all sales for corporations or partnerships.
Net_Foreign_Income	Sum of entries in net foreign non-business income earned in the year and net foreign business income earned in the year.
Net_Foreign_Income_binary	=1 if Net Foreign Income>0 and 0 otherwise.
Sales per ilu	trade_sales_goods_services per ilu. The sales values per workforce is introduced as a measure of firm productivity. It could also be an indicator of the intensity of labor in the industry, the sales per workforce being lower in industry intensive in labor.
Total grants and subsidies	= subsidies_grants + sred_deducted_parti + rd_deduction (see below for the definitions)
Instruments of potential endogenous variables[20]	
part_sal_rd	=rd_wagesandsalaries/rd_totalexpenditures
subsidies_grants	Subsidies and grants. Government assistance and subsidy payments (for non-fishing corporations), federal, provincial, territorial, or municipal grants received.
sred_deducted_parti	Amount of SR&ED credit deducted from Part I tax. Introduced as a % of sred_expenses
rd_deduction	SR&ED deduction claimed for the year. Introduced as a % of sred_expenses
sred_refunded	Value of any refunded credit claimed on SR&ED expenditures. Introduced as a % of sred_expenses.
sred_carried_back	SR&ED credit carried from previous tax year (1,2 and 3).
total_tangible_assets	Total tangible capital assets.
interest_and_bank_charges	Interest and bank charges. Generic entry for finance charges, bank charges, and interest payments on capital leases. (operating expenses)

[20] All the variables used as instruments could be included in the vector of the variables of the selection model (Semykina and Wooldridge, 2013).

Table 5. Variables used in the model of investment in R&D (value and intensity) (Cont'd)

Variables name	Variables description
Explanatory variables of the selection equation	
Characteristics of the firm	
age of the firm	Age of the firm in year.
ilu	Sum of Individual Labour Units (ILUs) for enterprise.
Sales per ilu	trade_sales_goods_services per ilu. The sales values per workforce is introduced as a measure of firm productivity. It could also be an indicator of the intensity of labor in the industry, the sales per workforce being lower in industry intensive in labor.
Avgpay	Average payroll reported from PD7s. Calculated by taking the mean of all monthly payroll submissions (including 0s). The average payroll could be considered as a proxy of workforce. We hypothesize that, all thing being equal, the average payroll is increasing in the quality of workforce.
total_tangible_assets	Total tangible capital assets.
Net_Foreign_Income_binary	=1 if Net Foreign Income>0 and 0 otherwise.
rd_wagesandsalaries	Wages and salaries paid to employees directly engaged in SR&ED.
rd_totalexpenditures	Total expenditures on SR&ED. Calculated by taking total allowable SR&ED expenditures less third party payments, and contract expenditures.
part_sal_rd	=rd_wagesandsalaries/rd_totalexpenditures
Government support	
subsidies_grants	Subsidies and grants. Government assistance and subsidy payments (for non-fishing corporations), federal, provincial, territorial, or municipal grants received.
sred_deducted_parti	Amount of SR&ED credit deducted from Part I tax. Introduced as a % of sred_expenses
rd_deduction	SR&ED deduction claimed for the year. Introduced as a % of sred_expenses
sred_refunded	Value of any refunded credit claimed on SR&ED expenditures. Introduced as a % of sred_expenses.
sred_carried_back	SR&ED credit carried from previous tax year (1,2 and 3).
Industries	
naics_311	=1 if naics code is 311 and 0 otherwise.
naics_312	=1 if naics code is 312 and 0 otherwise.
naics_313	=1 if naics code is 313 and 0 otherwise.
naics_314	=1 if naics code is 314 and 0 otherwise.
naics_315	=1 if naics code is 315 and 0 otherwise.
naice_316	=1 if naics code is 316 and 0 otherwise. Industry of reference.

In the estimation procedure, the continuous variables are transformed in log.

3.2 Measures of export performance

We analyzed extensive and intensive margins (Martincus and Carballo, 2008). The trade data used are disaggregated at the HS8 level.

3.2.1 The extensive margin of trade

As noted above, the US market is the main export destination for Canadian agri-food SMEs. In this section, we analyze variables explaining the capacity for SMEs to gain access to several export markets (extensive margin) and more specifically the impact of R&D investments. The extensive margin measure, in addition to being noncontinuous, is bounded by zero and by the maximum number of potential partner countries for Canadian firms. This implies that the use of standard estimators (Ordinary Least Squares or the Poisson Model) can lead to a bias (Silva, Tenreyro and Wie, 2014). Therefore, we followed Silva et al. (2014) and analyzed the extensive margin using a Bernouilli model estimated from a pseudomaximum likelihood (Papke and Wooldridge, 1996).[21] Following this procedure, we estimated the following model:

$$(6) \qquad s_{it} / S = 1 - \left(1 + \omega \exp\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)\right)^{\frac{-1}{\omega}} + u_{it}$$

where s_{it} is the number of firm i's export destinations for period t, S is the number of potential destinations, and u_{it} is an error term such as $E\left(s_{it} / S \mid u_{it}\right) = 0$. $\boldsymbol{\beta}$ and ω are parameters to be estimated. $\mathbf{x}_{it}$ is a set of variables representing firm characteristics, which change over time. For a function F such as $F\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right) = 1 - \left(\omega \exp\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)\right)^{\frac{-1}{\omega}}$, Papke and

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[21] A recent application of this approach to the agri-food sector is described by Scoppola, Raimondi and Olper (2018).

