CEP 12-02

Border Effects Before and After 9/11: Panel Data Evidence Across Industries

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February 2012

CARLETON ECONOMIC PAPERS

Carleton University
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Panel Data Evidence Across Industries

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Abstract

We build a unique industry-level panel data set to estimate border effects with respect to U.S.-Canada trade for each year from 1992 to 2005. Estimates from data aggregated at the province/state level yield border effects in the early 1990s that increase slightly and then decline after the implementation of the North American Free Trade Agreement (NAFTA), but significantly increase after 2001. Results based on three digit NAICS level data reveal higher border effects in the early 1990s and considerable heterogeneity across industries. These results imply that the tragic events of 9/11 had considerable adverse impacts for U.S.-Canada trade.

JEL: F1, F11, F14

Keywords: border effects, interprovincial trade, inter-state trade, border security, NAFTA, 9/11

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* We acknowledge assistance with data collection from Linda Jonker and Derek Khoo. This paper would not have been possible without some particularly outstanding research assistance from Wai Hong Choi.

** We thank Marc Duhamel and participants to the 2010 Carleton Library Series Workshop on Industrial Organization and Market Structure in Canada. Chen gratefully acknowledges financial assistance from the Social Sciences and Humanities Research Council.

1. Introduction

A persistent and extremely surprising empirical result in the international trade literature is the existence of rather strong 'border effects.' The conundrum consists of the fact that intra-national trade is typically found to be a multiple of international trade, even after controlling for a diverse array of barriers such as distance, economic size, explicit trade obstacles and a host of other country specific characteristics, such as common language, adjacency, remoteness or alternative trading opportunities. The seminal study by McCallum (1995) compares trade among Canadian provinces relative to corresponding flows with American states for 1988, in a gravity equation framework and using aggregate trade volumes. The key finding is that inter-provincial trade is roughly twenty times larger than flows between provinces and states. Subsequent studies have generally found border effects of smaller but comparable magnitudes in North America and Europe.[1] In a much cited paper, Obstfeld and Rogoff (2001) view McCallum's results as one of the six major puzzles in international macroeconomics.

The key contribution of this study stems from our construction of a comprehensive industry specific (at the three digit NAICS level) database that covers intra-national and international trade flows between 1992-2005 within Canada, and between Canada and the United States. By incorporating state-to-state trade volumes, in addition to province-to-province and province-to-state flows, these data allow us to analyze the effects of borders in international trade from a dual perspective. The long time-series of our data is also important as most studies have typically relied on single year cross-sections. The use of disaggregated industry level data over multiple years enables us to reliably assess the existence,

[1] See Helliwell and McCallum (1995), Helliwell (1998), Wei (1996), Head and Mayer (2000), Nitsch (2000), Hillberry (2002), Anderson and van Wincoop (2003), Evans (2003 and 2006), and Chen (2004 and 2011). Particularly notable are estimates by Anderson and van Wincoop (2003) that reduce Canada's borders effects to a range between 14 and 16. See the Appendix for a slightly more detailed review of this literature.

persistence and variability of border effects across sectors, and to control for potentially confounding year specific shocks. Exclusive reliance on aggregate trade effectively imposes a uniform response not only of province-state pairs, but also across trading sectors of the two economies. Perhaps more importantly, the time span of these data allows us to evaluate the effects of two significant shocks that theoretically should have impacted the magnitude of border effects between Canada and the United States. Specifically, the 1994 North American Free Trade Agreement (NAFTA) and the increase in border security in the aftermath of the tragic September 11, 2001 (or 9/11) events.

Why do we see any significant border effects at all? As noted by Goldfarb (2007), an obvious consequence of enhanced border security is longer and less predictable waiting times, which contributes to increased expenditures on variable inputs such as fuel and drivers hours, as well as more rapid depreciation of trucks and related capital equipment. Manufacturers might respond to possible delays by increasing average inventory levels or by sending goods earlier in order to ensure timely arrival. Border delays are especially critical for perishable commodities. All else being equal, border delays increase the costs of international trade and enhances the attractiveness of domestic substitutes. The possibility of this resulting in lower trade is evident.

Exploiting the effects of NAFTA and 9/11 may shed some light on the source, economic nature and composition of border effects. For example, if non-tariff trade barriers are partly responsible for the border effects, then we expect to see a decrease after NAFTA, above and beyond the decrease recorded as a result of the 1988 Free Trade Agreement, which largely dismantled tariff barriers. On the other hand, there also exists some evidence of a 'September 11' effect in bilateral trade flows between Canada and the United States. In the wake of the terrorist attacks on the United States, a series of measures aimed at tightening border security have been adopted, and these are largely considered to have led to a substantial border thickening and thereby to a slowing down, if not a reversal, of closer economic integration between Canada and the United States. Negotiations to speed up the flow of goods and people across the border are currently under way between Canada and the United States. The currently proposed security perimeter and regulatory cooperation agreement[2] is aimed at promoting trade, economic growth and jobs on both sides, while maintaining a high security level. These efforts are based on the belief that the border thickened. However, we are unaware of any existing empirical evidence of such impacts. This paper aims to fill this void.

The raw data certainly exhibits features of both events. Based on data from twenty-five (three digit) NAICS level industries (predominantly in manufacturing), Figure 1 reveals that in absolute terms, imports by Canadian provinces from the U.S. increased by roughly 100% while exports rose by over 150% over the whole period. However, both exports and imports fell rather sharply and over a short duration following 9/11 - by almost 130% from 2000 to 2003. Subsequent years witnessed a comparable rise in trade flows comparable to pre-2000 levels.[3]

Our estimates based on aggregate province-state data are consistent with recent studies, which suggest that McCallum's border effects are biased upwards. Furthermore, border effects decline during the late 1990s after the signing of NAFTA. However, of considerable interest is the significant spike in their magnitude after 2001. Results from disaggregated three digit NAICS level data reveal larger border effects during the early 1990s, that are closer to McCallum's initial findings. On the other hand, the trends are consistent with results from the aggregated data as there is a clear decline in border impacts after the implementation of NAFTA, followed by pronounced increase after 2001. Our inference is that the 9/11 terrorist attacks, which resulted in enhanced security measures at the U.S.-

[2] For a complete picture of the recently devised Canadian 'Border Action Plan' see $http://goo.gl/sFiiR$ (accessed September 11, 2011).

[3] Globerman and Storer (2008) estimate before and after import and export equations which include demand and exchange rate terms and report a significant and persistent effect on Canadian exports to the US and a less persistent effect on the US exports to Canada. Employing a different specification of the time effect, Burt (2009) finds some contrary evidence, while Globerman and Storer (2009) provide a synthesis of the limited existing econometric evidence.

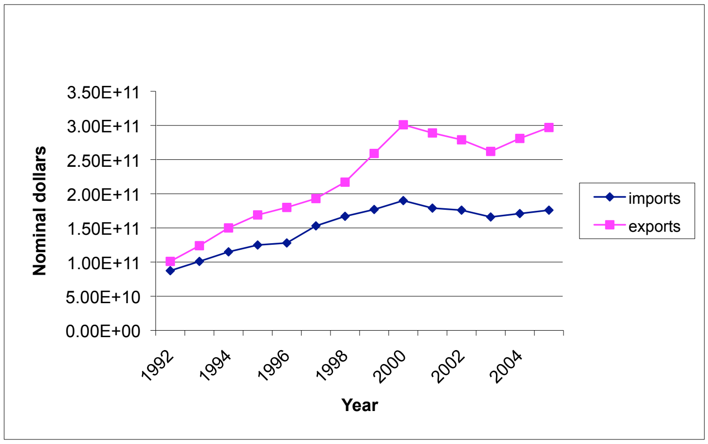

Figure 1: Canadian Imports and Exports from/to the U.S. in nominal dollars. (Source: Statistics Canada.)

Canada border, considerably impacted trade flows between the two countries. We find pronounced border effects with respect to Canadian exports to the U.S. as well as for Canadian imports from the United States. Finally, our estimates reveal some heterogeneity in border effects, that is, however, consistent with institutional details specific to each industry.

2. Methodology

Details on data compilation and sources are contained in the Appendix. Hence we only note the basic sources here. Three digit NAICS level Canadian province to province trade data (1997-2005) - mostly from the manufacturing sector - were obtained from the Input-Output Division of Statistics Canada.[4] Corresponding three digit NAICS data on exports

[4] The specific industries included along with the NAICS code: 114 Fishing, Hunting and Trapping; 211 Oil and Gas Extraction; 212 Mining (except Oil and Gas); 213 Support Activities for Mining and Oil and Gas Extraction; 311 Food Manufacturing; 312 Beverage and Tobacco Product Manufacturing; 313 Textile Mills; 315 Clothing Manufacturing; 321 Wood Product Manufacturing; 322 Paper Manufacturing; 323 Printing and Related Support Activities; 324 Petroleum and Coal Products Manufacturing; 325 Chemical Manufacturing; 327 Non-Metallic Mineral Product Manufacturing; 331 Primary Metal Manufacturing; 332 Fabricated Metal Product Manufacturing; 333 Machinery Manufacturing; 334 Computer and Electronic

from provinces to states (in the U.S.) and imports from states to provinces are available from Industry Canada's Trade Data Online database. State to state trade flows at the three digit NAICS level are from the United States Census Bureau's Commodity Flow Surveys.

