Products and Provinces: A Disaggregated Panel Analysis of Canada's Manufacturing Exports

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by Itai Agur

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Abstract

The waning of the commodity boom places renewed emphasis on manufacturing as an engine for Canadian growth. However, Canadian manufacturing exports have been relatively stagnant since 2000. While the exchange rate depreciation over the past two years has energized export growth, the response has not been as strong as would have been expected given the size of the depreciation. More fundamental issues appear to be impeding the growth of the Canadian manufacturing sector. This study analyzes the structural factors behind export competitiveness by using unique Canadian data on exports, which are disaggregated both by province and by product. Matching exports to similarly disaggregated data on R&D, the capital stock and other supply-side variables, we find that these variables significantly affect export growth, beyond the impact of the exchange rate. In particular, investment in R&D, capital infrastructure and vocational training improves innovation and production capacity. These results are robust to a factor-augmented approach that controls for multicollinearity.

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Keywords: Competitiveness, Productivity, Innovation, R&D, Structural reform

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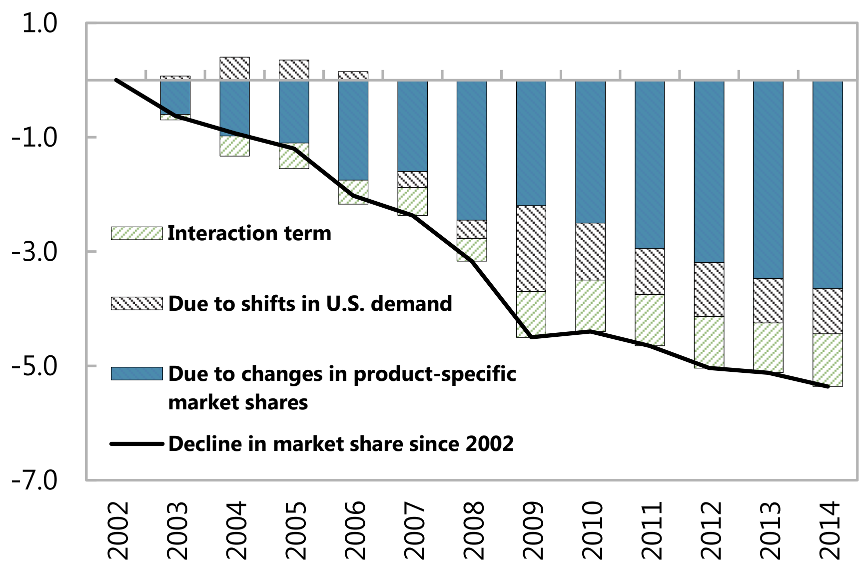
I. INTRODUCTION

Canada's manufacturing export performance has been relatively lackluster for quite some time. In fact, the volume of Canadian non-energy exports in 2015 was nearly the same as in the year 2000 (around 370 billion in real 2007 Canadian dollars). A gradual erosion of market share in the US played a key role in the stagnation of Canadian manufacturing exports. While such a decline in market share could be driven by a number of possible factors, including a substitution between product categories among US consumers, Barnett and Charbonneau (2015) find that this is overwhelmingly due to changes in product-specific market shares (Figure 1). In other words, Canadian manufactured goods exporters have lost competitiveness to other exporters within their product categories.

Figure 1: Cumulative change in Canada's share in the US non-energy import market

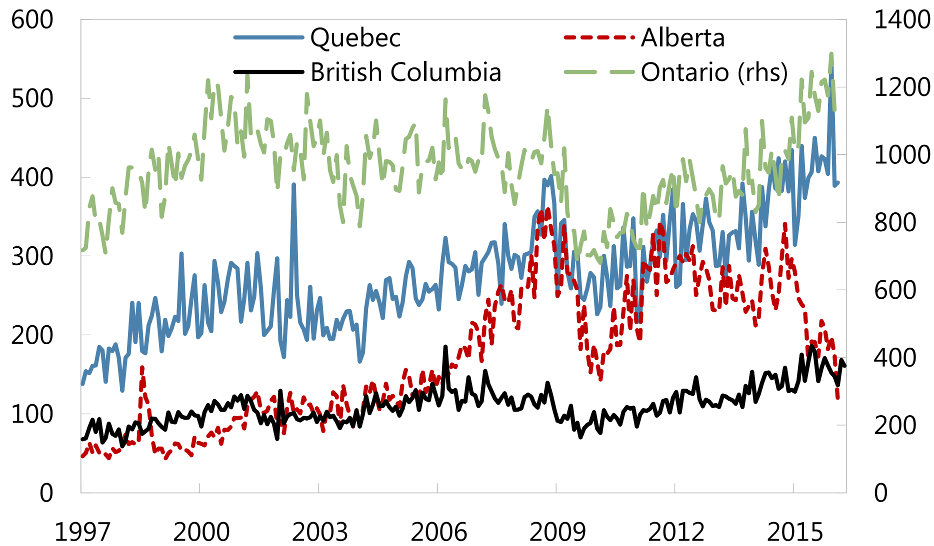


Understanding what underlies this loss of external competitiveness is of essence, as Canadian policy makers weigh their policy options. In the wake of the slump in oil and commodity prices, the limelight is on the Canadian manufacturing sector to deliver growth. The price competitiveness of Canadian manufacturing exporters has certainly improved during 2014-2015, as the exchange rate underwent a steep depreciation. But will that depreciation by itself suffice to restore manufacturers' export performance? Or has there been a deeper-rooted loss of capacity during the commodity boom years? Are there structural, supply-side factors that might prove inhibiting, and that would warrant particular attention on the part of policymakers?

Canadian provincial data offer a unique opportunity to analyze the importance of structural factors for export performance. Statistics Canada publishes a remarkably rich dataset of merchandize exports for each product category by each province. A panel dataset is most effective when it offers variation within a comparable cross-section. Unlike in a cross-country setting where the differences between the countries can be so fundamental that they are hard to control for with econometric techniques, here all the provinces fall within the common fold of one country, and of one currency. The variation in manufacturing export

performance among provinces is considerable, even within the same product category, as shown for the example of industrial machinery exports by four major provinces in Figure 2.

Figure 2: Industrial machinery exports by four major provinces (mln. Can $)



Source: Statistics Canada.

Statistics Canada also publishes many supply-side variables at disaggregated provincial and/or product levels. This means that we can tease out the effects of these variables on export performance by using a panel regression. To what extent can structural variables explain manufacturing export performance over and above the impact of simple price competitiveness measures, such as the exchange rate?

We find that structural variables do have a significant and economically sizeable impact on Canadian export performance. Physical capital, human capital and innovation all matter in boosting competitiveness. Physical capital is the single largest contributor among these, as the capital stock has a sizeable impact on export performance. Second among structural variables comes R&D spending. This result is particularly powerful because Statistics Canada's R&D data is as rich as its trade data, covering both the product and province dimensions.

The outcome on R&D plays directly to the policy debate on boosting R&D investment by Canadian businesses. R&D spending peaked in Canada in 2000 and has been in decline ever since, contrary to the US, the EU and Japan, and this decline has been entirely driven by R&D in the manufacturing sector (Statistics Canada, 2015). Indeed, while Canada's business environment is generally well-regarded, innovative capacity is seen as one of its most prominent constraints (World Economic Forum 2015/2016 report).

Other supply-side variables that significantly affect export growth include inward FDI and vocational training, which is adult education for specific trades that may be of particular importance for the manufacturing sector. This is not to say that exchange rates do not matter. On the contrary, in line with other literature on Canadian export performance, price

competitiveness is essential. It is the single most important factor determining export growth. But we find that price competitiveness is not the whole story and structural policies can play a supportive role in restoring Canada's manufacturing export performance.

Our results are based on an export supply regression, whereas most of the literature has used export demand regressions. [1] In an export supply specification the global price of a good is given (a small open economy assumption). Canadian exporters determine how much to supply based on the product price and on their own capacity constraints. Foreign demand enters such a specification only indirectly, through its effects on the product prices (export deflators). Instead, supply side factors are explicitly modeled, contrary to export demand specification where these remain unaddressed.

While the use of Canada's provincial export data in the context of an export supply regression is novel, provincial data has been used in other types of studies before. In particular, there is a large literature on the border effects of trade. McCallum (1995) found that controlling for economic size and geographical distance, Canadian interprovincial trade is about 21 times larger on average than between Canadian provinces and US states. This gave rise to a body of work on the border effects of trade.[2] This literature utilizes the regional Canadian and US export and import data, using gravity equations on the direction of trade (i.e., from province to province or to US state).[3]

The literature on export demand regressions found three main results on Canadian export performance:

- There was evidence that the commodity boom pushed out manufacturing exports through real appreciation ("Dutch disease"), although the extent to which this happened differs across studies.[4]

- There was limited evidence for structural breaks in the relationship between trade volumes and prices.[5]

[1] Earlier supply-side focused studies have looked mainly at the relationship between trade liberalization plant-level productivity (Trefler, 2004; Baldwin and Gu, 2003; Baldwin and Yan, 2012).

