The factory and the hub
Revisiting Canada's import dependence on the US*

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Abstract

We revisit the question of the reliance of Canada on the US for its imports using new product-level data on the country of origin, the last exporting country, and the transport mode of Canadian imports. The US is a key supplier of Canada, but also a key logistical hub: half of the imports from non US-suppliers enter Canada through the US. About 80% of Canadian imports are thus tied to the US through production or logistical linkages, way above the 55% usually reported in the public debate. We show this reliance on the US is effective across most product categories, including the "covid products" used to fight against the pandemic. We use gravity models to show this reliance goes beyond what the economic geography of Canada and the US predicts, and to understand better the different forms of logistical dependency. Using input-output tables, we finally provide a measure of the direct and indirect reliance of Canadian industries on the US through their input usage.

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1 Introduction

The shortage of medical supplies and the anecdotal disruption of supply chains during the first months of the Covid-19 pandemic have highlighted the central role of global value chains in the functioning of our economies. Many commentators questioned this outward dependence and focused their critics on the dependence on China due to its central role in GVCs.[1]

Whereas China is central in *global* value chains, Canada is mostly integrated with the North-American value chain, which is dominated by the US. This dependence on the US was striking in early April 2020, at a critical moment of the fight against the Covid-19, when Donald Trump asked the American multinational 3M to stop exporting its N95 masks, in particular to Canada and Latin American countries. The Canadian authorities had to display their whole diplomatic know-how to overturn this directive.

The Covid-19 crisis is thus a reminder of how dependent Canada is on the US for its imports. In this paper, we show that once we account for the imports from non-US partners that reach Canada through the US for logistical reasons, the dependence of Canada on the US is even worse than usually thought. We believe that our results make the question of the diversification of Canadian imports away from the US pressing, and they point out logistical diversification as a complement to traditional supplier diversification.

More specifically, the key statistics usually discussed in the public debate is that about 55% of Canadian imports are produced in the US. Thanks to a uniquely detailed database on Canadian imports reporting information not only on the origin country of the goods (where they receive their last production stage), but also on the (final) exporting country of the goods and on their transport mode (for their last leg) to Canada, we argue that Canada's

[1] To be clear, there is no systematic evidence (yet) that more integrated supply chains have been more severely hit during the crisis (Maliszewska et al. 2020).

reliance on the US is greater than what this figure suggests. Half of the goods imported from non-US suppliers enter Canada through the US-Canada border. The US is thus not only the main supplier of Canada, but also a critical logistical hub for Canadian imports. Overall, about 80% of Canadian imports are tied to the US, either because the goods are produced there, or because the goods cross the US to enter Canada. This level of dependence on the main trade partner is unique among developed economies. The US being economically big and geographically close to Canada, this huge reliance could be the mere result of economic geography. However, based on the estimation of gravity equations, we find that this is not the case.

We then show that indirect imports are particularly prevalent for some of the main trade partners of Canada. For example, it is more than 90% of the imports from Mexico, the Canada's second main trade partner, that are routed through the US. From a sectorial perspective, the reliance of Canadian imports on the US is high both as a producer and a logistical hub for printing, paper and motor vehicles products; more than 80% of Canadian imports of these products are tied to the US in the end. Imports of pharmaceutical products and textile and clothing products rely less on the US (about 50% of imports being tied to the US in these sectors). These patterns are similar if one focuses on so-called covid-products (used in the fight against the Covid-19 pandemic), which suggests that considering logistical ties is important to have a complete picture of the reliance of Canada's imports on the US.

We also find that for a given product and non-US origin country, the value of Canadian imports that enter through the US is relatively smaller than direct imports. This revolves to the fact that indirect imports often relate to shipments that are too small to fill an entire container to Canada, and/or that need to arrive quickly in "just-in-time" production lines, which explains why they are bought from US wholesalers or entrepôts.

Finally, we assess how much Canadian industries rely on the US for the provision of their inputs. Using input-ouptut matrices, we build a sectoral measure of dependence on the US that accounts for both the "direct" and "indirect" US-content of the inputs used by Canadian industries: we account for both the US-related inputs directly used by Canadian producers and for those used by their domestic suppliers. We show the reliance of Canadian manufacturing sectors on inputs produced or distributed by the US is extremely high, with significant variations across manufacturing sectors: the automobile and transport equipment industries are extremely dependent on the US, the chemical, pharmaceutical and metal product industries are less so. Even though much smaller, this dependence is also non negligible for services.

Our paper speaks to different strands of the literature. First, it relates to the literature on the diversification of trade flows. Part of this literature deals with the interconnections between international trade, sectorial diversification of production, output volatility and growth (see, e.g., di Giovanni & Levchenko 2009, Cadot et al. 2011). The geographic diversification of trade flows is less studied, and when it is so, the main focus is on the export side. For example, Caselli et al. (2020) show that the geographic diversification of exports allows to reduce the volatility of the demand faced by domestic producers, and Martin & Mayneris (2015) examines the relationship between the quality of exports and their geographic diversification. An exception is Cadot et al. (2014) who relate the search process for high-quality suppliers by OECD buyers to the patterns of geographic diversification of OECD countries' imports. We adopt a different view here by documenting the high dependence of Canada for its imports on a single trade partner, the US, and by showing that this dependence is not only related to sourcing strategies but also to logistical reasons.[2]

[2]See Beaulieu & Song (2015) for an analysis of Canada's reliance on the US for its exports.

Our paper also participates to the literature on "indirect trade". Traded goods are not always directly shipped from the producer to the buyer. They might travel through a third country for reasons related to tariff evasion (Rotunno et al. 2013), fiscal evasion(Laffitte & Toubal 2019) or logistics (Ganapati et al. 2020). In particular, based on very detailed data on the containers shipped to the US, Ganapati et al. (2020) show that the majority of US imports that travel by the sea arrive in US ports indirectly. Indeed, the country of origin of the goods is not necessarily the country where the shipment was loaded onto the containership, and/or the container makes multiple stops in different countries before reaching the US. The authors relate these patterns to the fact that shipping activities "are concentrated at entrepôts, trading hubs where goods travel through–from other origins, and bound for other destinations". Our data is less detailed and the type of indirectness we can capture is slightly different from what they have, but our paper revolves to the same ideas and shows that in the case of Canada, these logistical considerations increase the dependence of the country on the US.