To establish comparability with the literature, we first aggregate the data across sectors, by province-province and province-state trade flows. The basic empirical specification is the following gravity model:[5]

$$lnTRADE_{ij} = \beta_0 + \beta_1 DUMPROV_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnPOP_i + \beta_5 lnPOP_j + \beta_6 lnDIST_{ij} + \epsilon_{ij} \quad (1)$$

where ln is the natural logarithm, i refers to the originating jurisdiction and j to the destination. $TRADE_{ij}$ represents total exports and imports between jurisdictions i and j, $DUMPROV_{ij}$ is equal to 1 for interprovincial trade and 0 otherwise, GDP_i (POP_i) is total GDP (population) for jurisdiction i, GDP_j (POP_j) is total GDP (population) for jurisdiction j, $DIST_{ij}$ is total distance between jurisdictions i and j and ϵ_{ij} is the error term. We use actual driving distances from Google maps, in addition to direct line distances, which have been the norm in the literature. This is arguably a superior proxy for transportation costs, since truck shipping is the mode of choice for a large proportion of Canada-U.S. trade.

The exponential of $DUMPROV_{ij}$ yields the border effect. We run this regression separately for each year from 1992-2005. Each of these regressions will be based on a maximum of 690 annual observations consisting of 90 (10 x 9) observations for interprovincial trade and 600 (10 x 30 x 2) observations for province-state trade.[6] The dependent variable will take a value of zero in cases where there is no trade between any jurisdictions i and j. Equation (1) is estimated using OLS and standard errors of coefficient estimates are clustered by

Product Manufacturing; 336 Transportation Equipment Manufacturing; 337 Furniture and Related Product Manufacturing; and 339 Miscellaneous Manufacturing.

[5] See for example McCallum (1995).

[6] Following the existing literature, our dataset includes the 10 Canadian provinces and the 30 US states most active in bi-lateral exchanges. Please refer to the Appendix for a listing of the included jurisdictions.

originating jurisdiction, in order to account for unobserved correlations that might impact trade flows specific to the jurisdiction.[7]

This is the standard approach used by studies that have relied on interprovincial and province-state trade flows. We augment this specification by also employing data on state to state trade flows. Therefore, the empirical specification becomes:

$$lnTRADE_{ij} = \beta_0 + \beta_1 DUMPROV_{ij} + \beta_2 INTERSTATE_{ij} + \beta_3 lnGDP_i + \beta_4 lnGDP_j + \beta_5 lnPOP_i + \beta_6 lnPOP_j + \beta_7 lnDIST_{ij} + \epsilon_{ij} \quad (2)$$

where $DUMPROV_{ij}$ is equal to 1 for inter-provincial trade flows and is 0 otherwise, while $INTERSTATE_{ij}$ is 1 for state to state trade flows and is 0 otherwise. Therefore, consistent with (1), the omitted category is province-state trade flows. Anderson and van Wincoop (2003) estimate a similar specification with 1993 data. In contrast, we incorporate the 1993, 1997 and 2002 Commodity Flow Survey waves. Given our specific focus on the effects of NAFTA and the September 11, 2001, including these data is important in order to provide a dual perspective on the issues. The data allows us to evaluate whether border effects are unilateral or bilateral. We run equation (2) separately for each year of available data (1993, 1997 and 2002) in order to estimate border effects over time. Therefore, regressions are based on a sample of 90 (10 x 9) observations for interprovincial trade, 600 (l0 x 30 x 2) observations for province-state trade, and 870 (30 x 29) observations for interstate trade (for the three years of availability), resulting in a maximum sample of 1,560 observations annually. As in (1) above, we use OLS to estimates equation (2) and standard errors are clustered by originating jurisdiction.[8]

While useful for assessing the overall magnitude of border resistance, the above methodologies do not allow to properly identify the source of the border effect and understand which industries are differentially impacted. Therefore, we run the specifications with three digit level NAICS data. Employing these data also enables us to use dummies for the orig-

[7] The relevant summary statistics are provided in the Appendix, Table 1a.
[8] The relevant summary statistics are provided in the Appendix, Table 2a.

inating and destination jurisdictions i and j even if the regression is based on a single year. These regressions are important given the reliance of most studies on aggregate trade flow data from a single year, which does not shed any light on potential industry specific sources of border effects as well as possibly being confounded by unobserved jurisdiction and year specific shocks.

Single year regressions with respect to 21 three-digit level NAICS codes without interstate trade data are based on a maximum of 1,890 (10 x 9 x 21) observations for interprovincial trade and 1,260 (21 x l0 x 30 x 2) observations for province-state trade resulting in a sample of 3,150 observations. The use of interstate data adds a further 18,270 (30 x 29 x 21) observations. However, there are a number of zero observations with disaggregated data, since a number of jurisdictions do not trade with each other in a variety of goods and services. There is a possibility that underlying and unobserved characteristics specific to such jurisdictions determine the existence (or lack) of significant trade flows. Moreover, the data collecting agencies (e.g. Statistics Canada, Industry Canada and the US Census Bureau) only record 'significant' flows of goods, which implies that a zero in the data may reflect either no trade or shipments, or trade and shipments below an arbitrary threshold.[9] Given this, the use of truncated regression models[10] are appropriate for estimating equations (1) and (2) when using three digit NAICS data. Summary statistics of these data are available in the Appendix, Table 3a. The first estimable framework then becomes:

$$
\begin{aligned}
lnTRADE_{ijk} = \beta_0 + \beta_1 DUMPROV_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnPOP_i + \beta_5 lnPOP_j \\
+\beta_6 lnDIST_{ij} + \sum_i PROV_i + \sum_k NAICS_k + \epsilon_{ijk} \quad (3)
\end{aligned}
$$

if $TRADE_{ijk} >$ threshold and where k refers to the specific three digit NAICS indus-

[9] Depending on the dataset used and according to the documentation obtained from the data provides, the truncation level with respect to trade flows in a particular industry is defined as equal to \$100,000 for inter-provincial and province-states trade, and \$1 million for state-state trade.

[10] The Stata command `truncreg` uses the normality assumption of the entire population to fit a regression model using a sample drawn from the restricted part of the population. See e.g. Wooldridge (2003), p. 579.

try. $\sum_i PROV_i$ represents dummies for the originating province and $\sum_k NAICS_k$ refers to NAICS level dummies. Therefore, border effects are identified here by exploiting variation across trade flows between provinces and provinces to states, while holding constant unobserved shocks specific to an originating province and industry. In these regressions, standard errors of coefficient estimates are clustered by industry and the originating jurisdiction.

3. Empirical Estimates

3.1. Regressions based on aggregate provincial and state level trade flows

Table 1 contains baseline OLS estimates of the border effect for each year from 1992-2005, based on equation (1). The exponential of the coefficient estimate of $DUMPROV_{ij}$ is reported beneath the associated coefficient. Our results are comparable to Helliwell (1998) and Anderson and van Wincoop (2003) and reveal border effects from 9 to 11 between 1992 and 1995. Recall that McCallum (1995) obtain a border effect of 22 based on 1988 data and Anderson and van Wincoop (2003) suggest a border effect of 10.7 using 1993 data. We obtain an almost identical estimate of 10.8 from 1992 data and border effects ranging from 9 to 10 for 1993-1995.

