

The effect of interprovincial trade agreements in Canada

Ryan T. Godwin*, Umut Oguzoglu, and Kris Shaw

Department of Economics, University of Manitoba, Winnipeg, MB, R3T5V5, Canada

Abstract

We examine the effectiveness of interprovincial trade agreements (ITAs) in Canada. Preliminary evidence suggests that the effect of three ITAs may be twice that of the historical world average of regional trade agreements between 1999 and 2022. We embed province-to-province and province-to-country trade flows within a global gravity model of trade. We estimate the effect of ITAs using an extended two-way fixed effects (ETWFE) differences-in-differences (DiD) estimator that is valid in the presence of staggered treatment adoption.

Keywords: gravity, trade, staggered treatment, differences-in-differences, fixed effects, ETWFE

*Corresponding author. Email addresses: ryan.godwin@umanitoba.ca (R. Godwin); umut.oguzoglu@umanitoba.ca (U. Oguzoglu); kris.shaw@umanitoba.ca (K. Shaw)

1 Introduction

On February 1, 2025 the U.S. administration announced 25% tariffs on Canadian imports and 10% levy on energy products. By December 2025, Canada's nominal exports to the United States had fallen 16.7% over the year (Gellatly and McCormack, 2026). Among the efforts to mitigate trade loss with the U.S. there emerged a renewed interest in easing interprovincial trade barriers among the provinces and territories within Canada. We provide quantitative evidence regarding the effectiveness of any future efforts, by estimating the average treatment effect of previous interprovincial trade agreements (ITAs).

We estimate the effect of ITAs by nesting provincial trade, both to other provinces and to foreign countries, within a global gravity model of international trade. In the global model, Canada is effectively replaced with 13 provinces and territories that are treated as if each were a separate country. This approach has several advantages.

Treating each province or territory as if it were a separate country allows us to draw from the vast literature on gravity models of trade, and on the effectiveness of regional trade agreements (RTAs). In our setup, RTAs and ITAs are conceptually the same treatment, and are differentiated by a dummy interaction term, allowing for a heterogenous treatment effect.

We follow the current best practices on gravity estimation from (Larch et al., 2025b) who claim that the gravity model of trade is the most widely used empirical model in economics. Hence, many recent advances have been made in the literature. Among the recommendations for the new gravity models are the inclusion of three fixed effects, including trade between and with all countries, using de-aggregated product level data, and using internal

Table 1: Major Canadian interprovincial trade agreements, taken from Beaulieu and Zaman (2019)

Agreement	Provinces	Year	Purpose
Partnership Agreement on Regulation and the Economy	NB and NS	2009	Enhance competitiveness, improve productivity, contribute to workforce development, and positively influence issues of mutual interest by removing duplication and harmonizing regulations and practices between the provinces.
Trade and Cooperation Agreement	QC and ON	2009	Eliminate obstacles to interprovincial trade, labour mobility, public procurement, transportation, financial services, agriculture, and environment, and facilitate economic cooperation and the execution of joint projects between the provinces.
New West Partnership Trade Agreement	BC, AB, SK, and MB	2010 (MB in 2017)	Builds on the Trade, Investment and Labour Mobility Agreement to remove interprovincial barriers through full mutual recognition or reconciliation of the rules affecting trade, investment, or labour mobility among the four provinces.

trade flows. For the analysis of the ITAs (and RTAs) we follow the recent literature on differences-in-differences estimation in the presence of fixed effects and staggered treatments (Wooldridge, 2025; Callaway and Sant’Anna, 2021; Sun and Abraham, 2021), and its very recent extension to non-linear models (Wooldridge, 2023). Estimating a non-linear model is necessary since the famous result in (Silva and Tenreyro, 2006) that the gravity model cannot be log-linearized. Finally, recent advances in the estimation of high dimensional fixed effects in non-linear models (Correia et al., 2020) make the proposed estimating model computationally feasible.