[2] See for instance Anderson and Smith (1999), Anderson and Van Wincoop (2003) and Helliwell and Schembri (2005). Also see the literature survey of Suvankulov (2015).

[3] The product dimension is usually not included in these studies, but see Chen, Rus and Sen (2012) for an estimation of border effects that disaggregates at the industry level. Their main finding is that 9/11 increased the border effect between Canadian provinces and US states, although with wide heterogeneity across industries. See also Evans (2003) for an industry level estimation of border effects in the EU context.

[4] See Bayoumi and Mühleisen (2006), Beine, Bos and Coulombe (2012), Shakeri, Gray and Leonard (2012).

[5] See Binette, de Munnik and Gouin-Bonenfant (2014), Binette, de Munnik and Melanson (2015), Kim (2015), and Bruneau and Moran (2015). Similarly, IMF WEO (October 2015) finds no clear-cut indications of breaks in the trade elasticities of any advanced economy, other than Japan.

- Weak US demand in the wake of the global financial crisis, as well as increased competition in the US market (from China and Mexico in particular) played an important role in inhibiting a Canadian export recovery.[6]

Our study neither confirms nor questions these results. It instead adds another dimension to the debate, namely the role of supply-side factors. Of course, the extent to which these supply-side factors prove constraining differs greatly by manufacturing industry. We document the extent of supply and/or demand constraints per industry and relate these to the policy options that emerge from our study. Sections II-IV describe our methodology, data and results, respectively. Section V relates these results to industry-specific developments. Section VI concludes.

II. METHODOLOGY

In an export supply equation global demand is taken as given.[7] That is, foreign demand is perfectly elastic at prevailing global prices for a product, and thus the country is assumed to be a small open economy that has no price setting power. In this setup Canadian exporting firms are seen as price takers and how much they export will depend positively upon prices and upon structural factors, such as those affecting supply capacity. The impact of foreign demand is indirect in such a formulation: a rise in foreign import demand materializes through an increase in the product price of an export good. In mathematical form:

$$X_t^i = p_t^i Q_t^i(p_t^i, s_t^i). \tag{1}$$

Here *i* is the product category, *X* is the export value per product, *p* is the export price per product, and *Q* is the export supply per product. Moreover, *s* represents a set of structural factors that are determinants of supply. We can rewrite this to

$$x_t^i = Q_t^i(p_t^i, s_t^i), \tag{2}$$

where x represents real exports (export volume, i.e., *X/p* per product). Introducing the province dimension, denoted by *j*, we can write the following specification:

$$\ln x_t^{ij} = \alpha_t^{ij} + \beta \ln \lambda_t^{ij} + \gamma \ln \theta_t^i + \delta \ln \varphi_t^j + \varepsilon_t^{ij} \tag{3}$$

Here α_t^{ij} represents constant term effects; β represents the coefficients on λ_t^{ij}, which are explanatory variables that vary across both products and provinces; γ represents coefficients on θ_t^i, which are explanatory variables that vary across product categories, but not provinces

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[6] See Morel (2012), De Munnik, Jacob and Sze (2012), Medas (2013), Kim (2015) and Barnett and Charbonneau (2015).

[7] For background on export supply equations and their estimation see Tokarick (2010).

(which includes p_t^i); and δ represents coefficients on φ_t^j, which are explanatory variables that vary across provinces but not product categories.

This is our baseline panel specification. However, because multicollinearity among some of our explanatory variables is a concern, we also work with an alternative methodology: a factor augmented panel. This is a two-step methodology in which the common variation of collinear variables is distilled into one factor in the first step. That factor represents the common variation of these variables in a joint single variable in the panel regression in the second step. A detailed description of this methodology is provided in Appendix D, which also describes the results of non-stationarity tests for our panel data.

III. DATA

A full description of all variables can be found in Appendix A. Here we give a short overview of the main variables. Several variables that we experimented with but which were not significant are not discussed here, but are included in Appendix A. All our data are annual and sourced from Statistics Canada.

Our dependent variable is the growth of export volume, which is expressed in millions of 2007 Canadian dollars (most of the explanatory variables are similar in real growth terms, but see Appendix A for full details). The Statistics Canada export data contains 3 dimensions: time (1997-2014), product categories (8) and provinces (10). Thus, the data contains 80 cross-section categories (products per province). Several of the explanatory variables are reported per industry: Appendix B details the conversion from industry categories to product categories

We have three categories of explanatory variables:

1. Price, cost and efficiency variables that broadly capture the notion of 'price competitiveness.'

- **Relative prices**: this variable is essentially a real exchange rate at the product level. It takes the export deflator of a product, which is used as a proxy for its global price, relative to its domestic price. Since both are expressed in Canadian dollar terms, the nominal exchange rate affects this variable (converting from a US dollar based global export price to Canadian dollar prices).

- **Real wages**: computed from the hourly wage per industry, deflated by CPI.

- **Labor productivity**: GDP / Labor supply (in hours worked, per province), as an indication of production efficiency.

One might expect that these three variables are strongly correlated with each other, but they are not (a pairwise correlation table is included in Appendix D). In part, this is because these variables capture different dimensions of the data: labor productivity is per province whereas real wages are per product (converted from industry classifications). Moreover, while wages are an input to price formation, we do not observe collinearity between relative prices and

real wages in our data. That is because global factors largely determine export prices for a small open economy. Real wage movements do not always fully transmit to prices, and can instead be absorbed in the profit margins of exporting firms. The impact of wages on firms can therefore be different than what is captured by the relative price variable alone. Hence, relative prices and real wages capture somewhat different angles of 'price competitiveness', which is why the correlation among these variables is quite low.

2. Structural variables that relate to the supply-side of the economy.

- **Capital stock**: Statistics Canada publishes the total gross non-residential capital stock (of all industries) per province. This variable represents physical production constraints.

- **Research & Development**, namely business expenditures on R&D. This data is available per province per industry. However, due to data issues described in Appendix A, we have to split it into two variables, **R&D per industry** and **R&D per province**.

- **Inward Foreign Direct Investment**: increased FDI could contribute to export growth if the investment is part of a multinational trade platform or if there is technology transfer associated with the FDI. The FDI data only start in 1999, however, which is why we also consider full-sample regressions without this variable.

- **Government investment** per province. Infrastructure could play a role in facilitating export performance. However, there is no provincial data on infrastructure investment. We therefore use total government gross fixed capital investment per province, which may be too broad brush to capture infrastructure specifically.

- **Vocational Training**: training for specific trades, which may be an important input into manufacturing industries. We use data on the number of people that are registered for vocational training per province per year.[8]

Among several of these variables pairwise correlation is very high. To address possible multicollinearity problems we run a factor-augmented panel regression in addition to the baseline panel regressions (methodology in Appendix D).

3. Control variables that control for provincial characteristics:

- **Energy Share**: the share of provincial GDP coming from the extractive industries (namely mining, and oil and gas extraction).

[8] Regressing the level of exports on the number of people registered for vocational training would be problematic, but because the variables are included in log form in the regression no further scaling is needed: the regression compares growth rates to growth rates.

- **Population Density**: provincial population time series divided by the square kilometer size of the province.

- **Foreign Import Ratio** and the **Inter-Provincial Import Ratio** (% of provincial GDP) to capture potential border effects.

IV. Regression Results

Table 1 shows our main results. This table only contains our key variables, in 4 different specifications. One specification (ex-FDI) excludes FDI to obtain the maximum balanced sample length. Another specification (Full sample) includes all variables, with the sample starting in 1999 (FDI data becomes available) rather than 1997. The specification in the first column (Baseline) retains only those variables that are significant in the full set of variables. All these regressions include a single lag for the explanatory variables and include random effects. We use standard log transformations, where a logged time series is approximately equivalent to a first difference (i.e., export *growth*), while the logs allow for the interpretation of coefficients as elasticities. Appendices C and D provide a larger set of alternative specifications, including more variables and robustness checks for different types of effects, as well as a discussion of the data's statistical properties.