In contrast, the border effect for 1997 is relatively larger at 14 but remains stable otherwise at roughly 12 until 2000. While the increase in border effects after the signing of NAFTA in 1994 might seem paradoxical, the result is consistent with Helliwell (1998) who also finds an increase in border effects immediately after the Free Trade Agreement of 1987 and a corresponding decrease only 3 years later, and could be explained by the time lag necessary for trade pattern adjustments (Helliwell (1998), p. 22). On the other hand, there is a clear increase from 2001 onwards, rising to more than 17 in 2003 and 2004 and more than 19 in 2005. All border effect coefficient estimates are statistically significant at the 1% level. In terms of other covariates, the GDP of originating and destination jurisdictions possess the expected positive signs and are statistically significant at the 1% level. The coefficient estimates of distance are close to unity, also significant at the 1% level (across

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
interprov	2.38***	2.24***	2.23***	2.34***	2.41***	2.65***	2.50***	2.50***	2.48***	2.55***	2.70***	2.85***	2.85***	2.95***
	(0.15)	(0.15)	(0.16)	(0.14)	(0.14)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)
border effect	*10.80*	*9.39*	*9.30*	*10.38*	*11.13*	*14.15*	*12.18*	*12.18*	*11.94*	*12.81*	*14.88*	*17.29*	*17.29*	*19.11*
ln(orig_gdp)	1.25***	1.24***	1.21***	1.21***	1.17***	1.14***	1.12***	1.09***	1.05***	1.03***	1.07***	1.05***	1.02***	1.05***
	(0.039)	(0.040)	(0.039)	(0.036)	(0.037)	(0.038)	(0.035)	(0.033)	(0.033)	(0.033)	(0.033)	(0.032)	(0.033)	(0.035)
ln(dest_gdp)	0.92***	0.93***	0.96***	1.01***	1.03***	0.96***	0.95***	1.00***	1.04***	1.01***	1.04***	1.03***	1.05***	1.12***
	(0.037)	(0.037)	(0.040)	(0.035)	(0.036)	(0.036)	(0.033)	(0.039)	(0.035)	(0.035)	(0.035)	(0.034)	(0.033)	(0.043)
ln(dr_dist)	-1.36***	-1.39***	-1.41***	-1.41***	-1.40***	-1.37***	-1.34***	-1.35***	-1.33***	-1.32***	-1.42***	-1.40***	-1.37***	-1.50***
	(0.082)	(0.084)	(0.084)	(0.079)	(0.078)	(0.078)	(0.075)	(0.071)	(0.071)	(0.072)	(0.072)	(0.072)	(0.072)	(0.080)
Constant	-26.2***	-25.7***	-25.7***	-26.9***	-26.5***	-24.3***	-23.6***	-24.0***	-24.1***	-23.2***	-24.1***	-24.0***	-23.9***	-25.5***
	(1.67)	(1.60)	(1.71)	(1.56)	(1.60)	(1.54)	(1.53)	(1.60)	(1.49)	(1.57)	(1.55)	(1.55)	(1.58)	(1.70)
Obs	680	682	681	684	680	686	683	685	686	687	688	685	686	686
R-squared	0.745	0.737	0.743	0.770	0.771	0.770	0.778	0.782	0.788	0.781	0.798	0.792	0.784	0.749

Notes: Province-province and province-state trade flows included, inter-provincial dummy (interprov). The dependent variable is the natural logarithm of the adjusted trade flows (l_atrade). Standard errors in parentheses, clustered by origin-destination: *** p<0.01, ** p<0.05, * p<0.1

Table 1: OLS Estimates of Inter-provincial Border Effects from 1992 to 2005, Aggregate Data. (Source: Statistics Canada, Industry Canada.)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	1993	1997	2002	1993	1997	2002
interprov	2.29***	2.79***	2.80***	2.17***	2.85***	2.76***
	(0.15)	(0.11)	(0.10)	(0.16)	(0.11)	(0.10)
border effect	*9.87*	*16.28*	*16.44*	*8.76*	*17.29*	*15.80*
interstate	0.56***	-0.21***	-0.43***	0.67***	-0.27***	-0.40***
	(0.070)	(0.065)	(0.069)	(0.078)	(0.071)	(0.073)
border effect	*1.75*	*0.81*	*0.65*	*1.95*	*0.76*	*0.67*
ln(orig_gdp)	1.19***	1.17***	1.09***	1.00***	1.86***	0.45**
	(0.028)	(0.027)	(0.026)	(0.31)	(0.26)	(0.23)
ln(dest_gdp)	1.01***	1.10***	1.14***	-0.29	1.11***	1.05***
	(0.028)	(0.027)	(0.028)	(0.29)	(0.23)	(0.23)
ln(drdist)	-1.16***	-1.23***	-1.29***	-1.17***	-1.23***	-1.29***
	(0.044)	(0.042)	(0.044)	(0.043)	(0.041)	(0.043)
ln(orig_pop)				0.19	-0.77***	0.69***
				(0.33)	(0.27)	(0.25)
ln(dest_pop)				1.44***	-0.0054	0.089
				(0.32)	(0.25)	(0.25)
Constant	-28.3***	-29.4***	-28.2***	-15.2***	-35.7***	-21.5***
	(1.10)	(1.12)	(1.15)	(4.24)	(3.52)	(3.33)
Obs	1521	1507	1467	1521	1507	1467
R-squared	0.808	0.819	0.811	0.812	0.820	0.812

Notes: Province-province and province-state trade flows included, inter-provincial and inter-state dummies (interprov and interstate). The dependent variable is the natural logarithm of the adjusted trade flows (l_atrade). Standard errors in parentheses, clustered by origin-destination, *** p<0.01, ** p<0.05, * p<0.1

Table 2: OLS Estimates of Inter-provincial and Inter-state Border Effects from 1992 to 2005, Aggregate Data. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

all columns) and have the expected negative signs. Population levels in the originating and destination jurisdictions are sporadically significant with no clear patterns.

Table 2 consists of border effects estimates of equation (2), which incorporate interstate trade flows. The estimates are for 1993, 1997 and 2002 only, due to the US data availability discussed above. Given this, it is not possible to evaluate directly whether border effects decreased right after NAFTA came into force or whether they increased in magnitude precisely from 2001 onward. However, the estimates are consistent in size to the results in Table 1. Columns 1-3 contain estimates that do not control for population of origin and final destinations, while results in columns 4 -6 are conditioned on population. Border effect estimates are quite similar to corresponding figures discussed previously. Specifically, the border effect estimates for 1993, 1997, and 2002 from Table 1 are approximately 9, 14, and 15. By comparison, the estimates for the same years from columns 4, 5, and 6 in Table 2 are roughly 9, 17, and 16, respectively. All these coefficient estimates are statistically significant at the 1% level. Coefficient estimates of interstate trade ($INTERSTATE_{ij}$) are also significant at the 1% level across all columns with different signs. Origin and destination GDP are also significant across all columns with positive signs, and distance is negative and significant at the 1% level.

As expected, the estimates based on 1993 data parallel findings from Anderson and van Wincoop (2003). First, our border effect of 9.87 in column 1 is only slightly lower than their estimate of 10.7. Second, our estimate of the difference in interstate trade flows relative to province-state trade ($INTERSTATE_{ij}$) is 1.75, which is only slightly larger than their result of 1.5. As a further sensitivity analysis, we re-ran the regressions in Tables 1 and 2, but using difference - in - difference specifications that condition border effect estimates on unobserved time specific shocks through year specific dummies. Employing difference-in-difference models yields separate border effects for each year but also has the advantage of allowing us to employ province (state) and year fixed effects in order to control for unobserved shocks that are fixed within jurisdictions over time or simultaneously impact all provinces and states in a given year.

Equation (1) thus becomes:

$$
\begin{aligned}
lnTRADE_{ij} &= \beta_0 + \beta_1 DUMPROV_{ijt} + \beta_2 (DUMPROV_{ijt} * YEAR1994_t) \\
&+ \beta_3 (DUMPROV_{ijt} * YEAR1995_t) + \beta_4 (DUMPROV_{ijt} * YEAR1996_t) \\
&+ \beta_5 (DUMPROV_{ijt} * YEAR1997_t) + \beta_6 (DUMPROV_{ijt} * YEAR1998_t) \\
&+ \beta_7 (DUMPROV_{ijt} * YEAR1999_t) + \beta_8 (DUMPROV_{ijt} * YEAR2000_t) \\
&+ \beta_9 (DUMPROV_{ijt} * YEAR2001_t) + \beta_{10} (DUMPROV_{ijt} * YEAR2002_t) \\
&+ \beta_{11} (DUMPROV_{ijt} * YEAR2003_t) + \beta_{12} (DUMPROV_{ijt} * YEAR2004_t) \\
&+ \beta_{13} (DUMPROV_{ijt} * YEAR2005_t) + \beta_{14} lnGDP_i + \beta_{15} lnGDP_j \\
&+ \beta_{16} lnPOP_i + \beta_{17} lnPOP_j + \beta_{18} lnDIST_{ij} + \sum_i ORIG_i + \sum_t YEAR_t + \epsilon_{ij} \qquad (4)
\end{aligned}
$$

where the t subscript denotes the year. β_1 now yields the border effect for 1993 and the other coefficients (β_2 through β_{13}) measure the incremental border effect for each subsequent year. $\sum_i ORIG_i$ represents originating province dummies and $\sum_t YEAR_t$ are year specific dummies. Equation (2) is also modified as:

$$
\begin{aligned}
lnTRADE_{ij} &= \beta_0 + \beta_1 DUMPROV_{ijt} + \beta_2 (DUMPROV_{ijt} * YEAR1997_t) \\
&+ \beta_3 (DUMPROV_{ijt} * YEAR2002_t) + \beta_4 INTERSTATE_{ijt} \\
&+ \beta_5 (INTERSTATE_{ijt} * YEAR1997_t) + \beta_6 (INTERSTATE_{ijt} * YEAR2002_t) \\
&+ \beta_7 lnGDP_i + \beta_8 lnGDP_j + \beta_9 lnPOP_i + \beta_{10} lnPOP_j \\
&+ \beta_{11} lnDIST_{ij} + \sum_i ORIG_i + \sum_t YEAR_t + \epsilon_{ij} \qquad (5)
\end{aligned}
$$

β_4 is the benchmark effect for interstate flows for 1992 and the other coefficients (β_5, β_6) measure the incremental impacts for each subsequent year. In both specifications, standard errors are clustered by origin and destination in order to account for unobserved jurisdiction-level correlations.