We merge four large datasets to accomplish our analysis: (i) trade between all countries; (ii) trade between provinces and countries; (iii) trade between provinces; and (iv) all RTAs between countries. We then determine the timing of ITAs according to Beaulieu and Zaman (2019) (see Table 1).

With our merged dataset, we estimate the extended two-way fixed effects (ETWFE) differences-in-differences (DiD) estimator for the effect of ITAs (and RTAs) in a gravity model of trade. Preliminary results suggest that ITAs may be twice as effective as RTAs at increasing trade flows.

2 ETWFE within a gravity model of trade

Early models of trade:

$$Y_{ij} = \beta_0 X_i^{\beta_1} X_j^{\beta_2} D_{ij}^{\beta_3} \times \epsilon_{ij}$$

were seen to resemble Newton’s law of gravity:

$$F = G \frac{m_1 m_2}{d^2}$$

where force F corresponds to the trade Y between i and j , the mass of the objects (m_1 and m_2) to the size of the economies (X_i and X_j), and the distance between the objects d to the distance between countries D (broadly defined to include common languages, religions, etc.). Hence the name “gravity model of trade”.

A more modern gravity model of trade (Larch et al., 2025b) is given by:

$$X_{ij,t}^k = \underbrace{\left(\frac{Y_{i,t}^k}{Y_t^k} \right) (\Pi_{i,t}^k)^{\theta^k}}_{O_{i,t}^k} \times \underbrace{E_{j,t}^k (P_{j,t}^k)^{\theta^k}}_{D_{j,t}^k} \times \underbrace{\left(t_{ij,t}^k \right)^{-\theta^k}}_{T_{ij,t}^k}$$

or just:

$$X_{ij} = O_i \times D_j \times T_{ij},$$

where O_i are exporter factors, D_j are importer factors, and T_{ij} are bilateral trade costs. This structural model has evolved in order to, among other things, take into account multilateral resistances (Anderson and Van Wincoop, 2003); the idea that trade between i and j also depends on how difficult it is to trade with the rest of the world. By including in T_{ij} policies such as regional trade agreements (RTAs), tariffs, or in our case interprovincial trade agreements (ITAs) for example, the effect of those policies on trade X_{ij} may be estimated.

Larch et al. (2025b) make several recommendations on estimating gravity models and the specific form that they should take, and we follow as many of them as we can. One important recommendation is that, while gravity can be estimated for a single country (or in our case for a single province), multilateral resistances must then be controlled for by appropriate proxy variables. This is a heroic task, and often important controls will be unavailable leading to biased estimates. However, by including all countries into the sample (and in our case provinces as well), the multilateral resistances can be controlled for using country-specific fixed effects. This is “Recommendation 1” from (Larch et al., 2025b), and requires that we nest provincial trade (both province-to-province and province-to-country) within a global model of trade. This, to our knowledge, has not been done before. While the provincial case for Canada has yet to be nested in a global network, there is precedent for extending gravity estimation to sub-national trade flows, for example Anderson and Yotov (2010).

The two-way fixed effects (TWFE) estimator for the effect of RTAs within a gravity model, used up until very recently, resembles something like:

$$X_{ij,t} = \exp \left[\delta_{ij,t}^{\text{TWFE}} \text{RTA}_{ij,t} + \text{controls} + \text{fixed effects} \right] \times \epsilon_{ij,t}. \quad (1)$$

where $X_{ij,t}$ are exports from region i to region j at time t , and $\delta_{ij,t}^{\text{TWFE}}$ is the differences-in-differences (DiD) parameter representing the effect of trade policies on trade flow.

In panel data settings, treatment rarely occurs in the same time period for all treated units. Rather, the time at treatment for units is “staggered.” This is indeed the case for both $RTA_{ij,t}$ and the interprovincial trade agreements in which we wish to study ($ITA_{ij,t}$).