Wooldridge (1996) assumed that the variance of s_{it} / S is proportional to $F\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)=\left(1-F\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)\right)$. This condition allows one to estimate parameters of the model by maximizing the following likelihood function:

(7) $$L(\omega,\beta)=\left(s_{it}/S\right)\ln\left(F\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)\right)+\left(1-s_{it}/S\right)\ln\left(1-F\left(\mathbf{x}_{it}'\boldsymbol{\beta}\right)\right)$$

Silva et al. (2014) argued that the inference should focus on the partial effects of regression factors rather than on the estimated parameters.

Measures of the extensive margins of trade

We analyze two measures of extensive margins. The first is the probability of the export (*EM_1*) of a good *hs* from firm *i* to destination *d* (Tamini, Gervais and Larue, 2010). We defined this measure as follows:

(8) $$EM\_1_{i,hs,d}=\begin{cases}1 & if \quad trade_{i,hs,d}>0\\ 0 & if \quad trade_{i,hs,d}=0\end{cases}$$

This measure simply analyzes the capacity to export without considering the number of destinations involved. Thus, we cannot analyze whether a firm can export multiple products to multiple destinations. The second measure refers to the number of firm destinations (*EM_2*). For each firm *i*, we define this measure as follows:

(9) $$EM\_2_i=\sum_d 1\left[trade_{i,hs,d}>0\right]$$

This measure is a count variable that for each firm indicates the number of destinations involved regardless of the good exported. This measure's upper bound is valued at 110, and the number of destinations is presented in the database (see Appendix 1). It measures the diversification of export destinations.

3.2.2 The intensive margin of trade

It is assumed that trade flows result from: (i) the decision to export and (ii) the chosen level of exports. The estimation strategy follows two decision paths. First, a binary variable determines whether exports to a particular destination are positive and this indicator depends on a latent variable with a censored distribution. Second, a model of export value is estimated using a two-step Heckman sample selection estimator (Heckman, 1979) to correct for zeroes (Tamini, Doyon and Simon, 2016). The generic form of the model is as follows:

$$(10) \qquad A_{idt} = \beta_0 + \boldsymbol{\beta_1} \ln \boldsymbol{\Lambda}_{it} + \boldsymbol{\beta}_2 \ln \boldsymbol{\chi}_{dt} + \boldsymbol{\beta}_3 \boldsymbol{\Psi}_{dt}^{can} + \beta_4 \Gamma_{idt} + \xi_{idt}$$

where A is the log of the export volume of firm i sent to country d at time t, $\boldsymbol{\Lambda}_{it}$ is a vector of specific variables of firm i that varies over time, $\boldsymbol{\chi}_{dt}$ is a vector of the specific variables of a destination country (d) and $\boldsymbol{\Psi}_{dt}^{can}$ is a variable that characterizes the relationship between Canada and the destination country. Parameter Γ is the inverse mills ratio and ξ is the error term.

Measures of the intensive margins of trade

We analyze two measures of intensive margins. The first measure (*IM_1*) applies to each firm and product (HS8) as a measure of the value of trade. The second measure (*IM_2*) applies to each firm as the total value of its international trade as follows:

$$(11) \qquad IM\_2_i = \sum_{hs} \sum_{d} 1\left[trade_{i,hs,d} \mid trade_{i,hs,d} > 0 \right]$$

3.3 Estimating the R&D effect with a difference-in-difference (DiD) estimator

The difference-in-difference approach is a research method for estimating causal effects (Puhani, 2012; Lechner, 2011; Athey and Imbens, 2006). As indicated by Lechner (2011), DiD is suitable for estimating the effects of interventions that do not affect everyone at the same time and in the same way. Following Puhani (2012) and his notation, we defined the effect of having R&D expenses (*I*), which is the difference in potential outcomes, as follows:

$$(12) \qquad \tau = E\left[Y^1 \mid T=1, \Im=1, \mathbf{x}\right] - E\left[Y^0 \mid T=1, \Im=1, \mathbf{x}\right]$$

where Y^1 and Y^0 are the potential outcomes with and without investment in R&D, respectively. T is a binary time period that groups indicators. Parameter $\Im$ is coded as 0 or 1 when a firm belongs to the group of firms having R&D expenses $(I=1)$. Parameter $\mathbf{x}$ is a vector of the control variables, and finally $E[\cdot]$ is the expectation operator. The following formula indicates participation in the group of innovators:

$$(13) \qquad Y = 1\left[T=1, \Im=1\right] = T \times \Im$$

where $1[\cdot]$ is the indicator function. The observational rule for the outcome variable is as follows:

$$(14) \qquad Y = I \times Y^1 + (1-I) \times Y^0$$

Let us now assume that $\varphi(\cdot)$ is a nonlinear and strictly monotonic transformation function. The conditional expectations of binary potential outcomes Y^0 and Y^1 are as follows:

$$(15) \qquad E\left[Y^0 \mid T, \Im, \mathbf{x}\right] = \varphi\left(\alpha T + \beta\Im + \mathbf{x\theta}\right)$$

$$(16) \qquad E\left[Y^1 \mid T, \Im, \mathbf{x}\right] = \varphi\left(\alpha T + \beta\Im + \gamma + \mathbf{x\theta}\right)$$

When combining (13), (14), (15) and (16) we have the following DiD model (Puhani, 2012)):

$$(17) \qquad E\left[Y^1 \mid T, \Im, \mathbf{x}\right] = \varphi\left(\alpha T + \beta\Im + \gamma T\Im + \mathbf{x\theta}\right)$$

Additionally, the effect of being an innovator is as follows:

$$(18) \qquad \begin{aligned} \tau &= E\left[Y^1 \mid T = 1, \Im = 1, \mathbf{x}\right] - E\left[Y^0 \mid T = 1, \Im = 1, \mathbf{x}\right] \\ &= \varphi\left(\alpha + \beta + \gamma + \mathbf{x\theta}\right) - \varphi\left(\alpha + \beta + \mathbf{x\theta}\right) \end{aligned}$$

The estimated average effect of being engaged in R&D activities is the expected effect on the outcome that firms gain as a result of having R&D expenses. We define variable $\Im$ as follows:

$$\Im_t = \begin{cases} 1 & if \quad srd\_binary_{t-1} = 1 \\ 0 & if \quad srd\_binary_{t-1} = 0 \end{cases}$$

3.4 Variables used in estimating the impact of innovation

Table 6 presents the variables used when estimating the impact of innovation on trade performance. Firms' characteristics explain their propensity to innovate. We do not use them when estimating the impact of innovation.