Finally, our paper contributes to the literature on the measurement of sectoral exposure to foreign shocks through input usage. For instance, Boehm et al. (2019) show that Japanese affiliates in the US were strongly affected by the 2011 Tohoku earthquake because they sourced their inputs from Japan. Here, we do not look at the realized impact of a US shock on Canadian sectors, but we measure their ex-ante reliance on the US by considering the share of their inputs that are directly or indirectly tied to the US. Our measure of sectoral reliance builds on input-output (I-O) tables. The manipulation of I-O tables to go beyond raw exports and imports statistics is now well established in the trade literature (see Johnson 2018, for a review). It has been recently used to measure the exposure of countries to the corona-shock in China through global value chains (Gerschel et al. 2020).

The rest of the paper is organized as follows. We present in section 2 the data and some

definitions we use throughout the analysis. Section 3 discusses some descriptive statistics showing the huge dependence of Canada on the US both as a supplier and as a logistical hub for its imports. In section 4, we shed light on the origin countries and the sectors for which the reliance of Canada on the US a supplier and/or a logistical hub is the most important. We present in section 5 our sectoral measure of dependence on the US for input provision. Finally, section 6 concludes with some implications of our results for policy-making.

2 Data and definitions

The main database we use for our analysis is the Canadian International Merchandise Trade Database released by Statistics Canada. We have it for the year 2015. It reports the value and the quantity of Canadian imports disaggregated by 6-digit product in the Harmonized System (HS) nomenclature, the country of origin (where the last production step occurs), the exporting country (whose customs, but not necessarily borders, are the last to be crossed before reaching Canada), the transport mode on the last leg to Canada, and the port of entry.

The information on the origin country, the exporting country and the transport mode (for the last leg) of the goods that enter Canada allows us us to track the Canadian imports that go through the US on their way to Canada without being produced there. We distinguish two types of such indirect imports that are tied to the US for logistical reasons. First, a product might be exported by the US but not produced in this country. In the following, we refer to this situation as imports from a US "export platform" (they are also sometimes called "re-exports").[3] Second, there are "in-transit" imports. These imports are flagged neither

[3]The formal definition given by the Census is the following: "Exports of foreign goods (re-exports) consist of commodities of foreign origin that have previously been admitted to a U.S. Foreign Trade Zones or entered the United States for consumption, including entry into a CBP bonded warehouse, and which, at the time of exportation, are in substantially the same condition as when imported" (see https://www.census.gov/foreign-trade/reference/definitions/index.html).

as having a US origin nor as being imported from the US, but they enter Canada through the Canada-US ground border, i.e. their registered transport mode is "road" or "rail" (the only ground border of Canada being with the US). Unlike the imports from a "US platform", in-transit shipments are not recorded in the US statistics.[4]

In the end, we can identify in our data three types of Canadian manufacturing imports that are related to the US: i) the goods that are produced in the US; ii) the goods that are not produced in the US but are exported to Canada via US logistical platforms; and iii) the goods that are not produced in the US nor shipped to Canada through a US logistical platform, but transit through the US on their way to Canada.[5]

We also use several other databases for different parts of the analysis. The UN Comtrade and the BACI databases are used to obtain bilateral trade flows at the HS6-product level for more than 200 countries. The former is maintained by the United Nations from national Customs data; we use a version that registers export flows by exporting countries (i.e. it includes direct exports and export platform shipments in the export flows). The latter is built and maintained by CEPII[6] based on UN Comtrade data and registers export flows by supplying countries (shipments that reach their destination through an export platform are registered at the level of the country where the good receives its last production step).

The GDPs, bilateral distances between countries and various proxies for trade costs used to estimate gravity equations come from the Gravity database constructed from several sources and maintained by CEPII.

[4]The US Census' definition for this type of trade flows is: "Goods shipped through the United States, Puerto Rico, or the U.S. Virgin Islands from one foreign country or area to another foreign country or area without entering the consumption channels of the United States. In-transit shipments should not be part of the U.S. international trade data" (see https://www.census.gov/foreign-trade/reference/definitions/index.html).

[5]Note the data do not allow us to track in-transit imports that enter Canada by air through US airports. Our measure of the reliance of Canada on the US should thus be seen as a lower bound.

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Finally, the input-output table for Canada that is used to compute our sectoral index of dependence on US-related inputs is taken from the WIOD.[7]

3 The reliance of Canadian imports on the US

We first show that ignoring the indirect imports that go through the US leads to a severe under-estimation of the dependence of Canada on its Southern neighbor. When then compare Canada and other countries in terms of their dependence on their main trade partner and find that Canada is the only developed country to be so commercially dependent. Finally, based on the estimation of gravity equations, we find that this dependence is greater than what the size of and the distance between Canada an the US predict and that it is highly asymmetric.

3.1 The reliance of Canada on the US for its imports is worse than usually thought

In 2015, as displayed in Table 1, 55.3% of the value of Canadian imports have the US as their origin country. However, an additional 13.9% of the value of Canadian imports are not produced in the US but are exported by the US, which acts as an export platform country in this case. And finally, another 8.3% of Canadian imports transit through the US without being recorded in the data as part of the US exports to Canada. In total, nearly 80% of the value of Canadian imports originates from the US in some way or another, out of which almost 25 p.p. is related to the US for logistical, and not production, matters. The reliance of Canada on the US for its import provision is thus much greater than suggested by the statistics we usually use.

[7] World Input-Output Database (see http://www.wiod.org/home).

Table 1: ***Value of Canadian imports in 2015***

US origin imports	270
US platform imports	67.8
US transit imports	40.5
Total imports	488

Notes: Authors' calculations from the Canadian International Merchandise Trade Database. Figures are in billions of Canadian dollars. "US origin imports" are the imported goods produced in the US, "US platform imports" are those imported from the US but not produced there, and "US transit imports" are goods that are not produced in nor exported by the US but that enter Canada by road or rail.

3.2 Canada is the only developed country in the pool of commercially highly dependent countries

To assess whether Canada is an outlier regarding its reliance on its main trade partner, we compute the share of the main supplier in the imports of more than 200 countries. We do this for the imports registered in terms of origin country on the one hand, and in terms of exporting country on the other. This second measure allows us to account for export platform flows, but unfortunately we still miss the in-transit shipments that are impossible to track in internationally harmonized trade data.