Table 3 contains OLS estimates of equations (4) and (5) for the aggregate data pooled for all available years. For the sake of brevity we do not report all interaction coefficients. The figures and trends for the *year*border* interaction terms are quite similar to those contained in Tables 1 and 2. Estimates reveal 'Canadian-side' border effects ranging from around 10 in 1992-93, roughly 9.5 in 1994, increasing until 1997 to around 16 and declining thereafter to about 14 in 2001. From 2001 onward, we again witness a significant increase to about 19 in 2004/2005. Regressions based on (5) and also including state to state data yield 'US-side' border effects for 1992, 1997 and 2002 comparable to previous results.

Next, we further augment the gravity specification with remoteness measures. The need to control for remoteness stems from interpreting the border effect on trade as a bilateral trade barrier relative to the average trade barrier of the two countries with all of their third trading partners (Anderson and van Wincoop (2003), p. 170). The recent literature on border effects suggests several ways to control for these third-party effects.[11] We follow most of the literature (including Anderson and van Wincoop (2003), p. 174) in defining the remoteness of a country i as a weighted average of the distances to all of its trading partners other than j, where the weights are the respective partners GDP levels. This is calculated for both the exporter and the importer for every year and the remoteness variables are included as controls. As expected, both remoteness coefficients are positive (third-party remoteness increases bilateral trade) and statistically significant at the 1% level for all years, and their magnitude is consistent with other studies (e.g. Helliwell (1998), p.44). More importantly, as can be seen by comparing the results in Table 4 with those in Table 1, accounting for remoteness does reduce the border effect by a modest, but not significant margin, which is again consistent with the literature.

A more comprehensive method in addressing the trading resistance factor in bilateral trade consists in controlling for multilateral resistance terms (MRTs). These are price indices which are functions of all bilateral trade barriers on both the exporter and the importer sides.

[11] One method to account for 'trading resistance' assumes that the most important barrier to trade is distance itself, and attempts to control for the opportunity cost of trade using various indicators of the remoteness of both trading partners.

VARIABLES	Inter-province and province-state data													
	overall	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
interprov	2.42***	-0.14	-0.16	-0.079	0.0018	0.34	0.21	0.19	0.14	0.23	0.33	0.49	0.5	0.54
	(0.16)	-0.046	-0.086	-0.079	-0.1	-0.13	-0.13	-0.13	-0.14	-0.14	-0.14	-0.14	-0.15	-0.15
implied border effect	*11.25*	*9.78*	*9.58*	*10.39*	*11.27*	*15.80*	*13.87*	*13.60*	*12.94*	*14.15*	*15.64*	*18.36*	*18.54*	*19.30*
year dummies	yes													
origin dummies	yes													
year*border	yes													
Constant	-32.4***													
	(4.31)													
Observations	9579													
R-squared	0.778													
	Inter-province, province-state and state-state data													
interprov	2.43***					0.17					0.16			
	(0.11)					-0.06					-0.056			
implied border effect	*11.36*					*13.46*					*13.33*			
interstate	0.52***													
	(0.068)					-0.61					-0.78			
implied border effect	*1.68*					*-0.048*					*-0.056*			
year dummies	yes													
origin dummies	yes													
year*border	yes													
Constant	20.4***													
	(5.51)													
Observations	12018													
R-squared	0.815													

Notes: Province-province and province-state trade flows included, inter-provincial and inter-state dummies (interprov and interstate). The dependent variable is the natural logarithm of the adjusted trade flows (l_atrade). The yearly border effect is calculated as algebraic sum between the overall and border-year interaction coefficients Standard errors in parentheses, clustered by origin-destination, *** p<0.01, ** p<0.05, * p<0.1

Table 3: OLS Estimates of Inter-provincial and Inter-state Border Effects from 1992 to 2005, with Year and Jurisdiction Dummies, Pooled Aggregate Data. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
interprov	2.34***	2.13***	2.18***	2.29***	2.35***	2.86***	2.46***	2.46***	2.44***	2.51***	2.91***	2.80***	2.79***	2.90***
	(0.15)	(0.15)	(0.16)	(0.14)	(0.14)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.099)	(0.10)	(0.10)	(0.12)
border effect	*10.38*	*8.41*	*8.85*	*9.87*	*10.48*	*17.46*	*11.7*	*11.7*	*11.47*	*12.3*	*18.36*	*16.44*	*16.28*	*18.17*
ln(orig_gdp)	1.18***	1.17***	1.13***	1.12***	1.09***	1.09***	1.05***	1.02***	0.98***	0.97***	0.99***	0.98***	0.94***	0.96***
	(0.039)	(0.027)	(0.039)	(0.037)	(0.037)	(0.027)	(0.037)	(0.035)	(0.034)	(0.035)	(0.025)	(0.034)	(0.034)	(0.037)
ln(dest_gdp)	0.85***	0.99***	0.89***	0.93***	0.95***	1.01***	0.88***	0.94***	0.97***	0.95***	1.03***	0.96***	0.98***	1.04***
	(0.036)	(0.026)	(0.038)	(0.033)	(0.035)	(0.026)	(0.033)	(0.038)	(0.035)	(0.035)	(0.027)	(0.034)	(0.034)	(0.041)
ln(dr_dist)	-1.56***	-1.46***	-1.61***	-1.61***	-1.60***	-1.37***	-1.51***	-1.52***	-1.50***	-1.48***	-1.35***	-1.57***	-1.55***	-1.70***
	(0.086)	(0.045)	(0.089)	(0.085)	(0.085)	(0.043)	(0.080)	(0.078)	(0.077)	(0.076)	(0.043)	(0.081)	(0.081)	(0.088)
ln(rem_exp)	0.64***	0.77***	0.68***	0.71***	0.67***	0.54***	0.63***	0.60***	0.62***	0.58***	0.33***	0.66***	0.70***	0.70***
	(0.13)	(0.097)	(0.14)	(0.13)	(0.13)	(0.084)	(0.11)	(0.11)	(0.11)	(0.12)	(0.092)	(0.12)	(0.11)	(0.13)
ln(rem_imp)	0.65***	0.83***	0.61***	0.65***	0.63***	0.61***	0.51***	0.50***	0.45***	0.49***	0.68***	0.51***	0.47***	0.56***
	(0.13)	(0.097)	(0.13)	(0.12)	(0.12)	(0.090)	(0.12)	(0.12)	(0.12)	(0.12)	(0.094)	(0.12)	(0.12)	(0.13)
Constant	-22.4***	-26.4***	-21.5***	-22.4***	-22.0***	-25.2***	-19.6***	-20.1***	-20.1***	-19.4***	-23.3***	-19.5***	-19.1***	-20.1***
	(1.66)	(1.06)	(1.67)	(1.58)	(1.62)	(1.13)	(1.60)	(1.63)	(1.60)	(1.66)	(1.16)	(1.67)	(1.73)	(1.76)
Obs	680	1521	681	684	680	1507	683	685	686	687	1467	685	686	686
R-squared	0.759	0.817	0.759	0.786	0.787	0.828	0.791	0.795	0.800	0.793	0.814	0.806	0.798	0.764

Notes: Province-province and province-state trade flows included, inter-provincial and inter-state dummies (interprov and interstate). The dependent variable is the natural logarithm of the adjusted trade flows (l_atrade). Remoteness dummies are calculated for each respective year. Standard errors in parentheses, clustered by origin-destination, *** p<0.01, ** p<0.05, * p<0.1

Table 4: OLS Estimates of Inter-provincial Border Effects from 1992 to 2005, with Remoteness Control, Pooled Aggregate Data. (Source: Statistics Canada, Industry Canada.)

On the other hand, as Anderson and van Wincoop (2003) point out (p. 179) these terms are not observables, and the relatively involved numerical approximation and non-linear estimation procedure has led to a low rate of adoption of the method in subsequent papers. However, we acknowledge that controlling for the multilateral resistance terms is important for establishing the robustness of our results.

To this end we use a custom Stata program[12], which solves the non-linear system analytically and has several advantages beyond user-friendliness over the original procedure. The method yields a reduced form log-linear gravity equation which can be estimated using standard econometric techniques. The first column in Table 4a in the Appendix presents the summarized results using the Anderson and van Wincoop structural estimation procedure, while the second column is a comparable reduced form model, using origin and destination fixed effects. Comparing the two sets of results, it can be observed that, while this particular expression of the border coefficient[13] is reduced when controlling for the theoretically-sound multilateral resistance terms, the difference when compared to the simple OLS model including origin/destination dummies, is not substantial.[14] Hence, the differences between our jurisdiction-dummy estimations above and the theoretically-sound structural parameter estimates is not likely to be large.

