Border Effects and the Availability of Domestic Products Abroad[1]

Carolyn L. Evans[2]
Federal Reserve Bank of New York

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[2] International Research, 3rd Floor, Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 1004, Carolyn.Evans@ny.frb.org.

Abstract

Borders have a sizeable negative impact on trade flows. Given the vast number of individual goods potentially traded, this "border effect" could have two possible explanations: (1) less international than domestic trade in the goods that are actually traded between countries ("flow"); or (2) differences between the sets of goods traded internationally and domestically, i.e. fewer goods are available as exports than are sold in the home market ("availability"). Most of the previous literature on border effects has ignored the possible role of this second factor, instead reporting a single border effect which contains the embedded assumption that identical sets of goods are available in the domestic and export markets. In contrast to this assumption, evidence on the activities of firms shows that only a fraction of domestic products are actually exported.

This paper provides theoretical and empirical work that incorporates the distinction between the "flow" and "availability" explanations of border effects. A model which includes heterogeneous fixed costs of trade illustrates how either of these two factors could underlie a given border effect. The empirical work incorporates the fact that not all firms export by examining only the fraction of total domestic production attributable to those firms that actually do sell abroad. The results suggest that a portion of the border effect is indeed due to differences between the set of goods available domestically and internationally. I find that, on average across industries, around one-half of the border effect is due to the "flow" explanation, while the remaining half may be attributed to "availability." Given that the policy and welfare implications of border effects depend on the relative importance of these two explanations, future work should take care to specify clearly which aspect of the "border effect" is being measured.

1 Introduction

A growing literature has documented the downward impact of national borders on trade flows. With McCallum (1995) as the initial evidence, subsequent work has illustrated that countries' domestic trade volumes are often five to fifteen times larger than their imports, even after controlling for a number of explanatory factors. Given the vast number of individual goods potentially traded, this reduction in aggregate trade could have two possible explanations: (1) less international than domestic trade in the goods that are actually traded between countries ("flow"); or (2) differences between the sets of goods traded internationally and domestically, i.e. fewer goods are available as exports than are sold in the home market ("availability").[1]

Most of the previous literature on border effects has implicitly assumed that identical sets of goods are available in the domestic and export markets, thereby ignoring the possible role of availability and focusing only on the flow explanation of border effects.[2] In contrast to this assumption, a body of evidence suggests that a reduction in the number of goods being traded internationally may be at least part of the explanation of border effects. For example, Hillberry (2001) shows that U.S. states export only a portion of the available set of goods to Canada. More broadly, in 1992 only about 25

[1] Note that these two aspects are distinct but also related to each other. Ad valorem barriers which directly affect "flow" also affect the profitability of exporting and, thus, differences between the sets of goods traded internationally and domestically. In turn, the number of goods traded internationally affects the relative price of every individual good, although this effect will impact sales of both domestic goods and imports equally, and thus will not lead to border effects.

[2] Hillberry (2001) analyzes the effects of the fact that U.S. states export only a portion of their goods to Canada.

percent of all U.S. firms sold their products to other countries.[3]

If availability does indeed play a role, recognizing the distinction between these two explanations of border effects is critical, as the welfare effects, policy implications, and magnitude of implied ad valorem barriers to trade all depend on their relative importance.[4] For example, if fewer goods are traded internationally than domestically, a desire to increase trade flows would include analysis of the reasons why not all products are exported. On the other hand, a policy prescription could focus primarily on tariff reduction if all goods are traded both internationally and domestically, but ad valorem policy barriers impede the volume of international trade in each individual good. Interpretation of the ad valorem border barriers implied by measured border effects will also depend on whether empirical estimates take into account the possibility that not all domestic products may be available abroad.[5]

[3] U.S. Bureau of the Census (1992).

[4] In the model presented here, the welfare impact of a given border effect depends on the relative importance of the flow and availability explanations of border effects, with the magnitude of the difference depending on the elasticity of substitution, where welfare is measured as the realized utility level. In a more general sense, the effects of a given barrier are far higher when a change in the set of goods is taken into account. Romer (1994) provides a numerical example (for a model with fixed costs of trade) which illustrates that the reduction in national income caused by a 10 percent tariff is 20 percent if the set of goods imported falls, while it is only 1 percent if the set of goods remains constant. Klenow and Rodriguez-Clare (1997) calculate that welfare losses to Costa Rica from a 10 percent tariff are four times larger when a loss of variety is taken into account.

[5] Again note that ad valorem barriers have two effects. The direct effect of a given barrier is a reduction in the flow of the good which it impacts. The indirect effect is via its impact on the profitability of exporting and, thus, on its availability as an exportable. In order to measure the size of that barrier empirically, it is important to separate out the flows on which it clearly has this direct effect, i.e. trade in goods that are actually traded.

This paper provides theoretical and empirical work that incorporates the distinction between the "flow" and "availability" explanations of border effects. An illustrative model first incorporates a very plausible explanation of why all goods might not be traded: fixed costs of trade that vary across firms.[6] Within the model, the combination of fixed costs of trade, ad valorem trade costs, transport costs, and elasticities of substitution ultimately determine the profitability of exporting and, thus, the decision as to whether or not to enter the international market. The model illustrates how either, or both, a fall in the volume of trade in individual goods or a reduction in the set of goods traded may create border effects.

In my empirical work, I take into account the fact that not all firms sell abroad. If only a portion of domestic firms export, it is necessary to examine the fraction of total domestic production attributable to those firms that actually do sell abroad in order to measure the effects of borders on goods that are actually traded. Thus, I estimate border effects using only this portion of the aggregate domestic production bundle. By using this method, I do not need to specify the reasons why some firms export while others do not, so these empirical results are robust to a broad range of explanations of the decision to export, rather than being limited to the specific theoretical model presented here.

Otherwise, the border effect is the result of the indirect and direct effects of a given ad valorem barrier, as well as of the myriad of other factors which affect the profitability of exporting, including elasticities and the magnitude of fixed costs of trade.

[6] Note that the general point about the importance of differences between the production bundle available at home and abroad is not limited to this specific modeling context. As the empirics show, taking into account the fact that not all firms export their products changes the estimated ad-valorem impact of national borders, and this result would hold for a range of specific explanations of the heterogeneity across firms.

I provide estimates of the implied ad valorem costs of borders, as well as an indication of the portion of overall border effects and implied barriers that may be attributed to less trade in goods actually traded ("flow") rather than to availability. The results suggest that a portion of the border effect is indeed due to differences between the set of goods available domestically and internationally. I find that, on average across industries, around one-half of the border effect is due to the "flow" explanation, while the remaining half may be attributed to "availability."

The paper proceeds as follows. I first present an overview of the "benchmark" or standard model of trade in differentiated products and of my "amended" version in which only a fraction of firms export their products. In the empirical section, I estimate overall border effects and provide a decomposition into the flow and availability explanations. A summary and conclusions complete the paper.

2 Theory: The Benchmark and Amended Models

2.1 Introduction

Previous work has implicitly assumed that all goods sold domestically are also exported and thus attributed border effects to the effects of borders on the volume of trade in goods actually traded. This section provides a model which illustrates why, in fact, all firms may not export. If this is the case, a portion of measured border effects is in fact due to a difference between the bundle of goods traded domestically, as opposed to abroad.

More than one specific model could explain why some firms export while others do not. Ultimately, the profitability of exporting versus selling only domestically determines the decision as to whether or not to do so. In this section, I present a model which incorporates a very simple explanation of why some firms will choose to export, while others will not: heterogeneous fixed costs of trade. The model illustrates how the various factors affecting the profitability of exporting (including transport costs, border barriers, fixed costs of trade, and the elasticity of substitution among varieties of a product) determine the decision on whether to enter the international market. If doing so does not generate at least zero profits, a firm will not export, leading to a divergence between the sets of goods traded internationally and domestically.

The specific modeling framework is chosen to align with much of the recent literatures on both border effects and on explanations of trade flows. These previous studies of border effects have used the empirical framework of the gravity model of trade.[7] A common theoretical base for this gravity equation is a standard model of trade in which all countries produce and trade unique varieties of a differentiated product.[8]

Although this framework has proven both tractable and informative, two of its assumptions are at odds with recent empirical findings on the export process and on the identity of firms that sell internationally. First, the model assumes that the only costs of trade are of the per-unit iceberg form. In fact, a body of evidence suggests that fixed costs are an important

[7] A large number of studies document the empirical explanatory power of this model, which predicts that the aggregate volume of trade between two places will be determined by the income of the two countries and the distance between them. Some common references include Tinbergen (1962), Linneman (1966), and a large number of more recent papers.