The figures are shown in Table 2. Two main messages emerge from this table. First, the reliance of Canada on its main supplier, the US, is far above the average and the median observed across countries in the world, both as an origin country (56% *vs* 27% on average) and as an exporting country (70% *vs* 33% on average). Second, all of the countries that are together with Canada at the top of the distribution in terms of reliance on their main trade partner are small and/or poor countries and islands (North Korea, Bhutan, Saint-Pierre and Miquelon, Anguilla or Andorra are a few examples), except for Mexico. The huge import reliance of Canada on its main trade partner, the US, is thus very unique among developed economies.

Table 2: ***Share of the main supplier in overall imports by country***

Importing country	Main supplier	% in overall imports (by origin country)	% in overall imports (by exporting country)
Korea, Dem. People's Rep. of	China	87	87
Cocos (Keeling) Islands	Australia	80	46
Falkland Islands	United Kingdom	79	58
Turks and Caicos Islands	United States of America	79	85
Christmas Island	Australia	73	87
Bhutan	India	71	74
Marshall Islands	Korea	70	52
St. Pierre and Miquelon	France	69	54
Anguilla	United States of America	64	71
Macau (Aomen)	Hong Kong	63	53
Andorra	Spain	63	65
Lao People's Democratic Republic	Thailand	62	56
Antigua and Barbuda	United States of America	59	19
Bermuda	Korea	58	58
Greenland	Denmark	57	62
Canada	**United States of America**	**56**	**70**
Nepal	India	56	55
Sao Tome and Principe	Portugal	55	69
Belarus	Russian Federation	54	54
Mexico	United States of America	53	65
Median across all countries		**25**	**29**
Average across all countries		**27**	**33**

Notes: The trade data by origin country come from the BACI database for the year 2015, and those by exporting country come from Comtrade for the year 2014. The origin country is the country where the goods are produced and the exporting country are the one from which they are exported.

3.3 A reliance that goes far beyond the role of economic geography

It is now well established that international trade flows follow gravity (Head & Mayer 2014). Put differently, big and close countries trade more together. Consequently, it might be the case that the high reliance of Canada on the US just reflects economic geography: since the US is big and the US is close to Canada, Canada trades a lot with the US. However, this statement does not resist a careful empirical analysis.

More precisely, we estimate the following empirical model:

$$\text{Ln Exports}_{ijp} = \alpha \text{Ln GDP}_i + \beta \text{Ln GDP}_j + \gamma \text{X}_{\text{Trade costs}_{ij}} + \mu_p + \epsilon_{ijp}$$

where the log of the exports of product p from country i to country j is explained by the size of each of the two trading partners in terms of GDP, and a battery of variables that proxy for bilateral trade costs (the matrix $\text{X}_{\text{Trade costs}_{ij}}$). Among these variables we find the

bilateral distance between the trading partners as well as dummy variables identifying the pairs of countries that share a common border, an official language or a common currency, and the pairs of countries that participate in the same regional trade agreement. HS6-product fixed effects are also introduced to account for the fact that the average size of trade flows worldwide differs across products. On top of these variables that are now common in the analysis of the determinants of trade flows, we introduce two dummy variables that identify the flows between the US and Canada (one for the flows where Canada is the importer and the US the exporter, and another dummy for those where it is the other way around). The coefficients on these two dummies measure by how much the observed trade flows between the two countries differ from what economic geography, i.e. economic size, distance and other determinants of trade costs, predicts.

We estimate this gravity equation using the Comtrade data reporting export flows at the level of the country from where the products are finally exported to destination (and not necessarily produced).

The results are reported in Table 3. The first column shows that as expected, bigger countries trade more together (positive and significant coefficients on the GDP of both trading partners), whereas more distant countries trade less with each other (negative and significant coefficient on the bilateral distance between the two trading partners). All else equal, sharing a common border, a common language and a common currency also boosts trade flows. Column (2) shows that controlling for all of this, Canada and the US trade more together than expected. This is true for both Canadian imports from the US and Canadian exports to the US, but the premium is not symmetric: controlling for economic geography, the premium of US exports to Canada is stronger than the premium of Canadian exports to the US. This points at a clear asymmetry in the trade relationship between Canada and the US, to the

Table 3: ***Gravity determinants of bilateral trade flows***

	Ln Exports$_{ijp}$				
	(1)	(2)	(3)	(4)	(5)
Ln GDP$_i$	0.376^a	0.373^a			
	(0.009)	(0.009)			
Ln GDP$_j$	0.367^a	0.365^a			
	(0.007)	(0.007)			
Ln Distance$_{ij}$	-0.349^a	-0.351^a	-0.804^a	-0.801^a	-0.801^a
	(0.015)	(0.015)	(0.019)	(0.019)	(0.019)
$\mathbb{1}_{\text{Contiguous countries}_{ij}}$	0.583^a	0.564^a	0.559^a	0.535^a	0.535^a
	(0.050)	(0.049)	(0.053)	(0.051)	(0.051)
$\mathbb{1}_{\text{Common language}_{ij}}$	0.087^a	0.075^b	0.371^a	0.386^a	0.386^a
	(0.033)	(0.032)	(0.040)	(0.039)	(0.039)
$\mathbb{1}_{\text{Regional trade agreement}_{ij}}$	0.036	0.030	0.117^a	0.113^a	0.112^a
	(0.028)	(0.028)	(0.033)	(0.033)	(0.033)
$\mathbb{1}_{\text{Common currency}_{ij}}$	0.128^a	0.137^a	0.101^c	0.107^b	0.107^b
	(0.046)	(0.046)	(0.054)	(0.054)	(0.054)
$\mathbb{1}_{\text{US}_i-\text{CAN}_j}$		1.427^a	1.331^a	1.398^a	1.402^a
		(0.067)	(0.136)	(0.132)	(0.132)
$\mathbb{1}_{\text{CAN}_i-\text{US}_j}$		0.614^a	0.656^a	0.713^a	0.699^a
		(0.064)	(0.181)	(0.181)	(0.181)
$\mathbb{1}_{\text{US}_i-\text{MEX}_j}$				1.122^a	1.108^a
				(0.121)	(0.121)
$\mathbb{1}_{\text{MEX}_i-\text{US}_j}$				0.996^a	1.007^a
				(0.206)	(0.205)
$\mathbb{1}_{\text{MEX}_i-\text{CAN}_j}$					0.205^c
					(0.109)
$\mathbb{1}_{\text{CAN}_i-\text{MEX}_j}$					-0.387^a
					(0.090)
HS6 Product fixed effects	yes	yes	n.a.	n.a.	n.a.
Exporter×Product fixed effects	no	no	yes	yes	yes
Importer×Product fixed effects	no	no	yes	yes	yes
Observations	3,780,954	3,780,954	3,662,511	3,662,511	3,662,511
R-squared	0.273	0.274	0.612	0.612	0.612

