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James E. Anderson
Ingo Borchert
Aaditya Mattoo
Yoto V. Yotov

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ABSTRACT

A structural gravity model is used to estimate barriers to services trade across many sectors, countries and time. Since the disaggregated output data needed to flexibly infer border barriers are often missing for services, we derive a novel methodology for projecting output data. The empirical implementation sheds light on the role of institutions, geography, size and digital infrastructure as determinants of border barriers. We find that border barriers have generally fallen over time but there are differences across sectors and countries. Notably, border effects for the smallest economies have remained stable, giving rise to a divergent pattern across countries.

James E. Anderson
Department of Economics
Boston College
Chestnut Hill, MA 02467
and NBER
james.anderson.1@bc.edu

Ingo Borchert
Department of Economics
University of Sussex
Brighton, BN1 9SL, United Kingdom
I.Borchert@sussex.ac.uk

Aaditya Mattoo
The World Bank
amattoo@worldbank.org

Yoto V. Yotov
School of Economics
Drexel University
Philadelphia, PA 19104
and ERI-BAS
yotov@drexel.edu

1 Introduction

Given the economic importance of services trade, surprisingly little is known about trade costs in services. Transparent border measures like tariffs are less important in services than relatively opaque regulations that affect trade, for example, in professional and financial services. In addition, transport costs do not take the form of well-defined freight rates but hard-to-measure forms such as the costs of electronically delivering business services. The absence of explicit measures of either protection or transport costs suggests that an analytical model of trade flows can help reveal information about barriers to services trade.

We use the structural gravity model and a newly constructed dataset on production and trade in services to provide much new information about inferred services trade barriers. The paper makes three principal contributions. First, we estimate a rich pattern of border barriers at an unprecedented level of detail, varying by country, sector and over time. Such elaborate estimates of border barriers are predicated on the availability of services output data at a correspondingly disaggregated level. Second, since such services output data are not typically available outside the developed country realm, we develop a projection method that can, in principle, generate the required information, thereby facilitating the estimation of trade costs in services when key underlying data are missing or suspect. Third, the structural gravity theory employed for this procedure also helps us decompose border barriers. The empirical results are of interest in their own right as they shed light on the role of domestic institutions, geography, size, and digital infrastructure as determinants of border barriers and international trade of services.

We start by estimating a gravity model, described in Section 2, for 12 service sectors and 28 countries. For that purpose, we construct of a database combining information on services trade and production, respectively, covering the period 2000 to 2007. The broad sectoral and geographical coverage as well as the inclusion of intra-national trade flows sets this dataset apart from previous gravity estimations.[1] The data are described in Section 3. The

[1]The gravity model has previously been used to explain the pattern of services trade. For instance, to

results offer benchmark gravity estimates for sectoral cross-border services trade, alongside a detailed set of border effects.[2] Gravity works well with sectoral services data: most estimates are significant with expected signs and reasonable magnitudes. We document important differences in estimated coefficients of standard gravity variables between goods and services and across services sectors, respectively. For example, we obtain highly non-linear effects of distance on services trade with strong negative effects for short distances and insignificant effects for long distances. In addition, our estimates reveal that contiguity and colonial ties—traditionally strong predictors for goods trade—have more nuanced effects, with the effect of contiguity depending strongly on the particular sector and colonial ties being generally insignificant. In contrast, language effects are much stronger for services trade than for goods trade. We also demonstrate empirically that accounting properly for internal trade costs is important for proper estimation of international trade costs. These results are presented in Section 4.2.

A key output of this analysis is a multi-dimensional set of relative border barrier estimates by sector, country and year for cross-border services trade. Border barriers in services trade are large, significant, and vary widely. (i) Across countries, our estimates reveal that economic size reduces border barriers in services trade. (ii) Across sectors, border barriers vary in an intuitive way. (iii) Over time, border barriers in services trade have fallen, even though the decrease varies considerably across sectors and across countries. Border barriers have fallen in all sectors but more so in sectors with lower initial borders. Thus, border barrier

estimate the determinants of services trade compared to those of goods trade (Kimura and Lee, 2006; Lejour and de Paiva Verheijden, 2004; Tharakan *et al.*, 2005), to estimate the time trend in distance effects (Head *et al.*, 2008) or the effect of Internet penetration in partner countries on US services imports (Freund and Weinhold, 2004). Miroudot *et al.* (2012) provide evidence linking lower international trade costs with higher productivity in services sectors.

[2]Following the General Agreement on Trade in Services (GATS), it has become customary to take a broad view of trade in services to include not just cross-border trade but also international transactions through foreign investment or the movement of people. This paper, however, focuses only on trade costs associated with cross-border services trade and travel (i.e. people travelling abroad as consumers of services) because these are the only international transactions covered in trade statistics available for a significant number of countries. The focus on cross-border services trade, driven by data availability, also implies that we are abstracting from any potential correlation of cross-border trade with the ease of trading a particular service via other modes, in particular via establishing commercial presence abroad. On the interdependence of modes see eg. Christen and Francois (2010). Our estimates of trade barriers should be interpreted accordingly.

heterogeneity across sectors has actually increased. Across countries, larger economies in our sample have enjoyed a fall in border barriers whereas smaller and less developed economies have suffered an increase in services borders barriers. Thus globalization effects (in this sense) are convergent within a set of larger economies and divergent between the smallest countries and the rest. These findings, as well as patterns of convergence and divergence in individual sectors, are described in Section 4.3. To the best of our knowledge, these phenomena have not been documented in the literature before.

Widespread data deficiencies in services prevent comparable estimation of border barriers—and potentially other trade cost measures—for a wider set of countries. Hence, our second principal contribution is to derive and implement a novel procedure to recover missing output data based on the strong performance of structural gravity in combination with recently uncovered properties of the PPML estimator. The theory underpinning this method is introduced in Section 5.1.

A key step in this procedure is the analysis of determinants of border barriers, estimated earlier as gravity model fixed effects. Structural gravity theory suggests that border barriers consist of three principal components: country-specific internal trade costs, country-specific border barriers, and an average (across countries) border effect. Empirically, we project border barriers onto observable country characteristics by employing suitable proxies for each of the three constituent elements. The econometric results of that regression, which we call 'border estimation,' are a successful first attempt at separating cross-national variation in internal trade costs from variation in pure border-crossing costs. The coefficient estimates appear to be intuitive with expected signs, reasonable magnitudes, and a solid model fit. For instance, we find that internal distance lowers inferred border barriers as it raises internal trade costs. Conversely, business-friendly domestic regulations that lower internal trade costs result in higher inferred border barriers. We also find evidence for the positive effect on pure border-crossing costs of advanced digital infrastructure, which facilitates services trade and thus is associated with lower border barriers.

These results offer new insights on factors determining the size of border effects, some of which are potentially amenable to policy reform and, therefore, unveil channels that may translate unilateral policy intervention at the national level into changes in the volume of international services trade. In terms of the projection method, however, we exploit in particular the good model fit ($R^2 = 0.86$) for satisfactory out-of-sample predictions of border estimates. Indeed, the ability to consistently predict border effects is a necessary and sufficient condition for successfully recovering potentially missing output data. This analysis is presented in Section 5.2.

The availability of disaggregated output information in our dataset enables us to conduct various benchmarking exercises to evaluate the novel procedure's accuracy. We conclude that the projection method works well, and we are able to characterize in detail the accuracy of predictions across countries and sectors (Section 5.4). The procedure's good performance in a situation in which no production data are available at all is particularly appealing since this is going to be the norm if trade costs were to be estimated for economies beyond the developed country realm. While the current analysis focuses on services trade, our methods can be applied similarly to goods trade with potentially large payoffs. We leave such extensions for future work.

2 Structural Gravity Model

We start with a brief review of the structural gravity model. Assuming product differentiation by place of origin Armington (1969) and globally common CES preferences, Anderson (1979) develops a gravity theory of trade. Anderson and van Wincoop (2003, 2004) refine the gravity model to derive the following sectoral gravity system that applies to trade in any goods or services sector:[3]

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y^k}\left(\frac{t_{ij}^k}{\Pi_i^k P_j^k}\right)^{1-\sigma_k} \quad \forall i,j; \tag{1}$$

$$(\Pi_i^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_k} \frac{E_j^k}{Y^k},\ \forall i; \tag{2}$$

$$(P_j^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_k} \frac{Y_i^k}{Y^k},\ \forall j. \tag{3}$$

Let X_{ij}^k denote the value of shipments at destination prices from origin i to destination j in services class k. E_j^k is the expenditure on services k at destination j from all origins. Y_i^k denotes the sales of services k at destination prices from i to all destinations, while Y^k is the total output of services k at delivered prices. $t_{ij}^k \geq 1$ denotes the variable trade cost factor on shipments of k from i to j. σ_k is the trade elasticity of substitution across origin countries i in services class k. Π_i^k and P_j^k are theoretical constructs that capture general equilibrium trade cost effects. Anderson and van Wincoop (2003) refer to these terms as outward multilateral resistance (OMR) and inward multilateral resistance (IMR), respectively. Anderson and Yotov (2010a) refine the interpretation of the multilateral resistances as sellers' and buyers' incidence of all trade costs. The outward multilateral resistance Π_i^k consistently aggregates the incidence of trade costs on the producers of services k in origin i as if they shipped to a unified world market. The inward multilateral resistance P_j^k consistently aggregates the incidence of trade costs on the consumers of services k in destination j as if they consumed from a unified world market.

The structural gravity system (1)-(3) translates into a simple econometric specification. Following now standard practice, we assume that bilateral trade data follow a Poisson distribution (see Santos Silva and Tenreyro, 2006, 2011) with its conditional mean taking the

[3]The demand-side gravity theory that we present here has alternative theoretical foundations on the supply side, e.g. Eaton and Kortum (2002). Anderson (2011) and Costinot and Rodriguez-Clare (2014) review the literature on the theoretical foundations and extensions of gravity.

exponential form (for a generic sector):

$$E(X_{ij}|Z) \equiv \exp(Z'\beta) = \frac{Y_i E_j}{Y} \left(\frac{t_{ij}(\beta)}{\Pi_i P_j} \right)^{1-\sigma}, \tag{4}$$

which leads directly to an estimable equation of the form

$$X_{ij}^k = \chi^k x_i^k m_j^k \tau_{ij}^k + \epsilon_{ij}, \quad \forall i, j, \tag{5}$$

Here, χ^k denotes a constant term; x_i^k is an exporter fixed effect for country i, m_j^k is an importer fixed effect for destination j, and $\tau_{ij}^k \leq 1$ is a trade cost factor representing the effect of gravity forces that reduce bilateral trade between i and j, X_{ij}. ϵ_{ij} is an error term explained below. An important issue is whether sufficient data are available to distinguish between internal and external trade, i.e. within and between countries. When such data are available, which is the case in this study, it is possible to include and identify τ_{ii}, the intra-country trade cost. Its relationship to $\tau_{ij},\ i \neq j$ is a component reflecting the relative cost of crossing a border. An important contribution of our work is that we construct a multi-dimensional (country-sector-year) database of such relative border cost estimates and we study their determinants.

The final step in obtaining an econometric gravity specification is to model the unobservable bilateral trade frictions τ_{ij}^k from equation (5). Following the vast gravity literature for goods trade, the volume effect of bilateral trade costs $\tau_{ij}^k \equiv {t_{ij}^k}^{1-\sigma}$ for services are approximated by a set of observables:

$$\tau_{ij}^k = e^{(1-SMCTRY_{ij})[\sum_{m=1}^{2} \beta_m^k \ln DIST_{ij,m} + \beta_3^k CNTG_{ij} + \beta_4^k LANG_{ij} + \beta_5^k CLNY_{ij}] + \beta_6^k SMCTRY_{ij}}. \tag{6}$$

Here, $\ln DIST_{ij,m}$ is the logarithm of bilateral distance between trading partners i and j. Following Eaton and Kortum (2002), we decompose the distance effects into 2 intervals based on the median distance in our sample (about 2,551 km) in order to allow for non-linear effects of distance on services trade. $CNTG_{ij}$ captures the presence of a contiguous border between partners i and j. $LANG_{ij}$ and $CLNY_{ij}$ account for common language and colonial ties, respectively. Finally, $SMCTRY_{ij}$ is an indicator variable equal to 1 for $i = j$ and zero otherwise. $SMCTRY_{ij}$ has the advantage of being an exogenous variable that picks up all the relevant forces that discriminate between internal and international trade. We will define the $SMCTRY$ variable in two alternative ways. First, we will restrict $SMCTRY$ to a common effect across countries and years for each sector, in which case β_6^k is identified off variation over time and across countries. Second, we use a very flexible specification in which we allow for country-year-sector specific $SMCTRY$ effects $\beta_{it,6}^k$. The advantage of this approach is that it delivers a rich database of border estimates that will enable us to study their determinants.

In order to obtain econometrically sound gravity estimates for each service category in our sample, we adopt the latest developments in the empirical gravity literature. In particular, first, we account for the unobservable multilateral resistance terms with directional (source and destination), country-specific, time-varying dummy variables.[4] These country fixed effects also control for output and expenditures, as is apparent from equations (9) and (10). Second, our choice of estimation technique is the Poisson pseudo-maximum-likelihood (PPML) estimator which, as shown in Santos Silva and Tenreyro (2006, 2011), successfully addresses the prominent issues of heteroskedasticity and zeroes in bilateral trade flows. Importantly, the PPML estimator is perfectly consistent with the structural gravity model of Anderson and van Wincoop (2003), which serves as a theoretical foundation for our analysis. Finally, in order to address the critique from Cheng and Wall (2005) that the dependent variable in gravity estimations with fixed effects cannot fully adjust in a single year's time, we use panel data with 2-year intervals to obtain our most preferred gravity estimates.[5]

[4]Anderson and van Wincoop (2003) use custom programming to account for the multilateral resistances in a static setting. Feenstra (2004) advocates the directional, country-specific fixed effects approach in a cross-section setting. Olivero and Yotov (2012) demonstrate that the MR terms should be accounted for with exporter-time and importer-time fixed effects in a dynamic gravity setting.