Under staggered treatments, the TWFE DiD estimator $\hat{\delta}_{ij,t}^{\text{TWFE}}$ has recently been criticized for producing bias in the estimated treatment effects when the treatment effect is heterogeneous over time (Borusyak et al., 2024). “Forbidden comparisons” arise as already-treated units become controls for newly-treated units. Several already famous studies have sought to rectify this (Wooldridge, 2025; Callaway and Sant’Anna, 2021; Sun and Abraham, 2021).

Following (Wooldridge, 2023, 2025), we employ the extended two-way fixed effects (ETWFE) estimator, which is a heterogeneity-robust staggered DiD estimator. ETWFE has recently been employed in a revisit of the effects of RTAs (Nagengast and Yotov, 2025), and we follow their setup. The single parameter and indicator variable for the presence of treatment ($\delta_{ij,t}^{\text{TWFE}} RTA_{ij,t}$) is instead replaced with:

$$\sum_{g=q}^T \sum_{s=g}^T \delta_{gs} D_{gs}, \quad (2)$$

where region pair ij belongs to treatment cohort g if the RTA began in g , q is the first year of the treatment of cohort g , D_{gs} is equal to 1 for cohort g for all treatment years and 0 otherwise, and δ_{gs} captures the cohort-year specific treatment effects.

Following other recommendations in (Larch et al., 2025b), a base estimating equation is:

$$X_{ij,t}^{(k)} = \exp \left[\sum_{g=q}^T \sum_{s=g}^T \delta_{gs} D_{gs} + \pi_{i,t}^{(k)} + \chi_{j,t}^{(k)} + \tau_{ij} + \theta_{ii,t} \right] \times \epsilon_{ij,t}. \quad (3)$$

Here, $X_{ij,t}$ are exports from region i to region j at time t , for product sector k . $\pi_{i,t}$ and $\chi_{j,t}$ are exporter-sector-year and importer-sector-year fixed effects which control for multilateral resistance terms and other country-time determinants. τ_{ij} are region-pair fixed effects that can account for endogeneity and control for time-invariant trade costs (such as distance and common borders). $\theta_{ii,t}$ is a dummy variable that indicates when trade is internal, and is recommended when domestic trade data is available. Finally, we use disaggregated data over the 11 product categories k that the data allows.

The recommendation to include many fixed effects, and the need to include many cohort-time interactions in ETWFE, results in high dimensions with many parameters in a model that is inherently non-linear. Fortunately this coincides with the emergence of estimation routines that can handle such models (Correia et al., 2020). Estimation, however, is still very taxing and is prone to memory and convergence issues.

Equation 3 is the estimating equation used in Nagengast and Yotov (2025). They re-evaluate the finding, determined over multiple studies using the TWFE estimator, that the effect of RTAs is around 18%. Using the heterogeneity robust ETWFE estimator finds the effect of RTAs to be 46%. Such a dramatic increase in the estimated effectiveness of RTAs between TWFE and ETWFE highlights the importance of the use of ETWFE in the current study.

The main object of interest in the Nagengast and Yotov (2025) study is a single estimate

for the average treatment effect, which is a weighted sum of cohort-time treatment effects:

$$\text{ATT} = \bar{\delta} = \sum_{g=q}^T \sum_{s=g}^T \frac{N_{gs}}{N_D} \hat{\delta}_{gs}, \quad (4)$$

where N_{gs} are the number of treated units of cohort g in period s , and N_D is the total number of treated units.

We extend the estimating equation from Nagengast and Yotov (2025) (equation 3), adding a second double summation term to allow for heterogenous treatment effects:

$$X_{ij,t}^{(k)} = \exp \left[\sum_{g=q}^T \sum_{s=g}^T \delta_{gs} D_{gs} + \sum_{g=q}^T \sum_{s=g}^T \beta_{gs} D_{gs} \text{ITA}_{gs} + \pi_{i,t} + \chi_{j,t}^{(k)} + \tau_{ij}^{(k)} + \theta_{ii,t} \right] \times \epsilon_{ij,t}. \quad (5)$$