Table 1: Panel regression: key results (dependent variable: log exports)

Specification	Baseline	Full	Ex-FDI		Factor
Effects	Random	Random	Random		Random
Relative export price (log, 1 lag)	2.1***	2.1***	2.4***		2.5***
Labor productivity (log, 1 lag)	2.2***	2.2***	1.9***		2.5***
Real wages (log, 1 lag)	-1.2***	-1.4***	-1.3***		-1.8***
R&D per industry (log, 1 lag)	0.3***	0.2***	0.3***		0.3***
R&D per province (log, 1 lag)	0.1*	0.1**	0.1*	Capital factor	
Capital stock (log, 1 lag)	1.0***	0.9***	0.9***		1.4***
Vocational training (log, 1 lag)		0	0.2**		
Government investment (log, 1 lag)		0			
FDI (log, 1 lag)	0.2***	0.2***			
Energy share of provincial GDP (ratio, 1 lag)	-0.01**	-0.02**			
Population density (ratio, 1 lag)	0.06**	0.0484**	0.1***		0.1***
Foreign imports to GDP (ratio, 1 lag)	0.02***	0.02***	0.03***		0.03***
Interprovincial imports to GDP (ratio, 1 lag)	-0.02**	-0.02**	-0.02***		-0.03***
Observations	1200	1200	1360		1360
R-squared		0.6	0.58		0.6

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

Table 1 gives a summary overview of the factor-augmented panel regression (column Factor), wherein 4 of the structural variables are grouped together in what we term the 'capital factor'. These variables are the capital stock, R&D per province, vocational training and government investment, which have pairwise correlation coefficients in excess of 0.9.

The factor represents their common variation and is subsequently included as a variable in a panel regression. The overall impact of the factor exceeds that of its components, because explanatory power is lost when strongly correlated variables are separately included in a regression. Overcoming multicollinearity raises the joint sum of coefficients from 1.2 to 1.4. Appendix D provides both the methodological background and additional detail.

Both our basic and factor-augmented panel regressions paint a similar picture and show that price competitiveness matters greatly for export performance. Relative prices, real wages and labor productivity essentially capture three different aspects of price competitiveness. Our results show that these variables have a strong impact on Canada's trade competitiveness. In the longest sample (ex-FDI), the relative price of exports is the variable with the largest impact. While exchange rate movements take time to pass on to prices, this result indicates that Canada's non-energy export performance is quite sensitive to the value of the Canadian dollar. This reinforces existing results from the literature on export demand regressions (Binette, de Munnik and Melanson, 2015). Reduced input costs (lower wages) and increased output efficiency (labor productivity) also significantly affect export performance, although wages and labor productivity tend to be slower moving variables than the exchange rate.

Importantly, our results also show that there is more to improving manufacturing export growth than improving price competitiveness alone, which is the key finding of our study. If we sum together the capital factor with the coefficients of R&D per industry and FDI (which are not included in the factor, because they are not collinear), we obtain an impact of nearly 2 percentage points more rapid real export growth for 1 percentage point higher growth of capital investment as a whole. Looking at the individual structural variables we find that:

- **Capital stock** accumulation (machinery, factories, etc.) has the largest impact on manufacturing exports among the structural variables, with nearly a 1-to-1 impact on real export growth. In the long run capital accumulation is also a key determinant of labor productivity. Physical capital can thus also indirectly raise export growth, because it lifts labor productivity. Higher business investment thus carries a double potential to raise growth performance, both directly as a component of GDP as well as indirectly by raising export competitiveness.

- A 1 percentage point rise in real **R&D** growth brings about 0.4 percentage point faster real export growth (summing the product and province dimensions). This result would seem quite supportive of efforts to stimulate additional R&D spending among Canadian industries.[9] Canada has a generous R&D incentive scheme in place, although options to better target these funds (such as a focus on new rather than small firms, and perhaps on direct subsidies rather than tax incentives) are worth investigating (IMF 2016 Canada Art. IV Report).

[9] Nonetheless, some nuance may be warranted. Industries that are experiencing a more dynamic environment might simultaneously see higher R&D growth and rising export growth. But even so there may be a two-way interaction (dynamic industries invest more in R&D but possibly R&D also make industries more dynamic over time).

- **Inward FDI** into the Canadian manufacturing sector plays a role in raising export performance too, with about 0.2 percentage point faster export growth for a 1 percentage point increase in inward FDI growth. Efforts to raise the attractiveness of FDI in Canada may therefore result in enhanced export competitiveness. Policy options include tax incentives and trade agreements that promote investment liberalization and reduce trade barriers.

- Specialized or job-specific, **vocational training** could be a particularly effective way to improve job skills and job matching in the manufacturing sector. Canada's general education level and quality of universities is high, but it spends relatively little on publically funded vocational training compared to other OECD countries (IMF 2016 Canada Art. IV Report).

- **Government investment** is not significant, possibly because the variable does not capture infrastructure investment specifically, due to data limitations. Various IMF studies have shown that well-targeted projects, especially in infrastructure development, could stimulate ("crowd in") business investment, which raises physical capital and improves competitiveness (IMF WEO, April 2015).

Our control variables for provincial characteristics are significant in most specifications. Higher population density and a smaller share of energy in provincial output tend to raise manufacturing export growth. Finally, openness towards foreign imports is positive for manufacturing export growth, but interprovincial imports has the opposite effect. This may emanate from provinces' geography and physical infrastructure, as some provinces face stronger foreign border effects than others (Anderson and Smith, 1999). Such provinces could be more 'inward focused'. This would imply that openness to foreign and domestic trade are substitutes, to some extent, and therefore a higher interprovincial openness is seen to have a negative effect on export performance.

We have considered various other variables, mainly relating to taxation and labor market conditions (Appendix C). Among these we find that female labor force participation sometimes has a positive and significant impact on export growth.[10] However, this result is not robust across all specifications. The same is true for the degree of unionization, which has a weak negative impact on export performance in some specifications.

V. TRANSLATING THE RESULTS TO INDUSTRIES

Looking across Canadian manufacturing industries, which are the most likely to benefit from structural measures? Where are supply constraints most likely to be binding?

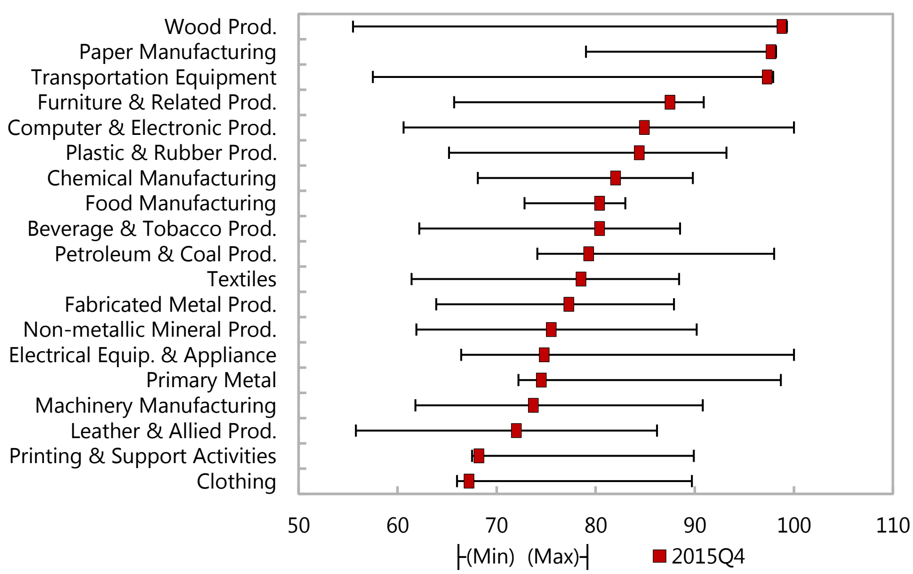
[10] Petersson (2016 forthcoming) studies Canadian labor productivity using a provincial panel and finds a role for female labor force participation that is robust, significant and economically sizeable.

Supply constrained industries

The automotive industry and wood products manufacturing are major industries that face relatively high US demand today. The increase in demand has been fueled by the exchange rate depreciation of the Canadian dollar over the past two years. Moreover, these industries are sensitive to components of US demand that have been performing well recently. The automotive industry depends primarily on US consumption, while the wood products industry relies on US residential investment (Kim, 2015). This stands in contrast to many other Canadian exporting industries, which depend on US business investment (Binette, de Munnik and Melanson, 2015). This component of US GDP has seen relatively sluggish growth in recent years.