[5]This is consistent with the three-year intervals used in Trefler (2004), who also criticizes trade estimations pooled over consecutive years. Cheng and Wall (2005) and Baier and Bergstrand (2007) use 5-year intervals,

3 Data Description

For our analyses, we construct a novel integrated dataset of services trade and production data at the sectoral level for 28 countries and 12 services sectors over the period 2000-2007.[6] The limiting factor in our data is the availability of sectoral services production statistics. Table 1 lists the range of services sectors covered and the complete dataset is available upon request. We briefly discuss each data component; more detailed information is contained in Appendix A.

The primary source of data on cross-border services trade flows are the "OECD Statistics on International Trade in Services: Volume II - Detailed Tables by Partner Country" (Complete Edition as obtained from OECD.Stat, henceforth "TiSP"). The database provides information on international trade in services by partner country for 32 reporting OECD countries plus the Russian Federation and Hong Kong China, which is in the top twenty service exporters in the world. In addition to the partner dimension, TiSP trade data are also broken down by type of service according to the Extended Balance of Payments Services (EBOPS) classification, i.e. standard components according to the fifth edition of the IMF's Balance of Payments Manual. The level of sectoral detail reported varies across countries.

We focus on export flows as a more reliable measure of trade flows due to stronger reporting incentives for the exporting firms. Using TiSP's import entries as mirror export flows allows us to recover additional export flows, thereby increasing the number of non-zero observations substantially.[7] We also use mirroring to recover services trade flows of two additional countries (Latvia and Lithuania) for which disaggregated output information

while Eichengreen and Irwin (1996) use 5- and 10-year intervals in gravity estimations. Finally, Olivero and Yotov (2012) experiment with various intervals to check the robustness of their dynamic gravity results. They find that the yearly estimates indeed produce suspicious gravity parameters. We chose 2-year intervals due to the short time-coverage of our data.

[6]The 28 countries with trade and production data are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, South Korea, Sweden, United Kingdom, United States. Trade information is available for another eight countries.

[7]For within-OECD trade, the original export flow is always retained even if a matching mirror flow would be found to exist.

exists in EUKLEMS but which do not report cross-border trade flows as part of OECD's TiSP dataset. Additional checks ensure that trade flows are consistent across different levels of the classification.

Even though the majority of OECD countries already accounts for a large share of global cross-border service trade[8], we attempt to maximize coverage of global trade flows by augmenting the OECD TiSP data with information from the "United Nations International Trade in Services Database" as published by the United Nations Department of Economic and Social Affairs, Statistics Division. Since OECD's TiSP constitutes our preferred data source, UN data serve to augment the dataset only in instance when the corresponding OECD observation is missing.[9] An additional 120,000 observations can be gained by updating OECD data with UN data, which underscore the usefulness of drawing on both datasets.

Annual production data for services sectors are obtained from the "EU KLEMS Growth and Productivity Accounts: November 2009 Release" as updated in March 2011. The EU KLEMS Database provides for one of the most detailed sectoral breakdowns available. Coverage comprises mostly of OECD members which corresponds closely to the source for cross-border services trade. The raw data consist of "gross output at current basic prices" in millions of local currency units. We use data covering 2000-2007 as EU KLEMS series currently extend only up to 2007. As noted above, availability of services production data predetermines the dimensions of our sample to 28 countries, 12 sectors, and 8 years over the period 2000-2007, even though the gravity model estimations in section 4 use trade data for an additional eight countries.[10]

Production data is reported according to the NACE Rev.1 classification. In order to estimate the gravity model, NACE output data need to be concorded to the trade classification for services, which was done on the basis of the "Correspondence between ISIC

[8]In 2007, the 28 OECD members accounted for 74 percent of world exports and 69 percent of world imports.

[9]This implies that mirror OECD flows take precedence over original UN exports even if an exact match exists, and no mirroring is performed on UN data.

[10]These countries are Chile, Hong Kong China, Israel, Mexico, Norway, New Zealand, the Russian Federation and Turkey.

Categories for Foreign Affiliates (ICFA) and Extended Balance of Payments Services Classification (EBOPS)" as published in Annex IV of the UN's Manual on Statistics of International Trade in Services, with some modifications. Table 1 displays the 12 sectors that could successfully be concorded. Internal trade and expenditure are calculated from production data in the usual way, ie. a country's internal trade for any given sector is obtained by subtracting sectoral exports from gross output. A country's sectoral expenditure data is backed out as the sum of imports from all origin countries including itself or, equivalently, gross output less exports plus imports from abroad.

Standard gravity variables such as distance, common language, contiguity and colonial ties are taken from CEPII's *Distances* Database (see Mayer and Zignago, 2006; Head and Mayer, 2000). An important advantage of that source is its provision of population-weighted distances, which can be used to calculate consistently both bilateral distances as well as internal distances. We use the former in the gravity estimations of international services trade and the latter in our study of the determinants of borders.

4 Gravity Estimation and Border Effects

This section offers partial equilibrium estimates and a discussion of the effects of standard trade cost variables (e.g. distance, common language, contiguity, etc.) on services trade for each of the sectors in our sample. An important contribution of our work is the treatment and analysis of international borders in services trade. Initially, we estimate the effects of international borders on services trade with an indicator variable that takes a value of one for trade flows within the same country ("$SMCTRY$") and zero otherwise, to capture the difference between internal and international trade. This approach is not new to the literature.[11] However, we make several contributions and extensions to this literature.

Unlike existing studies that focus on specific countries and obtain single border estimates

[11] See for example McCallum (1995); Anderson and van Wincoop (2003); Hillberry and Hummels (2003); Millimet and Osang (2007); Mayer and Head (2002); Anderson and Yotov (2010a,b); Coughlin and Novy (2013); Nitsch and Wolf (2013).

at a given point of time, our estimates are multi-dimensional. First of all, we obtain country-specific border estimates for all countries in our sample. This is an important departure from the existing trade literature that treats countries as point masses, an assumption that our estimates reveal is clearly rejected by the data. Second, we obtain time-varying border effects which enables us to study patterns over time. Our estimates reveal that, by and large, border barriers in services trade have fallen over time. Thus, we contribute to the literature by demonstrating that the effects of globalization are actually present and strong in gravity estimations of services trade. Combining country and time variation enables us to draw inferences about the differential effects of globalization. Third, we obtain border effects at the sectoral level. Our estimates reveal wide but intuitive variation across the service categories in our sample with potentially important policy implications. Finally, we are the first to analyze the determinants of international trade border effects. Our analysis focuses on services trade but our methods could be applied similarly to goods trade with potential for large payoffs. We leave such extensions for future work.

In order to emphasize the advantages of our methods, first we obtain and report results from a baseline model in which the $SMCTRY$ coefficient for each sector is restricted to be the same across all countries and years. This specification is consistent with the current treatment of domestic trade costs in the literature as equal (and equal to zero) for each country, i.e. treating countries as point masses. In Section 4.3 we present and discuss results from our preferred and more flexible specification, in which $SMCTRY$ coefficients are allowed to vary across countries and over time. These results reveal that proper account of internal trade costs has significant quantitative implications for the effects of the standard variables used to proxy for trade costs in empirical gravity models.

4.1 Gravity Estimates for Services Trade

We start with a specification of the gravity model that imposes the standard assumption of equal internal trade costs.[12] Table 2 reports gravity estimates for each service category in our sample[13] which, as discussed above, are obtained with 2-year lagged panel data, the PPML estimator, and time-varying, directional, country-specific fixed effects from the following econometric model:

$$X_{ij,t} = \exp\Big[(1 - SMCTRY_{ij})\left(\sum_{m=1}^{2}\beta_m^k \ln DIST_{ij,m} + \beta_3^k CNTG_{ij} + \beta_4^k LANG_{ij} + \beta_5^k CLNY_{ij}\right) + \beta_6^k SMCTRY_{ij} + \eta_{i,t} + \theta_{j,t}\Big] + \epsilon_{ij,t}, \qquad \forall\, k. \tag{7}$$

Here $SMCTRY_{ij}$ is the Kronecker delta, β_6^k is the common (across countries and over time) $SMCTRY$ coefficient, $\eta_{i,t}$ denotes the set of time-varying exporter dummies, which control for outward multilateral resistances and countries' output shares, and $\theta_{j,t}$ denote time-varying importer dummies that account for inward multilateral resistances and expenditure shares, respectively. Standard errors are clustered by country pair.[14]

Overall, we find that the disaggregated gravity model works well with services data. Estimated coefficients on standard trade cost variables in Table 2 almost always exhibit expected signs and reasonable magnitudes. We discuss the effects of standard gravity variables in greater detail below when $SMCTRY$ coefficients are allowed to vary across countries, sectors and time as this constitutes our preferred econometric specification. For now, the results in Table 2 reveal that, all else equal, international borders reduce services trade substantially. Ten of the twelve possible estimates on $SMCTRY$ are positive and six of them are large and highly significant. The border effects in services vary widely across sectors. This motivates our preferred specification that allows for *country-year*-specific estimates of

[12]Since the gravity model can only ever identify relative trade costs, our specification is equivalent to imposing the constraint of internal trade costs being equal and equal to zero.

[13]In Table 2 trade in 'research and development' services (RSRCH) is listed as a separate sector even though the EBOPS taxonomy treats it as a part of 'miscellaneous business services' (BUSIN). We think, though, that the results for both categories are of distinct economic interest. Our empirical results offer evidence for heterogeneous trade cost estimates in these two categories.

[14]Comparison between estimates obtained with and without clustering reveal that the clustered standard errors are a bit larger. This suggests positive intra-cluster correlations, as expected.

the border effects β_{it}^k for each sector in our sample according to:

$$X_{ij,t} = \exp\Big[(1 - SMCTRY_{ij})\Big(\sum_{m=1}^{2} \beta_m^k \ln DIST_{ij,m} + \beta_3^k CNTG_{ij} + \beta_4^k LANG_{ij} + \beta_5^k CLNY_{ij}\Big) + \beta_{it,6}^k SMCTRY_{ij} + \eta_{i,t} + \theta_{j,t}\Big] + \epsilon_{ij,t}, \qquad \forall\, k. \tag{8}$$

We start with a discussion of trade cost estimates from standard gravity variables in Section 4.2, then we analyse in detail estimated border effects in Section 4.3.

4.2 Results on Standard Gravity Variables and Services Trade

Estimates of the effects of standard gravity variables on services trade are reported in Table 3. We note first of all that the effects that we capture in Table 3 and the corresponding numbers in Table 2 are qualitatively similar. At the same time, there are also differences in terms of statistical significance and economic magnitude which underscore the importance of a flexible specification of border barriers. The price of this flexibility is that the associated coefficients are 'estimated' with zero degrees of freedom. Yet an auxiliary regression finds meaningful patterns in the flexible fixed effects estimates.

Distance is a significant impediment to trade in services, though its effect varies widely across sectors and depends on the distance interval. In many sectors such as Transportation, Travel, Communication, Construction, Merchanting and Audiovisual services, distance effects are large and highly significant only over short intervals. It appears intuitive that Travel services exhibit the largest distance effect. In Financial and Computer services, respectively, we obtain insignificant short-distance effects but negative and significant (though small) effects over long distances. Finally, distance does not exert any trade-impeding effect in Insurance services, Operational Leasing, Business services, and Research and Development. The highly non-linear effects of distance on services trade and the insignificant estimates that we obtain for one third of the sectors in our sample reveal important differences between the effects of distance for goods and for services trade and point to the need for further research.

We estimate positive and significant contiguity coefficients for only five out of twelve service categories. The rationale for significant effects in Transportation, Travel, and Communication services is straightforward; the explanation in the case of Operational Leasing is less obvious but could be related to the particular spatial location of lessors and lessees, respectively. In general, the role of contiguity in promoting cross-border services trade does not appear to be strong. This is in sharp contrast to the estimated effects of common borders on manufacturing trade (see e.g. Anderson and Yotov, 2010b).

As expected, sharing a common official language facilitates bilateral services trade. The largest effects are found in Insurance, Audiovisual and R&D services, which we attribute to the need for precise communication in these sectors. Business, Financial, and Merchanting services encompass a host of presumably coordination-/communication-intensive 'business process outsourcing' services, thus it is intuitive that the coefficients are of similar magnitude as the one in Communications.[15] Overall, language appears to exert a stronger effect on services trade than on manufacturing goods trade (Anderson and Yotov, 2010b), which is consistent with the higher requirement for personal interaction and communication in most services.

In contrast, colonial ties do not generally have much explanatory power for services trade. We conjecture that this is due to services trade being a relatively recent phenomenon, which is consistent with the results from Anderson and Yotov (2010b, 2011) who find the effects of colonial ties on manufacturing trade to have waned during the 1990s. The strongly negative and significant effects of colonial ties in Business and Research services, respectively, may reflect the fact that such services are increasingly being exchanged between highly industrialized economies that never had colonial relationships with each other. From a sampling perspective, it is probably also true that an indicator variable for colonial ties does not belong in the set of gravity covariates for a sample of OECD countries.

In sum, the estimates from this section reveal that the structural gravity model performs quite well with services data. Many of the standard gravity covariates are significant and

[15] The absence of a language effect e.g. in categories such as Computer services could point to the need for an alternative construction of language-related variables that go beyond common official language, see Melitz and Toubal (2014).

their estimates make good economic sense. At the same time, we document important differences in the effects of standard gravity covariates between goods and services trade. Our benchmark results point to avenues for further research in modeling trade costs in services, which we leave for future work. Instead, we now focus attention on estimated border effects.