Table 6. Variables used in the estimation of the impact of innovation on trade performances

Variables name	Variables description
Research and development	
sred_binary	=1 is sred_expenditures >0 and 0 otherwise.
International activities	
EM_1, EM_2	Extensive margin measures (defined before)
IM_1, IM_2	Intensive margin measures (defined before)
Net_Foreign_Income_binary	=1 if Net Foreign Income>0 and 0 otherwise.
Destination country	
agric_va	Share of agricultural production in the GDP. Introduced as the importance of the agricultural sector in the economy of the destination country.
eu_d	Country of destination is a member of European Union
USA	Country of destination is one of the States of the USA
distance	Distance (weighted) from Canada
gdp_pc	GDP per capita
Provinces	
BC	=1 if firm belongs in British Columbia
QC	=1 if firm belongs in Quebec
ON	=1 if firm belongs in Ontario
AT	=1 if firm belongs in province or territory other than QC, BC, ON
Industries	
naics_311	=1 if naics code is 311 and 0 otherwise. Industry of reference.
naics_312_316	=1 if naics code is 312 to 316 and 0 otherwise.

In the estimations, continuous variables are transformed in log.

4 Data sources

The empirical implementation of these methods requires the use of data on the characteristics of firms and on their innovation and export activities. The National Accounts Longitudinal Microdata File (NALMF) for 2010 to 2015 was used for this study. The file contains data on the characteristics of firms over time, such as employment, payroll, income, profits, assets, stock of capital, R&D capital stock, investment, added value and productivity. As the database does not use a direct measure of innovation, R&D spending by firms approximates the latter.

Because this study focuses specifically on the agri-food industry, we are interested in companies with three-digit North American Industry Classification System (NAICS) codes for Classes 311 (Food Manufacturing), 312 (Beverage and Tobacco Product Manufacturing), 313 (Textile Mills), 314 (Textile Product Mills), 315 (Apparel Manufacturing) and 316 (Leather and Allied Product Manufacturing). We compared the results for class 311 with those for the other classes. We used the definition employed by Statistics Canada to select SMEs to be included in the database: enterprises with between 1 and 499 employees.[22] Specifically, employment is measured with Individual Labor Units (ILUs), which are counts of persons who receive a T4 slip. A firm's employment is defined as the sum of its ILUs.[23]

NALMF data are merged with Trade by Exporter Characteristics (TEC) data. In identifying individual exporters, information listed in export records can be linked to information available from the NALMF database. Trade data are disaggregated at the HS8 level. This allows us to analyze levels of product diversification of each firm. We use data on exports by destination and considering American States individually, European Union countries individually and the main destination countries of Canadian agri-food exports. The final dataset includes 110 destinations (see Appendix 1).

The CEPII,[24] WDI[25] and FAO[26] databases are used to collect data on distances, GDP per capita and the share of the agricultural sector for different economies, respectively. Table 7 presents

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[22] See https://www.ic.gc.ca/eic/site/061.nsf/eng/03091.html. Accessed March 28, 2019.

[23] See Dixon and Rollin (2012) and The Longitudinal Employment Analysis Program (LEAP) at http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=8013 (Accessed March 28, 2019).

[24] See http://www.cepii.fr/CEPII/en/bdd_modele/bdd.asp.

[25] See https://datacatalog.worldbank.org/dataset/world-development-indicators .

[26] See http://www.fao.org/faostat/en/#home.

statistics on variables used for the estimations.[27] In total, 54.6% of the firms included in the database operate within the agri-food manufacturing industry (NAICS 311).

Table 7. Summary statistics of some variables used in the analyzes

Variables	**e(count)**	**e(mean)**	**e(sd)**
Sales of goods and services ($)	74,349	7,701,803.000	113,000,000.000
Age of firm (year)	74,349	15.834	8.086
Total payroll ($)	74,349	993,933.100	11,000,000.000
ILUs	74,349	26.059	217.344
Total tangible assets ($)	74,349	3,131,137.000	39,900,000.000
sred_expenses ($)	74,349	16,287.960	175,119.700
srd_binary	74,349	0.075	0.264
sred_p_sales (%)	52,961	2.360	142.514
BC	74,349	0.150	0.357
ON	74,349	0.360	0.480
QC	74,349	0.289	0.454
AP	74,349	0.201	0.400
naics_311	74,349	0.546	0.498
naics_312	74,349	0.094	0.292
naics_313	74,349	0.042	0.200
naics_314	74,349	0.082	0.275
naics_315	74,349	0.203	0.402
naics_315	74,349	0.203	0.402
EM_1	7,944,041	0.161	0.367
EM_2	7,944,041	1.534	6.095
Trade value (HS8, $)	7,944,041	46,463.150	923,977.100
gdpcap_d ($)	7,944,041	38,143.970	23,138.210
Distance (km)	7,993,852	5,373.311	3,786.869
agric_va (%)	7,944,041	2.566	3.069

Sources: calculation of the authors from NALMF, TEC, CEPII, WDI and FAO databases.

