The Border Effect Through the Rearview Mirror: Would the puzzle have existed if today's tools had been used?*

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Abstract

In this paper I re-evaluate the McCallum (1995) border puzzle in the light of recent developments in the empirical trade literature. First, I show that the data used in McCallum (1995) does not allow to simultaneously control for multilateral resistance terms (Anderson and van Wincoop 2003) and identify non-parametrically the border effect. Second, I show that the border effect, estimated by OLS, is biased upwards due to Jensen's inequality. When a non-linear estimation method is used, the estimated border effect is 35% to 45% smaller. Third, when non-linear estimation methods are used and a more flexible specification of the gravity equation is allowed, the border effect as presented in McCallum (1995) disappears. Instead, I find that distance affects international and intranational trade differently. In particular, distance matters more for international than for intranational trade. Finally, I use a standard model of international trade to discuss my empirical findings.

JEL classification codes: C20, F10, F14.

Key Words: Border effect, Gravity model, Jensen's inequality, Non-linear estimation.

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1. INTRODUCTION

One of the six major puzzles in international economics, as determined by Obstfeld and Rogoff (2001), is the *home bias* puzzle or border effect. In this paper I re-evaluate this result in the light of recent developments in the empirical trade literature. My results suggest that there is no "crossing the border" type of effect and instead, the effect of a border is reflected in the impact of distance on trade (larger for international than for intranational trade).

The *home bias* puzzle or border effect has its origins in a 1995 research article by John McCallum: "National Borders Matter: Canada–U.S. Regional Trade Patterns." In this article, the author estimates a gravity model for trade between Canadian provinces (intranational trade) and between Canadian provinces and U.S. states (international trade) and finds that interprovincial trade is approximately 20 times larger than trade between Canadian provinces and U.S. states. Taking this result at face value, it means that a simple administrative border imposes a disproportionately large barrier to trade between two countries that are very similar. More, if an administrative border could have such a great impact on trade between countries that are so similar, as is the case of the U.S. and Canada, then, this effect should be even larger for other countries that are much less alike.

This was a disturbing result and consequently generated substantial explanations. Of all these explanations, the most widely accepted is that provided by Anderson and van Wincoop (2003). These authors argue that McCallum (1995) had two fundamental problems: 1) omitted variable bias; and 2) interpretational incorrectness. When the omitted variable bias is dealt with, these authors report a comparable border effect of 16.5, which compares to a value of 20 reported in McCallum (1995). Regarding the interpretation of the border effect as presented in McCallum (1995), Anderson and van Wincoop (2003) point out that it is not possible to infer the economic importance of the border effect directly from the parameter estimate. When Anderson and van Wincoop (2003) take this fact into account, they report a border effect that is equivalent to a $20 - 50\%$ ad-valorem tariff. Despite this explanation being the most accepted one, it is not free of criticism. In a recent paper, Balistreri and Hillberry (2007) argue that Anderson and van Wincoop (2003) are not comparing the right figures when they compare the biased and non-biased estimates of the McCallum border effect. This is so, because in one case the income elasticities are freely estimated, while in the other they are imposed to be unitary. When this subtlety is taken into account, the estimation bias is only

8%. Therefore, the contribution of Anderson and van Wincoop (2003) is mostly concentrated on the interpretation of the estimated parameter and such interpretation will always depend on the underlying economic model. A good example of this limitation is the contribution of Chaney (2008), who uses a different model to gauge the economic importance of a border for international trade. Based on his model, Chaney (2008) estimates that the existence of a border is equivalent to a 21% ad-valorem tax, while the comparable number in Anderson and van Wincoop (2003) is 46%.

Another important contribution to this discussion is by Evans (2003) who systematically investigates the economic meaning of the border effect. This author argues that a border effect of 20 can either represent a high or a low economic cost. Using data for the E.U., Evans (2003) estimates that only 34% of the estimated border effect is due to distortionary barriers. Additional explanations for the magnitude of the estimated border effect are given by Rossi-Hansberg (2005) and Yi (2010). These authors argue that small trade frictions can create large trade barriers. In the case of Rossi-Hansberg (2005), this effect occurs through endogenous agglomeration of economic activity, while in the case of Yi (2010) vertical specialization can explain such outcome.

Despite the differences in all these explanations, all of them have in common the fact that they take the result of McCallum (1995) as given and try to explain it. In this paper, instead of trying to explain the result, I question its existence. To achieve this goal, I first review the results of McCallum (1995) in light of Santos Silva and Tenreyro's (2006) results regarding the estimation of gravity equations by OLS. That is, I evaluate the impact of McCallum (1995) having used OLS to estimate the gravity equation instead of using non-linear estimation methods. In this case, I find that, by estimating the McCallum (1995) gravity equation non-linearly, the border effect is reduced by 35% to 45%. Or, in other words, a border between the U.S. and Canada causes trade between Canadian provinces to be 11 to 13 times larger than trade between U.S. states and Canadian provinces - these two figures compare to a factor of 20 when this effect is estimated by OLS. Despite the large differences that are caused by using an inconsistent estimation method (i.e., OLS), the estimated border effect is still significantly large. Therefore, it is hard to argue that the puzzle would have not existed if McCallum (1995) had estimated his gravity equation non-linearly.

Next, I follow the results of Dias (2010), who shows that, for international trade, the effect of distance on trade is not independent of the effect of other non-distance related trade barriers.

Based on this idea, I re-estimate the McCallum (1995) gravity equation and allow the effect of distance and tariffs (vis-à-vis, the border) to be non-separable. When this alternative specification of the gravity equation is estimated non-linearly, I find no evidence of "a crossing the border" type of effect. Instead, I find that the effect of distance on interprovincial trade is smaller than on trade between U.S. states and Canadian provinces. Based on these results, I argue that the border puzzle, as we know it, would have not existed.