[8] Such as in Helpman and Krugman (1985) and Deardorff (1998). In the version of the model used in this paper, a large number of varieties are produced within each country. No two countries or two firms produce exactly the same good.

element of beginning the export process.[9] Second, the model assumes that all firms are identical, both in production technology and in their access to the international market. Again, this assumption is at odds with recent empirical findings.[10] Exporters and non-exporters, in particular, have been found to differ substantially along several dimensions, including productivity and size.[11] In the theoretical model, these two assumptions lead to a result that again contradicts observational evidence: all firms export. In fact, in the U.S. in 1992 only about 25 percent of all firms sold their products to other countries.[12]

In order to illustrate why all goods may not, in fact, be exported, my amended model alters these two assumptions of the standard model. Thus, in order to export, firms incur fixed costs. Further, these fixed costs vary across firms. As a result of these modified assumptions, only a subset of domestic firms actually export. Consequently, even in the absence of ad valorem barriers to trade, borders may have a sizeable downward effect on trade flows because not all products available domestically are also exported. Thus, my modifications of the model illustrate that border effects may be due to a reduction in the number of goods traded, as well as to the direct effect of ad valorem border barriers on the volume of trade in individual goods.[13]

[9] Roberts and Tybout (1997), Bernard and Jensen (1995).

[10] Bernard and Jensen (1995, 1998), Roberts and Tybout (1997).

[11] Bernard and Jensen (1998), referring to Bernard and Jensen (1995).

[12] U.S. Bureau of the Census (1992).

[13] As discussed in notes 1 and 5, a given ad valorem border barrier has two effects - directly on the volume of trade in the individual good and indirectly on the profitability of exporting and thus on availability.

2.2 The Models

The benchmark model is a standard model of trade in differentiated products, such as in Helpman and Krugman (1985).[14] I assume that the number of varieties is fixed.[15] Appendix A also provides a version of the model in which N is endogenous; this version of the model provides similar results to those in the fixed N case. In this standard set-up, all firms are symmetric; they incur a one-time fixed cost to begin production. Once the initial up-front cost is paid, they are free to sell either domestically or to the foreign country. The only difference between domestic and international trade comes in the form of a difference in transport costs or in other trade costs of the iceberg form. An implication of these assumptions is that all firms sell in both the home and the export market.

As mentioned in the previous section, two aspects of this framework are at odds with empirical evidence. First, the model assumes that all firms are symmetric. Second, it assumes that the only distinction between domestic and international trade per se is in the form of differences in per-unit, iceberg costs of trade. These two assumptions in turn lead to the result that all firms export, an outcome also not consistent with empirical evidence.

The amended model alters these two assumptions of the benchmark

[14] See Appendix A for the full general equilibrium model, in which there are two countries, two goods, and one factor.

[15] As a result, in some cases active firms earn profits, which are rebated lump-sum to households and are part of national income. The appendix also presents versions of the models in which N is endogenous. The text focuses on the fixed N version because it illustrates more clearly the effects of a reduction in the set of goods traded and the implications of heterogeneous fixed costs of trade, and also allows for more obvious symmetry across the benchmark and amended models.

model.[16] First, there is a fixed cost of exporting which must be incurred in addition to the fixed cost of setting up a firm. A firm that wants to export as well as sell domestically must pay this additional fixed cost. These fixed costs of exporting could include the costs of setting up a distribution network or establishing brand recognition. There could also be costs associated with tailoring a product to fit the foreign consumer. For example, Roberts and Tybout (1997) note that many Columbian exporters were required to invest in product-quality upgrading after deciding to export.

Second, firms (indexed by i) are not identical; they differ in the magnitude of the fixed cost of exporting. For some firms, beginning the export process entails a fairly low fixed cost; for others, it is more costly. These differences across firms could be due to factors such as differences in knowledge of foreign markets, in levels of productivity in learning about exporting, or in access to information. In Columbia, as described by Roberts and Tybout (1997), larger firms found it easier to deal directly with final buyers in foreign countries than did smaller firms.

Solving the model requires first recognizing that all firms face a choice: to sell only domestically or to both sell domestically and export. Exporting will involve an additional fixed cost, so a firm will not choose to do so unless its resulting profits will at least cover the additional fixed cost. Along a distribution of fixed costs, firms with increasingly higher fixed costs will export up to and including the domestic (foreign) firm $\widetilde{i}(\widetilde{i^*})$ which will earn zero profits from entering the international market. Thus, all firms with fixed costs less than those of the $\widetilde{i}$ firm will export (and earn positive profits), whereas those with fixed costs above this firm will not.

[16] See Appendix A for the full general equilibrium model.

Thus, the assumptions of the amended model lead to the result that not all firms export. Note, however, that the overall set of firms that do actually export is determined by the profitability of doing so; this profitability is affected not only by fixed costs of trade, but also by border barriers, transport costs, and the elasticity of substitution. In any case, the ultimate impact is the same: only those firms with fixed exporting costs below the cutoff level export their products. Since all firms sell domestically, the range of varieties available at home versus as an export differs. As a result, differences between international and domestic trade are present both because of differences in the volume of trade in goods actually traded (as in the benchmark model) and also because of differences in the range of products available at home and abroad.

2.3 Consumption and Trade Flows

In the benchmark model, all firms both export and sell domestically. The price and the quantity produced will be the same across all varieties. Domestic consumption levels of an individual variety of the domestic and foreign differentiated product are described by the following two expressions:

$$C_x(i) = \frac{1}{p_x} \cdot \frac{\tau^{-\sigma}\gamma_X Y}{N\tau^{1-\sigma} + N^*(\tau^*\theta^*)^{1-\sigma}} \tag{1}$$

$$C_x^*(i^*) = \frac{1}{p_x} \cdot \frac{(\tau^*\theta^*)^{-\sigma}\gamma_X Y}{N\tau^{1-\sigma} + N^*(\tau^*\theta^*)^{1-\sigma}} \tag{2}$$

where $C_x(i)$ ($C_x^*(i^*)$) is domestic consumption of an individual variety i (i^*) of the domestic (foreign) good, γ_x is the share of the X good in spending, σ is the elasticity of substitution among varieties of the differentiated product, N (N^*) is the number of domestic (foreign) varieties, Y is national income,

τ (τ^*) represents domestic (international) transport costs, and θ^* is the ad valorem cost added by national borders.[17] The only difference between consumption of an individual variety of an import versus of a domestic good occurs because of differences in the iceberg transport costs, τ and τ^*, and the presence of ad valorem border barriers, θ^*. These ad valorem border barriers have a direct effect on the international versus domestic volume of trade in an individual good.

As for total trade flows, all varieties are both sold domestically and exported, so that total imports by the home country will be equal to $N^* C_x^*(i^*)$, and its exports will be $NC_x^F(i)$, where $C_x^F(i)$ represents consumption of a variety of the domestic good by the foreign country. Its total consumption of domestic goods will be $NC_x(i)$.

In the amended model, the expressions for consumption of an individual variety are quite similar to those for the benchmark model. Consumption levels of an individual variety of the domestic and foreign differentiated product are described by the following two expressions:

$$C_x(i) = \frac{1}{p_x} \cdot \frac{\tau^{-\sigma} \gamma_X Y}{N \tau^{1-\sigma} + \widetilde{i}^* (\tau^* \theta^*)^{1-\sigma}} \tag{3}$$

$$C_x^*(i^*) = \frac{1}{p_x} \cdot \frac{(\tau^* \theta^*)^{-\sigma} \gamma_X Y}{N \tau^{1-\sigma} + \widetilde{i}^* (\tau^* \theta^*)^{1-\sigma}} \tag{4}$$

where $\widetilde{i}^*$ is the number of foreign varieties imported by the domestic country. As in the benchmark model, the only difference between consumption of an individual variety of an import versus of a domestic good will occur because of differences in the iceberg transport costs, τ and τ^*, and in the iceberg costs of national borders, θ^*. Also as in the benchmark, the direct effect of

[17] Note that there are both domestic (τ) and international (τ^*) transport costs.

an ad valorem barrier occurs at this level of an individual good, leading to differences between consumption levels of the domestic good and the import.