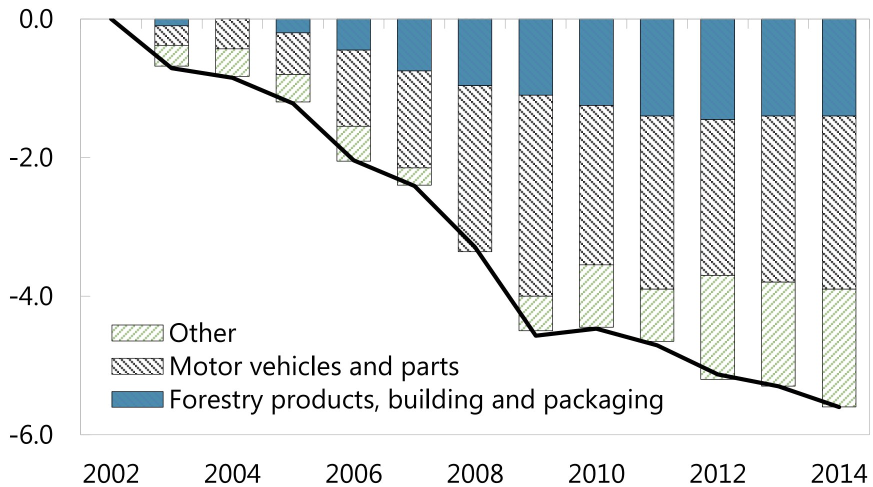
However, the automotive industry and wood products industries have limited capacity to respond to the higher demand because they are already operating at near 100% capacity, as shown by Figure 3.

Figure 3: Capacity Utilization Rates: Actual and Historical Min and Max (% of utilization)



Sources: Statistics Canada, Haver Analytics and IMF staff estimates.

Figure 4: Cumulative change in US non-energy import market share



Sources: Barnett and Charbonneau (2015), with data from Comtrade.

An important reason for the relatively constrained capacity in these two industries at present, is that both previously suffered prolonged and steep declines. As shown in Figure 4, these two industries accounted for a large fraction of the market share that Canadian manufacturing exporters lost in the US market during 2002-2014. The erosion in manufacturing capacity during the early 2000s would need to be restored to take full advantage of the increase in demand for these products. Hence, structural reform to expand capacity, including investment in human and physical capital and putting in place the right conditions to attract FDI could help boost exports in these supply-constrained industries.

In the case of the wood products industry an additional factor behind the constrained supply is the pine beetle epidemic, which significantly affects this industry's output in British Columbia and Alberta (Stickney, 2007).

Demand constrained industries

Industries such as the manufacturing of metal products, industrial machinery, plastic and rubber products, aircraft and parts, and computer and electronic products have plenty of production capacity but global demand for these products has declined.

a. Metal products are highly dependent on global construction demand. Exports of metal products grew rapidly when construction activity was booming in China; in particular, between 2002 and 2012 Canadian metal products exports to China increased eightfold. Since the slowdown in the Chinese economy, exports have declined, leaving the industry with low capacity utilization.

b. Industrial machinery, plastic and rubber products and aircraft and parts are dependent on US business investment (Kim, 2015). As said, this component of US GDP has seen sluggish growth in recent years.

c. Computer and electronic exports have suffered a setback mainly because Blackberry, which has been Canada's prime exporter, has seen a deep fall in its share of the global Smartphone market (Table 2).

Table 2: Worldwide Smartphone Operating System Market Share (in %)

Period	Android	iOS	Windows Phone	BlackBerry OS	Others
2015Q2	82.8	13.9	2.6	0.3	0.4
2014Q2	84.8	11.6	2.5	0.5	0.7
2013Q2	79.8	12.9	3.4	2.8	1.2
2012Q2	69.3	16.6	3.1	4.9	6.1

Source: IDC, Aug 2015.

In these industries where demand is constrained, exchange rate deprecation would help tilt price competitiveness in favor of Canadian exports. However, the demand for products depends on more than prices alone. Quality, variety and marketing also affect demand. For example, a smartphone producer like Blackberry would undoubtedly benefit from a cheap Canadian dollar, but this is unlikely to prove the single most important factor determining the demand for its products. Especially in industries at the technological frontier, innovative success is a prerequisite for sustained growth.

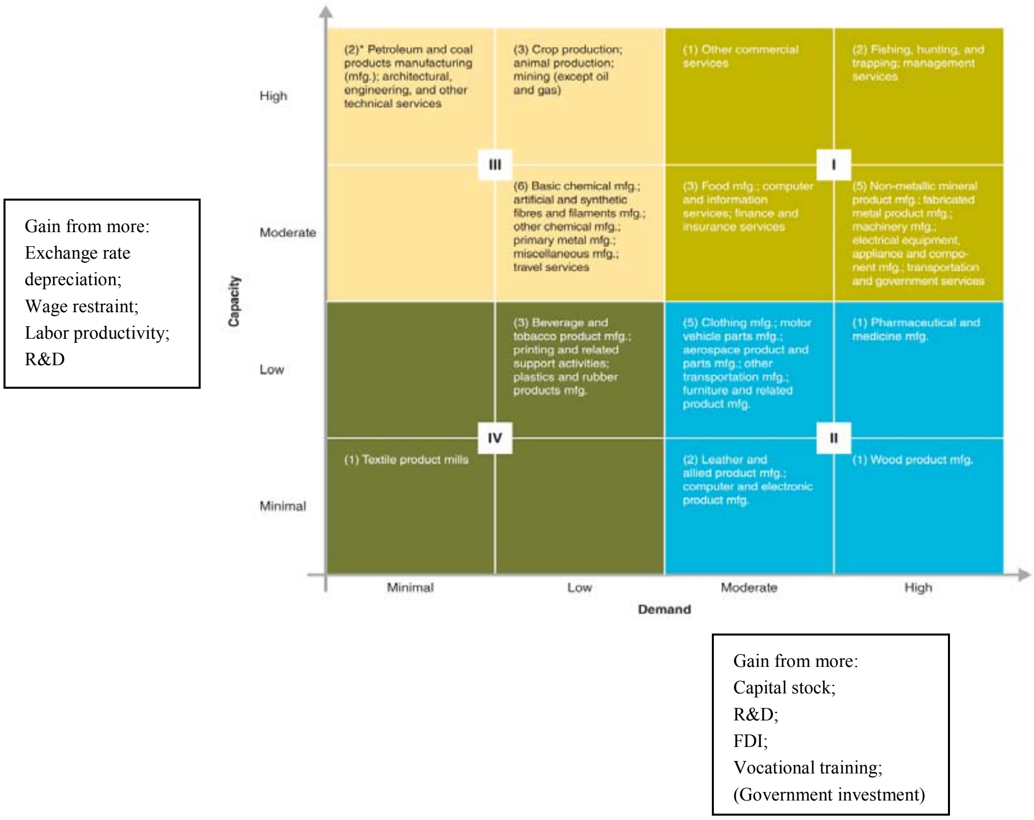
Therefore, alleviating demand constraints on Canadian manufacturing exporters requires structural improvement too. In particular, R&D to increase innovation may prove essential to enable these industries to compete in existing and new export markets, and claw back market share.

A summary view of industries and policy options

Figure 5 summarizes industrial constraints by drawing on a study by the Conference Board of Canada. That study ranks export industries according to supply-side and demand-side constraints. Note that the Conference Board applies judgment in addition to simple capacity utilization measures, which explains why more industries are qualified as supply constrained than in Figure 3.

We relate the policy options that we see emerging from our analysis to the industries in Figure 5. Industries in the second quadrant are supply constrained and are therefore likely to benefit from the structural variables we identified as being significant contributors to export growth, namely the capital stock, R&D, FDI and vocational training (we have placed government investment in parenthesis here, since it is not significant in our regressions, but may have indirect effects on business investment). Industries in quadrants III and IV instead require a demand boost, with industries in quadrant III particularly well placed to respond to any increase in demand because they already have a high production capacity. Variables that affect price competitiveness (exchange rate, labor productivity, real wages) and quality (innovation) are likely to be especially important for such industries.

Figure 5: Supply vs. demand constraints and policy options



Sources: Canadian Conference Board 2016 publication "Canada's Next Trade Era: Which Industries Are Prepared to Take on US Demand" and staff additions.

VI. Conclusions

Drawing policy implications from a statistical analysis is always a delicate matter. However, the topic at hand plays a central role in policy discussions about the Canadian economy: what is holding back the country's manufacturing competitiveness? Is the exchange rate the key variable, and is it therefore only a matter of time until the extensive depreciation of 2014-2015 boosts manufacturing exports? And given that Canadian dollar moves closely with the oil price, does this mean that Canada's manufacturing exports are at the whim of oil price movements? Or are there deeper-rooted, structural reasons behind Canada's low manufacturing export growth over the past decade and a half? If true, this could imply an active role for the government in setting the right conditions to help restore competiveness, a role moreover that is independent of the vicissitudes of commodity prices and exchange rate movements.

In this study we utilize Canada's unique, provincial product-level trade data to look at the structural determinants of its export competitiveness. Since various supply-side variables are available at the provincial level too, we can gauge the extent to which such variables explain the variation in export performance. We do so both within the context of a basic panel

regression as well as a factor-augmented approach that controls for multicollinearity among the structural variables.