An important remark, which is also one of the results of the paper, is that none of the estimations controls for the so called multilateral resistance terms (as suggested by Anderson and van Wincoop 2003). This is so because the data used in McCallum (1995) does not allow a non-parametric and simultaneous identifcation of the border effect and of all multilateral resistance terms. The identification of the two sets of parameters can only be achieved through a parametric approach (e.g. Anderson and van Wincoop 2003), or by augmenting the data with inter-state trade information.

The remainder of the paper is organized as follows: in section 2 I describe the data being used; in section 3 I show and discuss the empirical results; finally, in section 4 I present some concluding remarks.

2. DATA

The data used in this paper is a subset of the data used in Anderson and van Wincoop (2003). I use data on trade between Canadian provinces and between Canadian provinces and U.S. states, GDP for each of the regions, and the distance in kilometers between the capitals of each region. Anderson and van Wincoop (2003) also used data on trade between U.S. states, but, since in McCallum (1995) such data was not used, I opt for not including it. As in McCallum (1995), I only consider the ten Canadian provinces (no data for the three territories) and thirty U.S. states (a list is of these is provided in Appendix A). This data is available for the years 1988-1993 but, to be as close as possible to McCallum (1995), I center my analysis on the year 1988; I only use the 1989-1993 data to test the robustness of my results. More information on this data can be found in Anderson and van Wincoop (2003).

3. AN ALTERNATIVE EXPLANATION OF THE BORDER PUZZLE

In this section I illustrate the importance of using non-linear estimators in the estimation of the gravity equation. In the second part of this section, based on a consistent estimator and on a more flexible specification of the gravity equation, I provide evidence against a "cross the border" type of border effect. Alternatively, my results indicate that the existence of a border affects trade through a higher distance elasticity for international than for intranational trade. These results are confirmed by a series of robustness checks, which are presented in the third part of the section. In the last part of this section I use a standard model of international trade to discuss the empirical findings.

3.1. Linear vs. non-linear estimation of the McCallum gravity equation

In a recent paper, Santos Silva and Tenreyro (2006) show that log-linearizing the gravity equation can have important consequences for the correct estimation of the various parameters of interest. For such problems to arise it is sufficient to have heteroscedastic errors in the original non-linear model. The log-linearization of the gravity equation when the errors of the non-linear model are heteroscedastic will create endogeneity problems in the linear model. To answer the question of how different the McCallum (1995) border effect would be if, instead of OLS, non-linear estimation methods are used, I use the data described in the previous section for the year 1988. The choice of 1988 is due to the fact that this was the year used in McCallum's (1995) regressions.

The gravity model used by McCallum (1995) is the following:

$$\begin{aligned} x_{ij} &= \exp\left(\alpha_1 + \alpha_5 \delta_{ij}\right) \frac{y_i^{\alpha_2} y_j^{\alpha_3}}{d_{ij}^{\alpha_4}} + \nu_{ij} \\ &= \exp\left(\alpha_1 + \alpha_2 \ln y_i + \alpha_3 \ln y_j + \alpha_4 \ln d_{ij} + \alpha_5 \delta_{ij} + \ln \widetilde{v}_{ij}\right), \end{aligned} \tag{1}$$

where x_{ij} denotes trade between regions i and j, y_i and y_j are regions i and j GDP, respectively, d_{ij} is the distance between regions i and j measured in kilometers, δ_{ij} is a dummy variable that takes the value 1 if both regions i and j are Canadian provinces and 0 otherwise, ν_{ij} is a stochastic term with conditional mean equal to 0 - $E\left[\nu_{ij}|\, y_i, y_j, d_{ij}, \delta_{ij}\right] = 0$, and $\widetilde{\nu}_{ij} = 1 + \frac{\nu_{ij}}{E[x_{ij}|y_i, y_j, d_{ij}, \delta_{ij}]}$. It is straightforward to see that the log-linearization of equation (1) yields the same equation used by McCallum (1995) and also corresponds to equation (1) in Anderson and van Wincoop (2003). That is,

$$\ln x_{ij} = \alpha_1 + \alpha_2 \ln y_i + \alpha_3 \ln y_j + \alpha_4 \ln d_{ij} + \alpha_5 \delta_{ij} + \varepsilon_{ij}, \tag{2}$$

with $\varepsilon_{ij} = \ln \widetilde{v}_{ij}$.

Before presenting the first set of results it is important to discuss why I don't use the Anderson and van Wincoop (2003) method for the estimation of this gravity equation. As mentioned previously, Anderson and van Wincoop (2003) contributed to this literature by showing that the results of McCallum (1995) suffered from an omitted variable bias. The variables that, according to Anderson and van Wincoop (2003), were missing in McCallum's (1995) specification were the price levels of the exporter and importer - the so-called multilateral resistance terms. Unfortunately, with this data, such approach is not possible. This is so because δ_{ij} and the multilateral resistance terms are perfectly collinear when there is no data on inter state trade. In Appendix B I show why this happens and present some alternative regressions where this problem does not occur.