On the other hand, for total trade flows there are important differences from the benchmark case. Since not all foreign varieties are imported, total imports by the home country will be equal to $\widetilde{i}^* C_x^*(i^*)$, rather than $N^* C_x^*(i^*)$, and its exports will be $\widetilde{i} C_x^F(i)$, rather than $N C_x^F(i)$. Domestic trade remains the same at $N C_x(i)$. Also, note that in the amended model, an ad valorem barrier has an indirect effect at this aggregate level (in addition to its direct effect at the level of the individual good) via its impact on the profitability of exporting and thus on $\widetilde{i}^*$.

2.4 The Border Effect and Empirical Implications

The border effect is represented by the difference between consumption of foreign and domestic goods, after controlling for the other explanatory variables in the model. In the benchmark model, aggregate trade flows (at either an industry or economy level) are used, so that the raw ratio of the two types of consumption will be:

$$\frac{N C_x(i)}{N^* C_x^*(i^*)} = \frac{\tau^{-\sigma} N}{(\tau^* \theta^*)^{-\sigma} N^*} \tag{5}$$

Empirical analysis usually makes the assumption that all goods are indeed traded internationally, and then controls for differences in traditional transport costs (τ, τ^*) and economy or industry size (N, N^*), so that the residual may then be interpreted as barriers to trade presented by national borders.

In the amended model, on the other hand, the raw ratio of total consumption of foreign and domestic goods will be:

$$\frac{N C_x(i)}{\widetilde{i}^* C_x^*(i^*)} = \frac{\tau^{-\sigma} N}{(\tau^* \theta^*)^{-\sigma} \widetilde{i}^*} \tag{6}$$

Note the difference between this expression and equation 5. Rather than N^*, $\widetilde{i}^*$ appears in the denominator. Previous empirical analysis has used GDP or total national production levels of the exporter on the right-hand-side in order to control for differences in N versus N^*; in using these aggregate GDP or production levels, the implicit assumption is made that this entire bundle of goods is available to the export market. The amended model, however, recognizes that not all domestic goods may be exported, and the relative consumption of domestic products versus imports is predicted to be higher than in the benchmark case.

Empirical estimates of relative consumption of domestic goods and of imports have shown that domestic goods are in fact consumed in a much higher proportion than are imports, after controlling for a number of the other explanatory factors. In the benchmark model, a reduction in the volume of trade in goods actually exchanged, due to higher marginal costs of international trade in the iceberg form, is the chief explanation for such deviation, so that the relatively lower levels of consumption of imports have been taken as evidence of the existence of large ad valorem barriers to trade at the border. The amended model introduces an additional explanation of these differing consumption levels. All firms sell domestically, but not all export, so that the range of products available at home, versus as an export, differs. As a result, differences between international and domestic trade are present both because of differences in per-unit iceberg costs and the resulting reduction in the volume of trade at the level of the individual good (as in the benchmark model), and also because of differences in the range of products available at home and abroad.

The presence of these two effects has implications for the interpretation of border effects. A given aggregate border effect could arise from a reduction in the volume of trade in an individual good, a reduction in the set of goods available abroad as opposed to domestically, or a combination of these two factors. Table 1 provides an example in which the same aggregate border effect could be caused by any of these three possibilities.[18] The results are based on the general equilibrium model presented in Appendix A. In Column (i), a 54 percent ad valorem trade barrier leads to a border effect of 6; this effect occurs entirely via a reduction in the volume of trade in each individual imported variety. In Column (ii), on the other hand, the same border effect of 6 results from a case with absolutely no ad valorem barrier to trade, but differences between the sets of goods traded internationally and domestically. Whereas 50 varieties are produced and consumed domestically, only 9 of them are exported. Column (iii) illustrates how this same border effect could also be due to a combination of these two factors.[19]

[18] These results are based on numerical solutions to the two general equilibrium models presented in Appendix A. Parameter assumptions are also in Appendix A. I assume symmetry between the two countries in country size and number of varieties, and an elasticity of substitution between varieties of two. In addition, I assume that international transport costs are equal to domestic transport costs. Similar parameter assumptions are made for the two models. Appendix A, Table A1, also provides numerical results for the model with N endogenous. The outcomes are broadly similar, except that the border effect in the amended model with endogenous N is larger than in the version with fixed N.

[19] I have also examined the effects of changes in the parameters which affect the zero profit condition for the cutoff $(\widetilde{i})$ firm and thus the proportion of firms that export and the magnitude of the border effect. I have examined results for the cases with both fixed and endogenous N; they are broadly similar. The results show that an increase in the elasticity of substitution leads to a fall in the number of imported varieties $(\widetilde{i}^*)$ and an increase in the border effect, while an increase in the fixed costs of trade reduces the number of imported varieties relative to the total number of varieties and increases the border effect. Increases in the iceberg cost of transporting goods internationally (τ^*)

Some studies have interpreted a given border effect as implying something about the level of ad valorem barriers to trade. However, as the example illustrates, when the assumption is made that identical sets of goods are available domestically and internationally, aggregate border effects may provide misleading information about the level of underlying border barriers. This mismeasurement arises in part because, in the amended model, a given per-unit trade cost affects the profitability of exporting and thus the range of products available abroad. This indirect effect is in addition to the direct effect on the volume of trade in an individual good. Thus, when examining aggregate trade flows without dealing with the possibility that all goods may not be exported, a given border effect combines the direct and indirect effects of a given ad valorem barrier, as well as other factors, such as transport costs, fixed trade costs, and elasticities, which determine the set of goods that are actually exported. In order to correctly measure the implied ad valorem barrier, it is instead necessary to examine only the portion of goods which are actually available both at home and abroad. Further, given that the welfare and policy implications of border effects depend on the relative importance of the flow and availability explanations, correct interpretation of the sources of border effects is critical.

3 Introduction to Empirics

3.1 The Benchmark and the Amended Model

In the context of the gravity model, previous empirical work has implicitly utilized the benchmark model described above. Taking logs from the the-

and in marginal barriers to international trade (θ^*) lead only to very small changes in the relevant variables. The results are available from the author upon request.

oretical expressions above (equations 1, 2), the difference between domestic and international aggregate trade flows in the benchmark case will be:

$$\ln NC_x - \ln N^*C_x^* = \ln(\frac{N}{N^*}) + \ln(\frac{\tau}{\tau^*})^{-\sigma} + \ln(\frac{1}{\theta^*})^{-\sigma}$$

Empirically, differences between international and domestic production levels and transport costs are controlled for (i.e. $N = N^*$, $\tau = \tau^*$), so that the difference between domestic and international trade, i.e. the border effect, is:

$$\ln NC_x - \ln N^*C_x^* = \ln(\frac{1}{\theta^*})^{-\sigma} = \sigma \ln \theta^*$$

However, if not all firms export the difference between international and domestic trade is, by contrast (from equations 3, 4):

$$\ln NC_x - \ln \widetilde{i}^*C_x^* = \ln(\frac{N}{\widetilde{i}^*}) + \ln(\frac{\tau}{\tau^*})^{-\sigma} + \ln(\frac{1}{\theta^*})^{-\sigma}$$

If empirical analysis assumes identical production levels and transport costs for both domestic and international trade (i.e. $N = N^*$, $\tau = \tau^*$), then the difference, i.e. the border effect, becomes:

$$\begin{aligned}\ln NC_x - \ln \widetilde{i}^*C_x^* &= \ln N^* - \ln \widetilde{i}^* + \ln(\frac{1}{\theta^*})^{-\sigma} \\ &= \ln N^* - \ln \widetilde{i}^* + \sigma \ln \theta^*\end{aligned}$$

in which case the measured border effect captures both ad valorem barriers to trade and the difference between production levels available at home and abroad. As such, it combines the effects of a reduction in the volume of goods actually traded and a reduction in the number of goods in the export production bundle. Further, it does not provide an accurate measure of per unit impediments to trade across countries.

To address this issue, my own empirical analysis instead controls for the portion of aggregate domestic production actually available to foreign consumers. I then compare measures of border effects in the benchmark-type analysis to those in my amended model in order to examine the extent to which ignoring the distinction highlighted here affects estimates of border effects, thereby providing an indication of the relative importance of the flow and availability explanations of border effects.