Standard errors clustered at the importer-exporter level in parentheses
^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1
Data taken from the Comtrade database and registered at the level of the exporting country.

benefit of the US. In column (3) we control for exporter-product and importer-product fixed effects. Doing so, we control for the size of the partner countries in terms of GDP, but also for all of the determinants of trade flows that enter the multilateral resistance terms

in the structural gravity framework (Head & Mayer 2014).[8] This does not affect much the estimation of the "excess" trade between Canada and the US. In column (4), we also estimate the trade premia between Mexico and the US. Our results show that there is also "excess" trade between Mexico and the US, and the premia we estimate are interestingly not that far from those we find for the Canada-US relationship even though more balanced.[9] Finally, in column (5), we also add dummies to estimate the trade premia between Canada and Mexico. This does not affect the estimates of the trade premia for the two other pairs of countries, and we find that at the HS6-product level, if anything, Canada exports less to Mexico than what economic geography predicts, whereas Mexico exports slightly more to Canada. However, in terms of magnitude, the deviations from the gravity benchmark are much smaller for the Canada-Mexico trade flows than those measured for the Canada-US and Mexico-US pairs.[10] This suggests that the North-American value chain is strongly built around the US economy.

4 The US as a logistical hub for Canadian imports: a geographic and sectoral perspectives

In this section, we discuss how important the US is as a logistical hub for various non-US trading partners of Canada and various sectors, with a specific focus on covid-products. We then show that the imports from non-US countries that reach Canada through the US are relatively smaller in value, than those that reach Canada "directly".

[8] This includes comparative advantage, level of competition, access to markets and suppliers, prices etc.

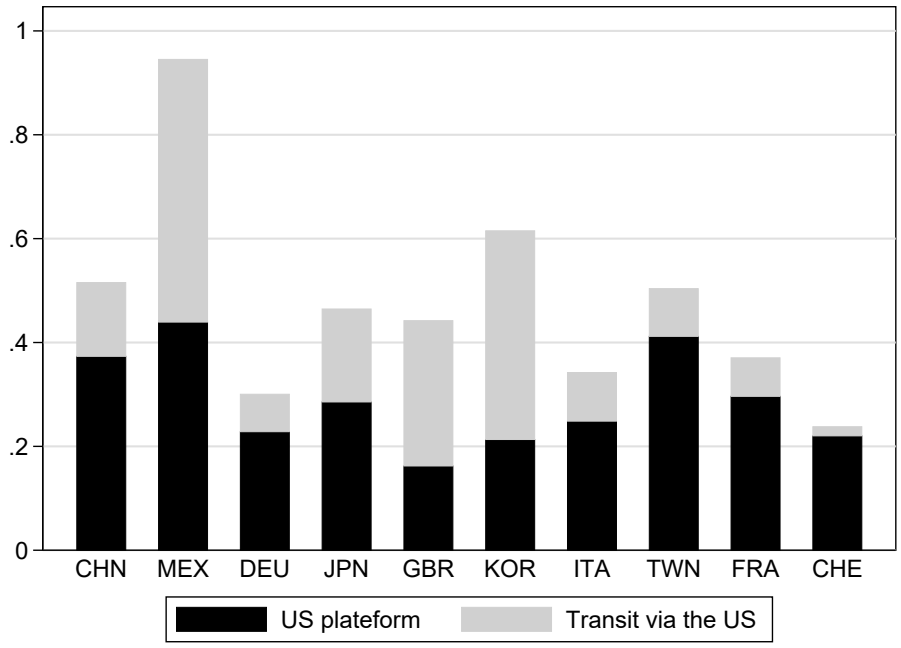
[9] Note that the premia we measure are quantitatively quite big, but these high average values might hide considerable heterogeneity across sectors.

[10] Note that the results are qualitatively robust when measuring exports flows at the level of the origin country instead of the exporting country (see Table 6 in Appendix). However, the premia observed for the trade between the CUSMA countries are quantitatively different. The comparison of both sets of results is coherent with the figures discussed in section 4 showing that a lot of the trade between Canada and Mexico is intermediated by the US.

4.1 US-related imports by origin country

Figure 1 provides information on the share of the imports from Canada's main partners that pass through the US, either through export platform or through simple ground transit. The countries are ranked in decreasing order based on their share in total Canadian imports (the main partner, the US, being of course excluded).

Figure 1: ***Share of Canadian imports from its top partners routed through the US***



Notes: Notes: authors computation from Canadian customs data. Each bar represents the share of Canadian imports from a given origin that is routed through the US before entering Canada. Some of these imports are re-exported by US companies and thus recorded in US trade statistics (US plateform), some are not but they do cross the US to enter Canada (transit via the US).

For most of them, the share of their exports that reach Canada through the US is close to or above 40%. For Mexico, it is actually more than 90% of its exports to Canada that transits through the US or is sent via US export platforms. The US is also a major hub for Canadian imports from China, Taiwan, and South Korea; the share of indirect imports in overall imports from these countries ranges from 50% to 60%. About 45% of the imports from Japan and the UK pass through the US. Indirect imports through the US are less prevalent

for EU countries such as France, Germany, or Italy but remain non negligible (30% to 35%).

The US is thus a key hub for Canadian imports from its main non-US trade partners, especially for Mexico and Asian countries.