3.2. Regressions based on NAICS level disaggregated data

Table 5 contains empirical estimates of equation (3) based on three-digit level NAICS data and employing truncated regression models. Relative to previous estimates based on aggregate province-state data, there are differences in the magnitude of border effects. Specifically, we now obtain border effects ranging from 17 to 20 from 1992 to 1996, all of which are statistically significant at the 1% level and much larger than estimates in Tables

[12] The code for avwtransform.ado was written by Bas Straathof and is described in Straathof (2008).

[13] Note that the use of structural estimation precludes a directly comparable border effect estimate relative to our earlier results.

[14] Similarly, Balistreri and Hillberry (2007) show that structurally estimating Canadian border effects with Canadian data only reduces the OLS estimates by a modest amount.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
interprov	2.89***	2.83***	2.91***	2.99***	3.03***	2.40***	2.33***	2.27***	2.37***	2.33***	2.41***	2.62***	2.63***	2.63***
	(0.11)	(0.10)	(0.10)	(0.100)	(0.097)	(0.092)	(0.085)	(0.084)	(0.081)	(0.082)	(0.080)	(0.084)	(0.085)	(0.083)
border effects	*17.99*	*16.94*	*18.36*	*19.86*	*20.7*	*11.03*	*10.28*	*9.68*	*10.7*	*10.28*	*11.13*	*13.73*	*13.87*	*13.87*
ln(orig_gdp)	0.39	0.31	0.17	0.26	0.39*	0.67***	0.50**	0.21	0.18	0.16	0.080	-0.014	0.076	0.26
	(0.27)	(0.25)	(0.24)	(0.23)	(0.23)	(0.20)	(0.21)	(0.21)	(0.19)	(0.21)	(0.23)	(0.22)	(0.19)	(0.18)
ln(dest_gdp)	1.28***	1.21***	1.53***	1.70***	1.61***	1.70***	1.90***	2.09***	2.02***	1.88***	2.21***	2.02***	1.92***	1.84***
	(0.30)	(0.27)	(0.25)	(0.24)	(0.23)	(0.21)	(0.22)	(0.22)	(0.18)	(0.19)	(0.21)	(0.20)	(0.19)	(0.18)
ln(dr_dist)	-0.98***	-1.03***	-1.05***	-1.05***	-1.06***	-1.18***	-1.17***	-1.16***	-1.21***	-1.21***	-1.21***	-1.24***	-1.23***	-1.26***
	(0.056)	(0.055)	(0.054)	(0.052)	(0.051)	(0.044)	(0.042)	(0.042)	(0.043)	(0.045)	(0.044)	(0.047)	(0.045)	(0.047)
ln(orig_pop)	0.64**	0.73***	0.90***	0.79***	0.64***	0.41*	0.59**	0.89***	0.92***	0.92***	0.97***	1.12***	0.97***	0.78***
	(0.30)	(0.28)	(0.26)	(0.26)	(0.25)	(0.22)	(0.23)	(0.23)	(0.21)	(0.23)	(0.25)	(0.24)	(0.21)	(0.19)
ln(dest_pop)	-0.67**	-0.58*	-0.92***	-1.05***	-0.96***	-1.04***	-1.24***	-1.47***	-1.35***	-1.18***	-1.54***	-1.31***	-1.21***	-1.10***
	(0.33)	(0.30)	(0.27)	(0.26)	(0.25)	(0.24)	(0.25)	(0.24)	(0.20)	(0.21)	(0.23)	(0.22)	(0.21)	(0.19)
Constant	-19.4***	-17.9***	-19.9***	-22.8***	-22.9***	-26.7***	-27.3***	-25.9***	-25.3***	-23.7***	-25.6***	-24.1***	-23.3***	-24.5***
	(4.07)	(3.70)	(3.41)	(3.42)	(3.30)	(3.04)	(3.27)	(3.15)	(2.61)	(2.88)	(3.16)	(3.10)	(2.87)	(2.66)
Obs	7110	7284	7411	7502	7561	8747	8915	9186	9037	9158	9008	9107	8921	8949

Notes: Province-province and province-state trade flows included, inter-provincial and inter-state dummies (interprov and interstate). The dependent variable is the natural logarithm of the adjusted trade flows (l_atrade). Truncated regressions (at 100,000 CAD). Standard errors in parentheses, clustered by origin-destination, *** p<0.01, ** p<0.05, * p<0.1

Table 5: Truncated Regression Estimation of Inter-provincial Border Effects from 1992 to 2005, NAICS-level Data. (Source: Statistics Canada, Industry Canada.)

1 and 2, which suggest a border effect of around 10. On the other hand, the trends outlined above are maintained: there is a sharp decrease in border effects from 1997 to 2001, with estimates from 10 to 12 that are consistent with findings based on aggregate data. Finally, as was the case with aggregate data, we observe an increase in border effects to 12-15.8 from 2002-2005. Several additional robustness checks, including the use of NAICS level dummies confirm the results.[15]

The estimates from NAICS level data certainly correspond with ex-ante intuition as they suggest a sharp drop in border effects following NAFTA. However, why should border effects based on industry level data be larger in magnitude than corresponding results from aggregate province-state data?[16] A tentative answer is based on the prevalence of zero flows in the data and their distribution between national and international flows. Specifically, for some products there exists only state-province trade and no state-state trade. Collapsing various NAICS codes to obtain the aggregate measure, results in increasing inter-country trade, leading to a lower border effect estimate. When performing the disaggregated analysis however, all of these zero flows will actually drop out of the industry-level sample. Consequently, the implied border effect may appear magnified. Therefore the extensive margin of trade and the effect of aggregation present a possible explanation for the difference.

3.3. Sources of Border Effects

In order to shed some more light on the source of border effects, we ran our simple baseline regression (equation 1) separately for imports and exports by and from Canadian provinces to the United States. Coefficient estimates of border effects are statistically significant (at the 1% level) with respect to both exports and imports. For the sake of brevity, we summarize the regression results in Figure 2, which graphs the border effects over time. Initially, border effects for Canadian exports are larger in magnitude. In contrast, border

[15] Detailed results are available upon request.

[16] As mentioned previously, Hillberry (2002) suggests the converse could be true. In contrast, we obtain larger effects when using disaggregated data.

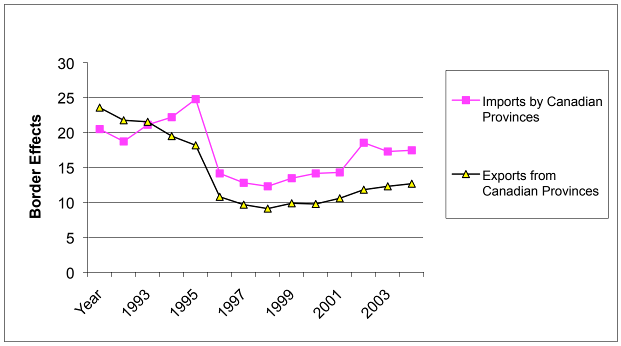

Figure 2: OLS Estimates of Interprovincial Border Effects 1992-2005 based on Aggregate Data. (Source: Statistics Canada, Industry Canada.)

effects for imports exceed corresponding impacts for exports from the mid-1990s onwards. However, border effects for both exports and imports closely parallel each other over time and are consistent with the broad trends outlined in the previous regressions. Specifically, there is a clear decline in border effects following NAFTA, succeeded by a post 9-11 increase. In other words, firms on both sides of the border experienced similar costs.

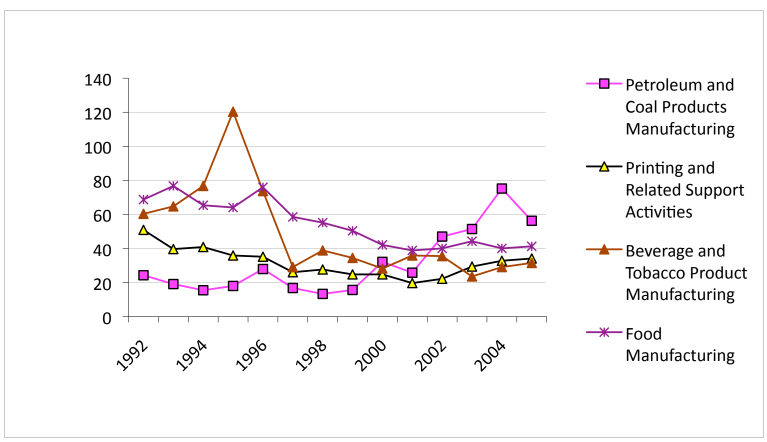

Figure 3: OLS Estimates of Interprovincial Border Effects by Industry (1992-2005) based on Aggregate Data. (Source: Statistics Canada, Industry Canada.)