4.3 Results on International Border Effects in Services Trade

Equation (8) delivers a multi-dimensional data set of sector-country-time estimates of the border effects in services trade. Due to the large number of $SMCTRY$ estimates, we first display the overall distribution of border effects across countries, sectors and years. Then we characterize border effects separately along each of the three dimensions of our new database (and their interactions whenever possible).

Figure 1 shows the full distribution of $SMCTRY$ estimates across all 12 sectors, 28 countries and 4 years. Our data enabled us to estimate 1,231 (out of 1,344 possible) border effects. The median coefficient estimate is 5.35, which points to substantial border effects in services trade. To get a sense of the magnitude of the border barriers, note that the median border effect $(\exp\{5.35\} - 1) \times 100 = 20,961$, which suggests that the border enormously deflects international trade in services. We attribute the large estimates of border effects in services trade to the fact that consumption of services is highly localized.

Figure 1 also reveals that there exist some negative $SMCTRY$ estimates, suggesting that internal trade is smaller than international trade. The negative estimates are concentrated primarily in Travel services[16] and/or are obtained for large developed countries such as Germany and the United States. Thus the distribution of SMCTRY estimates for Travel services is shown separately in light gray in Figure 1. The largest border estimates in Figure 1 are for smaller and less developed economies such as Slovakia, Estonia, and Lithuania, and are concentrated in sectors such as Finance services, Insurance services and Research

[16] To a lesser extent also in Transportation services.

and Development services. Next we focus on the distribution of $SMCTRY$ estimates across sectors and across countries.

Figure 2 depicts the variation of the average (across countries) estimates of the $SMCTRY$ coefficients by sector. Border effects in services vary widely across sectors, which we believe owes much to the high concentration of some service categories in certain developed parts of the world. The largest border effects are observed in Finance services, Insurance services, and Research and Development services, respectively. The large estimates for Finance and Insurance services correspond to the fact that an overwhelming share of banking and insurance services are produced and consumed domestically. Our findings for Finance services are consistent with the results from Jensen and Lori Kletzer (2005) about the tradability of services based on sectors' geographic concentration within the United States. For instance, banking activities exhibit very low geographic concentration, suggesting low tradability due to the need for face-to-face interaction. It is also interesting to see that the Research and Development sector has a noticeably higher average $SMCTRY$ coefficient than miscellaneous Business services (in terms of the EBOPS classification the former is part of the latter, see Note 13 above). Here, disentangling both sectors brings to the fore how business process outsourcing and related developments have lowered revealed border effects whereas R&D is still predominantly produced locally (possibly within the confines of the firm). At the other extreme, consistent with our priors, by far the lowest border barriers exist in the Travel, Transportation, and Communications sectors, respectively.

Figure 3 depicts the distribution across sectors of $SMCTRY$ estimates by country. The figure suggests that, on average, the border barriers in services trade are appreciably higher for smaller and less developed economies than for large industrialized countries. Slovakia, Estonia, Lithuania, Latvia and Slovenia exhibit the sample's largest average $SMCTRY$ coefficients, whereas the coefficients associated with Great Britain, Holland, Canada, Germany, and Austria are the smallest in the sample. The United States is the only country that exhibits negative average border effects. The inverse relationship between openness to international trade in services and country size is confirmed in Figure 4 in which average border estimates per country are plotted against real GDP. The negative relationship between the two variables is clear and the correlation index $\rho = -.76$ is large and statistically significant. The result that richer/more developed countries face lower barriers in services trade is consistent with, and complements, the findings of Waugh (2010) who shows that less developed countries face larger aggregate trade costs. Next, we extend Waugh's analysis by studying the evolution of services borders over time.

Table 4 shows the evolution of average (across countries) $SMCTRY$ estimates over time for each sector. The main finding is that services borders have fallen significantly during the period of investigation (2000-2006) in all sectors and without exception. Our interpretation of the magnitude of the decrease in border barriers is that it reflects the effects of globalization on sectoral services trade. Our estimates also reveal that sectors with higher initial borders were subject to smaller effects of globalization, while the opposite is true for the sectors with lower initial borders. The correlation between the initial level of the border and decrease (in absolute value) is a remarkable -0.88. Thus, the order of sectors in terms of estimated border barriers is, in general, fairly stable over the period considered here, but the gap between the sectors with high and low borders has widened. This finding has potentially important policy implications.

We view the variation of the effects of globalization on services borders across sectors as intuitive. For instance, we find that sectors that experienced the largest decrease in borders include Travel services (120% decrease), Transportation services (61% decrease), and Communication services (36% decrease). Anecdotal evidence suggests that these are exactly the sectors where the effects of improved communications and technology should be the strongest. On the opposite side of the spectrum we find sectors such as Audiovisual services (4% decrease) and Operational Leasing services (7% decrease). Interestingly, Insurance services (8% decrease) and Finance services (12% decrease) are also on the lower end of the distribution, suggesting that these categories have not been affected by globalization as much as other sectors in our sample. The highly localized consumption of financial and insurance services is a possible explanation for these results. Finally, we note that Research and Development services (12% decrease) is another category that is not very much affected by globalization.

Table 5 depicts the evolution of average (across sectors) $SMCTRY$ estimates over time for each country. The average change across all countries in our sample is a decrease of 14%; however, the fall is not across-the-board and the effects vary widely across countries. Border barriers in services trade have decreased for about two-thirds of the countries in our sample and they have increased for the rest of the countries.[17] Based on the change in the border effects, we classify the countries in our sample in four groups. The first group includes countries that experienced a significant fall in services borders. These countries are relatively richer and include most of the more developed European economies (e.g. Great Britain, Belgium, Holland, and Denmark, among others), some smaller European countries that have developed relatively fast (e.g. Poland and Hungary), and Korea.

The second group of countries also experience decrease in services borders but the change is significantly smaller in magnitude. This group consists of relatively less developed economies including some European countries that are behind the European economic powers (e.g. Sweden, Spain and Portugal), some economies that were in transition (e.g. Slovenia and Slovakia), and Canada and Japan. The third group includes countries that actually suffered an increase in the borders for services trade. These countries include struggling and less developed economies such as Greece, Estonia, Latvia, and Lithuania. Finally, we put Germany and the United States in a separate group because these are two developed economies for which we observe an increase in the borders to services trade, however, these are also the two countries with the lowest borders in the initial and in the final year of our sample.

In order to check whether the effects of globalization are indeed related to country size

[17] We remind the reader that we measure *relative* border barriers, so increase means relative to the average which itself is decreasing.

and economic development, we split the countries in our sample into quintiles according to real GDP and we plot the evolution of the corresponding SMCTRY estimates in Figure 5. As before, motivated by the fact that Germany and the US are the only large developed economies that experience a small increase in the SMCTRY estimates over time and are also the two countries with the smallest borders to start with, we put those two countries in a separate group. Figure 5 captures several interesting features. First, as established before, smaller countries face higher borders in services trade. Second, it reveals that the border estimates for the countries in the lowest quintile have remained stable (or increased a bit) over the period of investigation. Third, we observe a decrease over time for the border estimates for the countries in the four upper quartiles in our sample. Our interpretation of this result as a reflection of globalization forces contributes to the extensive literature concerned with the "missing globalization" puzzle.[18] Specifically, we demonstrate that, in the case of services, globalization is an active force that is captured by the gravity model of trade.

Fourth, the decrease in the border effects on services trade has been faster for the countries in the second and third lowest quintiles as compared to the larger countries which, as noted before, face lower border barriers to begin with. This points to a convergence story among the countries in four upper quartiles. In contrast, over the period of inspection border effects for the smallest economies (first quintile) remained stable. Altogether this implies divergence between the smallest countries and the rest of the countries in our sample. Thus, in addition to complementing the finding from Waugh (2010) that less developed countries face larger resistance in the case of services trade as compared to richer countries, we also find that the group of smallest economies has not been reached by globalization forces. To the best of

[18]Coe *et al.* (2002) coin the term "missing globalization" and Disdier and Head (2008) provide a survey of the robust evidence for stable gravity estimates of distance over time. Our findings are in accordance with the results for goods trade from Yotov (2012) and Bergstrand *et al.* (2015). Yotov (2012) uses manufacturing goods data and demonstrates that the "distance puzzle" is resolved once the effects of international distance are measured properly relative to the corresponding effects of internal distance. Bergstrand *et al.* (2015) generalize this result to resolve the "missing globalization puzzle" with both sectoral goods data as well as with aggregate data.

our knowledge, the phenomenon of divergence in border barriers has not been documented before. Finally, it is worth noting that the $SMCTRY$ estimates for the first and the second quintiles in our sample have increased between 2000 and 2002, while the estimates for the rest of the countries during this period have been stable. A possible explanation for these results is the recession in the early 2000s which may have raised protectionism and slowed down globalization forces, perhaps more so in poorer economies.

In order to further explore the convergence or divergence effects of globalization, we construct figures that capture the evolution of border effects across small and large countries, in terms of relative output shares in world supply, for each sector in our sample. Based on individual sectoral figures, we identify three groups of sectors. The first group includes sectors for which we observe convergence between the small and the large countries in our sample. The categories in this group include Transportation services, Travel services, and Merchandize services. Figure 6 illustrates for the case of Transportation services. The second group includes sectors in which the border barriers fell but in a way that rendered the gap between large and small countries largely stable. Here, we find sectors such as Construction services, Communication services, and Business and Professional services. Figure 7 illustrates for the case of Construction services. Finally, the third group includes sectors where there has been divergence in the effects of borders between small and large countries. This group includes Financial services, Insurance services, Operational Leasing, Research and Development services, and Audiovisual services. Figure 8 illustrates using Research and Development services.

The descriptive analysis of border effects in services trade that we offer in this section can be summarized as follows. First we find that, for the most part, border barriers in services trade are large and significant. Second, we obtain heterogeneous border estimates across sectors that vary in an intuitive way. Third, our country-specific estimates reveal that smaller and less developed countries face larger resistance to international services trade. Fourth, we find that border effects in services trade have fallen over the period of investigation for all sectors in our sample. Finally, our estimates reveal that the more developed countries in our sample have enjoyed a fall in the borders in services trade, while smaller and less developed economies have suffered from an increase in services border barriers.

5 Recovering Missing Output Information

This section derives and empirically implements a procedure for recovering output information. Sectoral output data or, equivalently, internal trade flows observed in addition to border-crossing trade flows, are a necessary precondition for estimating border barriers as defined in the trade cost function (equation 6).[19] Whenever such statistical information for services sectors is not available at the desired level of disaggregation, this methodology can provide a way forward in instances in which trade costs could otherwise not be estimated. The fact that for the 28 OECD countries in our sample output information is available from the EUKLEMS database (cf. Section 3) allows us to assess the accuracy of our procedure.

5.1 Structural Gravity with Missing Data

Following on from Section 2, equation (4) admits a structural interpretation of the exporter and importer fixed effects, respectively, for any generic sector:

$$\exp(x_i) = \Pi_i^{\sigma-1} Y_i, \quad \forall i > 0, \tag{9}$$

$$\exp(m_j) = P_j^{\sigma-1} E_j, \quad \forall j > 0, \tag{10}$$

As defined before, Y_i denotes output (total sales at end user prices) and E_j denotes total expenditure, while Π_i and P_j denote outward and inward multilateral resistances. In practice, the fixed effects are estimated relative to a base country so, for example, m_0 and x_0 are not

[19] That information is generally required for making full use of structural gravity, eg. estimating general equilibrium trade costs indices, which we do not further pursue in this paper.

estimated, allowing for a standard constant term χ.[20] For the base country, we assume that Y_0 is observed, from which E_0 is inferred as 'apparent consumption' deducting exports and adding imports to Y_0. A normalization of the set of P's and Π's is required in any case, so it is natural to choose $P_0 = 1$ (see Anderson and Yotov, 2010a).[21]

Limited data on sectoral output constitutes an important problem, for unfettered use of the structural gravity model requires the full set of output and trade data for all countries. An important contribution of this study is therefore to show how the gravity model can be used to project output information. Our methodology imposes the theoretical identity between the estimated importer and exporter country fixed effects with their structural gravity expressions in order to recover the required information. Fally (2015) shows that the fixed effects estimated with PPML are exactly consistent with the theoretical values from (9)-(10). Specifically, the importer fixed effect is equal to the product of regional expenditure and the power transform of inward multilateral resistance, whereas the exporter fixed effect is equal to the product of regional output and the power transform of outward multilateral resistance. Combining equations (5), (9) and (10) thus implies:

$$P_j^{\sigma-1}\Pi_i^{\sigma-1} = kY\frac{x_i m_j}{E_j Y_i} \qquad \forall\, i, j. \tag{11}$$

The MR system from structural gravity is:

$$1 = \sum_j \tau_{ij} P_j^{\sigma-1}\Pi_i^{\sigma-1}\frac{E_j}{Y} \qquad \forall\, i, \tag{12}$$

$$1 = \sum_i \tau_{ij} P_j^{\sigma-1}\Pi_i^{\sigma-1}\frac{Y_i}{Y} \qquad \forall\, j. \tag{13}$$

[20] Structural gravity in theory has a scaling term equal to the inverse of worldwide sales times the mean measurement error in the bilateral trade data, data that are notoriously rife with measurement error. The practice in (5) combines the importer 0 and exporter 0 fixed effects with the worldwide scaling effect. Regression cannot identify both terms because the full set of fixed effects regressors are perfectly collinear when the constant vector is also included. (Perfect collinearity also arises if x_0 or m_0 is attempted to be estimated.)

[21] This normalisation implies $m_0 = E_0$ whilst x_0 is identified from $x_0 = Y_0/k\sum_j \tau_{0j} m_j$. Then $\Pi_0^{\sigma-1} = 1/k\sum_j \tau_{0j} m_j$ completes the identification of multilateral resistances from observed and inferred variables.