Our study does reaffirm that exchange rates play a central role in determining external competitiveness. Our relative price variable, which is directly linked to exchange rate movements, has a large impact. Other variables that affect price competitiveness, namely real wages and labor productivity, are also highly significant and economically sizeable.

However, structural variables have a meaningful impact as well, leaving the door open for Canadian policy makers to affect competitiveness with policies targeted at strengthening the supply side of the manufacturing sector. Canadian manufacturing exports are not only at the whim of the country's commodity-driven currency fluctuations. An important place in the policy debate is reserved for the role of R&D investment, and this study's findings are supportive of this focus. While cautious interpretation is called for, business expenditures on R&D per industry are found to be positive, economically sizeable and highly significant.

Further evidence for the role of business investment in export growth comes from our results for the physical capital stock and the inward FDI variable. The capital stock has a sizeable impact, suggesting that stimulating business investment in the manufacturing sector can yield substantial gains to Canada's export competitiveness. Government investment could potentially have a role to play in this, to the extent that its infrastructure investment alleviates bottlenecks and thereby crowds in business investment. Finally, education policy that is targeted at the specific needs of the manufacturing sector, through vocational training for adults, also boosts export growth.

APPENDIX A: DATA OVERVIEW & DESCRIPTION OF VARIABLES

Variables (annual; 1997-2014 unless otherwise mentioned)	**Inclusion form**	**Product dimension**	**Province dimension**	**Additional info & Statistics Canada Table no. (in parenthesis)**
Export volume	Log	X (NAPCS)	X	In mln 2007 constant dollars (228-0060)
Relative price	Log	X (NAPCS)		Export / import deflator (228-0063)
Capital Stock	Log		X	(031-0007)
Labor Productivity	Log		X	GDP / Labor supply per province (383-0038 & 282-0016)
Real Wages	Log	X (NAICS)		Hourly wage per industry deflated by CPI (383-0031)
R&D	Log	X (NAICS)	X	Split into 2 variables: product and province. R&D business expenditure (mln constant dollars, deflated by bus. investment component of GDP deflator) (358-0161)
Vocational training	Log		X	No. of registrations for vocational training per province (477-0055)
FDI (Starts in 1999 instead of 1997)	Log	X (NAICS)		Inward FDI in mln 2007 constant dollars (deflated by the bus. investment component of the GDP deflator) (376-0052)
Government investment (2 variables in separate specifications)	Log & Ratio		X	Log: Gov. GFC in mln 2007 constant dollars. Ratio: % of provincial GDP. Not together in same regression. (383-0038)
Female labor force participation rate	Ratio		X	Among woman between ages 25-54 (282-0002)
Import ratio	Ratio		X	Foreign imports / provincial GDP (383-0038)
Inter-provincial imports	Ratio		X	As % of provincial GDP (383-0038)
Tertiary education	Ratio		X	Share of labor force with tertiary education (282-0004)
Energy share	Ratio		X	Share of provincial GDP from the extractive industries, namely mining, and oil and gas extraction (379-0025 & 379-0028)
Corporate taxation	Ratio		X	Corporate tax revenue to GDP per province (385-0001 & 385-0034)
Migration	Ratio		X	Foreign migrant inflow as a % of provincial population (051-0037)
Population density	Ratio		X	Population over province size (051-0001 & size from Wikipedia)
Unemployment rate	Ratio		X	(282-0004)
Unemployment benefits acceptance rate	Ratio		X	Benefits acceptance as % of submissions to proxy for tightness of benefit policy (276-0004)
Unionization	Ratio		X	Share of union membership among labor force (282-0078)

Description of the explanatory variables

Below is a complete summary of the included explanatory variables, organized in four different categories:

1. Price, cost and efficiency variables

2. Structural variables

3. Other policy related variables

4. Control variables

Price, cost and efficiency variables
Relative prices are a part of an export-supply specification, determining how exporters react to rising/declining global export prices compared to domestic prices of a given good. This is essentially a product-level Real Exchange Rate, since the export price deflator is expressed in Canadian dollars, which means it takes account of nominal exchange rate movements. Our variable for the **Relative Price** would ideally divide the export price deflator by the domestic consumer price or producer selling price. While this can be done at the aggregate macroeconomic level, however, at the disaggregated level of NAPCS product categorizations there are no matching series from CPI or PPI. Instead, we approximate the domestic price in a given product category by using the import price deflator. After all, the import price deflator is what a foreign firm selling on the Canadian market could be expected to receive for its product. This cannot be distant from the prevailing price for domestic Canadian sales within that same product category.

As production input cost variable, we include **Real Wages**. At the aggregate level these might be expected to be collinear with labor productivity or with an export price deflator, since wage are obviously related to productivity and are also a determinant of product prices. However, at the disaggregated level there is sufficient idiosyncratic information that this collinearity does not arise (see Appendix D). Real wages are here computed from the hourly wage per industry (NAICS), deflated by CPI. Using the mapping in Appendix B, moreover, the industry categories are converted into (NAPCS) product categories.

Moreover, **Labor Productivity** can be inferred from GDP / Labor supply per province. Both would a priori be expected to have a significant positive impact on export growth performance.

Structural variables
Production capacity is a key part of any export-supply specification. Statistics Canada publishes data on the total gross non-residential **Capital Stock** per province.

Statistics Canada's **Research & Development** data is unique in that it matches the province times product margin of the export data. As can be seen from the data overview table above, business expenditure on R&D is the only variable in our dataset that mirrors the richness of

the export data. The data originally comes in the form of NAICS industry classification, but is converted to NAPCS product categories using the mapping in Appendix B.

However, one issue that must be dealt with is that the R&D data contains many blanks if taken at the province x product margin. For the provinces like Ontario and Quebec most of the product categories have entries for much of the sample. However, for various other provinces there are many missing entries. This is not due to genuine “zeroes”, but rather to a data quality criterion that Statistics Canada applies, which leads it not to publish certain data-points that do not meet this criterion. We deal with this issue by splitting the R&D data into two variables: **R&D per industry** and **R&D per province** (both directly downloaded in the separation of industries and provinces from Statistics Canada (i.e., not self-aggregated)). In this format the R&D data has no blanks. We deflate the FDI series by the business investment component of the GDP deflator to obtain the real series (in millions of 2007 Canadian dollars)

Another investment-related variable of interest is inward **Foreign Direct Investment**. Statistics Canada publishes data on inward FDI per industry (NAICS), and as before we convert this to product categories (NAPCS). Like R&D, we deflate the FDI series by the business investment component of the GDP deflator. Unfortunately, the FDI data start only in 1999, two years later than the rest of our sample. As discussed in Section IV, we therefore run separate set of regressions with and without FDI (i.e., with maximum sample size).

Public investment is also a potentially interesting variable, especially in light of the new government’s push for increased investment, particularly in infrastructure. Physical infrastructure could conceivably play a key role in mitigating border effects, moreover, and thereby facilitate export growth. Regrettably, however, there is no provincial data on infrastructure investment in Statistics Canada. We therefore make do with government gross fixed capital investment per province. We consider this both in real growth terms as well as in ratio form (% of provincial GDP).

Finally, two variables are included to capture investment in human capital, namely **Tertiary Education** and **Vocational Training**. Tertiary education is the share of the labor force with post-secondary educational degrees. The vocational training variable instead focuses on training for specific trades, which may be an important input into manufacturing industries. We use Statistics Canada data on the number of people that are registered for vocational training per province per year.

Control variables

We include several variables to control for specific characteristics of provinces. One important such characteristic, for example, is the **Energy Share**: the share of regional GDP coming from the extractive industries. Some provinces, such as Alberta and Saskatchewan, are particularly rich in commodities and much of their economic activity is thus centered on the extractive industries, as opposed to for instance Ontario and Quebec, whose production base is more diverse. For countries as a whole this sign is usually expected to be negative, due to Dutch disease effects. At the provincial level this is less clear, given the common exchange rate. A booming energy sector might either dispel other exporting industries or,

conceivably, prove to be a complement by centering more economic activity in a given province.

We also include variables to represent border effects or potential hub-and-spoke structures among the provinces, namely the **Foreign Import Ratio** and the **Inter-Provincial Import Ratio**. The effect of Canadian provincial borders, as compared to the national border with the US, has long been of interest to economic research (McCallum, 1995). To the extent that some provinces are more secluded from international trade than others, for instance due to differences in physical infrastructure or Oceanic access, one would expect trade openness to be a good predictor of export growth. To avoid the clear endogeneity between these two variables (exports are a part of trade openness measures), we look at a province's foreign imports to provincial GDP. Similarly, we include a province's imports from other Canadian provinces as a ratio of that province's GDP. If hub-and-spoke structures are key in Canadian manufacturing exports, for instance, a positive sign would be seen here: provinces that are more like a hub for imports within Canada would be more likely to export abroad.