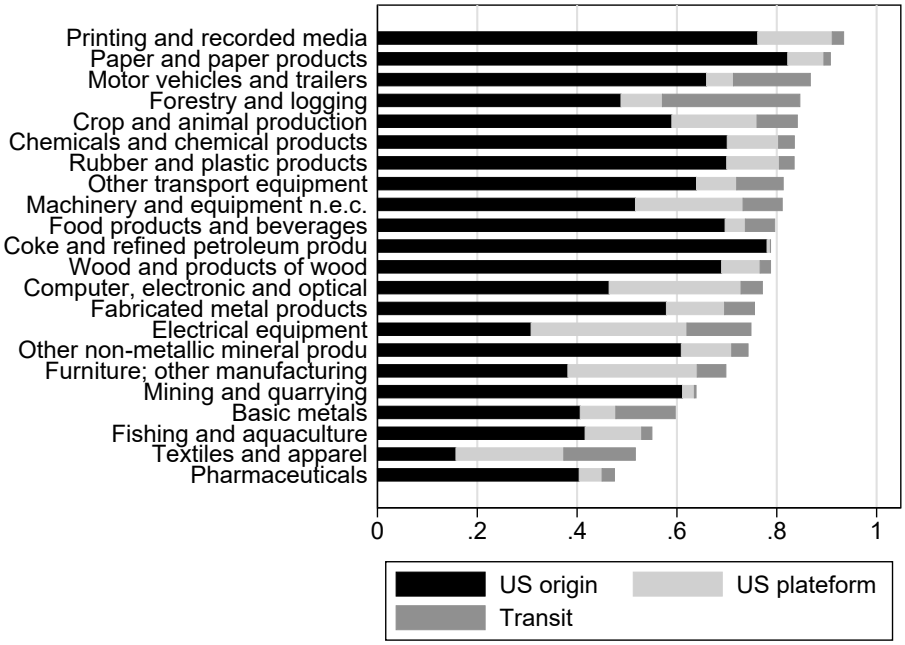
4.2 US-related imports by sector

All sectors. Figure 2 presents the import reliance of Canada on the US across (ISIC) sectors. We distinguish on this figure the three types of flows we already mentioned: US-origin, US-platform and US-transit imports. Consistent with the aggregate figures, the share of US-related imports is high in all sectors, ranging from a bit less than 50% in the pharmaceutical industry to 90% in the printing and recorded media industry. However, the nature of this reliance varies greatly across sectors. The pharmaceutical industry and the textile and apparel industry are interesting in this respect, since the overall shares of US-related imports in these two industries are close (45-50%) but hide different patterns. The lion share of the reliance of Canada on the US in the pharmaceutical industry is driven by pharmaceutical goods produced in the US. The textile and clothing industry is quite different since only a quarter of the US-related imports actually originate from the US, the rest consisting of foreign products crossing the US en-route to Canada.

When all three types of US-related imports are accounted for, the imported goods that are the most tied to the US are in the printing industry, the paper industry, and motor vehicle industry. When we focus on US-platform and US-transit imports, electrical equipment, textile and apparel, computer-electronic-optical products, furniture, and machinery and equipment industries clearly stand out.[11] This sectoral heterogeneity in the overall reliance and the nature of this reliance on the US will generate heterogeneity across industries in their

[11] Note that in these sectors imports often originate from Asian countries.

Figure 2: ***Three shades of exposure to the US, a sectoral view***



Notes: authors computation from Canadian customs data. US plateform are imports produced outside the US but re-exported from the US to Canada. Transit are imports produced outside the US, no recorded in US trade statistics but physically crossing the US to enter Canada.

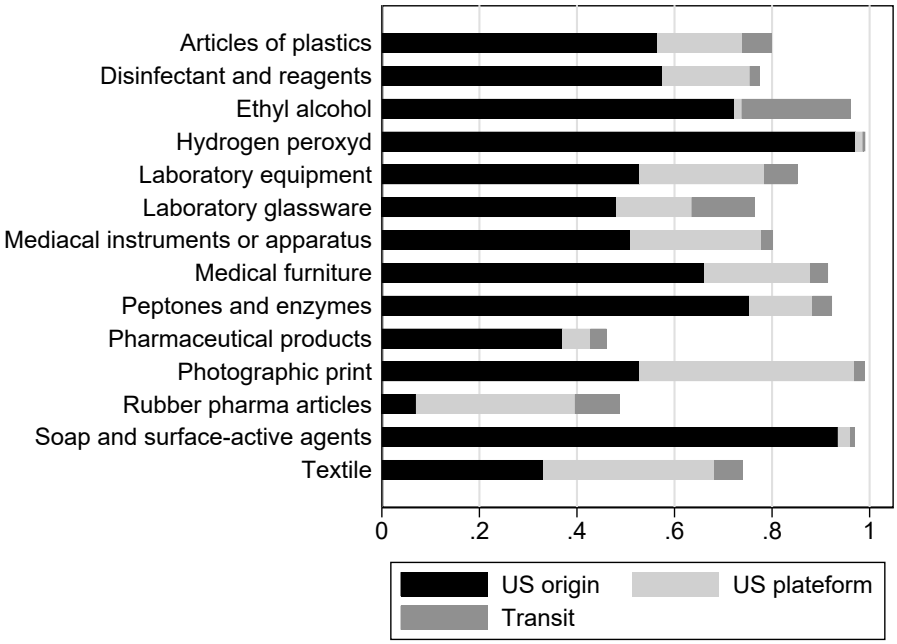
dependence on the US for the supply of their inputs (see section 5).

Covid products. In figure 3, we reproduce the same analysis as in figure 2 focusing on the products that are useful in the medical fight against Covid-19. The WTO released a list of 75 HS6 products used to fight against the pandemic.[12] This list includes pharmaceuticals, medical supplies, medical equipment, and personal protective products. For the clarity of the exposition, we combine together the HS6-products that belong to the same HS4 category (the labels reported in the figure refer to these HS4 categories).

The patterns we observe are quite similar for these products to those highlighted for overall Canadian imports. Across covid-product categories, 82% of Canadian imports on average are tied to the US, either because they are produced there or because they transit through the US on their way to Canada. Soap and ethyl alcohol are the product categories the most tied to

[12] See https://www.wto.org/english/news_e/news20_e/rese_03apr20_e.pdf .

Figure 3: ***Three shades of exposure to the US, covid products***



Notes: authors computation from Canadian customs data. US origin are imports produced in the US and shipped to Canada. US plateform are imports produced outside the US but re-exported from the US to Canada. Transit are imports produced outside the US, no recorded in US trade statistics but physically crossing the US to enter Canada.

the US, mostly because Canada imports these products from US producers. The protective equipments such as masks and gloves are in the rubber and textile articles categories. We see that a relatively small share of these products are produced in the US, but the reliance on the US for Canada is high due to the logistical importance of the US for the distribution of these articles in Canada.