[27] The data used are corporate tax return data and are therefore subject to confidentiality rules. Thus, as examples, minimums and maximums cannot be disclosed and when classes are created, each must include a sufficient number of firms.

5 Estimations results

5.1 Factors shaping investment in R&D

5.1.1 Factors shaping the propensity to invest in R&D

Table 8 presents results (coefficients and marginal impacts) of the estimation of the model on the propensity to invest in R&D.

Sales of goods and services are used as a proxy of firm size. Our results indicate that this has a positive impact on the propensity to engage in R&D. This result is consistent with the literature on Canadian manufacturing (Therrien and Hamel, 2010).[28] This is not the case for net foreign income with the impact being nonsignificant even at 10%. This result is not line with Baldwin et al.'s (2016) results for Canadian manufacturing. These authors found that being active in international markets has a positive impact on the propensity to engage in R&D. However, as indicated in the literature review, causality between the two variables is a subject of debate in reference to international trade both empirically and theoretically. Indeed, DiPietro and Anoruo (2006) and Salim and Bloch (2009) found that business R&D is not Granger caused by exports. The key rational behind exports directing the propensity to innovate related to higher competition (Munro et al., 2012). Monreal-Pérez et al. (2013) also found that firms do not experience learning-by-exporting effects in engaging in product or process innovation. However, one may note that most food manufacturing sector exports are sent to the USA. Moreover, as mentioned by Tamini et al. (2018), Canadian and US agri-food markets are integrated. The argument for higher innovation due to exports to the USA does not apply in this case. Filipescu et al. (2013) found exports to affect R&D activities when

[28] See Rogers (2004).

related to product innovation rather than process innovation. Being active in international markets creates an incentive and capacities to adapt products to consumers' demands. In addition, Salomon and Shaver (2005) explain that if a firm wishes to learn from international markets, it must engage in international expansion through an entry mode that requires a high level of commitment (e.g., FDI). Additionally, the researchers show that because intranational spillovers can be pervasive, domestic competitors may exploit the benefits of innovation before a firm is able to realize these benefits. Given these arguments, Salomon and Shaver (2005) conclude that participating in international markets does not systematically lead to a higher propensity to engage in R&D.

All variables used to characterize the firms have coefficients that are significant at 1% or less. Average pay for a firm (*avgpay*) is used as a measure of the quality of the workforce. It has a positive impact on the propensity to invest in R&D, which is expected (see Romijn and Albaladejo, 2002; Chen and Huang, 2010) as is the positive effect of total tangible assets of a firm (*total tangible assets*). On the other hand, the age of a firm and sales of a workforce have a negative impact on the propensity to engage in R&D. Baldwin et al. (2016) also found that a firm's age has a negative impact on the propensity to engage in R&D when it is extramural, which is largely the case in the agricultural sector (Munro et al., 2012). This result is also found by Capitanio, Coppola and Pascucci (2009) for the Italian agri-food sector. The result on sales generated per workforce is counter intuitive because this variable is considered a proxy of workforce productivity. It this case, as in Baldwin et al. (2016), when analyzing the entire manufacturing sector, the impact must be positive. However, as indicated by Capitanio et al. (2009), this variable can also be used as an indicator of firm labor intensity. The negative coefficient then shows that the less labor-intensive firms are, the less likely they are to innovate.

Table 3 shows that process and organization innovations are the most commonly observed in food manufacturing. Our results suggest that labor-intensive firms innovate to be more efficient.

Government support has an important effect on the propensity to engage in R&D activities. Subsidies, grants and deductions from R&D expenses have a positive and significant impact at 1% or less. The impact is stronger when considering R&D deductions. These results are consistent with the literature (see section 2.2).

We introduce the provinces of Quebec (QC), British Colombia (BC) and Ontario (ON) as binary variables while other provinces and territories are considered as reference geographical regions. Our results indicate that the propensity to invest in R&D is stronger in the provinces of BC, ON and QC than in the other provinces and territories. The difference is more pronounced for the province of Quebec. The marginal impact results indicate that operating in the province of Quebec increases the propensity to invest in R&D by 2.6% relative to the reference provinces and territories.

Finally, we take the agri-food industry (NAICS 311) as the industry of reference. If significant, the propensity to invest in R&D is higher for the other industries. This is found to be the case for industries 312 (Beverage and Tobacco Product Manufacturing), 313 (Textile Mills) and 315 (Apparel Manufacturing). Note that in general the marginal effects are minor. This is not surprising because only 7.5% of the firms included in the sample are engaged in R&D (see Table 7).

Table 8. Estimation results of the propensity to invest in R&D

	Dependent variable =1 if sred_expenditure>0			
Variables	Coefficient	Standard error	Marginal impact	Standard error
Sales and international activities				
log of sales_goods_services	0.033**	-0.015	0.001**	0.001
Net_foreign_income_binary	-0.14	-0.247	-0.005	0.009
Characteristics of the firm				
age of the firm	-0.023***	-0.005	-0.001***	0.000
Sales per ilu	-5.52e-09***	<0.000	<0.001***	<0.001
log of total tangible assets	0.070***	-0.017	0.002***	0.001
log of avgpay	0.282***	-0.032	0.010***	0.001
Government support				
log of subsidies grants	0.068***	-0.014	0.002***	0.001
sred deducted_parti	0.211***	-0.017	0.008***	0.001
rd_deduction	0.377***	-0.018	0.013***	<0.001
Provinces and territories				
BC	0.335**	-0.137	0.012**	0.005
QC	0.719***	-0.124	0.026***	-0.115
ON	0.455***	-0.115	0.016***	0.004
Others	-		-	
Industries				
Industry 311 (reference)	-		-	
Industry 312	0.425***	-0.13	0.015***	0.005
Industry 313	0.834***	-0.167	0.030***	0.006
Industry 314	-0.208	-0.136	-0.007	0.005
Industry 315	0.334***	-0.095	0.012***	0.003
Industry 316	-0.020	-0.169	-0.020	-0.169
Constant	-7.619***	-0.45		
Number of observations	32,633			
Log pseudo likelihood	-2,506.509			

Standard error are adjusted for 5,969 clusters of firms. *p<0.10, ** p<0.05, *** p<0.01.