3.2 Multi-country Gravity Model

For the empirical analysis, I use a multi-country industry-level gravity model which may be derived from the theoretical model described in the previous section.[20] Taking logs and assuming that the price of a good is one in the country of origin, the expression for aggregate imports by country c from country $c^{'}$ forms the basis for the estimation:

$$\begin{aligned} \log(N_{c^{'}}^{x} C_{cc^{'}}^{x}(i)) &= \log Y_c + \log Y_{c^{'}}^{x} + \log A_{c^{'}}^{x} + \log A_c^{x} \\ &\quad -\sigma^x \log \tau_{cc^{'}}^{x} - \sigma^x \log \theta_{cc^{'}}^{x} \end{aligned} \tag{7}$$

where Y_c is the income of the importer, $Y_{c^{'}}^{x}$ is total production by the producer ($c^{'}$) of good x, σ^x is the elasticity of substitution among varieties of good x, $\tau_{cc^{'}}^{x}$ and $\theta_{cc^{'}}^{x}$ represent, respectively, transportation costs (either domestic or international) and other costs of international trade, and $A_{c^{'}}^{x}$ and A_c^{x} are measures of a country's potential alternative trading partners; they

[20] See Appendix A. Note that translation of the model to the multi-country setting entails the implicit assumption that the fixed cost of exporting is the same across all partner countries and that once the exporting fixed cost is paid, a firm is able to export to any partner country. Given data availability, these assumptions are in accord with the nature of the data used for the analysis.

measure the distance-weighted GDP of a given country from these alternative partners.[21]

I assume that $\theta^x_{cc'} = 1$ for trade within a country, i.e. if $c' = c$. Thus, this variable ($\theta^x_{cc'}$) will capture differences between international and domestic trade. The border effect is the difference between local and international trade for two locations having identical values for all variables in the model other than $\theta^x_{cc'}$, i.e. $\sigma_x \log \theta^x_{cc'}$.[22]

The actual empirical specification will be:

$$\begin{aligned}\log SHIP^x_{cc'} &= \alpha_0 + \beta_1 \log GDP_c + \beta_2 \log PROD^x_{c'} \quad (8)\\ &+\beta_3 \log DIST_{cc'} + \beta_4 \log ALT_{c'} + \beta_5 \log ALT_c \\ &+\gamma HOME \quad (9)\end{aligned}$$

where GDP_c is national income, $PROD^x_{c'}$ is production of country c' in industry x, $DIST_{cc'}$ is the distance between c and c', ALT_c ($ALT_{c'}$) is the measure of alternative trading partners for country $c(c')$,[23] and $HOME$ is a dummy variable which takes the value 1 for trade within a country and 0 otherwise.

[21] See Appendix A for exact functional form.

[22] Note that in levels, rather than logs, it will be $\exp(\sigma^x \log \theta^x_{cc'})$.

[23] This measure of alternative trading partners ($ALT_{c'}$, ALT_c) is intended to capture the distance of a given country (c, c') from alternative trading partners. My empirical proxy for availability of alternative partners is based on the specification of Helliwell and Verdier (2000):

$$ALT_c = \sum_{c'} \frac{GDP_{c'}}{DIST_{cc'}}$$

where the countries c' are all of c's trading partners in the sample. Although not a direct translation of the theoretical definition of this term, this form captures the essential elements of the variable and embodies a number of desirable characteristics for this variable. See Helliwell and Verdier (2000) and Stein and Weinhold (1999).

In the amended model, for domestic trade observations, an expression such as equation 7 will be used, since the entire domestic production bundle is available within the producing country. For the international (i.e. bilateral trade) observations, on the other hand, the expression comparable to equation 7 will be:

$$\log(\widetilde{i}^x_{c'} C^x_{cc'}(i)) = \log Y_c + \log Y^{x\widetilde{i}}_{c'} + \log A^x_{c'} + \log A^x_c - \sigma^x \log \tau^x_{cc'} - \sigma^x \log \theta^x_{cc'} \tag{10}$$

where $Y^{x\widetilde{i}}_{c'}$ represents the proportion of domestic production actually available in foreign markets, rather than the entire domestic production bundle ($\log Y^x_{c'}$). This alteration reflects the fact that domestic and international trade flows may differ not only because of the effects of ad valorem trade costs on the volume of trade, but also because of differences in the number of varieties available domestically and abroad. The empirical specification follows similarly to equation 8.

3.3 The Data[24]

Investigation of the effect of fixed costs and variety availability on border effects requires a measure of the portion of the domestic production bundle actually available as an export. The U.S. Census of Manufactures provides information on the proportion of total domestic production accounted for by firms that both export and sell domestically. For example, suppose that industry total production is \$10 million; of this \$10 million, $\frac{1}{2}$ is produced by firms that both export and sell domestically, while the other $\frac{1}{2}$ is produced by firms that only sell domestically. There is no restriction on the portion of

[24] The data and sources are described in more detail in Appendix B.

the \$5 million produced by exporters which is sold domestically or exported. This information is provided at the 2-digit SIC level for two years, 1987 and 1992. Table 2 provides the available ratios.[25]

In order to use this information most accurately, I focus on the U.S. as an exporter to a number of countries, as well as on the domestic trade flows for this sample of countries. The other countries included in the data set are Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, and the United Kingdom. The industry disaggregation is at the 2-digit USSIC level.

This U.S. Census of Manufactures data on production by exporters is used to adjust the U.S.-exporter production level ($PROD^x_{c'}$) for exporters in the amended case, but not for the benchmark one. Thus, the benchmark regression uses data on total industrial production within an industry within a country, for all observations, including for U.S. exports. The amended regression uses U.S. production levels which have been adjusted in the observations on U.S. exports in order to account for the fact that the available U.S. production bundle differs for domestic sales and for exports. This adjustment involves multiplying the exporter production to all firm production ratio from the U.S. Census of Manufactures data (i.e. 50 percent in the example here) by aggregate industry production within the U.S. For the case of domestic sales (in all of the countries in the sample), production levels are not adjusted. This procedure should capture the fact that the production bundles available domestically and in foreign countries differ.

The dependent variable ($SHIP^x_{cc'}$) will be goods consumption by a coun-

[25] Differences across industries in this ratio are not necessarily linked directly to differences across industries in the magnitude of fixed costs, but are instead linked to the relative overall profitability of exporting.

try c of goods produced by producer c' in industry x. For the case of imports from the U.S., I use bilateral industry-level import data. For a measure of "domestic trade," i.e. how much a country consumes of its own goods, I use data on national production (gross output) within an industry less total gross exports by that industry.

The measure of bilateral distance ($DIST_{cc'}$) is the great circle distance, generally from capital to capital, between the two trading countries. For trade within a country, own distances are calculated as $\frac{1}{4}$ of the distance to the nearest trading partner; for islands, own distance was calculated as $\frac{1}{2}$ of the minor radius of the country.[26]

As mentioned above, the dummy variable $HOME$ captures the differences in consumption levels depending on the source of production. $HOME$

[26] The correct measure of domestic distance is an important issue. The main measure used here is based on Wei (1996) and has been used extensively. Although not ideal in the sense that it may not capture the exact distance over which domestic trade occurs, this measure should depict variation across countries in domestic transport costs. In fact, Helliwell (1997b) notes that for trade within Canada, this proxy produces measures very close to those calculated from data on interprovincial trade distances and some assumed distances for intra-provincial distances.

A number of recent papers (Helliwell and Verdier (2000), Nitsch (2000a, 2000b)) have examined variation across different alternative measures of domestic distance. This more recent work shows that for most countries the Wei measure is too small. A number of alternatives exist. Helliwell and Verdier (2000) suggest a population-weighted average internal distance, which takes a much more detailed account of a country's shape and structure. This is a very data-intensive calculation, which they have performed only for the U.S. and Canada. Nitsch (2000a, 2000b) proposes taking a country's own geographic size into account by using $\frac{1}{\sqrt{\Pi}} * \sqrt{AREA}$ and finds that this method yields reasonable results for the majority of governmental districts in Germany. Future research in the direction of Helliwell and Verdier should provide valuable additional information on internal country distances.

takes the value of 1 when the consumer and the producer are in the same location country and zero otherwise. Thus, the magnitude of the border effect ($\exp(\sigma^x \log \theta^x_{cc'})$ in the theoretical model) will be $\exp(\gamma)$, where γ is the coefficient on the $HOME$ dummy variable.