4.3 Canadian indirect imports are smaller, in value, than direct ones

To dig deeper into the understanding of these indirect imports, we use our main database on Canadian imports re-aggregated at the level of the origin country, exporting country, HS6 product and transport mode, where the transport mode simply identifies here whether the goods enter Canada by the ground (road or rail) or not.

In this database, the lines corresponding to US-platform imports (non-US origin but US-

exporter) and US-transit imports (non-US origin and non-US exporter but ground transport mode) represent nearly 50% of the entries, but a bit less than 25% for the value of imports. It must be that these indirect imports are smaller in value than those for which the origin and the exporting countries are the same and the registered transport mode is not a ground one. We call these latter flows the "direct import flows".[13]

To directly check for this, we keep the imports with a non-US origin country and we identify four types of flows: the direct flows, the US-transit flows, the US platform flows and the non-US platform flows. For a given origin country and HS6 product, we then compare the value of the transit and platform flows to the value of direct ones. The results are displayed in Table 4 and they reveal a clear-cut ranking. For a given origin country and HS6 product, the imports that transit through the US are smaller than those that are directly shipped to Canada, those that are exported from (but not produced in) the US are even smaller, and finally those that are exported from a non-US platform are the smallest ones. This holds even when we control for the GDP of the exporting country or for the fact that the goods enter Canada by the ground. Hence, even though a country has multiple ways of exporting the goods it produces to Canada, which translates into multiple entries in the Customs data for the same product and origin country, the shipments that go directly from the origin country to Canada remain the most important ones in value.

These patterns are coherent with insights obtained from informal discussions with people working in the freight industry who report that for shipments that are not big enough to fill a container, the least cost route to a destination is not always the direct one. In the case

[13]Note however that this terminology is sloppy since it can be the case that imported goods are loaded on a containership in their origin country, but then the containership makes multiple stops to load and unload other shipments before reaching Canada. The same applies to air transport. Put differently, we do not observe the exact route taken by the containerships or the aircrafts when imports are registered in the data as having the same origin and exporting country.

of Canada, the US being a much bigger market, it might well be often less expensive for exporters to load their small shipments to Canada in containers that go to the US. Also, the lean management production techniques that have become so popular in the past decades have lead producers to reduce drastically their input inventories. This might push producers who face a pressing and unforeseen need for inputs to purchase them from wholesalers located closer to them than the original producers of these inputs. In this perspective, it might be often quicker for Canadian producers to buy their inputs produced in Asia from establishments of the same multinationals located in the US (this was the case for example for the masks exported by 3M from the US to Canada during the pandemic, some of them being produced in China) or from American wholesalers.

Table 4: ***Value of flows originating from non-US countries by import mode***

	Ln Imports$_{oxpt}$		
	(1)	(2)	(3)
Transit via US	-1.224^a	-1.274^a	-1.858^a
	(0.016)	(0.016)	(0.021)
Platform US	-1.213^a	-2.007^a	-2.349^a
	(0.014)	(0.021)	(0.021)
Platform non-US	-4.229^a	-4.282^a	-4.428^a
	(0.018)	(0.018)	(0.017)
Ln GDP$_{\text{Exporting country}}$		0.256^a	0.251^a
		(0.005)	(0.005)
$\mathbb{1}_{\text{Ground}}$			0.588^a
			(0.014)
Origin country-HS6 Product fixed effects	yes	yes	yes
Observations	408,126	408,126	408,126
R-squared	0.252	0.260	0.267

Robust standard errors in parentheses
^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1

5 Input dependence of Canadian industries on the US

We have examined so far the share of Canadian imports that is tied to the US through production or logistical linkages. We found a strong heterogeneity in this US-dependence across product categories. Canadian industries use a different mix of inputs, which should translate into different levels of reliance on the US. In this section we propose a quantification of the input reliance of Canadian industries on the US. We find most Canadian industries strongly rely on the US, including those that do not directly import inputs from the US. This is because they use domestic inputs that are themselves produced with US-related inputs.

Accounting framework. To measure the reliance of Canadian industries on the US, we exploit the I-O matrix describing the domestic and foreign inputs usage of industries. We measure reliance as the total (direct and indirect) share of US-related inputs (m_i^{us}) in total inputs (z_i) used in industry i:

$$reli_i^{us} = \frac{m_i^{us}}{z_i}$$

The total share of US-related inputs is given by the industry's direct consumption of US-related inputs plus US-related inputs that enter the production of other domestic inputs used by this industry. More specifically, the total consumption of US-related inputs in an industry is given by:

$$m_i^{us} = d_i^{us} + \sum_j \frac{x_{ji} m_j^{us}}{y_j}$$

where d_i^{us} is the direct use of US-related inputs by industry i, y_j is the production in industry j, and x_{ji} is the value of inputs j used in the production of industry i.

Let M, D, and A be the vectors and matrix with elements m_i^{us}, d_i^{us}, and $a_{ji} \equiv \frac{x_{ji}}{y_j}$. We can write:

$$M = D + AM = (I - A)^{-1}D$$

It appears from the expression above that the total use of US inputs in a industry is an infinite sum, which includes the direct use of US-related inputs, the direct use of US-related inputs by domestic inputs used in the industry, the direct use of US-related inputs used in the inputs of the inputs used in the industries, and so on and so forth:

$$m_i^{us} = d_i^{us} + \sum_j a_{ji} d_j^{us} + \sum_j a_{ji}^2 d_j^{us} + \sum_j a_{ji}^3 d_j^{us} ...$$

Empirical application. To measure the reliance of Canadian industries on the US for their inputs, we exploit the I-O matrix of Canada published by WIOD (Timmer et al. 2015). For every pair of industries ij, the data report the value of purchases by industry i of inputs from industry j. Key to our analysis, the data provide the break down into purchases to domestic and foreign suppliers. The matrix A is computed from the domestic requirement of the different industries.[14] To compute the direct use of US inputs, we combine I-O information with international trade data. More specifically, we compute:

$$d_i^{us} = \sum_j d_{ij} \times \frac{imp_j^{us}}{imp_j}$$

where d_{ij} is the value of imported inputs from industry j used by industry i, imp_j^{us} is the value of Canadian imports of products in industry j that are tied to the US and imp_j is the total value of Canadian imports of products in industry j. We thus assume that the share of US-related imports of a given input is the same across industries that use this input, and

[14] Our method thus excludes the reliance on the US that comes from the use of US inputs by other Canadian foreign partners.

that it is equal to the aggregate share of US-related imports in overall Canadian imports for the industry this input belongs to.[15]

Results. For the average Canadian industry, the US-related inputs (either because they are produced there or because they cross the US border to enter Canada) that are directly purchased by Canadian producers represent 15% of the total value of their inputs. To get a complete picture of the reliance of an industry on US-related imports, the sourcing of the producers of domestic inputs should also be considered. Once this indirect reliance on US-related imports is taken into account, we find the US-related content of the average industries increases to 24% of the total value of its inputs.