5.1.2 Factors shaping R&D expenses and intensity levels

Estimation results for the models on R&D expenses and intensity levels are presented in Table 9. Overall, the model explaining R&D expenses works well. Indeed, coefficients of the correction terms (Inverse mills ratio, IMR) are mostly significant at 10% or less and the R-squared of the model is valued at 0.480. The model of the intensity of R&D does not work as well. Coefficients of the correction terms are nonsignificant even at 10%[29] and the R-squared value is weak at 0.077. The R-squared values are also less than 10% in the models of R&D intensity given in Baldwin et al. (2016). Some other variables may need to be considered to understand the dynamics of R&D intensity. Indeed, the database does not include specific variables on managers and their behaviors regarding R&D, which could offer better explanatory power. The model's linear functional form may also explain the intensity model's poor explanatory power.

Firm size proxied by sales of goods and services and government support and firm performance proxied by sales per worker have a statistically significant impact on R&D expenses and on R&D intensity measured as the ratio of R&D expenses to total sales. Firm size has the expected positive effect on value and a negative impact on intensity. For the latter we intuitively expected to find an inverted U-shaped curve denoting a positive relationship between firm size and R&D intensity for smaller firms in sustaining their growth, and then a negative impact with R&D expenses not showing a one-to-one increase with sales. Our results suggest that food manufacturing firms occupy to the decreasing part of the relationship between R&D intensity and firm size even if the average R&D expenses are low in this industry (see Table 7). As

[29] The two coefficients are significant at 15%.

mentioned before, extramural R&D is more important in the agri-food sector (Munro et al., 2012). This may also partly explain the negative relationship found between firm size and R&D intensity.

Government support and firm performance measured from sales generated by the workforce both have a positive impact on R&D intensity. These results are in line of those given in the literature (Dagenais et al., 2004; Baghana and Mohnen, 2009; Baldwin et al., 2016) as shown in section 2.

Table 9. Estimations results of R&D expenses and intensity

Dependent variables	**Log of R&D expenses**		**R&D expenses per sales**	
Explanatory variables	Coefficient	Standard error	Coefficient	Standard error
Results of the main equation				
Log of sales_goods_and_services	0.927***	0.141	-25.788**	12.144
Log of grants	0.096***	0.014	2.765*	1.552
sales_per_ilu	0.001***	0.000	0.010*	0.005
IMR_2010	0.437	0.327	10.482	6.825
IMR_2011	-0.409**	0.187	-0.172	3.999
IMR_2012	-0.300	0.217	-4.216	4.189
IMR_2013	-0.570*	0.343	-5.847	4.852
IMR_2014	-0.373	0.355	-6.561	4.312
IMR_2015	-0.767**	0.391	-7.594	5.490
2011 (=1)	-0.008	0.061	1.235	2.072
2012 (=1)	-0.167**	0.066	3.462*	2.024
2013 (=1)	-0.372***	0.077	4.211*	2.541
2014 (=1)	-0.611***	0.095	4.947*	2.943
2015 (=1)	-0.553***	0.104	6.878*	3.744

Table 9. Estimations results of R&D expenses and intensity (Cont'd)

Dependent variables / Explanatory variables	Log of R&D expenses		R&D expenses per sales	
	Coefficient	Standard error	Coefficient	Standard error
Results of the selection equation				
Mean[30] of log of subsidies_grants	-0.017*	0.009	1.060	1.535
Mean of sred_deducted_parti	-0.001	0.013	-0.559	0.642
Mean of sred_refunded	0.094***	0.010	0.548	0.566
Mean of rd deduction	0.028	0.020	12.684***	2.726
Mean of sred_carried_back	0.033	0.051	0.870	0.939
Mean of log of avgpay	-0.309***	0.112	14.257*	7.888
Mean of log of total_tangible_assets	0.046	0.053	8.064**	3.298
Mean entid_age	-0.013***	0.004	-0.429	0.304
Mean sales_p_ilu	0.000*	<0.001	<0.001	<0.001
Mean part_sal_rd	1.131***	0.216	-2.640	8.809
Mean net_foreign_income_b	0.347	0.224	0.466	3.540
Mean naics_311	-0.384**	0.196	2.883	3.500
Mean naics_312	-0.451**	0.220	-4.636	3.650
Mean naics_313	0.252	0.215	-1.592	2.719
Mean naics_314	-0.030	0.226	-1.099	2.346
Mean naics_315	-0.162	0.200	0.903	2.762
_cons	4.579***	1.095	-143.199	78.149
Number of observation	3,222		2,611	
R-squared	0.480		0.077	
Clusters (firm identity)	Yes (1,360)		Yes (1,022)	

Standard error adjusted for clusters. *p<0.10, ** p<0.05, *** p<0.01.