Finally, since Canadian provinces differ greatly in their degree of urbanization, **Population Density** is included as a control variable for provincial characteristics.

Other variables

The fact that the dataset is large by macroeconomic standards, with 80 cross-section categories for over a decade and a half, gives many degrees of freedom. Utilizing this to the maximum, we introduce several other province-level variables of which it might not be a priori expected that they would be strongly related to export growth. The aim herein is to cast the net as wide as possible.

The variables we add are related to taxation, migration and labor markets. Firstly, **Corporate Taxation**, in the form of corporate tax revenue to GDP per province, is taken as a proxy for the business-friendliness of the tax environment. Secondly, foreign migrant inflow as a % of the provincial population is included with a view on **Migration** policy. Finally, the labor market environment and policies are represented by four variables: the **Unemployment Rate** (per province), **Unionization** (as % of labor force per province), the **Unemployment Benefits Acceptance Rate** (% of unemployment benefits submissions that is accepted per province, as a measure for the tightness of benefits policy) and the **Female Labor Force Participation Rate**.

APPENDIX B: MAPPING FROM INDUSTRIES TO PRODUCTS

Statistics Canada categorizes its export data according to the North American Product Classification System (NAPCS). However, many of our explanatory variables are defined per industry, rather than per product. These follow the North American Industry Classification System (NAICS). The mapping between NAPCS and NAICS manufactured goods categories is not available from Statistics Canada (or any other official source), but is instead self-designed: by going over the various sub-components of each manufacturing industry and manufactured product category an accurate mapping has been constructed. This mapping, which is shown below, underlies our ability to match industry-categorized variables to the product-categorized export data, and may be of general value beyond this project.

North American Industry Classification System (NAICS)	Belongs in	North American Product Classification System (NAPCS) (2)
Food manufacturing [311]		Consumer goods [C22]
Beverage and tobacco product manufacturing [312]		Consumer goods [C22]
Textile mills and textile product mills [313-314]		Consumer goods [C22]
Wood product manufacturing [321]		Forestry products and building and packaging materials [C16]
Paper manufacturing [322]		Forestry products and building and packaging materials [C16]
Printing and related support activities [323]		Forestry products and building and packaging materials [C16]
Petroleum and coal products manufacturing [324]		Basic and industrial chemical, plastic and rubber products [C15]
Pharmaceutical and medicine manufacturing [3254]		Basic and industrial chemical, plastic and rubber products [C15]
Other chemicals manufacturing [3251-3253 and 3255-3259]		Basic and industrial chemical, plastic and rubber products [C15]
Plastic product manufacturing [3261]		Basic and industrial chemical, plastic and rubber products [C15]
Rubber product manufacturing [3262]		Basic and industrial chemical, plastic and rubber products [C15]
Non-metallic mineral product manufacturing [327]		Metal and non-metallic mineral products [C14]
Primary metal (ferrous) manufacturing [3311, 3312, 331511 and 331514]		Metal and non-metallic mineral products [C14]
Primary metal (non-ferrous) manufacturing [3313, 3314, 331523 and 331529]		Metal and non-metallic mineral products [C14]
Fabricated metal product manufacturing [332]		Metal and non-metallic mineral products [C14]
Machinery manufacturing [333]		Industrial machinery, equipment and parts [C17]
Computer and peripheral equipment manufacturing [3341]		Electronic and electrical equipment and parts [C18]
Communications equipment manufacturing [3342]		Electronic and electrical equipment and parts [C18]
Semiconductor and other electronic component manufacturing [3344]		Electronic and electrical equipment and parts [C18]
Navigational, measuring, medical and control instrument manufacturing [3345]		Electronic and electrical equipment and parts [C18]
Other computer and electronic products manufacturing [3343 and 3346]		Electronic and electrical equipment and parts [C18]
Electrical equipment, appliance and component manufacturing [335]		Electronic and electrical equipment and parts [C18]
Motor vehicle and parts manufacturing [3361, 3362 and 3363]		Motor vehicles and parts [C19]
Aerospace products and parts manufacturing [3364]		Aircraft and other transportation equipment and parts [C21]
All other transportation equipment manufacturing [3365, 3366 and 3369]		Aircraft and other transportation equipment and parts [C21]
Furniture and related product manufacturing [337]		Consumer goods [C22]
Other manufacturing industries [315, 316 and 339]		Consumer goods [C22]

Source: author's own derivation from further disaggregated sub-category descriptions on Statistics Canada's website.

APPENDIX C: FULL PANEL REGRESSION RESULTS (ALL VARIABLES)

Tables C.1 and C.2 report the results of our baseline panel regressions and factor-augmented panel, respectively.

The baseline regressions (Table C.1) includes 7 different specifications, which differ from each other along the following dimensions:

- FDI: Specifications (1) – (5) include the FDI variable at the cost of fewer observations (2 years less at the beginning of the sample), whereas specifications (6) and (7) exclude the FDI variable to analyze the other variables at the maximum number of observations, namely 1360.

- Effects: Specifications (1) – (3) include all explanatory variables, but with three different types of effects: random effects (i.e., in usual, GMM estimator based form), maximum likelihood (MLE) based random effects and fixed effects. Specifications (4) – (7) all use (GMM-based) random effects

- Government investment: Specification (4) replaces log real government investment growth with the government investment to provincial GDP ratio.

- Reduced variables: Specification (5) retains only the variables that are significant at the 5% level in (1) – (4) (i.e., regressions that include FDI), whereas specification (7) retains only the significant variables from specification (6), which excludes FDI.

The factor augmented regressions (Table C.2) includes 2 different specifications: one with all variables (except those included in the factor, see Appendix D for methodology) and another retaining only the significant variables.

Table C.1

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Effects	Random	MLE	Fixed	Random	Random	Random	Random
Log Relative Price (-1)	2.078***	2.054***	1.990***	2.078***	2.133***	2.489***	2.425***
	(0.186)	(0.181)	(0.183)	(0.186)	(0.184)	(0.179)	(0.175)
Log Capital Stock (-1)	0.887***	1.019***	0.331	0.833***	0.980***	0.767***	0.934***
	(0.247)	(0.258)	(0.403)	(0.213)	(0.158)	(0.254)	(0.193)
Log Labor Productivity (-1)	2.206***	2.377***	2.310***	2.221***	2.151***	2.004***	1.876***
	(0.572)	(0.560)	(0.590)	(0.557)	(0.487)	(0.602)	(0.434)
Log Real Wage (-1)	-1.362***	-1.214***	-0.535	-1.356***	-1.170***	-1.572***	-1.292***
	(0.251)	(0.256)	(0.328)	(0.249)	(0.147)	(0.252)	(0.169)
Log R&D per industry (-1)	0.247***	0.276***	0.300***	0.245***	0.250***	0.312***	0.329***
	(0.0524)	(0.0517)	(0.0528)	(0.0524)	(0.0506)	(0.0527)	(0.0492)
Log R&D per province (-1)	0.139**	0.0824	-0.00323	0.132*	0.116*	0.123*	0.106*
	(0.0674)	(0.0681)	(0.0704)	(0.0681)	(0.0602)	(0.0694)	(0.0617)
Log Vocational Training (-1)	0.0280	-0.00356	-0.130	0.0306		0.192*	0.180**
	(0.0999)	(0.0975)	(0.103)	(0.0999)		(0.0986)	(0.0901)
Log FDI (-1)	0.212***	0.220***	0.231***	0.212***	0.201***		
	(0.0411)	(0.0404)	(0.0413)	(0.0411)	(0.0408)		
Log Real Gov. Investment (-1)	-0.0653	-0.108	-0.170			0.0612	
	(0.115)	(0.113)	(0.117)			(0.122)	
Female Participation (-1)	0.00453	-0.00112	-0.0208	0.00466		0.0271**	0.0248**
	(0.0119)	(0.0119)	(0.0134)	(0.0119)		(0.0112)	(0.0101)
Foreign Import Ratio (-1)	0.0209***	0.0217***	0.0258***	0.0210***	0.0227***	0.0318***	0.0326***
	(0.00578)	(0.00580)	(0.00637)	(0.00567)	(0.00503)	(0.00575)	(0.00540)
Provincial Import Ratio (-1)	-0.0167**	-0.0153**	-0.0113	-0.0157*	-0.0176**	-0.0192**	-0.0173***
	(0.00790)	(0.00775)	(0.00807)	(0.00805)	(0.00730)	(0.00827)	(0.00641)
Tertiary Education (-1)	0.0146	0.0110	0.00736	0.0147		0.0121	
	(0.00955)	(0.00939)	(0.0102)	(0.00954)		(0.0100)	
Energy Share (-1)	-0.0160**	-0.0128*	-0.00342	-0.0169**	-0.0142**	-0.00256	
	(0.00729)	(0.00718)	(0.00749)	(0.00735)	(0.00620)	(0.00709)	
Corporate Tax Ratio (-1)	-0.0798	-0.0660	-0.0824	-0.0806		-0.0943	
	(0.0612)	(0.0594)	(0.0611)	(0.0612)		(0.0623)	
Migrant Inflows (-1)	-0.0623	-0.0647	-0.0261	-0.0561		-0.0412	
	(0.0793)	(0.0772)	(0.0797)	(0.0792)		(0.0810)	
Population Density (-1)	0.0484**	0.0580**	0.196**	0.0477**	0.0601***	0.0712***	0.0834***
	(0.0234)	(0.0288)	(0.0882)	(0.0234)	(0.0225)	(0.0238)	(0.0219)
Unemployment Rate (-1)	-0.0183*	-0.0142	-0.00901	-0.0175*		-0.00687	
	(0.0102)	(0.0102)	(0.0110)	(0.0102)		(0.0104)	
Unempl. Benefits Acc. Rate (-1)	-0.00602	-0.00641	-0.00540	-0.00609		0.00944	
	(0.00685)	(0.00662)	(0.00672)	(0.00685)		(0.00604)	
Unionization (-1)	-0.0163***	-0.0150**	-0.0134**	-0.0162**	-0.0141**	-0.00195	
	(0.00631)	(0.00621)	(0.00666)	(0.00630)	(0.00568)	(0.00632)	
Government Investment / GDP (-1				-0.0235			
				(0.0268)			
Observations	1,200	1,200	1,200	1,200	1,200	1,360	1,360
R-squared	0.5975	NA	0.2495	0.6004	0.576	0.5888	0.5674