The estimation of equation (1) by non linear least squares - NLLS - and pseudo Poisson maximum likelihood - PPML - and of equation (2) by OLS yield the following results:

	OLS $_{x_{ij}>0}$	NLLS	NLLS $_{x_{ij}>0}$	PPML	PPML $_{x_{ij}>0}$
α_1	-3.414^{***} (0.790)	-0.629 (2.989)	-0.629 (2.989)	-1.340 (1.148)	-1.334 (1.148)
$\alpha_2 - y_i$	1.221^{***} (0.039)	0.840^{***} (0.053)	0.840^{***} (0.105)	0.925^{***} (0.058)	0.924^{***} (0.058)
$\alpha_3 - y_j$	0.964^{***} (0.033)	0.890^{***} (0.055)	0.890^{***} (0.091)	0.876^{***} (0.038)	0.876^{***} (0.038)
$\alpha_4 - d_{ij}$	-1.331^{***} (0.069)	-0.912^{***} (0.071)	-0.912^{***} (0.194)	-0.949^{***} (0.138)	-0.949^{***} (0.138)
$\alpha_5 - \delta_{ij}$	2.961^{***} (0.108)	2.362^{***} (0.077)	2.362^{***} (0.224)	2.550^{***} (0.141)	2.550^{***} (0.141)
N	679	690	679	690	679
Border effect	19.32	10.61	10.61	12.81	12.80

Robust standard errors in parenthesis

*,**,*** denote 10%, 5% and 1% significance, respectively

Table 1 - Regression results using different estimation methods.

Table 1 has several results worth noting. First, the differences between linear and non-linear estimation are quite stark[1]. For all parameters, OLS estimates are always larger in magnitude than those obtained by NLLS or PPML. Ex-ante there is no reason to expect this to happen, but this implies immediately that if NLLS or PPML had been used by McCallum (1995), the estimated border effect would have been substantially smaller.[2] In particular, the NLLS and PPML border effect are around 45% and 35% smaller than the estimate obtained by OLS, respectively, but the effect is still fairly large. The second result of note is that the exclusion of the zero trade observations has almost no impact on the results. This finding is not completely surprising as it is in line with the results presented by Santos Silva and Tenreyro (2006). This result suggests that, in this particular case, Jensen's inequality is the main problem of log-linearizing the gravity equation and not the sample selection effect. The third result is that the NLLS and PPML estimates of the border effect are remarkably similar to the ones obtained by Anderson and van Wincoop (2003) and Balistreri and Hillberry (2007), which were obtained in the context of a structural model.[3] The final result to highlight relates to the income elasticities, which, in the majority of cases, for NLLS and PPML, are smaller than one. This result contradicts the hypothesis of Anderson and van Wincoop (2003), who in their estimation impose the elasticities to be unitary. In this case, it is almost impossible to distinguish the effect of income on trade that is not accounted for from the multilateral resistance terms.

Based on the results of Table 1, it is clear that the large border effect of McCallum (1995) was in part caused by using an inconsistent estimation method. Despite the significant difference between results (linear vs non-linear estimation), the effect is still large and therefore there is no reason to think that these results would not have been seen as puzzling.

[1] Notice that if the error terms were "well-behaved", i.e., independent and identically distributed, the OLS results should be very similar to the ones obtained with non-linear estimators. The only significant difference should come from the constant term. Because the results are so different for linear and non-linear estimation, I don't find it necessary to test if the errors are not "well behaved" - for instance, testing for heteroskedasticity.

[2] The estimate of the border effect is calculated as in McCallum (1995) - $Border \;\; Effect = \exp(\alpha_5)$.

[3] In Anderson and van Wincoop (2003) and Balistreri and Hillberry (2007) the data is for 1993 while these results are for 1988. If instead of using data for 1988 I had used data for 1993, the border effect estimated by PPML would be 9.2.

3.2. A different view of the border puzzle

In the previous section I showed empirically how different the estimates of the McCallum (1995) gravity equation would have been if instead of using a linear estimation method, OLS, non-linear estimation methods, such as NLLS or PPML, had been used. Here I follow Dias (2010) and allow for the possibility that the effects of tariffs and distance are not separable in order to understand how this would have changed the results of McCallum (1995). The implication of Dias' (2010) result is that when there are trade costs that do not depend on distance, the effect of distance is smaller and therefore, the effect of distance should be different for trade within Canada and for trade between U.S. and Canada. When this fact is not taken into account, the estimate of the border effect can be biased.

In McCallum (1995), as pointed out by Anderson and van Wincoop (2003), the empirical specification of the gravity equation implicitly assumes a certain specification for the trade costs function. In particular, it assumes that $t_{ij} = b_{ij} d_{ij}^{\rho}$, where t_{ij} are ad-valorem transportation costs between regions i and j, $b_{ij} = 1 + tariff_{ij}$ and d_{ij} is the distance between regions i and j. One important implication of this assumption is that it is possible to separate the effect of the transportation cost from the effect of the tariffs. That is,

$$\ln t_{ij} = \ln b_{ij} + \rho \ln d_{ij} \tag{3}$$

In Dias (2010) it is shown that for international trade, the data rejects such an assumption. Since t_{ij} in general is not known, Dias (2010) suggests using a polynomial function to approximate $t_{ij}\left(b_{ij}, d_{ij}\right)$:

$$\ln t_{ij}\left(b_{ij}, d_{ij}\right) \simeq \gamma_0 + \gamma_1 \ln b_{ij} + \gamma_2 \ln d_{ij} + \gamma_3 \ln b_{ij} \ln d_{ij} \tag{4}$$

One of the problems with the available data is that there is no information on tariffs or any other trade barriers at the state and province level. In other words, b_{ij}, the tariff charged for trade between province (state) i and state (province) j is not observed.[4] The information that is available only allows to distinguish trade within Canada from trade between U.S. and Canada. Therefore, b_{ij} equals 1 when the trade flow is between Canadian provinces, and b_{ij}

[4]Notice that this information is different from information on tariffs charged on trade flows between the U.S. and Canada. This is so because different regions produce different goods and therefore may be subject to different tariff rates.

is larger than 1 when the trade flow is between U.S. states and Canadian provinces. Based on this information, b_{ij} can be replaced by a dummy variable $\widetilde{\delta}_{ij} = 1$ if the trade flow is between a U.S. state and a Canadian province, and 0 otherwise.