4 Empirical Results

To implement the test, I run two separate equations simultaneously in a three-stage-least-squares framework. The first equation contains the benchmark model and data, while the second is associated with the amended model with the adjusted U.S. exporter production data. Thus, the coefficient on the border variable ($HOME$) in the benchmark model includes the effects of all differences between international and domestic trade, while the amended model eliminates the portion of the border effect due to the fact that not all firms export. Thus, the amended model illustrates the border effect for goods that are actually traded. I test for equality of the border effect in the two models. Instrumental variables techniques are used due to the endogeneity of production and GDP.[27] Industry and year fixed effects and distance-industry interaction terms are included.

[27] The estimation technique is three-stage-least-squares with population and population-based remoteness measures as instruments for GDP and GDP-based remoteness measures. As instruments, based on Harrigan (1995, 1996), several endowment measures are used as instruments for production levels. Measures of the log of the number of workers, the log of the capital stock, and the log of agricultural land are interacted with industry dummy variables to create a set of $12 * 3 = 36$ instruments for production. Note that with three-stage-least-squares, all non-endogenous independent variables are also included in the set of instruments. Industry-specific regressions of the log of production on the instruments yields R^2s ranging between .68 and .98 for the benchmark case, and between .65 and .98 for the amended case.

Table 3 provides the results. The results for the two equations at the aggregate level are reported in columns (ia) and (ib), followed by the implied border effect and the p-value associated with the hypothesis that the benchmark and amended border effects are equal. The overall results indicate border effects for the two cases which do differ significantly from each other, as shown by the p-value in column (ie).

As for the industry level, in the benchmark case (Column (iia)), all industries except for SIC 35 (Industrial machinery and equipment) and 37 (Transportation equipment) exhibit statistically significant border effects. Magnitudes range between 2 and 194 (Column iic). For the amended model (Column (iib)), on the other hand, both border effects and significance levels are lower in all industries. Note that the amended model estimates provide some indication of the magnitude of the flow portion of border effects; they suggest to what extent the effects of ad valorem barriers on goods actually exchanged impede trade. For five of the industries, the border coefficient is not statistically significant. Border effect magnitudes range between 2 and 174. The P-values in the table indicate that I can reject the hypothesis that the coefficient on the border variable is the same in the two models for all industries, except for SIC 21 (Tobacco Products) and SIC 38 (Instruments). Thus, the results suggest that a portion of previously-reported border effects may indeed be due to differences in the sets of goods available at home and abroad, as opposed to being due only to a reduction in the volume of goods actually traded.

The gap between the measured border effects in the benchmark and the amended models differs across industries. This gap provides information about the relative importance of the flow and availability aspects of the overall border effect, since the amended model results indicate the portion due to impediments to goods actually traded. Table 4 provides the percent of the overall border effect and implied ad valorem border impediments attributable to this flow explanation. The remainder of the border effect may be attributed to differences between the sets of goods available at home and abroad.[28] The flow portion of border effects ranges from a low of 23 percent to a high of 90 percent. The portion of implied ad valorem border barriers due to impediments on goods actually traded varies between 39 percent and 97 percent.[29] In the context of the model presented above, variation across industries could correspond to the relative profitability of exporting. Industries with a low flow component are those in which a large part of the benchmark border effect could be due to the fact that only a small portion of the domestic production bundle is available as an export. For these industries, exporting would tend to be relatively less profitable, whether due to high ad valorem trade costs, high transport costs, high fixed costs of trade, high elasticities of substitution, or some combination thereof.

5 Summary and Conclusions

A growing literature has documented the downward impact of national borders on trade flows. For the most part, this literature has ignored the distinction between two broad explanations of border effects: (1) less inter-

[28] Based on the definition of the border effect, the implied barrriers may be calculated as $\theta^x_{cc'} = \exp[\frac{\gamma^x}{\sigma}] - 1$, where γ^x is the coefficient on the $HOME$ dummy variable within industry x. The results for the implied border barriers are based on three values for the elasticity of substitution between domestic goods and imports (σ).

[29] Although I have used one value for the elasticity for all industries for illustrative purposes, clearly this number will vary across industries. See Hummels (1999) for some discussion of estimation of industry-level elasticities.

national than domestic trade in the goods that are actually traded between countries ("flow"); or (2) differences between the sets of goods traded internationally and domestically, i.e. fewer goods are available as exports than are sold in the home market ("availability"). This paper provides theoretical and empirical work that incorporates this distinction. A model which includes heterogeneous fixed costs of trade illustrates how either of these two factors could underlie a given border effect. The empirical work then incorporates the fact that not all firms export by examining only the fraction of total domestic production attributable to those firms that actually do sell abroad. The results suggest that a portion of the border effect is indeed due to differences between the sets of goods available domestically and internationally. I find that, on average across industries, around one-half of the border effect is due to the "flow" explanation, while the remaining half may be attributed to "availability." Given that the policy and welfare implications of border effects differ depending on the relative importance of these two explanations, future work should take care to specify clearly which aspect of the "border effect" is being measured.

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A Theory Appendix

A.1 The Benchmark Model

The model is a standard model of trade in differentiated products, such as in Helpman and Krugman (1985). There are two countries, two goods, and one factor (L). One good, Y, is a homogeneous product which is costlessly traded; Y will serve as numeraire. The other good, X, is a differentiated product, which incurs both domestic and international transport costs. Both countries produce a large number of varieties of the differentiated product; I assume that the number of varieties is fixed. As a result, in some cases active firms earn profits, which are rebated lump-sum to households and are part of national income.

Consumer optimization is based on the utility function:

$$
\begin{aligned}
U &= C_Y^{\gamma_Y} C_X^{\gamma_X} \\
C_X &= (\sum_{i=1}^{N} C_x^{\rho}(i) + \sum_{i=N+1}^{N^*} C_x^{*\rho}(i^*))^{\frac{1}{\rho}}
\end{aligned}
$$

where $C_x(i)$ ($C_x^*(i^*)$) is domestic consumption of an individual variety i (i^*) of the domestic (foreign) good, $\gamma_x + \gamma_y = 1$, $\rho = \frac{\sigma-1}{\sigma}$, and σ is the elasticity of substitution among varieties of the differentiated product; N (N^*) is the number of domestic (foreign) varieties.

Y is produced using a constant-returns-to-scale technology:

$$L_Y = \beta_Y Y$$

X has increasing-returns-to-scale in production:

$$L_x(i) = \beta_X x(i) + \lambda_X$$

where $x(i)$ is the quantity of an individual variety i of x produced, λ_X is the fixed cost of production, and β_X is the marginal cost. Technology and preferences are similar in the foreign country.

This model may be solved for the six endogenous variables (w, p_x, x, x^*, Y, Y^*). The wage to labor is the same in both the foreign and home country, and is given by:

$$w = \frac{1}{\beta_Y}$$

The price of an individual variety of the differentiated product is:

$$p_x = \frac{\sigma}{\sigma - 1}(\frac{\beta_X}{\beta_Y})$$

The price and the quantity produced will be the same across all varieties. All firms both export and sell domestically.

The quantity of Y produced domestically is:

$$
\begin{aligned}
Y &= (\frac{\overline{L}}{\beta_Y} + \Pi) \cdot [\gamma_Y + \frac{N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}{N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}} \cdot \gamma_X] \\
&\quad -(\frac{\overline{L}^*}{\beta_Y} + \Pi^*) \cdot [\frac{N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}{N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}} \cdot \gamma_X]
\end{aligned}
$$

where τ (τ^*) represents domestic (international) transport costs, and θ^* is the ad valorem cost added by national borders.