Figures 3 and 4 illustrate regression estimates (also based on a specification resembling equation (1)) for the 11 industries with the highest average border effects.[17] [18] The results in figure 3 demonstrate considerable heterogeneity across industries. For example, food manufacturing has the highest border effect in the early 1990s, but then experienced a rapid decline during the mid and later part of the decade, probably because of the decline in tariffs generated by NAFTA. Further, there is no strong post 9-11 effect. In contrast, there is a significant spike in border effects for beverage and tobacco in the mid-1990s followed by a rather sharp decline and then a more or less constant trend until 9-11.

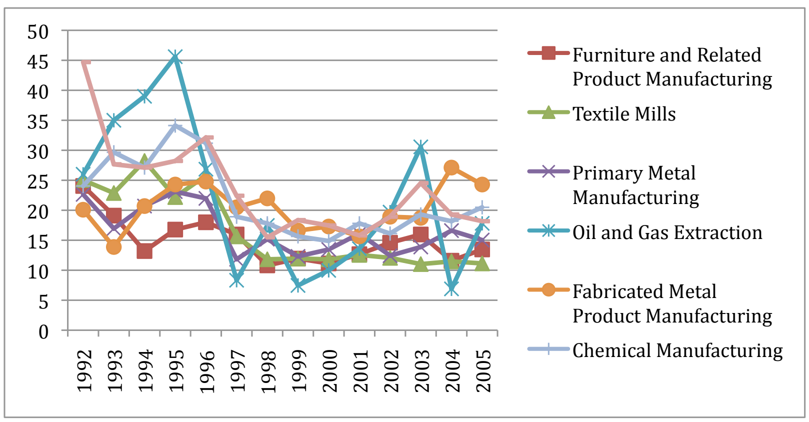

Figure 4: OLS Estimates of Interprovincial Border Effects by Industry (1992-2005) based on Aggregate Data. (Source: Statistics Canada, Industry Canada.)

These results are consistent with industry specific policies. In the early 1990s, Canadian cigarettes were extremely expensive relative to comparable U.S. products because of high excise taxes.[19] However, federal and provincial governments significantly reduced taxes during the mid-1990s in order to stop the flow of cross-border smuggling from the United States. As a result, Canadian tobacco products became cheaper and attractive for U.S. importers.

[17] The complete results are available upon request. Most of the border effects reported in figures 3 and 4 are statistically significant at either the 1% or 5% levels.

[18] These industries constitute a significant amount of province-province and province-state trade. For example, in 2000 these industries accounted for 25% of trade.

[19] See Gruber, Sen, and Stabile (2003) for further details.

On the other hand, border effects remained stable for much of the 1990s for petroleum products, which is unsurprising given the low tariffs on these products even before NAFTA. However, a significant increase is visible post 9-11. This result does again correspond with our intuition. Retail demand for gasoline has to be met rapidly and any cross-border delays may be extremely expensive for refiners. Printing and the other industries in figure 4 demonstrate very similar results. In summary, there is evidence of a post NAFTA decline followed by a 9-11 increase in the restrictive effect of borders on trade flows.

Table 6 offers further evidence that buttress the above results. Specifically, the table contains the proportion of aggregate trade flows by province-province and province-state for the sample endpoints 1992, 2005 and midpoint 2000. The proportion of province-state trade with respect to food manufacturing grew from 38% in 1992 to roughly to 45% (42%) in 2000 (2005) which is consistent with the fall in international tariffs over the same period. Similarly, there has been an increase in province-state trade in beverage and tobacco, which coincided with the drop in Canadian tobacco taxes over time. Specifically, while international trade constituted roughly 40% of the total in 1992, the corresponding statistic in 2005 was 46%.

The above discussion confirms that not all industries conform to the 'on-average' estimates of border effects in previous tables that suggest a post NAFTA dip succeeded by a subsequent 9-11 increase. However, border effects for these industries do seem to correspond with other institutional changes that occurred over the same time period. Moreover, results from the seven industries illustrated in figure 4 show that border effects for most industries are in fact consistent with our 'on-average' findings. In summary, this industry - specific analysis yields some further reassurance on the robustness of our findings and that they are not confounded by unobserved jurisdiction or year specific shocks.

4. Conclusion

The broad objective of our research is to shed some more light on the 'black box' of border effects in international trade flows between Canada and the U.S. Unlike most comparable

Proportions (%)	*1992*	*intl*	*domestic*	*1993*	*2000*	*intl*	*domestic*	*2005*	*intl*	*domestic*
114 Fishing, Hunting and Trapping	0.19	0.13	0.06	0.02	0.23	0.15	0.08	0.24	0.18	0.06
333 Machinery Manufacturing	7.04	6.30	0.74	0.92	7.38	6.72	0.66	5.65	4.84	0.81
339 Miscellaneous Manufacturing	3.19	2.52	0.67	7.92	3.44	2.95	0.49	3.06	2.42	0.65
334 Computer and Electronic Product Manufacturing	6.67	5.56	1.11	1.08	8.69	8.03	0.66	5.00	4.35	0.65
336 Transportation Equipment Manufacturing	28.15	25.56	2.59	18.33	27.87	26.23	1.64	24.19	22.58	1.61
212 Mining (except Oil and Gas)	1.37	1.07	0.30	0.71	0.87	0.69	0.18	1.21	0.79	0.42
322 Paper Manufacturing	4.81	3.63	1.19	0.58	4.75	3.77	0.98	4.19	3.06	1.13
327 Non-Metallic Mineral Product Manufacturing	2.48	1.00	1.48	1.83	1.46	1.15	0.31	1.29	0.84	0.45
321 Wood Product Manufacturing	2.56	1.89	0.67	2.13	3.11	2.46	0.66	3.55	2.58	0.97
337 Furniture and Related Product Manufacturing	1.07	0.63	0.44	1.67	1.59	1.23	0.36	1.40	1.11	0.29
313 Textile Mills	1.59	0.85	0.74	0.19	1.49	1.16	0.33	1.18	0.90	0.27
331 Primary Metal Manufacturing	4.81	3.26	1.56	0.58	4.75	3.44	1.31	5.32	4.03	1.29
211 Oil and Gas Extraction	5.56	3.70	1.85	0.71	8.03	6.23	1.80	13.87	10.97	2.90
332 Fabricated Metal Product Manufacturing	3.00	1.81	1.19	15.42	3.61	2.62	0.98	2.90	1.77	1.13
325 Chemical Manufacturing	8.52	4.81	3.70	13.75	8.20	5.90	2.30	9.84	7.1	2.74
315 Clothing Manufacturing	3.30	1.44	1.85	0.41	3.28	2.46	0.82	2.74	1.93	0.81
324 Petroleum and Coal Products Manufacturing	2.78	1.41	1.37	1.67	2.79	1.46	1.33	5.48	2.74	2.74
323 Printing and Related Support Activities	1.85	0.96	0.89	0.23	1.25	0.70	0.54	1.32	0.63	0.69
312 Beverage and Tobacco Product Manufacturing	1.30	0.52	0.78	0.58	1.08	0.48	0.61	0.84	0.39	0.45
311 Food Manufacturing	7.78	2.96	4.81	16.67	6.07	2.79	3.28	6.77	2.90	3.87

Note: *Intl* columns show the absolute value of Can-US flows. *Domestic* columns show Canadian province to province flows. Figures expressed in (e+10).

Table 6: Proportions of total Canadian and US intranational and international trade, by NAICS. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

studies, we do not exclusively rely on aggregate data but we also evaluate border effects at the three digit NAICS level. Specifically, we employ industry level panel data on domestic and cross border trade flows between Canada and the United States from 1992-2005. The long time span of our data allows us to identify border effects through the enactment of NAFTA and the 9/11 terrorist attacks, both of which impacted trade flows for very different reasons. The disaggregate nature of the data enables us to evaluate which industries experienced the most significant border effects. We are also able to condition our estimates with the use of province/state specific controls and year dummies. In other words, our dataset allows us to expand the analysis of border effects further beyond what most existing studies based on aggregate data with very limited time-series variation have managed to achieve.

A wide array of regressions based on many different empirical specifications and varying levels of aggregation not only confirm the existence of border effects in U.S.-Canada trade, but more importantly they also reveal similar trends through time in bilateral Canada-US border effects. There is a visible decrease in border effects after the enactment of NAFTA, and an upward spike up after the 9/11 attacks. While there is some heterogeneity in border effects across industries, a majority correspond with these broad trends. Those that do not, exhibit border effects which are consistent with specific institutional details. Finally, border effects are apparent for exports from Canadian provinces as well as for imports.