$$\ln t_{ij}\left(\delta_{ij}, d_{ij}\right) \simeq \gamma_0 + \widetilde{\gamma}_1 \left(1 - \widetilde{\delta}_{ij}\right) + \gamma_2 \ln d_{ij} + \widetilde{\gamma}_3 \left(1 - \widetilde{\delta}_{ij}\right) \ln d_{ij} \tag{5}$$

Or, in order to be as close as possible to McCallum's (1995) specification, instead of using a dummy signalling a trade flow between a state and a province, expression (5) can be re-written as

$$\ln t_{ij}\left(\delta_{ij}, d_{ij}\right) \simeq \gamma_0 + \widetilde{\gamma}_1 \delta_{ij} + \gamma_2 \ln d_{ij} + \widetilde{\gamma}_3 \delta_{ij} \ln d_{ij}, \tag{6}$$

where $\delta_{ij} = 1 - \widetilde{\delta}_{ij}$ is a dummy variable taking the value of 1 if the trade flow is between Canadian provinces. Based on equation (6), the econometric model to be estimated is the following:

$$\begin{aligned} x_{ij} &= \exp\left(\widetilde{\alpha}_1 + \widetilde{\alpha}_5 \delta_{ij}\right) \frac{y_i^{\widetilde{\alpha}_2} y_j^{\widetilde{\alpha}_3}}{d_{ij}^{\widetilde{\alpha}_4} d_{ij}^{\widetilde{\alpha}_6 \delta_{ij}}} + \nu_{ij} \\ &= \exp\left(\widetilde{\alpha}_1 + \widetilde{\alpha}_2 \ln y_i + \widetilde{\alpha}_3 \ln y_j + \widetilde{\alpha}_4 \ln d_{ij} + \widetilde{\alpha}_5 \delta_{ij} + \widetilde{\alpha}_6 \delta_{ij} \ln d_{ij} + \ln \widetilde{v}_{ij}\right). \end{aligned} \tag{7}$$

The log-linear representation of equation (7) is:

$$\ln x_{ij} = \widetilde{\alpha}_1 + \widetilde{\alpha}_2 \ln y_i + \widetilde{\alpha}_3 \ln y_j + \widetilde{\alpha}_4 \ln d_{ij} + \widetilde{\alpha}_5 \delta_{ij} + \widetilde{\alpha}_6 \delta_{ij} \ln d_{ij} + \varepsilon_{ij}. \tag{8}$$

The results from estimating equation (7) by NLLS and by PPML and equation (8) by OLS are presented in Table 2.

	OLS $x_{ij}>0$	NLLS	NLLS $x_{ij}>0$	PPML	PPML $x_{ij}>0$
$\widetilde{\alpha}_1$	-3.575^{***} (0.895)	0.850 (3.283)	0.850 (3.349)	-0.179 (1.207)	-0.175 (1.207)
$\widetilde{\alpha}_2 - y_i$	1.222^{***} (0.039)	0.879^{***} (0.129)	0.879^{***} (0.129)	0.916^{***} (0.057)	0.915^{***} (0.057)
$\widetilde{\alpha}_3 - y_j$	0.965^{***} (0.034)	0.919^{***} (0.087)	0.919^{***} (0.087)	0.867^{***} (0.036)	0.866^{***} (0.036)
$\widetilde{\alpha}_4 - d_{ij}$	-1.312^{***} (0.084)	-1.281^{***} (0.257)	-1.281^{***} (0.257)	-1.086^{***} (0.172)	-1.086^{***} (0.172)
$\widetilde{\alpha}_5 - \delta_{ij}$	3.588^{***} (0.916)	-2.592 (1.924)	-2.592 (1.924)	-0.620 (1.441)	-0.618 (1.441)
$\widetilde{\alpha}_6 - \delta_{ij} \ln d_{ij}$	-0.084 (0.122)	0.765^{***} (0.274)	0.765^{***} (0.274)	0.452^{**} (0.201)	0.452^{**} (0.201)
N	679	690	679	690	679
$Border\ effect$	36.16	0.07	0.07	0.54	0.54
	Robust standard errors in parentheses *,**,*** denote 10%, 5% and 1% significance, respectively				

Table 2 - Regression results using different estimation methods and a generalized trade cost function.

Like the previous results, there are stark differences between the estimations based on linear estimators (OLS) and non-linear estimators (NLLS and PPML). When OLS is used, not only is the border effect larger, but also the interaction term between distance and the interprovincial dummy is not statistically significant. When NLLS or PPML are used the results are very different. The first result, for both NLLS and PPML, is that in both cases the coefficient associated with δ_{ij}, the interprovincial trade dummy, is not statistically significant. This suggests that trade is not affected by the simple crossing of the border. The second result relates to the interaction term between distance and the interprovincial dummy. When NLLS or PPML are used, this term is positive and significant. This means that the effect of distance on trade is different for intranational and international trade. In particular, trade between regions of different countries is more affected by distance, than trade between regions of the same country.

From this result it is not possible to say that there is no border effect as the higher impact of distance on international trade may be caused by some distortionary policy (or policies). What is possible to say is that there are potentially many other reasons for the effect of distance to be higher for international trade than for intranational trade, which are not caused by any distortionary policy. For example, if the international distribution market is less competitive than the internal, the impact of distance may be higher for international than for intranational trade. Another possible explanation is the fact that in Canada there are more efficient distribution channels than in the U.S.. A simple, but plausible explanation, is differences in the composition of trade flows as the trade flows within Canada are of higher value than between Canada and the U.S.. In sub-section 3.4 I use a standard model of trade to test some of these possibilities and also give some economic interpretation to the empirical findings. Before doing that, I first present some results regarding the robustness of the findings presented in Tables 1 and 2.