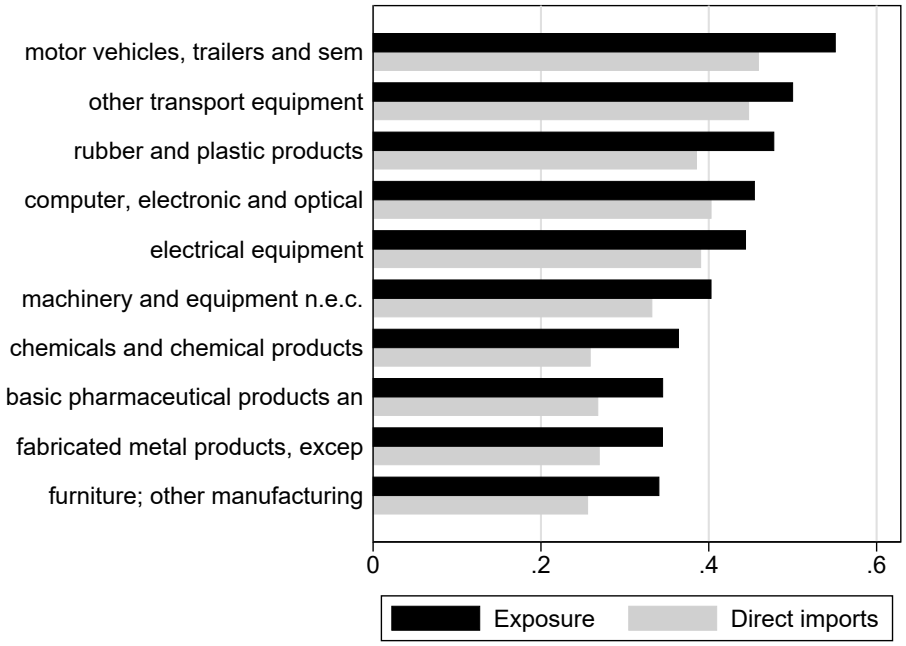
Figures 4 and 5 present the ten most and least exposed industries to the US. The full list of sectors is presented in Table 5. The industries that rely the most on the US for their inputs are manufacturing industries such as vehicle, plastic and rubber products, or computer and electronic products. In the motor vehicle industry, overall US-related imports amounts to half the total value of inputs.

Services are among the industries that depend the less on the US, with an reliance on US-related inputs below 10%. Their reliance is however way above the share of US-related inputs they directly they purchase. This large discrepancy is explained by the fact that services use domestic inputs from industries that rely more than they do on the US.

These results show all industries rely significantly on US-related inputs. Whereas manufacturing industries are the most dependent, services are not immune to trade disruption with the US.

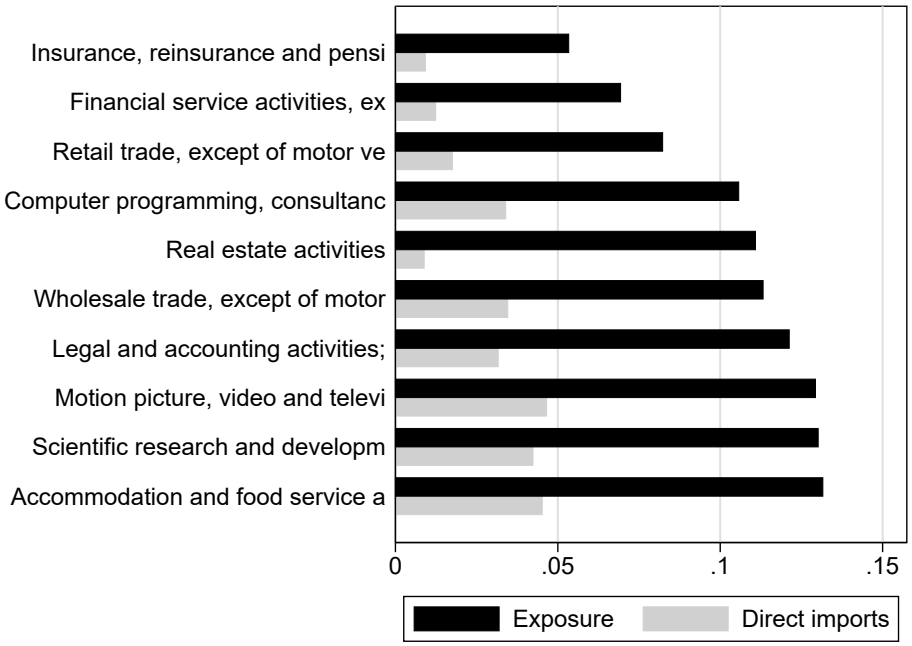
[15]For instance, we assume that the share of US-related chemicals in the imports of chemicals by the textile industry is the same as the share US-related chemicals in the imports of chemicals by the car industry, and that it is equal to the the share of US-related imports of chemicals in overall Canadian imports of chemicals.

Figure 4: ***Most exposed Canadian industries***



Notes: List of the ten most US-exposed industries in Canada. *Direct imports* is the share of inputs imported from the US (either produced in the US or in transit from the US). *Exposure* combines direct imports from the US and indirect exposure through the US-exposure of domestic inputs.

Figure 5: ***Least exposed Canadian industries***



Notes: List of the ten least US-exposed industries in Canada. *Direct imports* is the share of inputs imported from the US (either produced in the US or in transit from the US). *Exposure* combines direct imports from the US and indirect exposure through the US-exposure of domestic inputs.