Our findings suggest that NAFTA did accomplish its trade facilitation objectives. However, the reduction in border effects was reversed with 9/11 which resulted in increased security and enhanced travel restrictions between Canada and the United States. The implication is that there was a loss of trade and associated costs on both sides of the border. We believe that our results are of contemporary relevance given the current discussions between the two countries on measures designed to reduce cross-border delays and facilitate mutually beneficial trade flows.

For Online Publication

Appendix

Literature Overview:

Helliwell and McCallum (1995) and Helliwell (1998) offer some comparable results for 1990 and up to 1996, suggesting border effects ranging from 11 to more than 20. Wei (1996) finds significant, but lower home bias effects for OECD countries over the period 1982-1994. Head and Mayer (2000) evaluate the European Single Market Programme and report significant market fragmentation in the European Union, even after the elimination of most tariff barriers and quotas in 1968 and the establishment of the Single European Market in 1992. Nitsch (2000) also finds substantial border effects in the European Union from 1979 to 1990. Anderson and van Wincoop (2003) employ 1993 data and obtain significant border effects, ranging from 14 to 16 for Canada. Smaller border effects on the US side and for disaggregated data are found in Hillberry (2002), who uses state-to-state trade data for 1993 and tries to account for potential endogenous location of industries and zero trade flows. Evans (2003) shows that at least a fraction of the border effect is attributable to a higher elasticity of substitution between foreign and domestically produced goods. Thus, welfare calculations that take into account the border effects are likely overestimating the cost of borders. Employing data on US multinationals, local and foreign affiliates, Evans also finds that the location of production, more than the nationality of the producer, is responsible for the border frictions. Evans (2006) asks whether the border effects are due more to the extensive or the intensive margins in international trade. The paper assumes firm heterogeneity in costs, leading to only a fraction of total firms to be actual exporters. The empirical application finds that both the extensive and the intensive margins contribute approximately equally to the border effects. Finally, a recent paper by Yi (2010) constructs a trade model with multistage production and uses calibrations to explain about two fifths of the border effect.

Data Description:

Our dataset were culled from several sources. Three digit NAICS level (detailed in table 1) Canadian province to province trade flows were drawn from the matrix of interprovincial trade produced by the Input-Output Division of Statistics Canada. The data are available from: (1) CANSIM Table 386-001 for all provinces from 1992-1999; and (2) CANSIM Table 386-002 for all provinces between 1997 and 2005.[20] These data contain estimates of shipments (in terms of final value added) between Canadian provinces.[21]

Corresponding three digit NAICS data on exports from provinces to states (in the U.S.) and imports from states to provinces were obtained from Industry Canadas Trade Data Online database.[22] Following McCallum (1995) and most subsequent studies, we include thirty states (the twenty with the largest population and all Canada-US border states), accounting for roughly 90% of bilateral trade.[23] Also following McCallum (1995) and also Helliwell (1996) and Anderson and van Wincoop (2003), we apply adjustment factors to trade flows in order to make them comparable.[24]

[20] CANSIM Table 386-001 covering the period 1992-1999 and available online at http://goo.gl/T1kTm, and CANSIM Table 386-002 covering the period 1997-2005, available online at http://goo.gl/9z1E.

[21] There are some differences in the process of data collection between the two series. While the first (386-0001) was conducted using the previous Standard Industrial Classification (SIC80) and the flows were constructed on an experimental basis, the second (386-002) is based on the North American Industrial Classification (NAICS) and the PIPES project (provincialization of all STATCAN surveys) and provides an improved quality of details by province. In order to obtain a homogeneous sample covering the entire period, we used the overlapping year from the second series and the growth rate in the first series iteratively to re-constitute the data and effectively roll-back the improved series. This procedure was based on correspondence and advice from Statistics Canada. A similar procedure was used in the recent paper by Yi (2010) on home bias and multi-stage production.

[22] Available at http://goo.gl/pls4.

[23] The thirty states are Alabama, Arizona, California, Florida, Georgia, Idaho, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, and Wisconsin.

[24] Please see the Data Appendix in McCallum (1995) for a description of this procedure.

State to state three digit NAICS data comes from the United States Census Bureaus Commodity Flow Surveys.[25] The CFS is a shipper based survey conducted every five years as part of the Economic Census. We follow Anderson and van Wincoop (2003) in using this source in order to obtain equivalent data for intra-state trade exchanges and thus be able to have a view of the border effect from the U.S. side as well. We also follow Anderson and van Wincoop (2003) in emphasizing the important caveat that this shipment data is not obtained using the same methodology as the inter-province and province-state merchandise trade data. Among the most notable differences, the CFS includes not just shipments from producer to the final user, but intermediate shipments as well, and it also excludes agricultural goods. Given these differences, the results including these data are not directly comparable to the ones excluding state to state exchanges.[26] However, given that we take a multi-year perspective and do not focus on directly comparing border effects magnitudes for provinces and states, the two-sided dataset is still informative. Moreover, as explained in Anderson and van Wincoop (2003) who compare the estimated coefficients with and without inter-state data, there are indications that the quality of the CFS data is satisfactory for estimating border costs.

Finally, both straight line and driving distance between state and provincial capitals data are included in the dataset. For straight line distances, the calculations are based on the spherical law of cosines. Driving distances are obtained via Google Maps API. As it turns out, results are not very different across the two measures. Given the high prevalence of the road transportation mode on the continent, the results reported in the paper use driving distances. All results using straight line distances instead are available from the

[25] See online at http://goo.gl/018B.

[26] Another reason is the different codification of industries used in the Commodity Flow Survey. The CFS 1993 data are STCC2-level, while the 1997 and 2002 data are SCTG2-level. We used documentation provided by the Bureau of Transportation Statistics (see http://goo.gl/NftHO) as well as expert advice from a BTS freight specialist to establish an equivalency to NAICS3. More information on this correspondence is available from the authors.

authors.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
origin	9581	18.8521	17.89854	1	60
destination	9581	18.9069	17.92069	1	60
year	9581	1998.51	4.03042	1992	2005
origin unemployment	9581	7.785847	3.802196	2.3	20.1
destination unemployment	9581	7.793184	3.836815	2.3	20.1
origin population	9581	5092836	5733661	130827	3.59e+07
destination population	9581	5092903	5733536	130827	3.59e+07
origin GDP	9581	1.89e+11	2.42e+11	2.35e+09	1.96e+12
destination GDP	9581	1.89e+11	2.42e+11	2.35e+09	1.96e+12
origin GDP (USD)	4161	255703.3	251521.6	12570	1628599
destination GDP (USD)	4178	254797.8	251415.2	12570	1628599
driving distance	9581	2821.966	1478.948	232.577	7396.486
straight distance	9581	2178.645	1140.327	157.629	5490.169
CAD/USD	9581	1.390921	.1099147	1.208341	1.570205
USD/CAD (OECD)	9581	.8214153	.0105951	.81	.84
USD/CAD (SNA)	9581	.8335831	.0110856	.81	.85
origin-destination	9581	1904.117	1779.894	102	6010
trade	9581	6.74e+08	2.70e+09	30	6.33e+10
adjusted trade	9579	7.03e+08	2.70e+09	142.8918	6.63e+10
interprovincial dummy	9581	.1296316	.3359152	0	1
interstate dummy	9581	0	0	0	0
Canadian importer	9581	.5639286	.4959222	0	1
Canadian exporter	9581	.565703	.4956902	0	1

Table 1a: Summary Statistics: Aggregated, province-province and province-state data for all years 1992-2005. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
origin	12020	22.4173	18.54615	1	60
destination	12020	22.41714	18.53596	1	60
year	12020	1998.249	3.993002	1992	2005
origin unemployment	12020	7.323527	3.558796	2.3	20.1
destination unemployment	12020	7.335291	3.585297	2.3	20.1
origin population	12020	5653456	6075726	130827	3.59e+07
destination population	12020	5684167	6074883	130827	3.59e+07
origin GDP	12020	2.10e+11	2.53e+11	2.35e+09	1.96e+12
destination GDP	12020	2.11e+11	2.53e+11	2.35e+09	1.96e+12
origin GDP (USD)	6600	251316.6	245204.9	12570	1628599
destination GDP (USD)	6617	252754.5	244766.1	12570	1628599
driving distance	12020	2637.869	1478.446	113.017	7396.486
straight distance	12020	2058.429	1143.425	105.3006	5490.169
CAD/USD	12020	1.395039	.1114174	1.208341	1.570205
USD/CAD (OECD)	12020	.8211631	.0101505	.81	.84
USD/CAD (SNA)	12020	.8341373	.011437	.81	.85
origin-destination	12020	2264.148	1849.587	102	6058
trade	12020	1.07e+09	3.16e+09	30	6.33e+10
adjusted trade	12018	1.10e+09	3.16e+09	142.8918	6.63e+10
interprovincial dummy	12020	.1033278	.3043992	0	1
interstate dummy	12020	.2029118	.4021841	0	1
Canadian importer	12020	.4495008	.497464	0	1
Canadian exporter	12020	.4509151	.4976055	0	1