where ITA_{gs} is an indicator variable equal to 1 if the trade agreement is between Canadian provinces. β_{gs} measures the difference between RTAs and ITAs. The main objects of interest in the present studies are now the average treatment effects of RTAs and ITAs¹:

$$\text{ATT}^{(RTA)} = \bar{\delta} = \sum_{g=q}^T \sum_{s=g}^T \frac{N_{gs}^{(I)}}{N_D^{(I)}} \hat{\delta}_{gs}, \quad (6)$$

and

$$\text{ATT}^{(ITA)} = \bar{\delta} + \bar{\beta} = \sum_{g=q}^T \sum_{s=g}^T \frac{N_{gs}^{(I)}}{N_D^{(I)}} \hat{\delta}_{gs} + \sum_{g=q}^T \sum_{s=g}^T \frac{N_{gs}^{(C)}}{N_D^{(C)}} \hat{\beta}_{gs}, \quad (7)$$

where $N^{(I)}$ denotes units treated internationally and $N^{(C)}$ denotes units treated within Canada. The $\hat{\delta}$ and $\hat{\beta}$ are estimated via the pseudo Poisson maximum likelihood (PPML) estimator recommend by Silva and Tenreyro (2006).

¹We actually take $100 \times (\exp \frac{N_{gs}}{N_D} \hat{\delta}_{gs} - 1)$ before summing (and similar for $\hat{\beta}_{gs}$).

Of further interest are the event-study estimands which can be calculated by averaging over cohorts according to:

$$\bar{\hat{\delta}}_{\cdot s}^{RTA} = \sum_{g=q}^s \left(\frac{N_{gs}^{(I)}}{N_{\cdot s}^{(I)}} \right) \hat{\delta}_{gs}, \quad (8)$$

and

$$\bar{\hat{\delta}}_{\cdot s}^{ITA} = \sum_{g=q}^s \left(\frac{N_{gs}^{(I)}}{N_{\cdot s}^{(I)}} \right) \hat{\delta}_{gs} + \sum_{g=q}^s \left(\frac{N_{gs}^{(C)}}{N_{\cdot s}^{(C)}} \right) \hat{\beta}_{gs}. \quad (9)$$

Finally, following the recommendations of Larch et al. (2025b), we cluster standard errors by (i) country-pair, (ii) exporter, importer, and time, (iii) exporter-time, importer-time, and country-pair.

2.1 Identification Assumptions

Our identification strategy follows the staggered DiD framework of (Wooldridge, 2023) adapted to the non-linear PPML setting.

2.1.1 No Anticipation

2.1.2 Parallel Trends in Untreated Potential Outcomes

3 Data

The International Trade and Production Database for Estimation (ITPD-E) Release 3 dataset (Larch et al., 2025a; Borchert et al., 2021) is used for trade flows between countries, for the years 1999 to 2022, and with product categories mapped into the regrouping variant of the North American Product Classification System (NAPCS) (Statistics Canada, 2023). Only the locations that overlap in the other data sets are kept for the ITPD-E data. The full list

of countries and Canadian provinces in the data set can be seen in Table 3.

We use detailed Statistics Canada data on trade flows between Canadian provinces and many other countries and regions in the world, for the years 1999 to 2022, and for many product categories (Statistics Canada, 2026a). We replace these trade flows with those for Canada in the ITPD-E dataset.

Province-to-province trade flows are also obtained from Statistics Canada (Statistics Canada, 2026b,c). Finally, we use Mario Larch’s Regional Trade Agreements Database from Egger and Larch (2008) for data on all RTAs between regions. When an RTA exists between Canada and some other country, the RTA is coded to exist for all provinces in the sample. ITAs for the provinces are coded according to Table 1.

After merging the four datasets, the final dataset that we use for analysis is 300 Mb uncompressed (with the “first treat” variable included for ETWFE estimation), and contains 9,914,667 observations.