The quantity of Y produced in the foreign country is:

$$
\begin{aligned}
Y^* &= (\frac{\overline{L^*}}{\beta_Y} + \Pi^*) \cdot [\gamma_Y + \frac{N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}{N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}} \cdot \gamma_X] \\
&\quad -(\frac{\overline{L}}{\beta_Y} + \Pi) \cdot [\frac{N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}{N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}} \cdot \gamma_X]
\end{aligned}
$$

where

$$
\begin{aligned}
\Pi &= \frac{\beta_X \sigma \cdot (N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) \cdot (x^* - x(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1})}{\beta_Y(\sigma-1)\gamma_X((\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma} - (\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1})} - \frac{\overline{L}}{\beta_Y} \\
\Pi^* &= \frac{\beta_X \sigma \cdot (N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) \cdot (x - x^*(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1})}{\beta_Y(\sigma-1)\gamma_X((\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma} - (\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1})} - \frac{\overline{L}^*}{\beta_Y}
\end{aligned}
$$

As for x and x^*, the quantities of an individual variety of the X good produced, the model yields the following two equations in two unknowns:

$$
\begin{aligned}
x &= (\overline{L} - N\lambda_X) \\
&\quad \cdot \left\{ \frac{(\sigma-1)\gamma_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})}{\sigma\beta_X(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1}(N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) - \gamma_X N \beta_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} \right\} \\
&\quad + x^* \left\{ \frac{\beta_X \sigma * (N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})}{\sigma\beta_X(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1}(N + N^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) - \gamma_X N \beta_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} \right\}
\end{aligned}
$$

$$
\begin{aligned}
x^* &= (\overline{L}^* - N^*\lambda_X) \\
&\cdot \left\{ \frac{(\sigma-1)\gamma_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})}{\sigma\beta_X(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1}(N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) - \gamma_X N^*\beta_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} \right\} \\
&+x \left\{ \frac{\beta_X\sigma * (N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})}{\sigma\beta_X(\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1}(N^* + N(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}) - \gamma_X N^*\beta_X((\frac{(\tau^*\theta^*)}{\tau})^{\sigma-1} - (\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} \right\}
\end{aligned}
$$

which may be solved explicitly for x and x^*.

A.2 The Amended Model

As with the benchmark, the model is a standard model of trade in differentiated products, such as in Helpman and Krugman (1985). There are two countries, two goods, and one factor (L). One good, Y, is a homogeneous product which is costlessly traded; Y will serve as numeraire. The other good, X, is a differentiated product, which incurs both domestic and international transport costs. Both countries produce a large number of varieties of the differentiated product, with the number of varieties fixed. The number of varieties is N (N^*), and firms are indexed by i (i^*). In some cases active firms thus earn profits, which are rebated lump-sum to households and are part of national income.

The major difference between the benchmark model and the amended model lies in the assumptions about production technology and the nature of firms. In this amended set-up, firms face a fixed cost of exporting, which must be incurred in addition to the fixed cost of setting up to sell domestically. There is heterogeneity across the set of firms in the magnitude of this fixed exporting cost. With firms indexed by i (i^*), it is given by $\lambda^E(i)$ ($\lambda^E(i^*)$).

Consumer optimization is based on the utility function:

$$\begin{aligned} U &= C_Y^{\gamma_Y} C_X^{\gamma_X} \\ C_X &= (\sum_{i=1}^{N} C_x^{\rho}(i) + \sum_{i^*=N+1}^{\widetilde{i}^*} C_x^{*\rho}(i^*))^{\frac{1}{\rho}} \end{aligned}$$

where $\gamma_x + \gamma_y = 1$, $\rho = \frac{\sigma-1}{\sigma}$, and σ is the elasticity of substitution among varieties of the differentiated product; N is the number of domestic varieties, while $\widetilde{i}^* \leqslant N^*$ is the number of foreign varieties available in the domestic market.

Y is produced using a constant-returns-to-scale technology:

$$L_Y = \beta_Y Y$$

X has increasing-returns-to-scale in production. For producing domestically,

$$L_x^D(i) = \beta_X x^D(i) + \lambda_X$$

where $x^D(i)$ is the quantity of variety i produced and sold in the domestic market, λ_X is the fixed cost of production, and β_X is the marginal cost. In order to export as well, firms face the following production requirements:

$$L_x^E(i) = \beta_X x^E(i) + \lambda^E(i)$$

where $x^E(i)$ is the quantity of an individual variety i of x produced for the export market, $\lambda^E(i)$ is the fixed cost of exporting for the i firm, and β_X is the marginal cost. I assume the functional form $\lambda^E(i) = \delta i$, where $\delta > 0$. Technology and preferences are similar in the foreign country.

In this amended model, there are ten endogenous variables: $\widetilde{i}$, $\widetilde{i}^*$, w, p_x, $x^D(i)$, $x^{D*}(i^*)$, $x^E(i)$, $x^{E*}(i^*)$, Y, and Y^*. $\widetilde{i}(\widetilde{i}^*)$ will be the index for the division between those domestic (foreign) firms that export and those that do not. Thus, all firms with fixed costs less than those of the $\widetilde{i}$ firm will export, whereas those with fixed costs above this firm will not. To solve the model, I assume that all firms face the choice of selling only domestically or of selling domestically and exporting. The cutoff $\widetilde{i}$ is determined by the firm that is indifferent between the two options. Thus, the $\widetilde{i}$ firm will earn no profits from exporting, but all firms with $i < \widetilde{i}$ will earn positive profits from doing so.

In order to clear the export market, all exporters produce the same quantity as the $\widetilde{i}$ firm; all firms charge the same at-the-factory price. (All firms also produce identical amounts for the domestic market.)

The wage to labor is the same in both the foreign and home country, and is given by:

$$w = \frac{1}{\beta_Y}$$

The price of an individual variety of the differentiated product is:

$$p_x = \frac{\sigma}{\sigma - 1}(\frac{\beta_X}{\beta_Y})$$

Note that these expressions are identical to those in the benchmark case.

Domestic production levels of the individual varieties by are given by:

$$x^D(i) = \frac{(\sigma - 1)\gamma_X(\overline{L} + \beta_Y \Pi)}{\beta_X \sigma(N + \widetilde{i}^*(\frac{(\tau^* \theta^*)}{\tau})^{1-\sigma})}$$

$$x^E(i) = \frac{(\sigma - 1)\delta\widetilde{i}}{\beta_X}$$

with similar expressions for the foreign country. Domestically-produced Y is:

$$Y = \gamma_Y(\frac{\overline{L}}{\beta_Y} + \Pi) + \frac{\sigma\delta((\widetilde{i}^*)^2 - (\widetilde{i})^2)}{\beta_Y}$$

and similarly for Y produced in the foreign country.

Finally, I am left with two equations in two unknowns, $\widetilde{i}$ and $\widetilde{i}^*$.

$$\begin{aligned}\overline{L} &= \left[(\widetilde{i}^*)^2 + \widetilde{i}^* \frac{N}{(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}\right] \cdot \left[\frac{(\sigma-1)\delta N}{(N + \widetilde{i}^*(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} + \frac{\sigma\delta}{\gamma_X}\right] \\ &\quad -\widetilde{i}^*\left[\frac{N\delta\sigma}{(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}\right] + N\lambda^D + \frac{\delta}{2}(\widetilde{i} - (\widetilde{i})^2)\end{aligned}$$

and

$$\begin{aligned}\overline{L}^* &= \left[(\widetilde{i})^2 + \widetilde{i} \frac{N^*}{(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}\right] \cdot \left[\frac{(\sigma-1)\delta N^*}{(N^* + \widetilde{i}(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma})} + \frac{\sigma\delta}{\gamma_X}\right] \\ &\quad -\widetilde{i}\left[\frac{N^*\delta\sigma}{(\frac{(\tau^*\theta^*)}{\tau})^{1-\sigma}}\right] + N^*\lambda^D + \frac{\delta}{2}(\widetilde{i}^* - (\widetilde{i}^*)^2)\end{aligned}$$

which I solve numerically for $\widetilde{i}$ and $\widetilde{i}^*$.

A.3 The Models with Endogenous N

Making N endogenous involves introducing two additional equations and two additional endogenous variables (N, N^*). The two additional equations are zero profit conditions for the number of firms. In the benchmark model, this equation will be:

$$p_x \cdot x(i) = w(\beta_X x(i) + \lambda_X)$$

In the amended model, it will be:

$$p_x \cdot x^D(i) = w(\beta_X x^D(i) + \lambda_X)$$

The benchmark model now has eight endogenous variables (w, p_x, x, x^*, Y, Y^*, N, N^*). The wage and price remain the same as in the fixed N case. For the other variables of interest, the relevant expressions are as follows.