5.2 Impact of R&D expenses on trade performance

5.2.1 Extensive margins of trade

Table 10 presents the estimated results for the model on the extensive margins of trade. In this table, as examples, *Innov_a11* measures the impact of R&D expenses for 2011. *Innov_a11_USA* captures the differentiated impact that results when the destination is an

[30] Averaged across individual (Semykina and Wooldridge, 2013)

American state in 2011. *Innov_a11_312_316* denotes the differentiated impact of R&D expenses results when the goods are of industries 312 to 316.

The results given in Table 9 indicate that for the two analyzed measures of extensive margins, having R&D expenses has a positive impact. For *EM_1*, the probability of exporting, the impact is weaker when considering American states (=*Innov_a11*+*Innov_a11_USA*) but remains positive. These results suggest that when exporting to American states, firms tend to specialize in specific destinations. This result is confirmed by estimations of the second measure of extensive margins: the number of destinations (*EM_2*). In 2011 and 2012, the impact of having R&D activities is negative, indicating that for the USA and these years, firms engaged in R&D focused their efforts on a few states. As indicated in the literature review, product innovation tends to increase production marginal costs with a potentially negative impact on the capacity to export while process innovation has a positive impact due to lowered marginal costs. Then, our results may also suggest that to maintain their main markets in the USA, firms engage in product innovation and must focus their activities on these main markets.[31] However, our results indicate that this is not the case for 2014 and 2015, as the impact of R&D expenses on the extensive margins is found to be positive even though it is less pronounced when considering destinations other than American states. They are in line of those of Alarcón and Sánchez (2016). These authors found that intramural R&D expenses have a positive impact on the probability to export while extramural R&D expenses even if positive have a nonsignificant impact.

[31] Deng et al., (2014) demonstrate that innovation could be detrimental to exporter survival for firms that have weak profitability and high outstanding receivables.

Our results indicate that differences between the agri-food industry and the other industries studied are nonsignificant when considering the probability of exporting (*EM_1*). For the number of destinations (*EM_2*), R&D activities tend to have a stronger impact on the agri-food industry, because the coefficients of variables *Innov_a13_312_316*, *Innov_a14_312_316* and *Innov_a15_312_316* are negative and significant at 5% or less.

Table 10. Estimation results of the models of extensive margins

Dependant variables	***EM_1***		***EM_2***	
Explanatory variables	Coefficient	Standard error	Coefficient	Standard error
Innov_a11	0.107***	0.009	0.057***	0.018
Innov_a12	0.106***	0.010	0.165***	0.018
Innov_a13	0.283***	0.010	0.154***	0.018
Innov_a14	0.283***	0.011	0.343***	0.018
Innov_a15	0.365***	0.012	0.477***	0.019
Innov_a11_USA	-0.055***	0.013	-0.172***	0.019
Innov_a12_USA	-0.055***	0.014	-0.205***	0.019
Innov_a13_USA	-0.141***	0.015	-0.165***	0.019
Innov_a14_USA	-0.107***	0.016	-0.221***	0.019
Innov_a15_USA	-0.122***	0.017	-0.360***	0.020
Innov_a11_312_316	0.150	.	0.013	0.009
Innov_a12_312_316	2.568	28.267	0.055***	0.009
Innov_a13_312_316	0.288	56.078	-0.021**	0.009
Innov_a14_312_316	0.343	.	-0.032***	0.009
Innov_a15_312_316	0.460	54.550	-0.052***	0.009
Number of observations	7,944,054		78,654	
Pseudo R-squared	0.470		0.204	

Detailed results of the estimations including coefficients of the control variables are given in the annexes.

5.2.2 Intensive margins of trade

Table 11 presents estimated results of the models of intensive margins. Because the value of the trade is in log (see Equation (10)), the estimated coefficients measure the change of trade in percentage because of R&D activities. For HS8 at the disaggregated level (*IM_1*), if a significant result is found, the impact of being an innovator is negative when considering destinations other than the USA. This is not the case when considering American states, as the impact of R&D activities on intensive margins is positive. For example, for 2011 the impact on the intensive margin is valued at 10.8% (0.108 =*Innov_a11*+*Innov_a11_USA*) of the increase of the value of trade. When considering all exports of a given firm (*IM_2*), the impact is positive and significant for two of the studied years: 2012 and 2014. The differential impact of the USA is not statistically significant even at 10%. To summarize, when considering American states as destination markets, R&D activities increase shipments made along tariff lines (HS8) and the total shipments of firms.[32] Second, when considering destinations other than American states, R&D activities tend to increase the total shipments of firms while reducing shipments made along tariff lines (HS8). As found in section 5.2.1., our analyses of extensive margins reveal a positive impact of R&D activities whatever the measure. These results for extensive and intensive margins suggest that gains derived from new destinations are not accompanied by a "sufficient" increase in the production capacities of firms. This could lead to a reallocation of exports to certain American states due to their proximity. Overall, the impact for industry 311 is less significant than is those of the other industries with the

[32] This result is in line with the literature on the impact of innovation of trade (e.g., Salim and Bloch, 2009).

coefficients being mostly positive and significant at 10% and less regardless of the intensive margin measure used.