3.3. Robustness check

In order to show that the results presented previously are robust and that they are not particular to 1988, I re-estimate equations (1) and (2) by PPML and OLS, respectively, for the years 1989-1993 and for the entire sample.[5] These results are summarized in Table 3.

		1989	1990	1991	1992	1993	$1988-93$
OLS	$\alpha_5 - \delta_{ij}$	2.925*** (0.108)	3.102*** (0.109)	2.968*** (0.109)	2.969*** (0.113)	2.802*** (0.125)	2.953*** (0.046)
	Border effect	18.6	22.2	19.5	19.5	16.5	19.2
PPML	$\alpha_5 - \delta_{ij}$	2.452*** (0.159)	2.568*** (0.172)	2.422*** (0.167)	2.263*** (0.177)	2.217*** (0.145)	2.405*** (0.069)
	Border effect	11.6	13.0	11.3	9.6	9.2	11.1

Robust standard errors in parentheses

*,**,*** denote 10%, 5% and 1% significance, respectively

Table 3 - Comparison of border effect estimates for different years using different estimation methods.

The results of Table 3 confirm the findings presented in Table 1 and show that the estimates of the border effect based on OLS are 60 to 100% larger than the ones obtained by PPML.

As I showed previously, this is not the only result that is affected by using OLS to estimate the gravity equation. Another consequence of having used OLS was that McCallum (1995) did not find that his estimates of the border effect could simply reflect differences in the distance elasticity for intranational and international trade. In the previous section I showed that indeed

[5] The choice of the years to perform the robustness check was determined by data availability.

this is the case, the trade elasticity with respect to distance is larger for intranational than for international trade. In order to confirm that this finding is robust, and it is not specific to that particular year (1988), I re-estimated equation (7) by PPML for the years 1989-1993 and for the entire sample. The results are presented in Table 4.

	1989	1990	1991	1992	1993	1988 − 93
$\widetilde{\alpha}_1$	0.362 (1.282)	−0.695 (1.475)	−0.352 (1.540)	0.494 (1.551)	0.133 (1.398)	0.038 (0.591)
$\widetilde{\alpha}_2 - y_i$	0.866*** (0.082)	0.967*** (0.052)	0.943*** (0.051)	0.832*** (0.084)	0.871*** (0.050)	0.893*** (0.028)
$\widetilde{\alpha}_3 - y_j$	0.840*** (0.038)	0.882*** (0.039)	0.859*** (0.042)	0.860*** (0.050)	0.891*** (0.050)	0.865*** (0.019)
$\widetilde{\alpha}_4 - d_{ij}$	−1.033*** (0.183)	−1.146*** (0.210)	−1.108*** (0.214)	−1.033*** (0.199)	−1.097*** (0.190)	−1.083*** (0.190)
$\widetilde{\alpha}_5 - \delta_{ij}$	−0.265 (1.511)	−1.232 (1.726)	−0.927 (1.754)	−0.573 (1.624)	−0.718 (1.563)	−0.711 (0.678)
$\widetilde{\alpha}_6 - \delta_{ij} \ln d_{ij}$	0.387* (0.215)	0.543** (0.238)	0.478** (0.241)	0.402* (0.229)	0.418* (0.217)	0.444*** (0.094)
N	690	690	690	690	690	4140
Border effect	0.77	0.29	0.40	0.56	0.49	0.49

Robust standard errors in parentheses

*,**,*** denote 10%, 5% and 1% significance, respectively

Table 4 - Regression results based on PPML for different years.

As was the case for 1988, for the years 1989-1993 and the entire sample there is no evidence of a "crossing the border" type of border-effect. Instead, what is supported by the data is that the distance elasticity is higher for international than for intranational trade. Also, for all the different samples, there is no statistical evidence of unitary income elasticities for the majority of the cases.

3.4. Discussion of results

In order to better understand the results of the previous sub-sections I use a standard model of international trade with the addition of an oligopolistic market of shipping services. This model is basically the same model used by Hummels et al. (2009) to analyze how market power in international shipping impacts trade flows and welfare.

The model

Consider an economy with $i = 1, 2, ..., M$ identical regions each of which consists of one representative consumer and one representative producer. Each producer/region produces a unique and differentiated good (a variety) that is consumed in the region of production and is sold to all other $M - 1$ regions - this corresponds to assuming an Armington type structure. In this economy consumers have quasi-linear preferences:

$$U_i = q_{i0} + \sum_{m=1}^{M} (q_{im})^{\frac{\sigma-1}{\sigma}}, \quad \sigma > 1 \tag{9}$$

Where q_{i0} is country's i consumption of a numeraire good and q_{im} is country's i consumption of the variety imported from region m. Without loss of generality, the price of q_{i0} - p_{i0} - is set to one and this good can be traded at no cost. Under these assumptions, the demand in region i from region $m's$ variety is the following[6]:

$$q_{im} = \left[\left(\frac{\sigma}{\sigma-1}\right) p_{im}\right]^{-\sigma} \tag{10}$$

Contrarily to the numeraire good, all other goods face transportation costs when consumed outside of the region where they are produced. Besides the transportation cost - f_{im} - that is present in each inter-regional transaction, there can also be an ad-valorem tariff - τ_{im} - if the trade flow is between two regions of different countries. The price of variety m consumed in region i is the following[7]:

$$p_{im} = \begin{cases} p_m + f_{im}, & \text{if } i \text{ and } m \text{ belong to the same country;} \\ p_m \tau_{im} + f_{im}, & \text{if } i \text{ and } m \text{ belong to different countries - } \tau_{im} \geqslant 1. \end{cases} \tag{11}$$

As mentioned previously, f_{im}, the price of shipping from region i to region m, is not set in a perfectly competitive market and therefore it will be higher than the marginal cost. Based on the assumption that shipping companies behave *a la Cournot*, and that for each possible trade flow (from region m to region i) there are N_{im} carriers, each carrier must solve the following problem:

[6] This result is obtained by dividing the first order condition with respect to the numeraire by the first order condition with respect to q_{im} - $\frac{1}{\frac{\sigma-1}{\sigma} q_{im}^{-\frac{1}{\sigma}}} = \frac{\lambda p_{i0}}{\lambda p_{im}}$, where λ is the lagrange multiplier.