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.2

Specification	(1)	(2)
Effects	Random	Random
Log Relative Price (-1)	2.498***	2.083***
	(0.179)	(0.187)
Log Labor Productivity (-1)	2.488***	2.606***
	(0.550)	(0.526)
Log Real Wage (-1)	-1.800***	-1.647***
	(0.249)	(0.247)
Log R&D per industry (-1)	0.318***	0.261***
	(0.0531)	(0.0529)
Log FDI (-1)		0.213***
		(0.0413)
Female Participation (-1)	0.0207*	0.00167
	(0.0105)	(0.0111)
Foreign Import Ratio (-1)	0.0364***	0.0283***
	(0.00538)	(0.00536)
Provincial Import Ratio (-1)	-0.0270***	-0.0268***
	(0.00767)	(0.00746)
Tertiary Education (-1)	0.0108	0.0114
	(0.00994)	(0.00951)
Energy Share (-1)	-0.00599	-0.0150**
	(0.00644)	(0.00658)
Corporate Tax Ratio (-1)	-0.102	-0.0836
	(0.0618)	(0.0612)
Migrant Inflows (-1)	-0.0927	-0.109
	(0.0773)	(0.0747)
Population Density (-1)	0.0584***	0.0372*
	(0.0218)	(0.0219)
Unemployment Rate (-1)	-0.0150	-0.0267***
	(0.00996)	(0.0100)
Unempl. Benefits Acc. Rate (-1)	0.00860	-0.00343
	(0.00588)	(0.00676)
Unionization (-1)	-0.00296	-0.0170***
	(0.00598)	(0.00608)
Capital Factor (-1)	1.397***	1.165***
	(0.166)	(0.168)
Observations	1,360	1,200
R-squared	0.5992	0.6049

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX D: MULTICOLLINEARITY AND NON-STATIONARITY

Dealing with multicollinearity among the structural variables

With this many explanatory variables, multicollinearity is an obvious concern. Coefficient estimates of highly correlated variables can be biased. In particular, a set of collinear variables might appear individually insignificant even though there is actually a common variation among them that does have explanatory power.

As it turns out, however, there is relatively little incidence of multicollinearity in our dataset, probably due to the availability of sufficient idiosyncratic information per variable at this level of disaggregation. With the important exception of one bloc of highly correlated variables, all other variables have relatively low pair-wise correlations: a correlation coefficient of 0.7 is usually considered a threshold value for identifying collinear variables. Most variable pairs have correlation coefficients below this value, as shown in the full pairwise correlation table (Table D.5).

As can be seen from inspecting Table D.5, there is one bloc of four variables that are very strongly correlated: capital stock, R&D per province, vocational training, and government investment. Table D.1 reports the correlation among these four variables only (in logs, since this is the form in which they are included in the regression specification). As seen from Table D.1, these variables have correlation coefficients greater than 0.95 with each other. This is interesting in its own right, as it is quite unexpected that the growth rate of vocational training registrations is so strongly correlated with a province's capital stock growth, or government investment growth. In all, these four variables seem to represent a "capital factor", which combines some different types of physical and human capital formation.

Table D.1: Pairwise correlation – 4 collinear variables

	log Capital Stock	log R&D per province	log Vocational Training	log Real Gov. Investment
log Capital Stock	1.00			
log R&D per province	0.95	1.00		
log Vocational Training	0.98	0.95	1.00	
log Real Gov. Investment	0.96	0.98	0.97	1.00

Collinearity between variables essentially means that these variables share a common component, and therefore their joint inclusion implies a large degree of overlap. One means to deal with such commonality is to extract the factor that the variables have in common. Factor analysis reduces the covariance matrix among a group of variables to one or a few common factors (Johnson and Wichern, 2007).

Applying this factor methodology to the four collinear variables we have identified, namely the capital stock, R&D per province, government investment and vocational training, gives the outcome represented in Table D.2. This can be read as follows. Factor 1 is shown to have a "proportion" of 0.997. This means that this one factor explains 99.7% of the common

variation amongst the four variables. Hence, this set of variables is so strongly related that it can be reduced to one single factor capturing almost their entire variation.

Table D.2: Factor analysis on 4 collinear variables

	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.864	3.830	0.997	0.997
Factor2	0.035	0.042	0.009	1.006

The "strength" of this capital factor can also be seen from the so-called factor loadings. As a rule of thumb, loadings above 0.7 (or below -0.7) are generally considered significant for datasets in excess of 50 observations (Habing, 2003). Here, in Table D.3, the loadings are all in excess of 0.9 in absolute terms. The loading is equivalent to the correlation between one variable and the created factor. Thus, here the (growth rate of the) capital stock correlates almost perfectly with the constructed factor, since its loading onto that factor is 0.98. The loadings of R&D per province, vocational training and government investment (all in logs) are virtually identical to that of the capital stock.

Table D.3: Factor Loadings

Log Capital Stock	0.982
Log R&D per province	0.978
Log Vocational Training	0.984
Log Real Gov. Investment	0.987

The common factor can be placed as a variable within the overall panel regression. Factor extraction allows for the formation of a time-series of factor scores. These scores are the demeaned weighted (by factor loadings) average of the variables included in the factor. The factor scores can be seen as a variable in its own right, a variable that is a composite derived from the common variation in the underlying variables. Thus, instead of four collinear variables, only one variable representing their common variation is included in the estimation. To account for the common variation among these four variables, we run a factor-augmented panel regression, the results of which are shown in Appendix C.

Stationarity properties

We employ a commonly used test for stationarity in panel data, by Levin, Lin and Chu (2002). The full results of this tests for each variable are presented in Table D.4 in p-values (rejecting the null is evidence of stationarity). Note that in the regression specification we take logs of the variables that are in levels (i.e., exports), while those variables that are in ratio form (i.e., population density) are not logged.

The log of export volume is found to be stationary. The time series of a logged variable is approximately identical to a first difference and is often used in econometric specifications, because it allows interpretation of the coefficients as elasticities. Our dependent variable, which is approximately the same as export growth, is I(0), meaning it is stationary. This

matters because if a non-stationary dependent variable is regressed on non-stationary explanatory variables, the results can be spurious.

Of the 21 dependent variables, 17 are also stationary, while the other 4 are trend stationary. Trend stationarity implies that there is a time trend contained in the variable. The most important of these trend stationary variables is the log of the capital stock: capital stock *growth* has a time trend. We refrain from further differencing this variable for two reasons. Firstly, the change in the log of capital stock (i.e., second derivative of capital stock) has no economic interpretation. Secondly, since the dependent variable is itself I(0) no spurious relation is induced by retaining a variable with a time trend on the right-hand side of the regression specification.