Substitute (11) into (12) and (13) to obtain:

$$\widetilde{Y}_i = kx_i \sum_j \tau_{ij} m_j \qquad \forall\, i \tag{14}$$

$$\widetilde{E}_j = km_j \sum_i \tau_{ij} x_i \qquad \forall\, j. \tag{15}$$

System (14)-(15) yields fitted values for output and expenditures, respectively. World output $\widetilde{Y} = k \sum_{i>0} x_i \sum_j \tau_{ij} m_j + Y_0$ is obtained by summing over all countries $i \in I$ in equation (14).

Notice that there is no problem at a theoretical level if some output in a particular sector and year were zero. The corresponding market clearing equation is dropped from the system, all demands X_{ij} for goods by destinations j from origin i are equal to zero, and outward multilateral resistance Π_i is not defined. Understanding that we have $Y_i = 0$ in equation (9), all the steps from equations (11)-(15) remain valid, and we can understand that where Π_i appears in (11) we may as well set $\Pi_i = 0$ because the equation for seller i does not hold due to there being no trade. However, the procedure for recovering output described in this section is all about our suspicion that there is some trade and output data even though it is not observed. In this case, rather than dropping the exporter-year fixed effect of i and setting $\hat{Y}_i = 0$, we exploit the panel structure and the properties of the PPML estimator to generate consistent estimates of output.

Taking the very strong stand that structural gravity generates the true data, these generated activity variables $\{\widetilde{Y}_i, \widetilde{E}_j\}$ are perfectly consistent with the theory. Their expected value (asymptotically) is the true value. In reality, both the fitted values $\widetilde{Y}_i$ and the observed values Y_i^* are measured with error, and the measurement error of the observed values might contaminate the estimates of the τ_{ij}'s such that the fitted values of (14) and (15) are not asymptotically unbiased.[22]

[22] Considering the potentially most problematic contamination issue is somewhat reassuring. The internal trade flows are typically generated as a residual $X_{ii}^* = Y_i^* - \sum_{j \neq i} X_{ij}^*$. The econometric model assumes that the observed bilateral trade flow value is related to the true value by $X_{ij}^* = X_{ij}\epsilon_{ij}$ where ϵ_{ij} is a random error term. The gravity estimation would apply this assumption to all trade flows, internal and international. When would this assumption be met? Generating $X_{ii}^* = Y_i^* - \sum_{j \neq i} X_{ij}^*$ is consistent with $X_{ii}^* = X_{ii}\epsilon_{ii}$ if and only if $Y_i^* = \sum_j X_{ij}\epsilon_{ij}$; that is, there is no additional source of measurement error in the output variables.

The primary challenge to implementing the system of equations (14)-(15) lies in the fact that, by definition, one crucial component ($\hat{\beta}^k_{it,6}$) of the trade cost function τ_{ij} cannot be estimated when output is missing or suspect. To see this, recall that the indicator for internal trade is the only variable that carries direct information on output. Thus we now turn to the issue of estimating border effects in the next section, in which we capitalize on the newly-created multi-dimensional database of border estimates from Section 4.3 to study their determinants.

5.2 On the Determinants of Border Effects in Services Trade

The wide variability across border estimates in each dimension (across countries, sectors, and time) sets the stage for meaningful econometric analysis. The contributions of this section are twofold. First, the empirical results from 'border estimations' add to our understanding of the forces behind the wedge between internal and border-crossing trade. This is an interesting question in itself because, as we demonstrated earlier, border effects in services trade are substantial while, at the same time, services now represent a larger share of GDP in the developed world compared to goods. Second, as discussed in the theoretical section, the ability to consistently predict border effects is a *necessary and sufficient* condition for successfully recovering missing output data.

The dummy variable nature of $SMCTRY_{ij}$ implies that the coefficient $\hat{\beta}^k_{it,6}$ is interpreted as a *relative* border effect:

$$\hat{\beta}^k_{it,6} = \ln\left(\frac{t^k_{ii,t}/b^k_{it}}{\bar{b}^k_t}\right)^{1-\sigma^k} = \ln X^k_{ii,t} - \hat{\eta}^k_{i,t} - \hat{\theta}^k_{i,t} \tag{16}$$

The middle expression captures the fact that for each sector the $SMCTRY$ estimates $\hat{\beta}^k_{it,6}$ account for, and consist of, three components that include *country-specific internal trade costs*, $t^k_{ii,t}$, and *country-specific border barriers*, b^k_{it}, which push in opposite directions and are

This is a plausible assumption because statistical practice would normally include such consistency checks. But it is not guaranteed.

identified relative to the third component, which is *an average border* $\bar{b}_t^k$. The terms on the right-hand side express the fitted value of the relative border cost as a deviation of observed internal trade from the importer and exporter fixed effects.

Our goal in this section is to find empirical proxies for the components of internal trade costs and border barriers that comprise $\beta_{it,6}^k$. However, before we do so, we find it instructive to rearrange the preceding equation to transform it into the following estimating equation:

$$\ln X_{ii,t}^k = \hat{\eta}_{i,t}^k + \hat{\theta}_{i,t}^k + \hat{\beta}_{it,6}^k. \tag{17}$$

Equation (17) represents a gravity model for internal trade and holds as an equality by construction. This is confirmed in column (1) of Table 6, where we regress the logarithm of internal trade on three covariates including the collection of border estimates $\hat{\beta}_{it,6}^k$, exporter-time fixed effects $\hat{\eta}_{i,t}^k$ and importer-time fixed effects $\hat{\theta}_{i,t}^k$, respectively. As expected, the coefficient estimates on each of these variables is equal to unity. The perfect model fit merely reflects the fact that the $SMCTRY$ coefficients embody all information about internal trade in gravity estimations when total output is known.

The idea in subsequent specifications (columns 2 and 3) is then to replace the $SMCTRY$ coefficient—as if it were unobservable—with observable country characteristics and gauge the explanatory power thereof. Equation (18) defines the empirical specification for decomposing the international border effect $\hat{\beta}_{it,6}^k$:

$$\ln X_{ii,t}^k = \gamma_1 \hat{\eta}_{i,t}^k + \gamma_2 \hat{\theta}_{i,t}^k + \underbrace{W_i \, \delta_1}_{t_{ii,t}} + \underbrace{Z_{i,t} \delta_2}_{b_{i,t}} + \underbrace{\nu^{\,k} + \mu_t}_{\bar{b}_t^k} + \varepsilon_{ii,t}^k, \tag{18}$$

Guided by the structural interpretation of $SMCTRY$ estimates from equation (16), we partition covariates into three groups. First, we chose the variables in vector W_i under the assumption that they primarily affect internal trade costs $t_{ii,t}$. These variables include internal distance, the domestic distribution/concentration of economic activity, an institutional index from the Worldwide Governance Indicators (WGI) as it relates to 'policies and regulations that permit and promote private sector development' (Kaufmann *et al.*, 2010), and—at the cost of losing some observations—the OECD's Product Market Regulation (PMR) index (Koske *et al.*, 2014). Guided by specification (17) we define $(\gamma_1 - 1)$ and $(\gamma_2 - 1)$ as size elasticities giving the effect on relative cross-border trade costs of variation in $\eta^k_{i,t}$ and $\theta^k_{i,t}$ respectively. The structural interpretation of these fixed effects is of effective demand size $E^k_{i,t}(P^k_{i,t})^{\sigma_k - 1}$ and effective supply size $Y^k_{i,t}(\Pi^k_{i,t})^{\sigma_k - 1}$ respectively. Notice that the size is defined at the sector level for each country i, anticipating heterogeneity across sectors for given countries.

The variables in the second group ($Z_{i,t}$) are chosen based on the assumption that they predominantly affect the size of the border barrier $b_{i,t}$. The vector of variables includes economic size (current GDP in PPP terms and population), the 'Rule of Law' index taken from the Worldwide Governance Indicators, the number of procedures it takes to enforce contracts (from the World Development Indicators), and measures of digital infrastructure assumed to facilitate cross-border services trade (the number of secure Internet servers, fixed-line teledensity, and the number of mobile subscriptions per 100 inhabitants, all taken from the WDI). Finally, we include sector and year fixed effects (ν^k and μ_t, respectively) in order to capture the fact that the border estimates are identified relative to an average border $\bar{b}_t$. The change in the overall fit of the model when we move from the perfect-fit specification of column (1) in Table 6 to the specification described by equation (18) will be informative about how well these proxies do in terms of explaining the variability of border effects and in predicting internal trade.

Our main findings are presented in column (2) of Table 6. With 86% of variation explained the model fit is fairly high.[23] Hence, the observable characteristics do well in controlling for unobservable internal trade costs (t_{ii}) and border barriers (b_i). In terms of predicted signs, factors that increase internal trade costs (W_i variables) will lead to lower internal trade, so we

[23]The majority of explanatory power is in fact due to observable country characteristics, as sector and year fixed effects alone explain only 28.7% of the variation in log internal trade.

expect a negative relationship. Factors that increase the border barrier ($Z_{i,t}$ variables) would, *ceteris paribus*, be associated with higher internal trade so we expect a positive coefficient.

The set of explanatory variables fits these priors very well; for instance, internal distance raises trade costs and thus comes in negative whereas business-friendly regulations lower trade costs and therefore exhibit a positive coefficient. Good digital infrastructure, in turn, reduces the deflective force of border barriers and leads to lower internal trade, thus coefficients of these variables generally exhibit a negative sign.

In column (3) we also consider the OECD's Product Market Regulation (PMR) indicator, which has been widely used and enables us to account for the effects on trade flows of domestic regulatory barriers in service sectors. Consistent with expectations, we find that higher PMR values are associated with lower internal trade. Indeed, the negative coefficient on the PMR indicator is driven by the PMR subindex that captures (i) more complex regulatory procedures, (ii) administrative burdens and (iii) barriers in network sectors, all of which are relevant for internal trade costs. As such, we think that these results offer important insights. They are reported in separate models, though, as PMR inclusion comes at the cost of losing some observations.[24]

The pooled regression is convenient for a quick insight into performance, but there is good reason to suspect that much heterogeneity obtains across sectors. Table 7 confirms this suspicion, but the main insights remain the same: negative size elasticities that are large in absolute value, not significantly different for exporter or importer size, negative distance elasticities, positive GDP per capita elasticities, large negative effects of the rule of law, etc.[25] One sector that performs relatively poorly is Travel, with a positive distance elasticity and notably poorer goodness of fit (at an adjusted R^2 of 0.736, low in the context of the other sectors).[26]

[24]The PMR indicators for the period under consideration are not available for Estonia, Lithuania, Latvia and Slovenia. PMR indices are only available at some discrete points in time; we take the 2003 values and exploit the variation in regulatory stringency across countries.

[25]Output projections of similar accuracy can be based on a more parsimonious model of national characteristics featuring only area, GDP, population and a governance index.

[26]The positive distance elasticity could reflect some idiosyncratic features of travel services. For instance,

Overall, we view our analysis of the determinants of international borders in services trade as a successful first attempt to study this matter. The estimates appear to be intuitive with expected signs, reasonable magnitudes and a remarkable model fit. Importantly, none of the regressors employed in our specifications relies on sectoral production data. The high $R^2 = 0.86$ in the main specification (column 2) is an encouraging and essential precondition for satisfactory out-of-sample predictions of border estimates, which in turn are crucial for the success of our methods to recover missing output. In the following section, we capitalize on the ability to predict internal trade and on the strong performance of the structural gravity model to test our new methods for recovering missing output data.

5.3 Econometric Approach

We use equation (18) as an empirical strategy for predicting internal trade and, in combination with observed international trade, to reconstruct output based on fitted values of $\hat{X}^k_{ii,t}$. In so doing we focus on the 'worst' case when no disaggregated production information is available at all for a given country and sector. Output predictions are then generated in four steps: (i) obtain a full set of country-sector-year specific $SMCTRY$ coefficients from estimating a gravity model; (ii) one particular country's internal trade flow is discarded (and so is the associated $SMCTRY$ coefficient) as if no output were available in this case; then use equation (18) to project the remaining internal trade flows onto observables as in the previous Section 5.2; (iii) predict out-of-sample so as to recover unobserved internal trade based on the particular country's observable characteristics; (iv) repeat steps (ii)-(iii) for each country and for each sector in our sample, collecting fitted values in each case. As a

it is not implausible that the substitution elasticity for domestic travel is substantially lower (below unity) than for international trips as many domestic trips rather resemble "necessities." We have experimented with including 'receipts from international tourism' as an additional control variable in the travel sector regression, the effect of which is positive and highly significant and renders the distance elasticity insignificant. This finding is consistent with two (not mutually exclusive) effects: it could either reflect mis-measurement in the sense that a good deal of internal travel might actually originate from international customers which, however, would be recorded in our setting as internal trade. There might also be a relative price effect at work such that a country's relative attractiveness as a tourist destination (as evidenced by large receipts) is observationally equivalent to a high barrier of going abroad for domestic residents. A larger share of residents in such countries would thus vacation at home, thereby giving rise to the positive correlation.

last step, we combine estimated internal trade with a country's total exports to obtain total output (or with total imports to obtain total expenditure, respectively) and evaluate these predictions against their true values.

5.4 Results on Predicted Output

We start by juxtaposing the overall distribution of actual log output (across all countries, sectors and years) and its estimated equivalent (Figure 9). Reassuringly, the kernel density estimates of the two distributions are fairly close, even though the novel procedure exhibits a slight tendency to overpredict output, and the representation in logs tends to de-emphasize large values. Therefore, we go on to evaluate the accuracy of our method in greater detail (i) by comparing the procedure's predictions to ones arising from a naïve benchmark, and (ii) by expressing imputed output as a percentage deviation from its true value. The former provides a sense to what extent the novel imputations outperform an agnostic benchmark, obtained directly as the simple average of output across those countries retained for fitting the auxiliary regression. The latter set of results then quantifies how closely the predictions come to their true values. Both exercises are based upon 1,215 output prediction that obtain from running out-of-sample estimations for each sector and country (each combination containing four years), as set out in section 5.2.