[7] The expression for import prices presented in equation (11) differs from the traditional iceberg assumption. Nevertheless, and as discussed in Hummels et al. (2009), this formulation is sufficiently general and the iceberg formulation is one particular case. For my results this choice is not very important, and the results are robust to other alternative formulations.

$$\max_{Q_{im}^n} \left\{ Q_{im}^n \left(f_{im} - c_{im} \right) \right\} \tag{12}$$

Where Q_{im}^n is the quantity shipped by firm n and $\sum_{n=1}^{N_{im}} Q_{im}^n = q_{im}$ is the total demand in region i of region $m's$ variety and c_{im} is the marginal cost of shipping from region m to region i - this cost is assumed to be identical across carriers. The solution to (12) is as follows[8]:

$$Q_{im}^n = \begin{cases} \frac{1}{N_{im}} \left[\left(\frac{\sigma}{\sigma-1} \right) \left(\frac{c_{im}+p_m}{1-\frac{1}{\sigma N_{im}}} \right) \right]^{-\sigma}, \text{ if the trade flow is between regions of the same country;} \\ \frac{1}{N_{im}} \left[\left(\frac{\sigma}{\sigma-1} \right) \left(\frac{c_{im}+p_m \tau_{im}}{1-\frac{1}{\sigma N_{im}}} \right) \right]^{-\sigma}, \text{ if the trade flow is between regions of different countries.} \end{cases} \tag{13}$$

$$f_{im} = \begin{cases} c_{im} + \frac{c_{im}+p_m}{\sigma N_{im}-1}, \text{ if the trade flow is between regions of the same country;} \\ c_{im} + \frac{c_{im}+p_m \tau_{im}}{\sigma N_{im}-1}, \text{ if the trade flow is between regions of different countries.} \end{cases} \tag{14}$$

To obtain total exports of variety m to region i it is just necessary to multiply Q_{im}^n by N_{im} - $q_{im} = N_{im} Q_{im}^n$.

A final step before establishing a parallel between the model derived here and the empirical model presented in sub-section 3.2 is to define the relation between the marginal cost of transportation - c_{im} - and distance. Once again I will follow very closely what was done by Hummels et al. (2009) with just a small change. The expression chosen for c_{im} is not the only possible one, but, whichever one is used it is important that the cost of transportation for a carrier increases with distance.

$$c_{im} = \beta_1 \left(dist_{im} \right)^{\beta_2} \tag{15}$$

In the previous equation, $dist_{im}$ denotes the physical distance between regions i and m.

Analysis of results

From the combination of equations (13) and (15) with the definition of q_{im} it is now possible to derive the theoretical counterpart of the distance elasticity parameters (for intranational and international trade) and the border effect implied by equation (7). In order to make the comparison of results easier, I use the same notation as in equation (7) and I just add a subscript T to denote that it is the theoretical counterpart:

[8] These results as well as the intermediate steps are presented in Hummels et al. (2009).

$$
\begin{aligned}
\left(\widetilde{\alpha}_4+\widetilde{\alpha}_6\right)_T &= -\left(\sigma-1\right)\beta_2\left(\frac{c_{im}}{c_{im}+p_m}\right) \\
\left(\widetilde{\alpha}_4\right)_T &= -\left(\sigma-1\right)\beta_2\left(\frac{c_{im}}{c_{im}+p_m\tau_{im}}\right) \\
\left[\exp\left(\widetilde{\alpha}_5\right)\right]_T &= \left(\tau_{im}\right)^{\sigma}
\end{aligned} \tag{16}
$$

The first two expressions in (16) reflect the elasticity of trade between regions i and m with respect to the distance between the two[9]. The third expression represents the ratio of trade quantities when the two regions belong to the same country, and therefore $\tau_{im}=1$, and in the other case the same regions belong to different countries, implying $\tau_{im}\geqslant 1$[10].

The first result that comes from (16) is that the number of competitors in the shipping market has no bearing on the distance elasticity nor on the effect of a border between two countries. This conclusion is conditional on the model used but it is also a sensible one as it is only reflecting the fact that competition in shipping affects trade in a proportional way over different distances.

From Table 2, the PPML and NLLS estimates for $\widetilde{\alpha}_5$ suggest that this parameter is not statistically different from zero, and consequently $\exp\left(\widetilde{\alpha}_5\right)$ must be equal to one. Based on the theoretical counterpart of $\exp\left(\widetilde{\alpha}_5\right)$, $\left[\exp\left(\widetilde{\alpha}_5\right)\right]_T=\left(\tau_{im}\right)^{\sigma}$, the only possibility to have $\left[\exp\left(\widetilde{\alpha}_5\right)\right]_T=1$ is when $\tau_{im}=1$ (by assumption $\sigma>1$). That is, there is no ad-valorem tariff for trade flows between regions of different countries. Additionally, if $\tau_{im}>1$, then $\frac{\left(\widetilde{\alpha}_4+\widetilde{\alpha}_6\right)_T}{\left(\widetilde{\alpha}_4\right)_T}=\left(\frac{c_{im}+p_m\tau_{im}}{c_{im}+p_m\tau}\right)>1$. That is, if an ad-valorem tariff exists, then the magnitude of the trade distance elasticity must be larger for trade-flows between regions of the same country, then for regions in different countries - this result is similar to the results in Dias (2010) and it was one of the motivations for the current paper. From Table 2, we see that this possibility is rejected empirically as the estimate of $\left(\widetilde{\alpha}_4+\widetilde{\alpha}_6\right)$ is, in absolute terms, smaller than the one for $\left(\widetilde{\alpha}_4\right)$.