Table 5: ***US exposure of Canadian sectors***

ISIC sector	Direct exposure	Total exposure
Manufacture of motor vehicles, trailers and semi-t	46%	55%
Manufacture of other transport equipment	45%	50%
Manufacture of rubber and plastic products	39%	48%
Manufacture of computer, electronic and optical pr	40%	45%
Manufacture of electrical equipment	39%	44%
Manufacture of machinery and equipment n.e.c.	33%	40%
Manufacture of chemicals and chemical products	26%	36%
Manufacture of basic pharmaceutical products and p	27%	35%
Manufacture of fabricated metal products, except m	27%	34%
Manufacture of furniture; other manufacturing	26%	34%
Wholesale and retail trade and repair of motor veh	25%	34%
Sewerage; waste collection, treatment and disposal	20%	32%
Manufacture of wood and of products of wood and co	19%	30%
Manufacture of textiles, wearing apparel and leath	21%	29%
Construction	20%	28%
Manufacture of paper and paper products	17%	28%
Printing and reproduction of recorded media	18%	28%
Manufacture of coke and refined petroleum products	21%	28%
Air transport	15%	27%
Forestry and logging	15%	26%
Fishing and aquaculture	13%	24%
Manufacture of basic metals	17%	24%
Manufacture of other non-metallic mineral products	13%	24%
Crop and animal production, hunting and related se	13%	24%
Human health and social work activities	14%	22%
Mining and quarrying	15%	22%
Publishing activities	12%	21%
Water transport	8%	20%
Postal and courier activities	9%	20%
Telecommunications	13%	20%
Manufacture of food products, beverages and tobacc	8%	19%
Education	7%	19%
Electricity, gas, steam and air conditioning suppl	9%	17%
Land transport and transport via pipelines	6%	17%
Other service activities	6%	16%
Warehousing and support activities for transportat	5%	16%
Administrative and support service activities	6%	15%
Architectural and engineering activities; technica	6%	14%
Advertising and market research	4%	14%
Other professional, scientific and technical activ	5%	14%
Public administration and defence; compulsory soci	6%	14%
Accommodation and food service activities	5%	13%
Scientific research and development	4%	13%
Motion picture, video and television programme pro	5%	13%
Legal and accounting activities; activities of hea	3%	12%
Wholesale trade, except of motor vehicles and moto	3%	11%
Real estate activities	1%	11%
Computer programming, consultancy and related acti	3%	11%
Retail trade, except of motor vehicles and motorcy	2%	8%
Financial service activities, except insurance and	1%	7%
Insurance, reinsurance and pension funding, except	1%	5%
Average	15%	24%

6 Conclusion

Once indirect trade is properly accounted for, the share of Canadian imports that are tied to the US is not, as usually thought, equal to more than 50% but instead closer to 80%. This dependence is huge and unique among developed economies. It cannot be entirely attributed to economic geography. And it generates non-negligible risks of supply disruption for Canadian consumers and producers in many manufacturing sectors. A recent example are the products used in the fight against the Covid-19 pandemic. Beyond this, the past few years years have shown that events that were seen as highly improbable so far, such as global pandemics, unilateral trade restrictions, end of free trade agreements, are not so unlikely in reality. The diversification away from the US thus seems more necessary than ever for Canada. What our results show is that diversifying does not only mean deepening trade agreements with other trade partners. Diversification has also to deal with logistical chains. To reduce the importance of indirect imports going through the US, avenues such as the mutualization of purchases to be able to fully fill containers shipped to Canada or the development of the maritime freight might be worth of investigation.

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7 Appendix

Table 6: ***Gravity determinants of bilateral trade flows***

	Ln Exports$_{ijp}$				
	(1)	(2)	(3)	(4)	(5)
Ln GDP$_i$	0.353^a	0.351^a			
	(0.008)	(0.008)			
Ln GDP$_j$	0.339^a	0.337^a			
	(0.006)	(0.006)			
Ln Distance$_{ij}$	-0.314^a	-0.315^a	-0.704^a	-0.702^a	-0.701^a
	(0.014)	(0.014)	(0.017)	(0.017)	(0.017)
$\mathbb{1}_{\text{Contiguous countries}_{ij}}$	0.505^a	0.487^a	0.486^a	0.466^a	0.466^a
	(0.047)	(0.047)	(0.050)	(0.049)	(0.049)
$\mathbb{1}_{\text{Common language}_{ij}}$	0.078^a	0.067^b	0.286^a	0.297^a	0.300^a
	(0.029)	(0.028)	(0.037)	(0.037)	(0.037)
$\mathbb{1}_{\text{Regional trade agreement}_{ij}}$	-0.001	-0.006	0.074^b	0.071^b	0.070^b
	(0.025)	(0.025)	(0.030)	(0.030)	(0.030)
$\mathbb{1}_{\text{Common currency}_{ij}}$	0.058	0.064	0.116^b	0.121^b	0.122^b
	(0.049)	(0.049)	(0.056)	(0.056)	(0.056)
$\mathbb{1}_{\text{US}_i-\text{CAN}_j}$		1.277^a	1.173^a	1.225^a	1.250^a
		(0.063)	(0.132)	(0.130)	(0.131)
$\mathbb{1}_{\text{CAN}_i-\text{US}_j}$		0.744^a	0.763^a	0.803^a	0.805^a
		(0.060)	(0.183)	(0.185)	(0.185)
$\mathbb{1}_{\text{US}_i-\text{MEX}_j}$				1.048^a	1.051^a
				(0.115)	(0.116)
$\mathbb{1}_{\text{MEX}_i-\text{US}_j}$				0.714^a	0.768^a
				(0.204)	(0.202)
$\mathbb{1}_{\text{MEX}_i-\text{CAN}_j}$					0.744^a
					(0.108)
$\mathbb{1}_{\text{CAN}_i-\text{MEX}_j}$					0.001
					(0.088)
HS6 Product fixed effects	yes	yes	n.a.	n.a.	n.a.
Exporter×Product fixed effects	no	no	yes	yes	yes
Importer×Product fixed effects	no	no	yes	yes	yes
Observations	3,780,954	3,780,954	3,662,511	3,662,511	3,662,511
R-squared	0.273	0.274	0.612	0.612	0.612

Standard errors clustered at the importer-exporter level in parentheses
^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1
Data taken from the BACI database and registered at the level of the origin country.