Upon computing the absolute deviation from a perfect prediction for both our procedure and the agnostic benchmark, respectively, we find that in 963 cases out of 1,215 country-sector-year estimates of output, equivalent to 79.3%, our method delivers more accurate predictions. The binary count measure comparison can be broken down by sector (Figure 10) and by country (Figure 11). Clearly, the accuracy of predictions is more varied in the country dimension. Nonetheless, it is reassuring to see structural gravity based imputations outperform an agnostic benchmark in nearly 80% of cases.[27]

We proceed to characterize the percentage deviation of predicted to actual output, again

[27]If the agnostic benchmark is taken to be *median* output, the share of better predictions is still 65.4%.

by sector (Table 8) and by country (Table 10). By construction, 100% corresponds to a perfect prediction. Across all countries, sectors and years, median predicted output equals 108.9% of actual output. The interquartile range (columns 4-5) is also reasonably tight considering that all production information has been dropped before making these imputations. That said, it is true that the distribution of predictions is skewed upward as a result of a few very large numbers that obtain when the base on which the percentage deviation is calculated (actual output) is a small number. Thus the mean prediction (148%) exceeds the median prediction.

The disaggregation of results indicates that the consistency of predictions as well as their dispersion is fairly homogeneous across different services sectors, while there exists appreciably more variation across countries. Hence, the prediction accuracy is mostly affected by outliers for individual countries in certain sectors. We suspect that such mis-predictions occur when a country's international services trade is minuscule relative to its internal trade, which leads to very large estimated border effects that in turn produce outlier predictions. Indeed, when partitioning the sample of predictions according to countries' supply shares in a given sector, we find that predictions tend to be worse, and exhibit a larger variance, when supply shares are low (Table 9). It is also true, as conjectured, that predictions are less accurate when a smaller share of production is exported abroad (ie. the share of internal trade is high).[28]

We conclude from this benchmarking exercise that the novel procedure of recovering missing output data based on structural gravity restrictions delivers reasonable results. Output figures thus estimated are robust to the specification of the auxiliary regression. The procedure's good performance in a situation in which no production data at all is available is particularly appealing because outside OECD countries, almost no measures but projected measures exist. At the same time, it is clear that the precision of the estimated quantities depends on how much actual output information is available for estimating equation

[28]A full break-down by sector and country (as in Tables 8 or 10) for either type of partitioning is available upon request.

(18). Thus we conduct a sensitivity check to illustrate how output predictions depend on the relative share of inferred to actual information, which demonstrates two regularities: first, median inferred output (as a percentage deviation from its true value) is stable as it is consistently estimated even as less information is used to predict it. Second, the confidence interval widens as the auxiliary regression is based upon less and less countries. The pattern of loss in accuracy is qualitatively similar across countries, and does also not vary across years. The results of this robustness exercise are obviously noisy due to small sample size in combination with influential data; however, they do support the notion that the method proposed in section 5.2 is not particularly sensitive to either the amount of data available or individual countries used for out-of-sample prediction. More details and figures are offered in Appendix B.

6 Conclusion

Structural gravity is applied to model barriers to services trade across many sectors, countries and time based on development of an integrated dataset for services production and trade. Border barriers are flexibly inferred relative to internal costs. An important regularity is that relative border barriers are declining in the size of sectoral activity. The cause of this external scale economy merits further investigation. We also find that border barriers have generally fallen over time but also identify differences across services sectors and countries; in particular, border effects for the smallest economies have remained stable, giving rise to a divergent pattern across countries.

The good fit and intuitive interpretation of the results encouraged development of a projection model whereby services production and trade data can be generated believably. A crucial step in this procedure decomposes border barriers according to their structural components, and the empirical estimation of the resultant model sheds light on the role of institutions, geography, size and digital infrastructure as determinants of border barriers.

The success of the projection method suggests that it could be usefully applied to analyse developing countries' services trade. More generally, beyond services trade, for which the missing data problem is especially severe, our projection method may be useful when other trade or production data quality is suspect.

The full general equilibrium effect of border barriers in services trade includes their effect on multilateral resistances (see Agnosteva *et al.*, 2014). We leave this extension for future work. Such general equilibrium analyses may also combine goods and services trade, for which the methods and results developed in this paper would be useful.

References

Agnosteva, D., Anderson, J. and Yotov, Y. (2014). 'Intra-national trade costs: Measurement and aggregation', *NBER Working Paper No. 19872*.

Anderson, J. (1979). 'A theoretical foundation for the gravity equation', *American Economic Review*, vol. 69(1), pp. 106–116.

Anderson, J. (2011). 'The gravity model', *Annual Review of Economics*, vol. 3, pp. 133–160.

Anderson, J. and van Wincoop, E. (2003). 'Gravity with gravitas: A solution to the border puzzle', *American Economic Review*, vol. 93(1), pp. 170–192.

Anderson, J. and van Wincoop, E. (2004). 'Trade costs', *Journal of Economic Literature*, vol. 42(3), pp. 691–751.

Anderson, J. and Yotov, Y. (2010a). 'The changing incidence of geography', *American Economic Review*, vol. 100(5), pp. 2157–2186.

Anderson, J. and Yotov, Y. (2010b). 'Specialization: Pro- and anti-globalizing, 1990-2002', *NBER Working Paper No. 16301*.

Anderson, J. and Yotov, Y. (2011). 'Terms of trade and global efficiency effects of free trade agreements, 1990-2002', *NBER Working Paper No. 17003*.

Armington, P. (1969). 'A theory of demand for products distinguished by place of production', *IMF Staff Papers*, vol. 16, pp. 159–176.

Baier, S. and Bergstrand, J. (2007). 'Do free trade agreements actually increase members' international trade?', *Journal of International Economics*, vol. 71(1), pp. 72–95.

Baldwin, R. and Taglioni, D. (2006). 'Gravity for dummies and dummies for gravity equations', *NBER Working Paper No. 12516*.

Bergstrand, J., Larch, M. and Yotov, Y. (2015). 'Economic integration agreements, border effects, and distance elasticities in the gravity equation', *European Economic Review,* forthcoming.

Cheng, I. and Wall, H. (2005). 'Controlling for heterogeneity in gravity models of trade and integration', *Federal Reserve Bank of St. Louis Review*, vol. 87(1), pp. 49–63.

Christen, E. and Francois, J. (2010). 'Modes of delivery in services', Centre for Economic Policy Research.

Coe, D., Subramanian, A., Tamirisa, N. and Bhavnani, R. (2002). 'The missing globalization puzzle', *IMF Working Paper No. 171.*

Costinot, A. and Rodriguez-Clare, A. (2014). 'Trade theory with numbers: Quantifying the consequences of globalization', Chapter 4 in the Handbook of International Economics Vol. 4, eds. Gita Gopinath, Elhanan Helpman, and Kenneth S. Rogoff, Elsevier Ltd., Oxford.

Coughlin, C.C. and Novy, D. (2013). 'Is the International Border Effect Larger than the Domestic Border Effect? Evidence from US Trade', *CESifo Economic Studies*, vol. 59(2), pp. 249–276.

Disdier, A. and Head, K. (2008). 'The puzzling persistence of the distance effect on bilateral trade', *The Review of Economics and Statistics*, vol. 90(1), pp. 37–48.

Eaton, J. and Kortum, S. (2002). 'Technology, geography and trade', *Econometrica*, vol. 70(5), pp. 1741–1779.

Eichengreen, B. and Irwin, D.A. (1996). 'The Role of History in Bilateral Trade Flows', National Bureau of Economic Research, Inc.

Fally, T. (2015). 'Structural gravity and fixed effects', *Journal of International Economics,* forthcoming, doi:10.1016/j.jinteco.2015.05.005.

Feenstra, R. (2004). *Advanced International Trade: Theory and Evidence*, Princeton, New Jersey: Princeton University Press.

Freund, C.L. and Weinhold, D. (2004). 'The effect of the internet on international trade', *Journal of International Economics*, vol. 62, pp. 171–189.

Head, K. and Mayer, T. (2000). 'Non-Europe: The magnitude and causes of market fragmentation in the EU', *Review of World Economics (Weltwirtschaftliches Archiv)*, vol. 136(2), pp. 284–314.

Head, K., Mayer, T. and Ries, J. (2008). 'How remote is the offshoring threat?', *European Economic Review*, vol. 53(4), pp. 429–444.

Hillberry, R. and Hummels, D. (2003). 'Intranational Home Bias: Some Explanations', *The Review of Economics and Statistics*, vol. 85(4), pp. 1089–1092.

Jensen, B.J. and Lori Kletzer, L. (2005). 'Tradable Services: Understanding the Scope and Impact of Services Outsourcing', *Institute for International Economics Working Paper*, vol. 05-9.

Kaufmann, D., Kraay, A. and Mastruzzi, M. (2010). 'The worldwide governance indicators: A summary of methodology, data and analytical issues', *World Bank Policy Research Working Paper, No. 5430.*

Kimura, F. and Lee, H.H. (2006). 'The gravity equation in international trade in services', *Review of World Economics*, vol. 142(1), pp. 92–121.

Koske, I., I.Wanner, Bitetti, R. and Barbiero, O. (2014). 'The 2013 update of the OECD product market regulation indicators: policy insights for OECD and non-OECD countries", *OECD Economics Department Working Papers.*

Lejour, A. and de Paiva Verheijden, J. (2004). 'Services trade with canada and the european union', CPB Netherlands Bureau for Economic Policy Analysis.

Mayer, T. and Head, K. (2002). 'Illusory border effects: Distance mismeasurement inflates estimates of home bias in trade', (2002-01).

Mayer, T. and Zignago, S. (2006). 'Notes on CEPII's distance measures', *CEPII*.

McCallum, J. (1995). 'National borders matter', *American Economic Review*, vol. 85(3), pp. 615–623.

Melitz, J. and Toubal, F. (2014). 'Native language, spoken language, translation and trade', *Journal of International Economics*, vol. 93(2), pp. 351–363.

Millimet, D.L. and Osang, T. (2007). 'Do state borders matter for U.S. intranational trade? The role of history and internal migration', *Canadian Journal of Economics*, vol. 40(1), pp. 93–126.

Miroudot, S., Sauvage, J. and Shepherd, B. (2012). 'Trade costs and productivity in services sectors', *Economics Letters*, vol. 114(1), pp. 36–38.

Nitsch, V. and Wolf, N. (2013). 'Tear down this wall: on the persistence of borders in trade', *Canadian Journal of Economics*, vol. 46(1), pp. 154–179.

Olivero, M. and Yotov, Y. (2012). 'Dynamic gravity: Endogenous country size and asset accumulation', *Canadian Journal of Economics*, vol. 45(1), pp. 64–92.

Santos Silva, J. and Tenreyro, S. (2006). 'The log of gravity', *Review of Economics and Statistics*, vol. 88(4), pp. 641–658.

Santos Silva, J. and Tenreyro, S. (2011). 'Further simulation evidence on the performance of the poisson pseudo-maximum likelihood estimator', *Economics Letters*, vol. 112(2), pp. 220–222.

Tharakan, P., Van Beveren, I. and Van Ourti, T. (2005). 'The determinants of india's software exports and goods exports', *The Review of Economics and Statistics*, vol. 87(4), pp. 776–780.

Trefler, D. (2004). 'The long and short of the canada-u.s. free trade agreement', *American Economic Review*, vol. 94(4), pp. 870–895.

Waugh, M.E. (2010). 'International trade and income differences', *American Economic Review*, vol. 100(5), pp. 2093–2124.

Yotov, Y.V. (2012). 'A simple solution to the distance puzzle in international trade', *Economics Letters*, vol. 117(3), pp. 794–798.

Tables and Figures

Table 1: Sector Description.

ID	Description	LABEL	EBOPS code	EBOPS level
1	Transportation	TRNSP	205	1
2	Travel	TRAVL	236	2
3	Communications services	CMMCN	245	3
4	Construction services	CSTRN	249	4
5	Insurance services	INSUR	253	5
6	Financial services	FINCE	260	6
7	Computer services	CMPTR	263	7.1
8	Merchanting/trade-rel services	TRADE	269	9.1
9	Operational leasing services	OPRNL	272	9.2
10	Business/prof/tech services	BUSIN	273	9.3
11	Research and development	RSRCH	279	9.3.3
12	Audiovisual and related services	AUDIO	288	10.1

Table 2: Panel PPML Gravity Estimates: Services, 2000-2006.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE
Distance (< med)	-0.330	-0.411	-0.100	-0.596	-0.055	-0.690
	(0.125)***	(0.102)***	(0.115)	(0.128)***	(0.240)	(0.259)***
Distance (> med)	0.047	-0.049	-0.028	0.023	-0.097	0.070
	(0.030)	(0.023)**	(0.031)	(0.036)	(0.041)**	(0.045)
Contiguity	0.733	0.877	1.214	0.705	0.481	-0.201
	(0.177)***	(0.141)***	(0.200)***	(0.227)***	(0.366)	(0.350)
Same Language	0.432	0.798	1.014	0.249	1.462	1.311
	(0.131)***	(0.139)***	(0.147)***	(0.301)	(0.300)***	(0.172)***
Colony	0.382	0.282	-0.288	-0.049	0.482	0.110
	(0.156)**	(0.164)*	(0.198)	(0.355)	(0.241)**	(0.215)
SMCTRY	2.824	0.966	6.440	4.135	6.355	2.215
	(0.901)***	(0.757)	(0.860)***	(0.944)***	(1.744)***	(1.886)
Observations	5151	5139	5151	5151	5000	4969

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
Distance (< med)	-0.983	-0.451	-0.603	-0.832	-1.210	-0.775
	(0.190)***	(0.138)***	(0.180)***	(0.164)***	(0.277)***	(0.300)***
Distance (> med)	0.013	0.030	0.020	0.047	0.165	-0.003
	(0.042)	(0.041)	(0.038)	(0.028)*	(0.052)***	(0.055)
Contiguity	0.236	0.498	1.363	0.225	0.099	0.486
	(0.311)	(0.276)*	(0.273)***	(0.338)	(0.475)	(0.450)
Same Language	0.173	0.672	-0.708	0.525	0.952	0.705
	(0.340)	(0.311)**	(0.251)***	(0.208)**	(0.294)***	(0.296)**
Colony	-0.346	-0.019	-0.264	-0.525	-1.572	0.252
	(0.293)	(0.491)	(0.404)	(0.242)**	(0.250)***	(0.265)
SMCTRY	-0.467	4.844	3.147	0.277	-3.033	2.884
	(1.356)	(0.996)***	(1.265)**	(1.248)	(1.976)	(2.165)
Observations	5001	5151	4461	5140	4933	4694

Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < .01$
Dependent variable: service exports.
Poisson estimation with std.err. clustered at country-pair level.
Full sets of exporter-year and importer-year fixed effects included but not reported.