If $\tau_{im}=1$ as these results suggest, then, a consequence is that $\widetilde{\alpha}_6=0$, i.e., the distance elasticity of trade must be the same for trade flows between regions of the same country as well as for trade flows between regions of different countries. The results of Table 2, which are

[9] $\left(\widetilde{\alpha}_4+\widetilde{\alpha}_6\right)_T=-\left(\sigma-1\right)\beta_2\left(\frac{c_{im}}{c_{im}+p_m}\right)=\left.\frac{\partial q_{im}}{\partial dist_{im}}\frac{dist_{im}}{q_{im}}\right|_{\tau_{im}=1}$ and $\left(\widetilde{\alpha}_4\right)_T=-\left(\sigma-1\right)\beta_2\left(\frac{c_{im}}{c_{im}+p_m}\right)=\left.\frac{\partial q_{im}}{\partial dist_{im}}\frac{dist_{im}}{q_{im}}\right|_{\tau_{im}\geqslant 1}$.

[10] $\left[\exp\left(\widetilde{\alpha}_5\right)\right]_T=\exp\left(\frac{1}{\tau_{im}}\right)^{-\sigma}=\frac{q_{im}\left(dist_{im}=0,\tau_{im}=1\right)}{q_{im}\left(dist_{im}=0,\tau_{im}\geqslant 1\right)}$

confirmed in Tables 4 and 2B, clearly reject this hypothesis and indicate that $\widetilde{\alpha}_6 > 0$, which implies that $|(\widetilde{\alpha}_4 + \widetilde{\alpha}_6)| < |(\widetilde{\alpha}_4)|$. From (16) and from the discussion on the value of τ_{im}, if all other parameters are the same for trade flows within a country and between countries , then the distance elasticity of trade must be the same for the two types of trade-flows. In order to have different distance elasticities, as suggested by the data, it is necessary that some of the parameters differ by type of trade-flow - in the same country vs. between different countries. One possibility would be having β_2 in c_{im} varying with the type of trade-flow. If β_2, which is a parameter that controls the importance of distance in the total costs of shipping, was larger for international than for intranational trade, then $|(\widetilde{\alpha}_4 + \widetilde{\alpha}_6)_T| < |(\widetilde{\alpha}_4)_T|$ - this is so because $\frac{\partial\left(-(\sigma-1)\beta_2\left(\frac{c_{im}}{c_{im}+p_m}\right)\right)}{\partial\beta_2} < 0$. If indeed the reason why the distance elasticities for intranational and international trade are different is because β_2 is larger for international for intranational trade, then one possible explanation for this parameter to be different may be due to different (better) distribution networks/infrastructures in Canada than in the U.S.. This explanation is not the only possible explanation, but it is a plausible one that deserves being analyzed further as it has important policy implications.

4. CONCLUDING REMARKS

In this paper I questioned the findings of McCallum (1995) regarding the effect of an administrative border on international trade. The two reasons that motivated the review of McCallum's (1995) results were: 1) the contribution of Santos Silva and Tenreyro (2006) relative to the estimation of gravity equations by OLS; and 2) the results of Dias (2010), who shows that, for international trade, the effect of distance on trade is not independent of the effect of other non-distance related trade barriers.

The results could not be more surprising. First, when a non-linear estimator is used to estimate McCallum's (1995) gravity equation the border effect is $35\% - 45\%$ smaller than the one obtained by McCallum (1995). This is a significant difference and is comparable to what was obtained in the context of structural estimations of a gravity model for trade between Canadian provinces and between U.S. states and Canadian provinces (Anderson and van Wincoop 2003 or Balistreri and Hillberry 2007). Despite the new results being substantially smaller than the previous ones, the estimated border effect would still be significant and economic meaningful.

The second result I obtain is even more surprising and raises several questions as to how to think about the effect of a border on international trade. When the gravity equation of McCallum (1995) is augmented with an interaction term between distance and the interprovincial trade dummy the effect of a border no longer shows up in the interprovincial trade dummy, instead I find evidence that distance affects intranational and international trade differently. In particular, international trade is more affected by distance than intranational trade.

This result does not preclude the existence of distortions due to administrative borders, but at the same time it is consistent with other situations that are not related to administrative policies. In my view, it is undeniable that if these results had been obtained 15 years ago, much of the research on this topic would have been focused on different questions, for example, understanding whether this result is driven by trade composition. Another possible explanation is related to understanding how the transportation/distribution industry works in each of the two countries. In particular, is regulation creating a situation in which international transportation is less competitive than intranational transportation? Or, alternatively, the transportation industry is more efficient in Canada than in the U.S. and therefore, in these regressions, international trade is more affected by distance than intranational trade[11].

Using a standard international trade model I provide some rational for the empirical results of subsection 3.2. In particular, I show that in order to have a zero border effect it must be the case that there are no barriers at the border (in the model this correspond to an ad-valorem tariff). I also show that without any differences in the parameters for intranational and international trade it is not possible to have different distance elasticities and one possible difference that would be consistent with the empirical results is a higher marginal cost of distance for international than for intranational shippings. From the discussions of subsection 3.4, the possibility of the differences in the distance elasticities for intranational and international trade being driven by differences in the competition level for these two types of trade flows was ruled out. On the other hand, differences in trade compositions and/or differences in the efficiency of the distribution channels are still possible explanations for the new empirical findings that deserve being further analyzed.