4 Results

Our benchmark model is ETWFE over the full sample (all product categories), which involves 57,468 fixed effects and 310 treatment effects. This model is yet to be estimated due to computational limitations. We also have yet to incorporate the internal trade dummy $\theta_{i,t}$, again due to computational constraints (we are confident these can be overcome). Instead, we aggregate over the product categories in Table 3, and drop values for internal trade. We also drop all trade flows where treatment occurred on or before the start of the sample in 1999. This leaves a smaller dataset of 1,106,857 observations from the full 9,914,667 observations.

Table 2: Results

Specification	RTA	ITA
TWFE full sample	10.4%	-1.4%
ETWFE full sample		
TWFE aggregated NAPCS	5.9%	-3.3%
ETWFE aggregated NAPCS	10.5%	19.7%
TWFE with internal trade		
ETWFE with internal trade		

The estimating equation in 5 is estimated via the `fixest` R package (Bergé, 2023). Although the `etwfe` R package (McDermott, 2024) is tailored for ETWFE, we seem unable to implement our fixed effects specification for the gravity model. There are too many estimated parameters to be shown. Instead, we average the parameter estimates according to equations 6 and 7.

The estimated ATEs of the RTAs and ITAs for the aggregated smaller dataset are shown in Table 2. The average effect of RTAs is estimated to be 10.5% and of ITAs to be nearly twice at 19.7%. The 10.5% estimate on the RTAs does not coincide with either the pre-ETWFE literature which estimates the effect to be around 18% or the post-ETWFE which estimates it to be 46% (Nagengast and Yotov, 2025).

However, two estimation parallels may be drawn that can potentially get these estimates in line with the literature for ETWFE in the full sample. While we cannot yet estimate ETWFE for the full sample, we can estimate TWFE. The effect of RTAs is estimated to be twice that for the full sample versus the NAPCS aggregated sample (10.4% versus 5.9% in Table 2). Further discrepancies relative to the literature may be a result of differences in the sample period (1986-2016 compared to our 1999-2022), and to the exclusion of internal trade. Finally, the biased TWFE estimators estimate a small negative effect for ITAs.

5 Summary

6 Appendix

Table 3: Countries and Provinces Included in the Sample

Code	Name	Code	Name
AB	Alberta	FSM	Micronesia
BC	British Columbia	GAB	Gabon
MB	Manitoba	GBR	United Kingdom
NB	New Brunswick	GEO	Georgia
NL	Newfoundland and Labrador	GHA	Ghana
NS	Nova Scotia	GIB	Gibraltar
NT	Northwest Territories	GIN	Guinea
NU	Nunavut	GLP	Guadeloupe
ON	Ontario	GMB	Gambia
PE	Prince Edward Island	GNB	Guinea-Bissau
QC	Quebec	GNQ	Equatorial Guinea
SK	Saskatchewan	GRC	Greece
YT	Yukon	GRD	Grenada
ABW	Aruba	GRL	Greenland
AFG	Afghanistan	GTM	Guatemala
AGO	Angola	GUF	French Guiana
AIA	Anguilla	GUM	Guam
ALB	Albania	GUY	Guyana
AND	Andorra	HKG	Hong Kong
ANT	Netherlands Antilles	HMD	Heard Island and McDonald Islands
ARE	United Arab Emirates	HND	Honduras
ARG	Argentina	HRV	Croatia
ARM	Armenia	HTI	Haiti
ASM	American Samoa	HUN	Hungary
ATA	Antarctica	IDN	Indonesia
ATF	French Southern Territories	IND	India
ATG	Antigua and Barbuda	IOT	British Indian Ocean Territory
AUS	Australia	IRL	Ireland
AUT	Austria	IRN	Iran
AZE	Azerbaijan	IRQ	Iraq
BDI	Burundi	ISL	Iceland
BEL	Belgium	ISR	Israel
BEN	Benin	ITA	Italy

Table 4: Countries and Provinces Included in the Sample (continued)