Table 3: Panel PPML Gravity Estimates: Services, Trade cost coefficients, 2000-06.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE
Distance (< med)	-0.678	-0.938	-0.732	-0.694	-0.119	0.028
	(0.094)***	(0.110)***	(0.159)***	(0.186)***	(0.326)	(0.186)
Distance (> med)	0.015	-0.024	-0.043	-0.047	-0.090	-0.130
	(0.020)	(0.020)	(0.028)	(0.043)	(0.062)	(0.041)***
Contiguity	0.355	0.427	0.416	-0.094	0.565	0.313
	(0.118)***	(0.120)***	(0.175)**	(0.227)	(0.305)*	(0.306)
Same Language	0.143	0.540	0.356	0.282	1.052	0.526
	(0.101)	(0.126)***	(0.148)**	(0.255)	(0.233)***	(0.174)***
Colony	0.204	0.303	-0.097	0.402	-0.081	0.195
	(0.127)	(0.171)*	(0.132)	(0.294)	(0.331)	(0.228)
Observations	5151	5139	5151	5151	5000	4969

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
Distance (< med)	-0.205	-0.694	-0.299	-0.239	-0.044	-0.609
	(0.245)	(0.201)***	(0.269)	(0.171)	(0.300)	(0.292)**
Distance (> med)	-0.147	-0.000	-0.007	-0.047	0.003	-0.018
	(0.041)***	(0.045)	(0.044)	(0.032)	(0.052)	(0.050)
Contiguity	0.248	-0.186	1.324	0.230	0.536	0.455
	(0.245)	(0.229)	(0.303)***	(0.192)	(0.358)	(0.341)
Same Language	-0.203	0.365	-0.470	0.556	1.070	1.061
	(0.265)	(0.219)*	(0.281)*	(0.231)**	(0.275)***	(0.320)***
Colony	0.418	0.344	-0.061	-0.521	-1.407	0.120
	(0.248)*	(0.257)	(0.334)	(0.280)*	(0.316)***	(0.219)
Observations	5001	5151	4461	5140	4933	4694

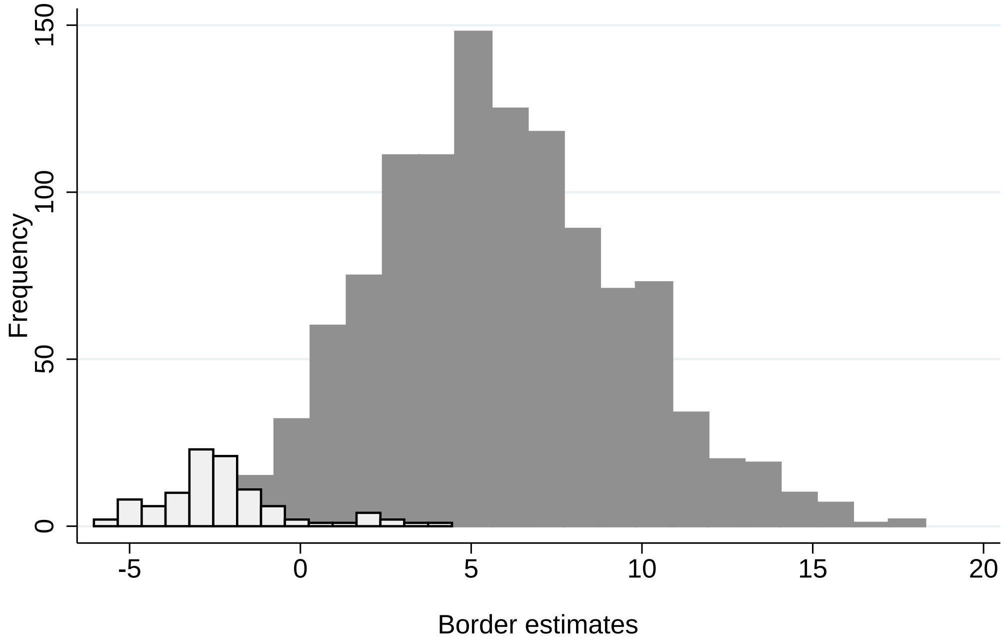
Standard errors in parentheses. * $p < 0.10$, ** $p < .05$, *** $p < .01$

Dependent variable: service exports.

Poisson estimation with std.err. clustered at country-pair level.

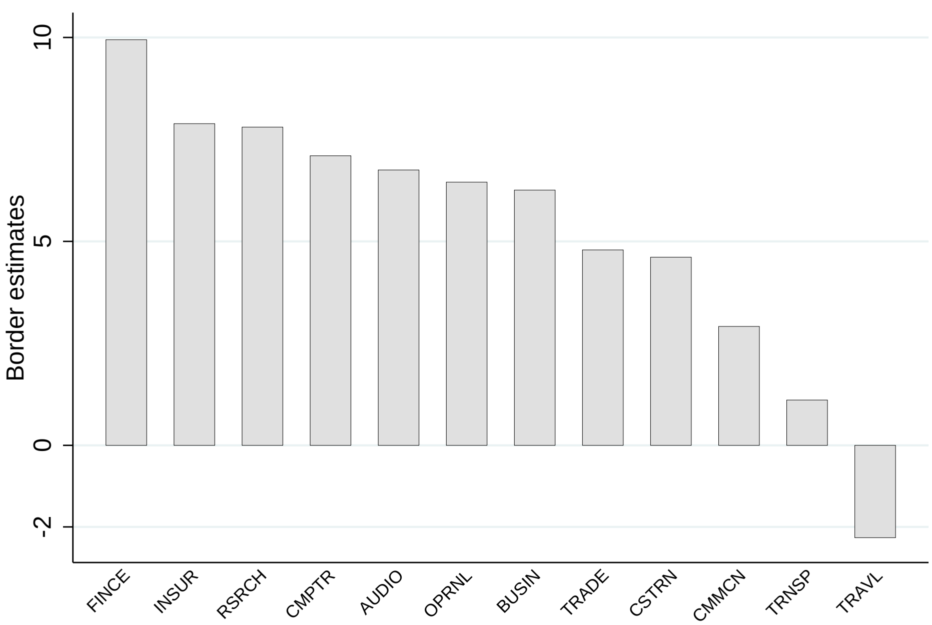
Full sets of exporter-year, importer-year and country-year-SMCTRY fixed effects included but not reported.

Figure 1: Overall Distribution of SMCTRY Coefficients



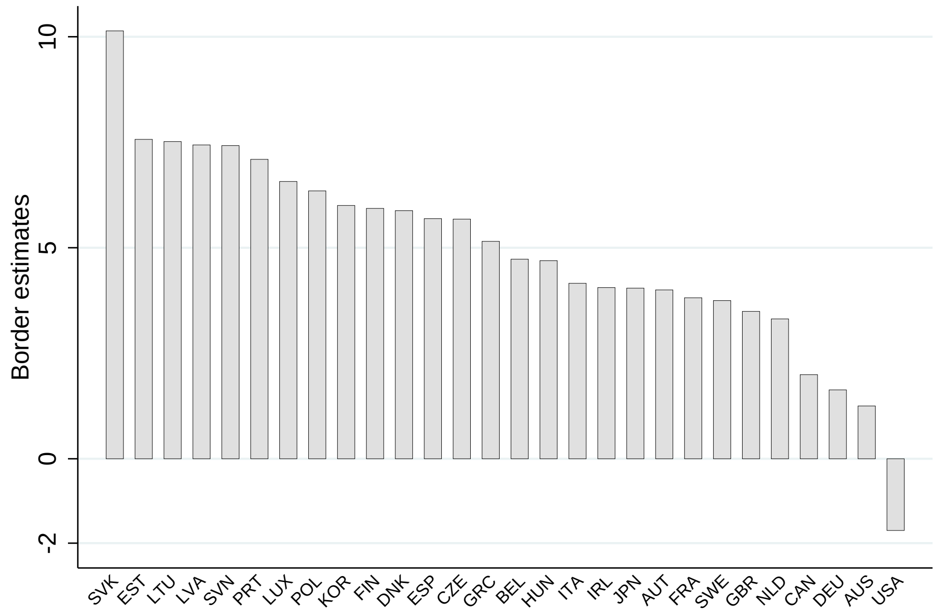
Notes:
Distribution based on 1231 SMCTRY coefficient estimates across all sectors, countries and years; Travel sector coefficients depicted separately in light grey. Median border estimate = 5.35

Figure 2: Border Effects across Sectors



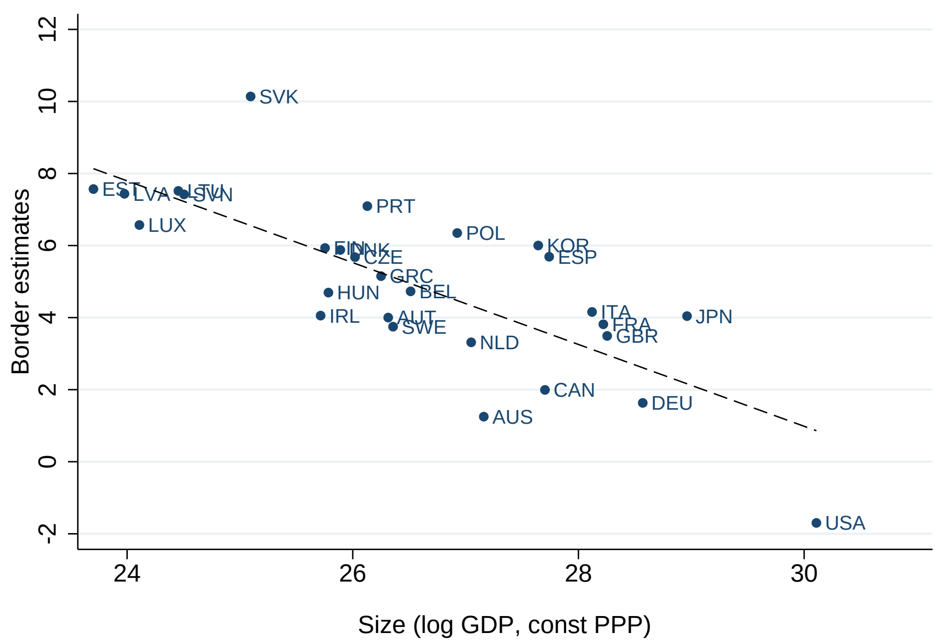
Note: Average SMCTRY coefficient per sector across countries and years.

Figure 3: Border Effects across Countries



Note: Average SMCTRY coefficient per country across sectors and years.

Figure 4: Border Effects and Country Size



Note: Correlation coefficient = -.76 (p-value: 0)

Table 4: Sectoral "SMCTRY" Estimates

(1) Sector	(2) 2000	(3) 2002	(4) 2004	(5) 2006
TRNSP	1.68	1.15	0.93	0.66
TRAVL	-1.25	-2.44	-2.74	-2.76
CMMCN	3.39	3.52	2.54	2.17
CSTRN	5.06	4.92	4.18	4.28
INSUR	7.85	9.18	7.30	7.22
FINCE	10.24	11.19	9.35	9.03
CMPTR	7.61	8.15	6.65	6.01
TRADE	5.64	5.51	4.13	3.85
OPRNL	6.45	7.29	6.09	5.97
BUSIN	7.10	6.89	5.56	5.48
RSRCH	7.93	8.51	7.73	7.01
AUDIO	6.49	7.98	6.31	6.20

Note: Average "SMCTRY" coefficient estimates per sector.

Table 5: "SMCTRY" Estimates by Country

(1) Country	(2) 2000	(3) 2002	(4) 2004	(5) 2006
AUS	1.48	1.12	1.42	0.97
AUT	4.42	4.42	3.55	3.58
BEL	6.86	5.28	3.33	3.44
CAN	2.02	2.09	1.88	.
CZE	6.20	6.28	5.37	4.86
DEU	1.41	1.33	1.94	1.85
DNK	7.67	7.51	4.76	3.58
ESP	6.08	6.08	5.45	5.15
EST	5.67	9.59	7.51	6.98
FIN	6.67	7.08	5.09	4.89
FRA	4.18	4.23	3.48	3.38
GBR	4.16	3.78	3.32	2.71
GRC	4.95	5.76	4.83	5.07
HUN	5.40	5.65	3.89	3.85
IRL	4.49	5.57	3.12	2.95
ITA	4.76	4.94	3.54	3.40
JPN	4.21	4.18	4.17	3.60
KOR	6.60	6.74	5.94	4.72
LTU	5.35	10.04	7.11	7.61
LUX	7.57	7.42	5.49	5.71
LVA	5.93	8.92	7.28	7.37
NLD	3.73	3.89	2.94	2.69
POL	7.34	7.97	5.35	4.72
PRT	7.17	8.35	6.40	6.46
SVK	11.41	10.01	9.77	9.37
SVN	8.00	6.51	7.67	7.44
SWE	4.12	4.15	3.27	3.45
USA	-2.16	-1.87	-1.50	-1.26

Note: Average "SMCTRY" coefficient estimates per country.