Production of an individual variety (x) of the X good:

$$x = \frac{\lambda_X \cdot (\sigma - 1)}{\beta_X}$$

$$x^* = \frac{\lambda_X \cdot (\sigma - 1)}{\beta_X}$$

Number of domestic and foreign varieties:

$$N = \frac{\gamma_X \cdot ((\tau^*\theta^*)^{1-\sigma}\overline{L}^* - \tau^{1-\sigma}\overline{L})}{((\tau^*\theta^*)^{1-\sigma} - \tau^{1-\sigma}) \cdot \lambda_X \sigma}$$

$$N^* = \frac{\gamma_X \cdot ((\tau^*\theta^*)^{1-\sigma}\overline{L} - \tau^{1-\sigma}\overline{L}^*)}{((\tau^*\theta^*)^{1-\sigma} - \tau^{1-\sigma}) \cdot \lambda_X \sigma}$$

The amended model now has twelve endogenous variables: $\widetilde{i}$, $\widetilde{i^*}$, w, p_x, $x^D(i)$, $x^{D*}(i^*)$, $x^E(i)$, $x^{E*}(i^*)$, Y, Y^*, N, and N^*. The wage and price again remain the same as in the fixed N case. For other variables of interest, the relevant expressions are:

Production for the domestic market of an individual variety (x) of the X good:

$$x^D(i) = \frac{\lambda_X(\sigma - 1)}{\beta_X}$$

$$x^{D*}(i) = \frac{\lambda_X(\sigma - 1)}{\beta_X}$$

Production for export of an individual variety (x) of the X good:

$$x^E(i) = \frac{(\sigma - 1)\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\beta_X}$$

$$x^{E*}(i) = \frac{(\sigma - 1)\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\beta_X}$$

Number of varieties exported:

$$\widetilde{i} = \frac{\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\delta}$$

$$\widetilde{i}^* = \frac{\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\delta}$$

Number of total varieties:

$$N = \frac{\gamma_X \overline{L}}{\lambda_X \sigma} + \left(\frac{\gamma_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{2\sigma}\right) \cdot \left\{\frac{\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\delta} - 1\right\} - \left((\frac{\tau^*\theta^*}{\tau})^{2-2\sigma}\right)\left(\frac{\lambda_X}{\delta}\right)$$

$$N^* = \frac{\gamma_X \overline{L}^*}{\lambda_X \sigma} + \left(\frac{\gamma_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{2\sigma}\right) \cdot \left\{\frac{\lambda_X(\frac{\tau^*\theta^*}{\tau})^{1-\sigma}}{\delta} - 1\right\} - \left((\frac{\tau^*\theta^*}{\tau})^{2-2\sigma}\right)\left(\frac{\lambda_X}{\delta}\right)$$

A.4 Parameters for numerical example

I make the following assumptions:

Parameter	Benchmark Model	Amended Model
$\overline{L}$	$10,000$	$10,000$
$\overline{L}^*$	$10,000$	$10,000$
N	50	50
N^*	50	50
σ	5	5
γ_Y	0.5	0.5
γ_X	0.5	0.5
β_Y	1	1
β_X	2	2
λ_D	10	10
τ^*	1	1
τ	1	1

A.5 Numerical Example

A brief numerical comparison between the two models illustrates that a given aggregate border effect may be due to a reduction in the volume of trade in an individual good, a reduction in the set of goods available abroad as opposed to domestically, or a combination of these two factors. Table 1 provides an example in which the same aggregate border effect could be caused by any of these three possibilities. For these calculations, I assume symmetry between the two countries in country size and number of varieties and an elasticity of substitution between varieties of two. In addition, I assume that international transport costs are equal to domestic transport costs. Similar parameter assumptions are made for the two models. The results are in Table 1 and are described in the text.[30] Table A1 provides the results for the case with N endogenous.

A.6 Multi-country gravity model

For the empirical portion of the paper, I derive a multi-country gravity model based on the two country model described above. In the benchmark model, aggregate imports by country c from country c' are given by the following expression:

$$N^x_{c'} C^x_{cc'}(i) = \frac{Y^x_{c'}(w_c \overline{L}_c + \Pi_c)}{(p^x_{c'c'})^{\sigma^x}(\tau^x_{cc'}\theta^x_{cc'})^{\sigma^x} P^x_c(\sum_c \frac{w_c\overline{L}_c+\Pi_c}{(p^x_{c'c'}\tau^x_{cc'}\theta^x_{cc'})^{(\sigma^x-1)}P^x_c})}$$

where $P^x_c = \sum_{c'} N_{c'}(p^x_{c'c'}\tau^x_{cc'}\theta^x_{cc'})^{(1-\sigma)}$.

In the amended model, the expression is:

$$\widetilde{i}^x_{c'} C^x_{cc'}(i) = \frac{Y^x_{c'\widetilde{i}^x_{c'}}(w_c \overline{L}_c + \Pi_c)}{(p^x_{c'c'})^{\sigma^x}(\tau^x_{cc'}\theta^x_{cc'})^{\sigma^x} \widetilde{P}^x_c(\sum_c \frac{w_c\overline{L}_c+\Pi_c}{(p^x_{c'c'}\tau^x_{cc'}\theta^x_{cc'})^{(\sigma^x-1)}\widetilde{P}^x_c})}$$

where $\widetilde{P}^x_c = N_c(p^x_{cc}\tau^x_{cc}\theta^x_{cc})^{(1-\sigma^x)} + \sum_{c'\neq c}\widetilde{i}^x_{c'}(p^x_{c'c'}\tau^x_{cc'}\theta^x_{cc'})^{(1-\sigma^x)}$.

The alternative trading partner measures in the benchmark model are defined as follows:

$$\begin{aligned} A^x_c &= P^x_c \\ A^x_{c'} &= (\sum_c \frac{w_c\overline{L}_c + \Pi_c}{(p^x_{c'c'}\tau^x_{cc'}\theta^x_{cc'})^{(\sigma^x-1)}P^x_c} \end{aligned}$$

[30] One difference between the benchmark and the amended models lies in the fact that the economy pays a higher overall fixed cost in the amended case. I have repeated this work incorporating an increase in λ_X in the benchmark model so that the overall fixed costs to the economy are equal for the adjusted benchmark and the amended models. This change does not affect the result that consumption levels of domestic goods and of imports are equal.

In the amended model, they are:

$$\begin{aligned} A_c^x &= \widetilde{P}_c^x \\ A_{c'}^x &= (\sum_c \frac{w_c \overline{L}_c + \Pi_c}{(p_{c'c'}^x \tau_{cc'}^x \theta_{cc'}^x)^{(\sigma^x - 1)} \widetilde{P}_c^x} \end{aligned}$$

B Data Appendix

B.1 Countries and Industries Included in Data Set

Countries Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, United Kingdom, United States

Industries The industries are the 2-digit SIC classifications: 20: Food products, 21: Tobacco products, 22: Textile mill products, 23: Apparel & other textiles, 24: Lumber and wood, 25: Furniture & fixtures, 26: Paper products, 27: Printing & publishing, 28: Chemical products, 29: Petroleum & coal products, 30: Rubber & misc. plastics, 31: Leather products, 32: Stone, clay, glass products, 33: Primary metal industries, 34: Fabricated metal products, 35: Industrial mach.& equip., 36: Electronic & elec. equip., 37: Transportation equip., 38: Instruments, 39: Misc. manufacturing inds.

B.2 Trade and Production Data

Data on bilateral trade flows are taken from Feenstra, Lipsey, and Bowen (1997), with the original source as the Statistics Canada World Trade Database. The data are provided on an SITC basis; they were concorded to ISIC based on Maskus (1991), and then to SIC.

Domestic trade is production (gross output) within each industry less exports from that industry.

Production data are from the OECD Statistical Analysis Database. The production data were converted to U.S. dollars using the annual exchange rate in the Database.

B.3 GDP, Population, Distance variables

The distance data were provided by John Helliwell. $DIST_{cc'}$ is the distance from exporter k to importer j. It is generally measured from capital to capital and calculated using Great Circle Distances from Latitude and Longitude given in *Direct Line Distances*, by Fitzpatrick (1986).

Own distances are calculated as $\frac{1}{4}$ of the distance to its nearest trading partner. For islands or countries with no trading partner in the sample group own distance was calculated as $\frac{1}{2}$ of the minor radius of the country. These internal distances are consistent with the formulation used by Wei (1996).

GDP and population data are taken from the PENN World Tables.

B.4 Other Variables

Alternative trading partner indices are calculated as $ALT_c = \sum_{c'} \frac{GDP_{c'}}{DIST_{cc'}}$, where the summation over c' is over all countries within the sample. Population is used instead of GDP for some of the analyses.