Table 11. Estimated results of the models of intensive margin

Dependant variables	***IM_1***		***IM_2***	
Explanatory variables	Coefficient	Standard error	Coefficient	Standard error
Innov_a11	-0.255***	0.028	0.174	0.134
Innov_a12	-0.016	0.029	0.351**	0.137
Innov_a13	-0.081***	0.029	0.192	0.142
Innov_a14	-0.193***	0.030	0.424***	0.147
Innov_a15	-0.522***	0.033	0.073	0.150
Innov_a11_USA	0.364***	0.030	-0.157	0.139
Innov_a12_USA	0.087***	0.031	-0.189	0.143
Innov_a13_USA	0.379***	0.031	0.107	0.150
Innov_a14_USA	0.452***	0.033	-0.126	0.154
Innov_a15_USA	0.814***	0.035	0.185	0.158
Innov_a11_312_316	-0.034**	0.015	-0.065	0.052
Innov_a12_312_316	0.028*	0.015	-0.091*	0.051
Innov_a13_312_316	0.141***	0.015	0.224***	0.052
Innov_a14_312_316	0.071***	0.016	0.178***	0.053
Innov_a15_312_316	0.089***	0.016	0.367***	0.052
Number of observations	975,173		49,128	
Adjusted R-squared	0.187		0.178	

More detailed results of the estimations including coefficients of the control variables are given in the annexes.

6 Summary and conclusions

Similar to other SMEs, food manufacturing firms face two major challenges. The first is related to innovation while the second concerns access to international markets. However, studies that address the relation between innovation and Canadian agri-food firms' export performance are almost nonexistent. This study aimed to fill this gap by focusing on agri-food firms (food manufacturing and beverage and tobacco product manufacturing) and on firms of two related sectors: those of the textile and clothing (textiles, textile factories and clothing manufacturing) and leather and allied product manufacturing sectors.

The National Accounts Longitudinal Microdata File (NALMF) for 2010 to 2015 was used for this study. The NALMF data are merged with Trade by Exporter Characteristics (TEC) data.

Our results indicate that the size of a firm, the quality of its workforce, its total tangible assets and government support have a positive impact on the propensity to have R&D expenses. On the other hand, firm age and sales per workforce have a negative impact. The negative coefficient found for sales per workforce indicates that less labor intensive firms are less likely to engage in R&D activities. Our results suggest that labor-intensive firms (process and organization) tend to be more efficient.

The size of the firms, government support and firm workforce performance have a statistically significant impact on R&D expenses and intensity measured as the ratio of R&D expenses to total sales. Firm size has an expected positive effect on the value and a negative impact on intensity. For the latter we find an inverse U-shaped curve with a positive relationship between firm size and the intensity of R&D for smaller firms in sustaining their growth and then, a negative impact, the R&D expenses not spurring a one-to-one increase with sales. Our results suggest that food manufacturing firms are in the decreasing part of the relationship between R&D intensity and firm size. Government support and firm performance both have a positive impact on R&D intensity.

Our results also indicate that being engaged in R&D activities has a positive impact on the extensive margins of trade with a lower impact when considering American states as export destinations. The results for the intensive margins of trade are mixed. When considering American states as destination markets, R&D activities increase shipments made along tariff lines (HS8) and the total shipments of firms. This is not the case for the other destinations with innovation activities increasing the total shipments of firms while reducing the number of shipments made along tariff lines (HS8).

Public policies including tax deductions, subsidies and grants are important for encouraging the involvement of agribusiness firms in R&D activities. In addition, firms with higher quality workers and exhibiting higher levels of labor productivity tend to be more innovative. Policies supporting firms in these two dimensions are therefore warranted. Finally, our results show that policies favoring entry into new markets must necessarily be accompanied by those in favor of increasing production capacity to take full advantage of gains generated from conquering new markets.

Finally, we wish to address some of the limitations of our study. We initially planned to work with two databases, the Survey on Financing and Growth of Small and Medium Enterprises (SFGSME) conducted by Statistics Canada in 2011 and 2014 and the *National Accounts Longitudinal Microdata File* (NALMF). However, we abandoned this option due to our review of only two years of data across different firms, and most importantly, it was impossible to guarantee the confidentiality of the results. We also explored the possibility of using the Annual Survey of Manufacturing and Logging Industries (ASML). Such data are not available for after 2010 and the team at Statistics Canada had deemed the measure of R&D an informal R&D measure that does not equate to what is reported in fiscal data. We thus decided, in accordance with the team at Statistics Canada, to focus on the NALMF merged with the TEC database. Unfortunately, in doing so, it was impossible to analyze different forms of innovation.

Analyzing the behavior of managers is important in understanding dynamics of the R&D activities of firms. A specific survey of agribusiness SMEs would offer a stronger understanding of the factors that shape innovation inputs and outputs. The estimation models were used to analyze factors explaining R&D expenses and the intensity of control for firm endogeneity and self-selection in regard to R&D. However, the performance of the model on R&D intensity is poor. More work must be done on factors explaining this phenomenon using variables of managers' behavior. Finally, our empirical method for estimating the impact of R&D uses a DiD approach with binary treatment. Two extensions could be applied to ensure that the results are robust. The first would involve combining DiD with matching methods. This would involve matching each innovative firm with one or more noninnovative firms according to their propensity scores. The use of a combination of matching and difference-in-difference methods is likely to improve the quality of nonexperimental evaluation studies (Blundell et al., 2004). In addition, we expect the impact of R&D to be a function of R&D intensity. Dose-response models (Cerulli, 2015) could be used to better reflect the impact of R&D on firm trade performance given that the associated effects are a function of R&D intensity.