Figure 5: Border Effects over Time, by GDP Quintile

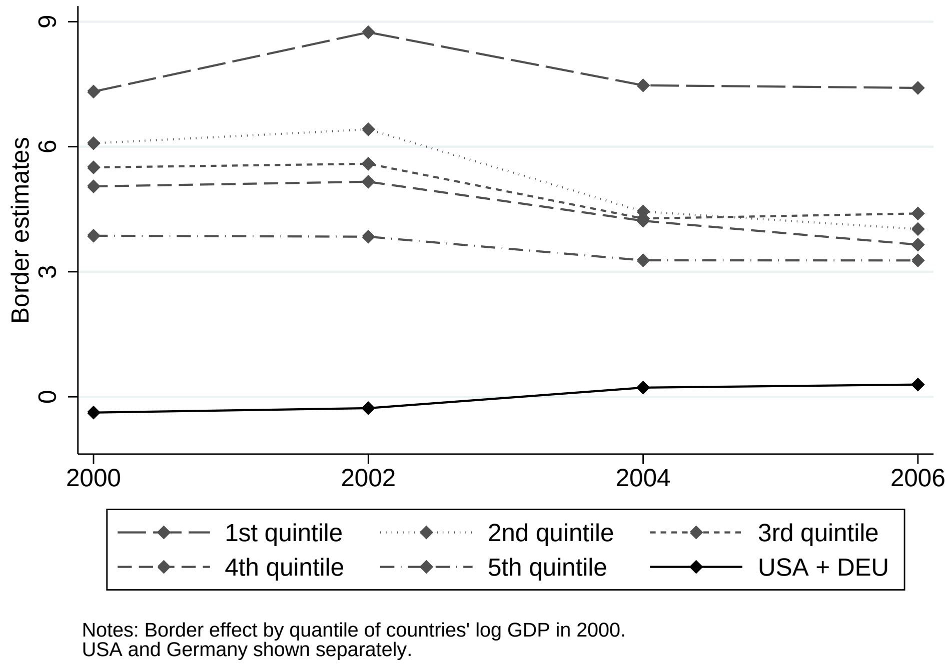


Figure 6: Border Effects over Time: Transportation Sector, by Output Share

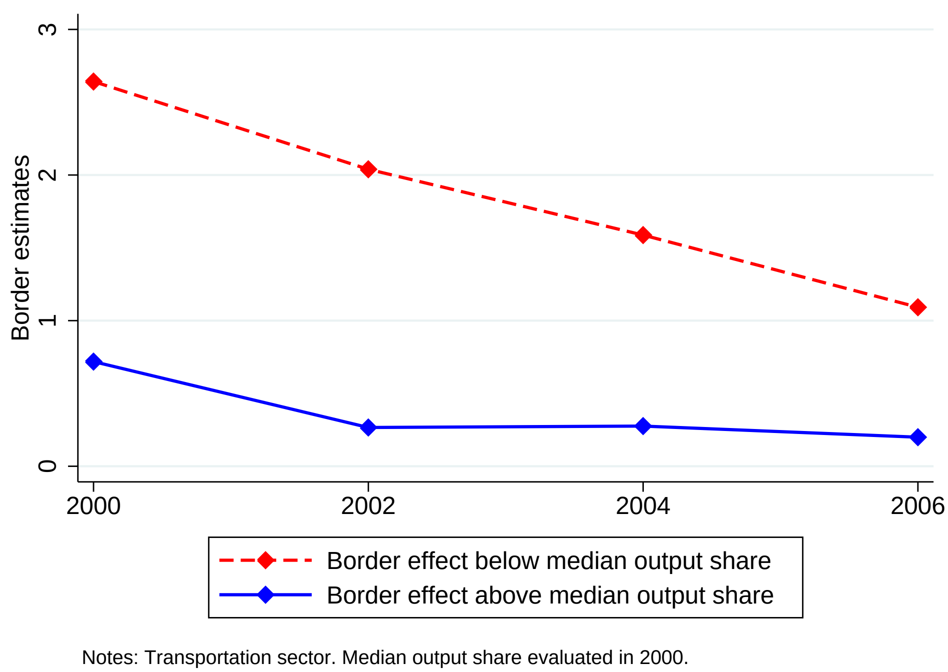
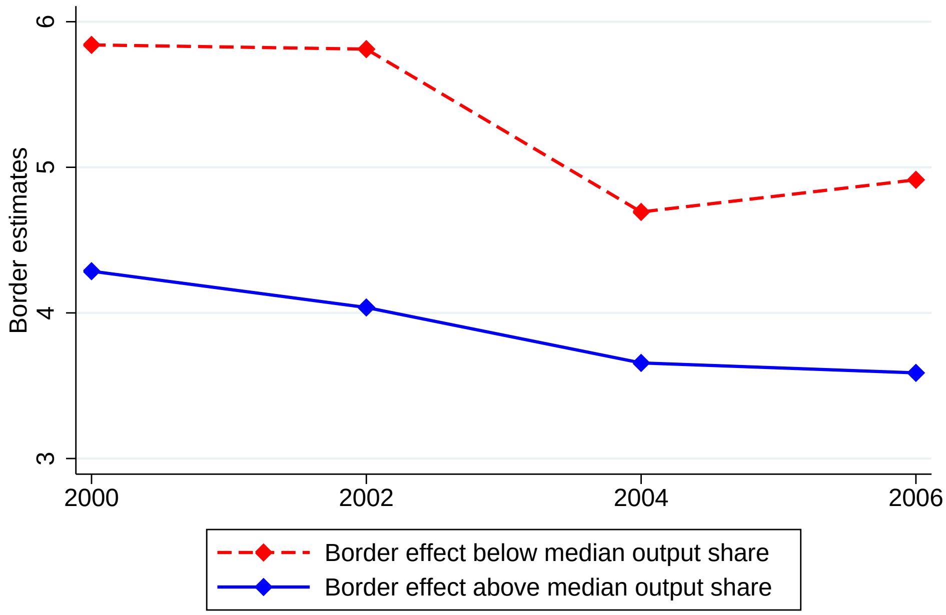
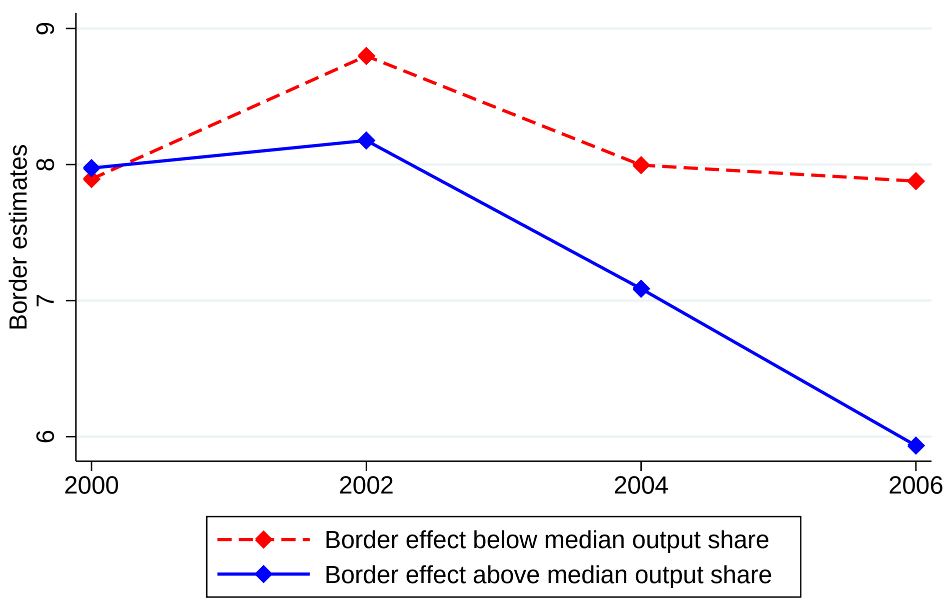


Figure 7: Border Effects over Time: Construction Sector, by Output Share



Notes: Construction sector. Median output share evaluated in 2000.

Figure 8: Border Effects over Time: Research/Development Sector, by Output Share



Notes: Research and Development sector. Median output share evaluated in 2000.
Countries AUS, CAN, EST and USA omitted (no sectoral output data).

Table 6: Home Bias Estimates (OLS), pooled estimation, 2000-06

	(1)	(2)	(3)
Gravity exporter FE	1.0000	1.0000	1.0000
	(0.000)	(0.000)	(0.000)
Gravity importer FE	1.0000	1.0000	1.0000
	(0.000)	(0.000)	(0.000)
Gravity $SMCTRY$ coeff	1.0000		
	(0.000)		
Size elasticity (exporter)	1.0000	-0.9442***	-0.9380***
	(0.000)	(0.026)	(0.027)
Size elasticity (importer)	1.0000	-0.8885***	-0.9319***
	(0.000)	(0.033)	(0.033)
Determinants of Internal Trade Costs, $t_{ii,t}$			
Log internal distance		-0.4205***	-0.3325***
		(0.060)	(0.054)
Dom distr econ activity		0.3920***	0.3733***
		(0.059)	(0.060)
Priv Sector Develop (WGI)		0.6505***	0.3391**
		(0.158)	(0.148)
OECD PMR Index			-1.2956***
			(0.194)
Border Barriers, $b_{i,t}$			
Log GDP (PPP, curr)		2.3294***	1.3739***
		(0.133)	(0.168)
Log Population		-1.5352***	-0.7218***
		(0.134)	(0.159)
Contract enforc (# proc)		0.0238***	0.0210***
		(0.006)	(0.007)
Rule of Law (WGI)		-0.7320***	-1.0670***
		(0.132)	(0.149)
Secure Internet servers		0.0365	-0.0509
		(0.052)	(0.087)
Fixed-line teledensity		-0.0241***	0.0013
		(0.003)	(0.004)
Mobile phone teledensity		-0.0205***	-0.0201***
		(0.002)	(0.002)
Average Border, $\bar{b}_t$			
Sector Fixed Effects, ν^k		Yes	Yes
Year Fixed Effects, μ_t		Yes	Yes
Observations	1215	1215	1051
Adjusted R^2	1.000	0.860	0.819

Dependent variable: $\ln X_{ii}$

Sector and year fixed effects included in models (2)-(3) but not reported.

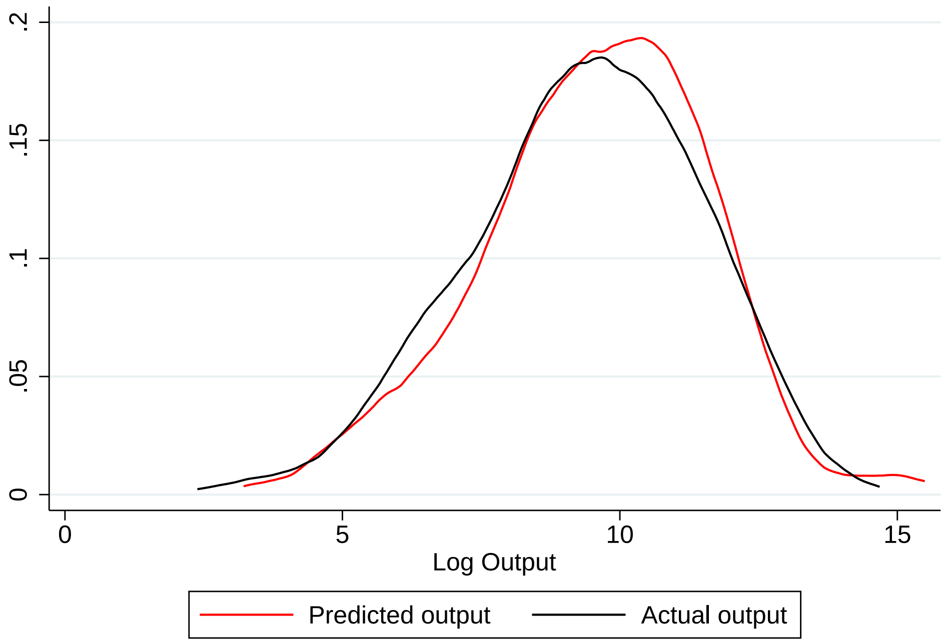
Least squares estimation with bootstrapped std.err. (500 replications).