Some endowment data used as instruments were provided by James Harrigan, with the original source as Penn World Tables (workers, capital stock) and World Bank World Development Indicators (agricultural land). Other data for instruments are from OECD (1998) (labor force), World Bank World Development Indicators (agricultural land), and the Penn World Tables (capital stock).

Table 1
The Origins of a Border Effect?

		(i) **Benchmark**	(ii) **Amended (1)**	(iii) **Amended (2)**
	Border Effect (7/8)	6	6	6
	Ad Valorem Trade Barrier (%)	54	0	9
	Number of varieties:			
1	Domestic	50	50	50
2	Home exports	50	9	13
3	Foreign	50	50	50
4	Foreign exports	50	9	13
	Consumption of individual varieties (units):			
5	Domestic	36	36	36
6	Imported	6	36	25
	Aggregate consumption of X good (units):			
7	Domestic	1793	1776	1777
8	Imported	318	315	316
9	Trade Fixed Cost Parameter	N.A.	2	1
10	Wage	1	1	1
11	Price of X	3	3	3

Note: In all columns, sigma=5 and there are no domestic or international transport costs.

Table 2
Exporting Establishments Value of Shipments

Ratio = Exporting Establishments Value of Shipments/
Total U.S. Value of Shipments

Industry	Ratio 1987	Ratio 1992
20: Food products	0.39	0.48
21: Tobacco products	0.82	0.96
22: Textile mill products	0.37	0.49
23: Apparel & other textiles	0.16	0.29
24: Lumber and wood	0.24	0.34
25: Furniture & fixtures	0.29	0.50
26: Paper products	0.52	0.62
27: Printing & publishing	0.20	0.28
28: Chemical products	0.72	0.80
29: Petroleum & coal products	0.45	0.47
30: Rubber & misc. plastics	0.50	0.61
31: Leather products	0.42	0.53
32: Stone, clay, glass products	0.36	0.44
33: Primary metal industries	0.62	0.70
34: Fabricated metal products	0.47	0.57
35: Industrial mach.& equip.	0.72	0.79
36: Electronic & elec. equip.	0.70	0.78
37: Transportation equip.	0.82	0.81
38: Instruments	0.87	0.89
39: Misc. manufacturing inds.	0.45	0.59

Source: U.S. Census of Manufactures

Table 3: Border Effects

	(i) (a)	(i) (b)	(i) (c)	(i) (d)	(i) (e)	(ii) (a)	(ii) (b)	(ii) (c)	(ii) (d)	(ii) (e)
			Border Effect					*Border Effect*		
	Benchmark	Amended	Benchmark	Amended	P-Value[1]	Benchmark	Amended	Benchmark	Amended	P-Value[1]
ln(Production)	0.87 *	0.86 *				0.95 *	0.96 *			
	(0.06)	(0.06)				(0.06)	(0.07)			
ln(GDP Consumer)	0.82 *	0.83 *				0.77 *	0.77 *			
	(0.06)	(0.06)				(0.06)	(0.06)			
ln(Distance)	-0.81 *	-0.78 *				-0.69 *	-0.69 *			
	(0.07)	(0.07)				(0.17)	(0.17)			
ln(Alternatives Producer)	-0.48 *	-0.47 *				-0.55 *	-0.56 *			
	(0.09)	(0.09)				(0.09)	(0.09)			
ln(Alternatives Consumer)	-0.51 *	-0.52 *				-0.49 *	-0.49 *			
	(0.06)	(0.06)				(0.06)	(0.06)			
Border Effects:										
Home	2.70 *	2.11 *	14.94	8.27	0.00					
(1 for dom. sales, 0 otherwise)	(0.23)	(0.22)								
Industry Dummy*Home										
20: Food products						3.36 *	2.55 *	28.65	12.77	0.00
						(0.70)	(0.71)			
21: Tobacco products						5.27 *	5.16 *	194.39	174.16	0.19
						(0.71)	(0.72)			
22: Textile mill products						4.59 *	3.78 *	98.04	43.91	0.00
						(0.72)	(0.72)			
23: Apparel & other textiles						4.19 *	2.73 *	65.78	15.26	0.00
						(0.73)	(0.74)			
24: Lumber and wood						2.75 *	1.54 *	15.70	4.69	0.00
						(0.70)	(0.71)			
25: Furniture & fixtures						3.11 *	2.17 *	22.39	8.78	0.00
						(0.70)	(0.71)			
26: Paper products						2.60 *	2.05 *	13.40	7.76	0.00
						(0.70)	(0.71)			
27: Printing & publishing						3.29 *	1.92 *	26.83	6.81	0.00
						(0.70)	(0.71)			
28: Chemical products						2.68 *	2.41 *	14.52	11.16	0.00
						(0.71)	(0.71)			
29: Petroleum & coal products						3.60 *	2.86 *	36.42	17.40	0.00
						(0.72)	(0.72)			
30: Rubber & misc. plastics						2.41 *	1.84 *	11.16	6.32	0.00
						(0.70)	(0.71)			
31: Leather products						2.56 *	1.85 *	12.98	6.39	0.00
						(0.71)	(0.72)			
32: Stone, clay, glass products						2.17 *	1.28	8.73	3.61	0.00
						(0.70)	(0.71)			
33: Primary metal industries						2.18 *	1.78 *	8.85	5.96	0.00
						(0.71)	(0.72)			
34: Fabricated metal products						1.74 *	1.11	5.70	3.04	0.00
						(0.70)	(0.71)			
35: Industrial mach.& equip.						1.13	0.87	3.10	2.39	0.00
						(0.72)	(0.73)			
36: Electronic & elec. equip.						1.62 *	1.33	5.04	3.78	0.00
						(0.70)	(0.71)			
37: Transportation equip.						0.64	0.44	1.89	1.55	0.02
						(0.70)	(0.71)			
38: Instruments						2.86 *	2.74 *	17.39	15.43	0.18
						(0.75)	(0.75)			
39: Misc. manufacturing inds.						2.83 *	2.19 *	16.90	8.95	0.00
						(0.74)	(0.74)			
Number of Observations	745	745				745	745			

1. P-value is the probability associated with the hypothesis that the benchmark and amended model effects are equal.
A low value indicates that we are able to reject that hypothesis, i.e. that the two differ from each other significantly.
* Significant at the 5% level.

Table 4
Decomposition: Portion Due to "Flow" Explanation

Table indicates what portion of overall border effect or ad valorem barrier may be attributed to "flow" component.

Industry	Border Effect	"Flow" Portion(%) Ad Valorem Border Barrier		
		Elasticity = 2	Elasticity = 5	Elasticity = 8
20: Food products	45	59	69	72
21: Tobacco products	90	94	97	97
22: Textile mill products	45	63	75	78
23: Apparel & other textiles	23	41	55	59
24: Lumber and wood	30	39	49	52
25: Furniture & fixtures	39	53	63	66
26: Paper products	58	67	74	76
27: Printing & publishing	25	39	50	53
28: Chemical products	77	83	88	89
29: Petroleum & coal products	48	63	73	76
30: Rubber & misc. plastics	57	65	72	74
31: Leather products	49	59	67	69
32: Stone, clay, glass products	41	46	54	56
33: Primary metal industries	67	73	78	80
34: Fabricated metal products	53	54	60	61
35: Industrial mach.& equip.	77	72	75	76
36: Electronic & elec. equip.	75	76	80	81
37: Transportation equip.	82	65	68	68
38: Instruments	89	92	95	95
39: Misc. manufacturing inds.	53	64	72	74

Table A1
The Origins of a Border Effect?
Endogenous N

		(i) **Benchmark**	(ii) **Amended (1)**	(iii) **Amended (2)**
	Border Effect (7/8)	19	19	19
	Ad Valorem Trade Barrier (%)	209	0	9
	Number of varieties:			
1	Domestic	100	95	95
2	Home exports	100	5	7
3	Foreign	100	95	95
4	Foreign exports	100	5	7
	Consumption of individual varieties (units):			
5	Domestic	19	20	20
6	Imported	1	20	14
	Aggregate consumption of X good (units):			
7	Domestic	1900	1904	1904
8	Imported	100	100	100
9	Trade Fixed Cost Parameter	N.A.	2	1
10	Wage	1	1	1
11	Price of X	3	3	3

Note: In all columns, sigma=5 and there are no domestic or international transport costs.