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8 Annexes

8.1 Appendix 1. List of destinations

Table 12. List of destinations

ARE	EST	MEX	USA_AH	USA_IO	USA_NY	ZAF
AUS	FIN	MLT	USA_AK	USA_IV	USA_OH	
AUT	FRA	MYS	USA_AS	USA_KA	USA_OK	
BEL	GBR	NLD	USA_CB	USA_KT	USA_OR	
BGR	GRC	NZL	USA_CD	USA_LO	USA_OS	
BRA	HKG	PHL	USA_CE	USA_MC	USA_PR	
CHE	HRV	POL	USA_CP	USA_ME	USA_PV	
CHL	HUN	PRT	USA_CS	USA_MF	USA_RI	
CHN	IDN	RUS	USA_CT	USA_MI	USA_TE	
CUB	IRL	SAU	USA_DN	USA_MJ	USA_TX	
CYP	ISL	SGP	USA_DS	USA_NB	USA_UT	
CZE	ITA	SVK	USA_DW	USA_ND	USA_VI	
DEU	JAM	SVN	USA_FL	USA_NH	USA_VO	
DNK	JPN	SWE	USA_GG	USA_NJ	USA_VT	
DOM	KOR	THA	USA_HA	USA_NK	USA_WA	
DZA	LTU	TTO	USA_IA	USA_NM	USA_WI	
EGY	LUX	UKR	USA_IH	USA_NS	USA_WY	
ESP	LVA	USA_AB	USA_II	USA_NV	VNM	

8.2 Appendix 2. Detailed results of the models of extensive margin

Table 13. Estimation results of the models of extensive margin of trade

Dependant variables	***EM_1***		***EM_2***	
Explanatory variables	Coefficient	Standard error	Coefficient	Standard error
Innov_a11	0.107***	0.009	0.057***	0.018
Innov_a12	0.106***	0.010	0.165***	0.018
Innov_a13	0.283***	0.010	0.154***	0.018
Innov_a14	0.283***	0.011	0.343***	0.018
Innov_a15	0.365***	0.012	0.477***	0.019
Innov_a11_USA	-0.055***	0.013	-0.172***	0.019
Innov_a12_USA	-0.055***	0.014	-0.205***	0.019
Innov_a13_USA	-0.141***	0.015	-0.165***	0.019
Innov_a14_USA	-0.107***	0.016	-0.221***	0.019
Innov_a15_USA	-0.122***	0.017	-0.360***	0.020
Innov_a11_312_316	0.150	.	0.013	0.009
Innov_a12_312_316	2.568	28.267	0.055***	0.009
Innov_a13_312_316	0.288	56.078	-0.021**	0.009
Innov_a14_312_316	0.343	.	-0.032***	0.009
Innov_a15_312_316	0.460	54.550	-0.052***	0.009
agric_va	-0.395***	0.046	-0.199***	0.076
eu_d	0.397***	0.002	0.229***	0.003
USA	1.709***	0.002	2.277***	0.006
Log of distance	-0.218***	0.001	-0.150***	0.002
Log of GDP per capita	0.182***	0.002	0.082	0.003
a2011	-0.115***	0.003	0.070***	0.008
a2012	-2.502	28.267	0.069***	0.008
a2013	-0.285	56.078	0.060***	0.008
a2014	-0.315***	0.003	0.066***	0.008
a2015	-0.448	54.550	0.126***	0.008
NAICS_312_316	-10.645	36.165	-1.480***	0.007
Innov_USA	0.073	0.009	-1.267***	0.014
Innov	-2.373	22.559	1.724***	0.014
Innov_312_316	3.491	22.559	1.193***	0.006
_cons	8.478	36.165	-0.556***	0.039
Number of observations	7,944,054		78,654	
Pseudo R2	0.470		0.204	

8.3 Appendix 3. Detailed results of the models of intensive margin of trade

Table 14. Estimated results of the models of intensive margin

Dependant variables	***IM_1***		***IM_2***	
Explanatory variables	Coefficient	Standard error	Coefficient	Standard error
Innov_a11	-0.255***	0.028	0.174	0.134
Innov_a12	-0.016	0.029	0.351**	0.137
Innov_a13	-0.081***	0.029	0.192	0.142
Innov_a14	-0.193***	0.030	0.424***	0.147
Innov_a15	-0.522***	0.033	0.073	0.150
Innov_a11_USA	0.364***	0.030	-0.157	0.139
Innov_a12_USA	0.087***	0.031	-0.189	0.143
Innov_a13_USA	0.379***	0.031	0.107	0.150
Innov_a14_USA	0.452***	0.033	-0.126	0.154
Innov_a15_USA	0.814***	0.035	0.185	0.158
Innov_a11_312_316	-0.034**	0.015	-0.065	0.052
Innov_a12_312_316	0.028*	0.015	-0.091*	0.051
Innov_a13_312_316	0.141***	0.015	0.224***	0.052
Innov_a14_312_316	0.071***	0.016	0.178***	0.053
Innov_a15_312_316	0.089***	0.016	0.367***	0.052
Innov_USA	0.217***	0.022	0.442***	0.103
Innov	-0.166***	0.021	-0.297***	0.099
Innov_312_316	0.125***	0.010	0.000***	<0.001
BC	-0.701***	0.008	-0.378***	0.046
QC	-0.883***	0.006	-0.909***	0.035
ON	-0.716***	0.006	-0.838***	0.034
agric_va	-0.275**	0.129	1.017	0.681
eu_d	-0.023***	0.006	-0.264***	0.032
USA	-0.187***	0.008	-1.633***	0.053
Log of distance	-0.018***	0.003	-0.140***	0.018
Log of gdp_pc	-0.002	0.005	0.148***	0.025
a2011	-0.006	0.013	0.031*	0.017
a2012	0.053***	0.014	0.077***	0.022
a2013	0.043***	0.014	0.028**	0.016
a2014	0.173***	0.014	>0.001***	<0.001
a2015	0.271***	0.014	0.111**	0.061
NAICS_312_316	-1.855***	0.013	-0.007*	0.004
IMR	-0.165***	0.006	-0.568	0.023
_cons	11.788	0.061	13.179***	0.329
Number of observations	975,173		49,128	
Adjusted R-squared	0.187		0.178	