Table D.4: LLC tests for stationarity, in p-values

	Basic	With trend
Log Exports	0	
Log Relative Price	0	
Log Capital Stock	0.67	0
Log Labor Productivity	0	
Log Real Wage	0	
Log R&D per industry	0	
Log R&D per province	0	
Provincial Import Ratio	0	
Log Vocational Training	0	
Log FDI	0	
Log Real Gov. Investment	0	
Government Investment / GDP	0	
Female Participation	0	
Foreign Import Ratio	0	
Tertiary Education	1	0
Energy Share	0	
Corporate Tax Ratio	0	
Migrant Inflows	1	0
Population Density	1	0
Unemployment Rate	0	
Unempl. Benefits Acc. Rate	0	
Unionization	0	

Table D.5: Full pairwise correlation table

	Log Relative Price	Log Capital Stock	Log Labor Productivity	Log Real Wage	Log R&D per industry	Log R&D per province	Provincial Import Ratio	Log Vocational Training	Log FDI	Unempl. Benefits Acc. Rate	Unionization	Log Real Gov. Investment	Female Participation	Tertiary Education	Energy Share	Migrant Inflows	Population Density	Unemployment Rate
Log Capital Stock	0.0																	
Log Labor Productivity	0.1	0.6																
Log Real Wage	0.4	0.1	0.2															
Log R&D per industry	0.0	0.0	0.0	0.2														
Log R&D per province	0.1	1.0	0.4	0.1	0.0													
Provincial Import Ratio	0.0	-0.9	-0.5	0.0	0.0	-0.9												
Log Vocational Training	0.1	1.0	0.6	0.1	0.0	1.0	-0.9											
Log FDI	-0.1	0.0	0.0	0.2	0.5	0.0	0.0	0.0										
Unempl. Benefits Acc. Rate	0.0	-0.6	-0.3	0.0	0.0	-0.5	0.4	-0.5	0.0									
Unionization	-0.1	0.0	0.1	-0.3	0.0	0.0	0.0	0.0	0.0	0.1								
Log Real Gov. Investment	0.1	1.0	0.4	0.1	0.0	1.0	-0.9	1.0	0.0	-0.5	0.0							
Female Participation	0.2	-0.2	-0.3	0.4	0.0	0.0	0.2	-0.2	0.0	0.0	-0.6	-0.1						
Tertiary Education	0.2	0.6	0.1	0.5	0.0	0.7	-0.6	0.6	0.0	-0.2	-0.4	0.7	0.2					
Energy Share	0.1	0.1	0.8	0.1	0.0	-0.1	0.0	0.1	0.0	-0.1	0.2	-0.1	-0.2	-0.3				
Migrant Inflows	0.1	0.4	0.1	0.3	0.0	0.5	-0.4	0.4	0.0	-0.4	-0.3	0.5	0.3	0.6	-0.3			
Population Density	0.0	-0.5	-0.7	0.0	0.0	-0.4	0.3	-0.5	0.0	0.4	-0.6	-0.4	0.4	0.1	-0.5	0.0		
Unemployment Rate	0.0	-0.5	0.1	0.0	0.0	-0.5	0.3	-0.4	0.0	0.6	0.4	-0.5	-0.4	-0.3	0.3	-0.5	0.1	
Corporate Tax Ratio	0.1	0.5	0.2	0.3	0.0	0.6	-0.6	0.6	0.0	-0.2	-0.3	0.6	0.2	0.7	-0.1	0.4	0.1	-0.3

References

Anderson, James E., and Eric van Wincoop (2003) "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review* (93), pp. 170–92.

Anderson, Michael A., and Stephen Smith, (1999) "Canadian Provinces in World Trade: Engagement and Detachment," *Canadian Journal of Economics* 32, pp. 23–37.

Baldwin, John R., and Wulong Gu (2003) "Export-Market Participation and Productivity Performance in Canadian Manufacturing," *Canadian Journal of Economics* 36 (3), pp. 635–657.

Baldwin, John R., and Beiling Yan (2012) "Export Market Dynamics and Plant-Level Productivity: Impact of Tariff Reductions and Exchange-Rate Cycles," *Scandinavian Journal of Economics* 114 (3), pp. 831–855.

Barnett, Russell, and Karyne Charbonneau (2015) "Decomposing Movements in U.S. Non-Energy Import Market Shares," Bank of Canada Discussion Paper, 2015-5.

Bayoumi, Tamim, and Martin Mühleisen (2006) "Energy, the Exchange Rate, and the Economy: Macroeconomic Benefits of Canada's Oil Sands Production" IMF Working Paper 06/70.

Beine, Michel, Charles S. Bos, Serge Coulombe (2012) "Does the Canadian Economy Suffer from Dutch Disease?" *Resource and Energy Economics* 34, 468–492

Binette, André, Daniel de Munnik, and Émilien Gouin-Bonenfant (2014) "Canadian Non-Energy Exports: Past Performance and Future Prospects," Bank of Canada Discussion Paper, 2014-1.

Binette, André, Daniel de Munnik, and Julie Melanson (2015) "An Update - Canadian Non-Energy Exports: Past Performance and Future Prospects," Bank of Canada Discussion Paper, 2015-10.

Bruneau, Gabriel and Kevin Moran (2015) "Exchange Rate Fluctuations and Labour Market Adjustments in Canadian Manufacturing Industries," Bank of Canada Staff Working Paper 2015-45.

Chen, Zhiqi, Horatiu A. Rus, and Anindya Sen (2012) "Border Effects Before and After 9/11: Panel Data Evidence Across Industries," Carleton Economic Papers No. 12-02.

Dawson, Laura (2015) "Toward Free Trade in Canada", Fraser Research Bulletin, November 2015, 1-14.

Evans, Charles L., (2003) "The Economic Significance of National Border Effects," *American Economic Review* 93, pp. 1291–1312.

Habing, Brian (2003) "Exploratory Factor Analysis" unpublished manuscript (http://people.stat.sc.edu/habing/courses/530EFA.pdf), University of South Carolina.

Helliwell, John F., and Lawrence Schembri (2005) "Borders, Common Currencies, Trade, and Welfare: What Can We Learn From the Evidence?" *Bank of Canada Review* (Summer), pp. 19–33.

International Monetary Fund (2015) World Economic Outlook, April issue, Ch. 4.

International Monetary Fund (2015) World Economic Outlook, October issue, Ch. 3.

International Monetary Fund (2016) Canada Article IV Consultation Staff Report.

Issa, Ramzi, Robert Lafrance, and John Murray (2008), "The Turning Black Tide: Energy Prices and the Canadian Dollar", *Canadian Journal of Economics*, 41(3), pp. 737–759.

Johnson, Richard A., and Dean W. Wichern (2007) *Applied Multivariate Statistical Analysis* 6th ed., Pearson Education (NJ: Upper Saddle River).

Kim, Minsuk (2015) "Canada's Non-Energy Exports: Assessment of Post-Crisis Growth Performance" IMF Country Report No. 15/23, pp. 3-15.

Levin, Andrew, Chien-Fu Lin, and Chia-Shang James Chu (2002) "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," *Journal of Econometrics* 108, pp. 1–24.

McCallum, John, (1995) "National Borders Matter: Canada–U.S. Regional Trade Patterns," *American Economic Review* 85, pp. 615–23.

Medas, Paulo (2013) "Canada's Loss of External Competitiveness: The Role of Commodity Prices and the Emergence of China," IMF Country Report, No.13/40, pp. 42-51.

Munnik, Daniel de, Jocelyn Jacob, and Wesley Sze (2012), "The Evolution of Canada's Global Export Market Share", *Bank of Canada Working Paper,* No. 2012–31

Morel, Louis (2012) "A Foreign Activity Measure for Predicting Canadian Exports," Bank of Canada Discussion Paper, 2012-1.

Petersson, Bengt (2016 forthcoming) "A Fresh Look at Productivity Challenges for Canada," IMF WP.

Suvankulov, Farrukh (2015) "Revisiting National Border Effects in Foreign Trade in Goods of Canadian Provinces," Bank of Canada Working Paper 2015-28.

Shakeri, Mohammad, Richard S. Gray, and Jeremy Leonard (2012), "Dutch Disease or

Failure to Compete? A Diagnosis of Canada's Manufacturing Woes", *IRPP Study,* No. 30, Institute for Research on Public Policy, May.

Statistics Canada (2015) Industrial Research and Development: Intentions.

Stickney, Dan (2007) "The Mountain Pine Beetle Epidemic and the Impact on Canada's Forest Products Industries" BUEC 560, University of Alberta.

Tokarick, Stephen (2010) "A Method for Calculating Export Supply and Import Demand Elasticities" IMF Working Paper 10/180.

Trefler, Daniel (2004) "The Long and Short of the Canada–U.S. Free Trade Agreement," *American Economic Review* 94, 870–895.