Table 2a: Summary Statistics: Aggregated, province-province, province-state and state-state data for all years 1992-2005. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
origin	166536	21.14614	18.47989	1	60
destination	166536	20.95033	18.47206	1	60
NAICS	166536	314.2563	43.09635	114	339
year	166536	1998.475	3.986495	1992	2005
trade	166536	7.74e+07	5.48e+08	1	5.42e+10
adjusted trade	164794	7.99e+07	5.51e+08	0	5.67e+10
origin unemployment	166536	7.125169	3.131042	2.3	20.1
destination unemployment	166536	7.21078	3.302486	2.3	20.1
origin population	166536	6022709	6145684	130827	3.59e+07
destination population	166536	5987087	6173331	130827	3.59e+07
origin GDP	166536	2.24e+11	2.59e+11	2.35e+09	1.96e+12
destination GDP	166536	2.24e+11	2.60e+11	2.35e+09	1.96e+12
origin GDP (USD)	84751	273405	255339	12570	1628599
destination GDP (USD)	83791	275934.2	257844.8	12570	1628599
driving distance	166536	2538.874	1429.211	113.017	7396.486
straight distance	166536	1987.856	1121.432	105.3006	5490.169
CAD/USD	166536	1.394598	.1104137	1.208341	1.570205
USD/CAD (OECD)	166536	.8213574	.0104158	.81	.84
USD/CAD (SNA)	166536	.8340765	.0111695	.81	.85
origin_destination	166536	2135.565	1840.647	102	6058
Canadian exporter	166536	.4625126	.4985942	0	1
Canadian importer	166536	.4968595	.4999916	0	1

Table 3a: Summary Statistics: Dissaggregated (NAICS level) data for all years 1992-2005. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

	(1) AvW Transformation	(2) Unbiased (origin and dest dummies)
Dependent Var: ln(adjusted trade) / (ln(origin's gdp)*ln(dest's gdp))		
1993		
ln(Distance): (1-σ)ρ	-1.15***	-1.17***
	0.04	*0.04*
Border: (1-σ)ln$b$	-1.84***	-2.01***
	0.06	*0.08*
R-squared	0.71	0.75
Obs	1425	1425
1997		
Distance: (1-σ)ρ	-1.15***	-1.23***
	0.04	*0.04*
Border: (1-σ)ln$b$	-1.48***	-1.75***
	0.06	*0.06*
R-squared	0.66	0.75
Obs	1446	1446
2002		
Distance: (1-σ)ρ	-1.23***	-1.29***
	0.04	*0.04*
Border: (1-σ)ln$b$	-1.37***	-1.71***
	0.06	*0.06*
R-squared	0.66	0.76
Obs	1447	1447

Notes: Province-province and province-state trade flows included.

Table 4a: AvWtransform and OLS Estimates of Border Effects with Multilateral Resistance Terms Controls in Aggregate Data. (Source: Statistics Canada, Industry Canada and U.S. Census Bureau.)

References

[1] J. E. Anderson, E. van Wincoop, Gravity with gravitas: A solution to the border puzzle, American Economic Review 93 (1) (2003) 170–192.
URL `http://ideas.repec.org/a/aea/aecrev/v93y2003i1p170-192.html`

[2] J. E. Anderson, E. van Wincoop, Trade costs, Journal of Economic Literature 42 (3) (2004) 691–751.

[3] R. Baldwin, D. Taglioni, Gravity for dummies and dummies for gravity equations, NBER Working Papers 12516, National Bureau of Economic Research, Inc (Sep. 2006).

[4] E. J. Balistreri, R. H. Hillberry, Structural estimation and the border puzzle, Journal of International Economics 72 (2) (2007) 451–463.

[5] J. H. Bergstrand, The generalized gravity equation, monopolistic competition, and the factor-proportions theory in international trade, The Review of Economics and Statistics 71 (1) (1989) 143–53.

[6] J. H. Bergstrand, The heckscher-ohlin-samuelson model, the linder hypothesis and the determinants of bilateral intra-industry trade, Economic Journal 100 (403) (1990) 1216–29.

[7] S. L. Brainard, A simple theory of multinational corporations and trade with a trade-off between proximity and concentration, NBER Working Papers 4269, National Bureau of Economic Research, Inc (Feb. 1993).

[8] W. M. Brown, Overcoming distance, overcoming borders: Comparing north american regional trade, Economic Analysis (EA) Research Paper Series 2003008e, Statistics Canada, Analytical Studies Branch (Apr. 2003).

[9] M. Burt, Tighter border security and its effect on canadian exports, Canadian Public Policy 35 (2) (2009) 149–169.

[10] N. Chen, Intra-national versus international trade in the european union: why do national borders matter?, Journal of International Economics 63 (1) (2004) 93–118.

[11] N. Chen, D. Novy, Gravity, trade integration, and heterogeneity across industries, Journal of International Economics In Press, Accepted Manuscript (2011) –.

[12] A. Deardorff, Determinants of bilateral trade: Does gravity work in a neoclassical world?, in: The Regionalization of the World Economy, NBER Chapters, National Bureau of Economic Research, Inc, 1998, pp. 7–32.

[13] A.-C. Disdier, K. Head, The puzzling persistence of the distance effect on bilateral trade, The Review of Economics and Statistics 90 (1) (2008) 37–48.

[14] C. L. Evans, The economic significance of national border effects, American Economic Review 93 (4) (2003) 1291–1312.

[15] C. Evans, Border effects and the availability of domestic products abroad, Canadian Journal of Economics 39 (1) (2006) 211–246.

[16] R. Feenstra, Advanced International Trade, Princeton University Press, Princeton, New Jersey, 2003.

[17] S. Globerman, P. Storer, The Impacts of 9/11 on Canada-U.S. Trade, University of Toronto Press, Toronto, 2008.

[18] S. Globerman, P. Storer, Border security and canadian exports to the united states: Evidence and policy implications, Canadian Public Policy 35 (2) (2009) 171–186.

[19] D. Goldfarb, Reaching a tipping point? Effects of post-9/11 border security on canadas trade and investment, Insights you can count on, The Conference Board of Canada (1997).

[20] J. Harrigan, Oecd imports and trade barriers in 1983, Journal of International Economics 35 (1-2) (1993) 91–111.

[21] J. F. Helliwell, Do national borders matter for quebec's trade?, Canadian Journal of Economics 29 (3) (1996) 507–22.

[22] J. Helliwell, How Much Do National Borders Matter, The Brookings Institution, Washington, D.C., 1998.

[23] K. Head, T. Mayer, Non-europe: The magnitude and causes of market fragmentation in the eu, Review of World Economics (Weltwirtschaftliches Archiv) 136 (2) (2000) 284–314.

[24] K. Head, T. Mayer, Illusory border effects: Distance mismeasurement inflates estimates of home bias in trade, Working Papers 2002-01, CEPII research center (Jan. 2002).

[25] R. H. Hillberry, Aggregation bias, compositional change, and the border effect, Canadian Journal of Economics 35 (3) (2002) 517–530.

[26] I. J. Horstmann, J. R. Markusen, Endogenous market structures in international trade (natura facit saltum), Journal of International Economics 32 (1-2) (1992) 109–129.

[27] T. Mayer, S. Zignago, Market access in global and regional trade, Working Papers 2005-02, CEPII research center (Jan. 2005).

[28] J. McCallum, National borders matter: Canada-u.s. regional trade patterns, American Economic Review 85 (3) (1995) 615–23.

[29] M. J. Melitz, The impact of trade on intra-industry reallocations and aggregate industry productivity, Econometrica 71 (6) (2003) 1695–1725.

[30] V. Nitsch, National borders and international trade: evidence from the european union, Canadian Journal of Economics 33 (4) (2000) 1091–1105.

[31] J. H. Rogers, H. P. Smith, Border effects within the nafta countries, International Finance Discussion Papers 698, Board of Governors of the Federal Reserve System (U.S.) (2001).

[32] A. K. Rose, E. van Wincoop, National money as a barrier to international trade: The real case for currency union, American Economic Review 91 (2) (2001) 386–390.

[33] B. Staathof, Gravity with gravitas: Comment, CPB Discussion Paper 111, CPB Netherlands Bureau for Economic Policy Analysis (2008).

[34] D. Trefler, Trade liberalization and the theory of endogenous protection: An econometric study of u.s. import policy, Journal of Political Economy 101 (1) (1993) 138–60.

[35] S.-J. Wei, Intra-national versus international trade: How stubborn are nations in global integration?, NBER Working Papers 5531, National Bureau of Economic Research, Inc (Apr. 1996).

[36] H. Wolf, (why) do borders matter for international trade, in: G. Hess, E. van Wincoop (Eds.), International Macroeconomics, Cambridge University Press, 2000, pp. 112–128.

[37] J. Wooldridge, Introductory econometrics: a modern approach, 2nd edition, South Western, 2003.