[11] It is important to remember that this data does not include trade data between U.S. states. Therefore, the identification of the effect of distance on intranational trade relies solely on data for trade between Canadian provinces.

Finally, regarding the question that is ask in the title of the current article, in the light of these new results, I claim that the border puzzle, as we know it, would have not existed and very likely the research that followed would have been substantially different.

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APPENDIX A

List of Canadian provinces and U.S. states used in the regressions.

U.S. states			**Canadian provinces**
Alabama	Maine	N. Carolina	Alberta
Arizona	Maryland	N. Dakota	British Columbia
California	Massachusetts	Ohio	Manitoba
Florida	Michigan	Pennsylvania	New Brunswick
Georgia	Minnesota	Tennessee	Newfoundland
Idaho	Missouri	Texas	Nova Scotia
Illinois	Montana	Vermont	Ontario
Indiana	New Hampshire	Virginia	Prince Edward Island
Kentucky	New Jersey	Washington	Quebec
Louisiana	New York	Wisconsin	Saskatchewan

Table 1A - List of Canadian provinces and U.S. states used in the regressions.

APPENDIX B

In subsection 3.1 of this paper I claim that with the data that was used in McCallum (1995) it is not possible to simultaneously identify the border effect and all the multilateral resistance terms. To show why this is true I am going to use a simple example that describes the data structure. In this example I start by assuming that there are only two Canadian provinces and one U.S. state.

Region		(1)	(2)	(3)	(4)	(5)
i	j	$\text{CA}_{\text{Exp.}}$FE	$\text{US}_{\text{Exp.}}$ FE	$\text{CA}_{\text{Imp.}}$ FE	$\text{US}_{\text{Imp.}}$ FE	Intraprovince
CA	CA	1	0	1	0	1
CA	US	1	0	0	1	0
US	CA	0	1	1	0	0

Table 1B - Structure of the data used in McCallum (1995)

In Table 1B I present the three possible cases of trade flows, i.e., from CA to CA, from CA to US and from US to CA. As mentioned in section 2, the original data that was used by McCallum (1995) did not include any trade data between US states and that is the reason why there are only three possible trade flows. In columns (1) to (5) I exemplify the value that each of the five variables (the four different multilateral resistance terms and the intraprovince dummy) would have for each of the three possible trade flows. It is easy to see that column (5) can be obtained by a linear transformation of columns (1) to (4), for example $(5) = (1) + 0 * (2) + 0 * (3) - (4)$. This example was just for a case of two provinces and one state, while in the data there are thirty states and ten provinces. To see that the perfect collinearity is also present in a more general case, just consider a new variable that corresponds to adding all the exporter fixed effects for the different provinces - CA_{Exp}FE. The same can be done for all the other fixed effects regarding the cases that the exporter is a US state - US_{Exp}FE, the cases where the importer is a Canadian province - CA_{Imp}FE, and for all the cases where the importer is a US State - US_{Imp}FE. These operations would result in a case that is identical to the one described in Table 1B and this would all be done through linear transformations of the original data. Therefore, the perfect colinearity that is exemplified in Table 1B would also exist in the data used in the present paper and in McCallum (1995).

Even though it is not possible to non-parametrically identify the border effect and all the multilateral resistance terms, it is possible to identify all multilateral resistance terms and distance effects that vary with the type of trade flow. That is, it is possible to estimate all parameters in the following equations:

$$x_{ij} = \exp\left(\beta_1 + \beta_2 \ln y_i + \beta_3 \ln y_j + \beta_4 \ln d_{ij} + \beta_5 \delta_{ij} \ln d_{ij}\right) + \eta_{ij}$$

$$x_{ij} = \exp\left(\beta_1 + \beta_4 \ln d_{ij} + \beta_5 \delta_{ij} \ln d_{ij} + \gamma_i + \gamma_j\right) + \eta_{ij}$$

In these two equations, x_{ij}, y_i, y_j, d_{ij} and δ_{ij} represent the same variables as previously and γ_i and γ_j represent the exporter and importer fixed effects, respectively. The estimations results are presented in Table 2B:

	1988		1988 – 1993	
	(1)	(2)	(3)	(4)
β_1	−0.430 (1.021)	18.232*** (1.255)	−0.222 (0.497)	18.390*** (0.745)
$\beta_2 - y_i$	0.918*** (0.060)	–	0.896*** (0.029)	–
$\beta_3 - y_j$	0.870*** (0.038)	–	0.869*** (0.020)	–
$\beta_4 - d_{ij}$	−1.060*** (0.123)	−1.020*** (0.072)	−1.056*** (0.060)	−1.028*** (0.032)
$\beta_5 - \delta_{ij} \ln d_{ij}$	0.365*** (0.016)	0.235** (0.104)	0.344*** (0.008)	0.243*** (0.046)
Exporter FE	*no*	*yes*	*no*	*yes*+
Importer FE	*no*	*yes*	*no*	*yes*+
N	690	690	4140	4140
Robust standard errors in parentheses; Estimations based on PPML				
*,**,*** denote 10%, 5% and 1% significance, respectively				
+These are time-varying fixed effects				

Table 2B - Estimation results with and without fixed effects.

The results of Table 2B give some indication that the results provided in section 3 are likely to be robust to the inclusion of exporter and importer fixed effects. Even though there are some numerical differences the qualitative results do no differ and both regressions support the idea that distance affects intranational and international trade differently.