Code	Name	Code	Name
JAM	Jamaica	MRT	Mauritania
JOR	Jordan	MSR	Montserrat
JPN	Japan	MTQ	Martinique
KAZ	Kazakhstan	MUS	Mauritius
KEN	Kenya	MWI	Malawi
KGZ	Kyrgyzstan	MYS	Malaysia
KHM	Cambodia	MYT	Mayotte
KIR	Kiribati	NAM	Namibia
KNA	Saint Kitts and Nevis	NCL	New Caledonia
KOR	South Korea	NER	Niger
KWT	Kuwait	NFK	Norfolk Island
LAO	Laos	NGA	Nigeria
LBN	Lebanon	NIC	Nicaragua
LBR	Liberia	NIU	Niue
LBY	Libya	NLD	Netherlands
LCA	Saint Lucia	NOR	Norway
LKA	Sri Lanka	NPL	Nepal
LSO	Lesotho	NRU	Nauru
LTU	Lithuania	NZL	New Zealand
LUX	Luxembourg	OMN	Oman
LVA	Latvia	PAK	Pakistan
MAC	Macao	PAN	Panama
MAR	Morocco	PCN	Pitcairn Islands
MCO	Monaco	PER	Peru
MDA	Moldova	PHL	Philippines
MDG	Madagascar	PLW	Palau
MDV	Maldives	PNG	Papua New Guinea
MEX	Mexico	POL	Poland
MHL	Marshall Islands	PRI	Puerto Rico
MKD	North Macedonia	PRK	North Korea
MLI	Mali	PRT	Portugal
MLT	Malta	PRY	Paraguay
MMR	Myanmar	PSE	Palestine
MNE	Montenegro	PYF	French Polynesia
MNG	Mongolia	QAT	Qatar
MNP	Northern Mariana Islands	REU	Réunion
MOZ	Mozambique	ROU	Romania

Table 5: Countries and Provinces Included in the Sample (continued)

Code	Name	Code	Name
RUS	Russia	THA	Thailand
RWA	Rwanda	TJK	Tajikistan
SAU	Saudi Arabia	TKL	Tokelau
SCG	Serbia and Montenegro	TKM	Turkmenistan
SDN	Sudan	TLS	Timor-Leste
SEN	Senegal	TON	Tonga
SGP	Singapore	TTO	Trinidad and Tobago
SGS	South Georgia and the South Sandwich Islands	TUN	Tunisia
SHN	Saint Helena	TUR	Turkey
SLB	Solomon Islands	TUV	Tuvalu
SLE	Sierra Leone	TWN	Taiwan
SLV	El Salvador	TZA	Tanzania
SMR	San Marino	UGA	Uganda
SOM	Somalia	UKR	Ukraine
SPM	Saint Pierre and Miquelon	UMI	United States Minor Outlying Islands
SRB	Serbia	URY	Uruguay
SSD	South Sudan	USA	United States
STP	São Tomé and Príncipe	UZB	Uzbekistan
SUR	Suriname	VAT	Vatican City
SVK	Slovakia	VCT	Saint Vincent and the Grenadines
SVN	Slovenia	VEN	Venezuela
SWE	Sweden	VGB	British Virgin Islands
SWZ	Eswatini	VNM	Vietnam
SXM	Sint Maarten	VUT	Vanuatu
SYC	Seychelles	WLF	Wallis and Futuna
SYR	Syria	WSM	Samoa
TCA	Turks and Caicos Islands	YEM	Yemen
TCD	Chad	ZAF	South Africa
TGO	Togo	ZMB	Zambia
		ZWE	Zimbabwe

Table 6: NAPCS merchandise aggregates used in the data

Code	Category
C11	Farm, fishing and intermediate food products
C12	Energy products
C13	Metal ores and non-metallic minerals
C14	Metal and non-metallic mineral products
C15	Basic and industrial chemical, plastic and rubber products
C16	Forestry products and building and packaging materials
C17	Industrial machinery, equipment and parts
C18	Electronic and electrical equipment and parts
C19	Motor vehicles and parts
C21	Aircraft and other transportation equipment and parts
C22	Consumer goods

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