Table 7: Home Bias Estimates (OLS), by sector, 2000-06.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
Gravity exporter FE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gravity importer FE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Size elasticity (exporter)	-0.8803***	-1.3706***	-1.0721***	-1.1509***	-0.8763***	-0.9154***	-1.1589***	-0.9533***	-0.9953***	-1.0065***	-1.2355***	-1.0803***
	(0.228)	(0.225)	(0.111)	(0.091)	(0.086)	(0.072)	(0.116)	(0.058)	(0.107)	(0.115)	(0.205)	(0.048)
Size elasticity (importer)	-0.7802***	-0.3076	-0.8044***	-0.7964***	-0.8761***	-0.7924***	-0.8715***	-0.9511***	-0.8163***	-0.6626***	-0.8001***	-0.9600***
	(0.235)	(0.288)	(0.126)	(0.146)	(0.118)	(0.093)	(0.140)	(0.087)	(0.144)	(0.138)	(0.166)	(0.061)
Determinants of Internal Trade Costs, $t_{ii,t}$												
Log internal distance	-0.5728***	0.6398*	-0.2891**	-0.2911**	-0.7953***	-0.4051**	-0.0813	-0.2844**	0.0835	-0.7470***	-0.8927*	-0.0415
	(0.134)	(0.361)	(0.122)	(0.135)	(0.202)	(0.161)	(0.220)	(0.128)	(0.357)	(0.210)	(0.488)	(0.182)
Dom distr econ activity	1.0354***	-0.6101**	0.2219*	0.1788	0.4432**	0.1971	0.8417***	0.2799*	0.0909	0.6982***	0.9369***	0.4833***
	(0.186)	(0.302)	(0.131)	(0.127)	(0.182)	(0.143)	(0.168)	(0.146)	(0.297)	(0.153)	(0.304)	(0.179)
Priv Sector Develop (WGI)	0.2939	1.2902	0.7910*	0.5161	0.9691**	0.9174**	0.9802*	0.5793	1.7756**	0.6557	0.1674	1.3019**
	(0.546)	(0.983)	(0.459)	(0.484)	(0.490)	(0.453)	(0.579)	(0.469)	(0.853)	(0.537)	(0.991)	(0.632)
Border Barriers, $b_{i,t}$												
Log GDP (PPP, curr)	1.7498***	4.1521***	1.8159***	2.2260***	2.9444***	2.5036***	3.5073***	1.8994***	2.5614***	1.9905***	2.4210**	2.7892***
	(0.395)	(0.791)	(0.334)	(0.350)	(0.543)	(0.468)	(0.459)	(0.400)	(0.601)	(0.513)	(0.956)	(0.563)
Log Population	-1.2049***	-2.6250***	-0.8885***	-1.1849***	-2.1426***	-1.7471***	-2.9804***	-0.9770***	-1.6621**	-1.2820**	-1.6215	-2.0656***
	(0.423)	(0.713)	(0.334)	(0.384)	(0.566)	(0.507)	(0.483)	(0.351)	(0.711)	(0.551)	(1.014)	(0.557)
Contract enforc (# proc)	0.0102	0.0296	0.0132	0.0170*	0.0172	0.0470**	-0.0050	0.0218*	-0.0045	0.0456***	0.0579	0.0249
	(0.012)	(0.032)	(0.011)	(0.010)	(0.022)	(0.019)	(0.019)	(0.013)	(0.025)	(0.017)	(0.054)	(0.016)
Rule of Law (WGI)	-0.3245	-1.2957**	-0.5410**	-0.3449	-0.8773**	-0.9244**	-1.3118***	-0.5016*	-1.1027	-0.6418	-0.6512	-1.6351***
	(0.360)	(0.636)	(0.259)	(0.339)	(0.433)	(0.431)	(0.461)	(0.281)	(0.725)	(0.476)	(1.005)	(0.561)
Secure Internet servers	-0.0187	-0.7950	-0.0746	-0.1398	0.0675	-0.1067	0.2814*	-0.0283	0.1050	0.0141	0.1662	0.1237
	(0.169)	(0.484)	(0.152)	(0.167)	(0.153)	(0.167)	(0.160)	(0.157)	(0.268)	(0.147)	(0.320)	(0.188)
Fixed-line teledensity	-0.0350***	-0.0167	-0.0243***	-0.0319***	-0.0359***	-0.0180**	-0.0316***	-0.0312***	-0.0333*	-0.0235**	0.0034	-0.0116
	(0.010)	(0.015)	(0.009)	(0.008)	(0.013)	(0.009)	(0.010)	(0.009)	(0.017)	(0.010)	(0.020)	(0.009)
Mobile phone teledensity	-0.0135**	-0.0150	-0.0177***	-0.0206***	-0.0275***	-0.0212***	-0.0275***	-0.0165***	-0.0224**	-0.0260***	-0.0305**	-0.0252***
	(0.006)	(0.012)	(0.006)	(0.007)	(0.009)	(0.008)	(0.008)	(0.006)	(0.010)	(0.007)	(0.013)	(0.008)
Average Border, $\bar{b}_t$												
Year Fixed Effects, μ_t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	111	99	111	111	96	97	98	111	94	100	96	91
Adjusted R^2	0.856	0.736	0.899	0.881	0.877	0.879	0.881	0.885	0.819	0.895	0.605	0.862

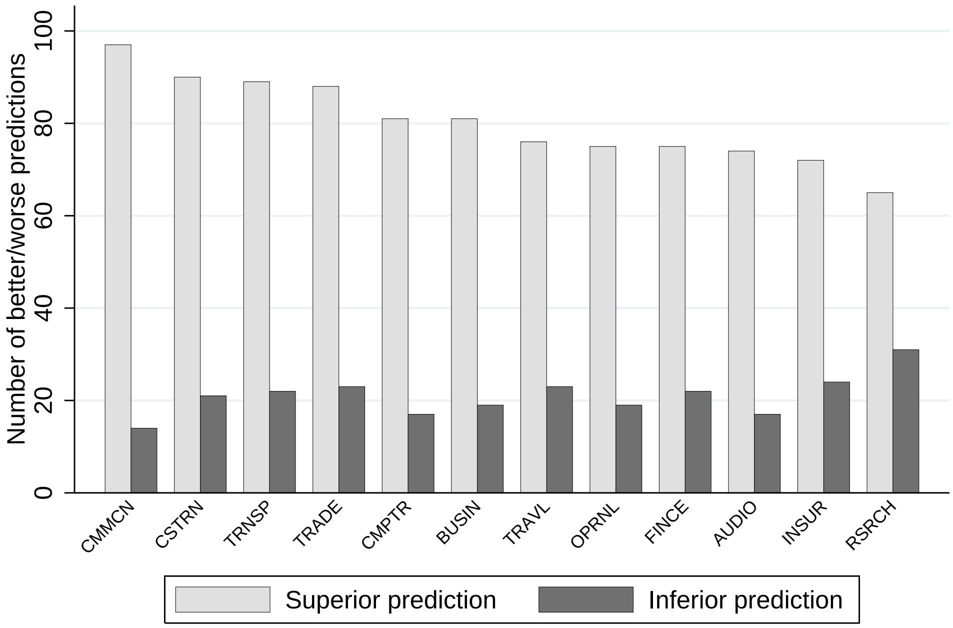
Dependent variable: $\ln X^k_{ii,t}$. Year fixed effects included but not reported.
Least squares estimation with bootstrapped std.err. (500 replications).

Figure 9: Accuracy of Output Estimation



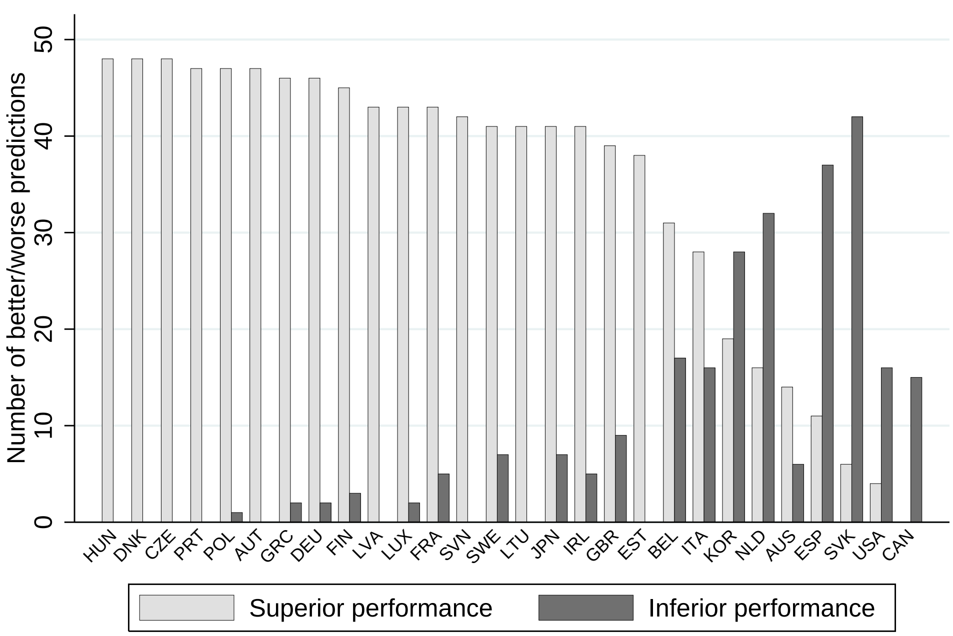
Notes: Densities based on 1332 observations across all sectors, countries and years.

Figure 10: Accuracy of Output Estimation (II), by sector



Note: superior prediction denotes instances in which novel procedure delivers output estimates that are closer to true value than naive benchmark.

Figure 11: Accuracy of Output Estimation (II), by country



Note: superior prediction denotes instances in which novel procedure delivers output estimates that are closer to true value than naive benchmark.

Table 8: Y prediction (percentage deviation)

	Obs	Median	Mean	P25	P75
TRNSP	111	104.3	161.5	65.9	312.5
TRAVL	99	114.1	229.8	67.6	304.2
CMMCN	111	128.5	122.0	76.3	151.8
CSTRN	111	130.8	170.0	72.4	306.7
INSUR	96	103.9	128.4	48.1	171.9
FINCE	97	107.1	117.2	59.5	156.4
CMPTR	98	94.3	99.4	42.8	118.1
TRADE	111	119.2	143.4	65.0	225.4
OPRNL	94	67.0	105.3	37.9	108.7
BUSIN	100	95.9	106.4	62.0	134.7
RSRCH	96	72.9	185.1	26.7	146.9
AUDIO	91	75.7	104.6	43.0	133.7
Total	1215	108.9	148.0	64.5	217.7

Table 9: Output predictions by subsamples

	Obs	Median	Mean	SD	P25	P75
Full sample	1215	108.9	148.0	140.6	64.5	217.7
Sample partitioned by median supply share:						
below	581	127.7	158.3	307.2	75.7	191.9
above	634	107.6	147.4	123.2	62.9	225.4
Sample partitioned by median trade concentration:						
below	589	95.0	121.2	157.5	68.0	142.0
above	626	125.1	158.1	132.3	59.2	239.7

Notes:
Threshold median calculated for country-sector combinations.
Trade concentration means share of internal to total trade.

Table 10: Y prediction (percentage deviation)

	Obs	Median	Mean	P25	P75
AUS	20	45.7	56.9	38.9	60.9
AUT	47	119.0	121.6	99.3	139.7
BEL	48	149.0	187.0	133.2	217.6
CAN	15	241.1	265.6	237.8	248.2
CZE	48	203.3	210.9	176.7	244.7
DEU	48	68.0	70.2	60.5	71.5
DNK	48	84.2	115.1	76.3	147.3
ESP	48	141.3	170.3	89.4	217.7
EST	38	152.7	148.8	122.1	171.0
FIN	48	164.6	173.8	132.3	199.2
FRA	48	107.0	101.7	76.8	128.5
GBR	48	46.1	50.1	43.1	53.5
GRC	48	104.3	134.8	42.2	166.1
HUN	48	332.8	373.5	309.4	443.8
IRL	46	118.4	164.2	79.2	205.6
ITA	44	79.3	99.9	73.1	107.6
JPN	48	89.4	99.3	64.9	131.4
KOR	47	125.1	186.2	118.2	270.9
LTU	41	192.0	204.8	190.3	233.1
LUX	45	47.3	84.5	34.8	96.5
LVA	43	152.6	160.9	145.2	171.0
NLD	48	169.5	191.7	159.1	200.8
POL	48	176.6	193.4	158.2	233.3
PRT	47	54.7	55.1	49.3	72.5
SVK	48	3.5	3.8	3.3	4.1
SVN	42	197.0	207.7	152.6	219.5
SWE	48	64.3	70.0	53.5	78.4
USA	20	255.3	288.7	225.4	338.6
Total	1215	108.9	148.0	64.5	217.7

Supplementary Material

Appendix A: Data Description

Supplementing Section 3, this appendix offers more detailed information on data sources and construction of variables.

Trade Data. Our primary source of data on cross-border services trade flows are the "OECD Statistics on International Trade in Services: Volume II - Detailed Tables by Partner Country" (Complete Edition as obtained from OECD.Stat, henceforth "TiSP").[29] The database provides information on international trade in services by partner country for 32 reporting OECD countries plus the Russian Federation and Hong Kong China, which is a non-member Special Administrative Region of China that is in the top twenty service exporters in the world. For each reporting country, data for at least the main trading partners are provided. We use data covering the period from 2000-2007. All values are in millions of US dollars.[30] In addition to the partner dimension, TiSP trade data are also broken down by type of service according to the Extended Balance of Payments Services (EBOPS) classification, i.e. standard components and possibly sub-items according to the fifth edition of the IMF's Balance of Payments Manual (BPM5); the BMP5's core recommendation calls on countries to report trade in 11 main categories of services and, as far as possible, the full detail of EBOPS sub-items. Thus, not surprisingly, the level of detail reported varies across countries.

We focus on export flows as a more reliable measure of trade flows due to stronger

[29] The data capture trade between residents and non-residents of countries and are reported within the framework of the Manual on Statistics of International Trade in Services.

[30] Baldwin and Taglioni (2006) discuss the implications of inappropriate deflation of nominal trade values, which they call "the bronze-medal mistake" in gravity estimations. Their most preferred econometric specification is one with un-deflated trade values, bilateral fixed effects, and time-varying country dummies, which, in addition to accounting for the multilateral resistances in a dynamic setting, will "also eliminate any problems arising from the incorrect deflation of trade." As mentioned above, the structural interpretation of the time-varying, country-specific, directional fixed effects (FEs) in our setting is a combination of the multilateral resistance terms and the trading partners output and expenditures. It is easy to see how the FEs would also absorb any deflator indexes, exchange rates, etc. Thus, the real- and nominal-trade estimates should be identical.

reporting incentives for the exporting firms. The initial dataset consists of some 400,000 non-missing OECD export flows across all country pairs, years and sectors; about half of these entries are zeros. After balancing the dataset with respect to sectors (EBOPS categories), missing values arise in the dataset for two reasons. On the one hand, if there is trade for any given country pair and any given service category in at least one year, then we assign missing values in all years in which no trade is observed. If no trade is observed in any year, a zero is instead assigned. On the other hand, the TiSP dataset flags "non-publishable and confidential value" entries, signifying that the original value is positive but undisclosed. There are about 144,000 such non-publishable observations. Using the TiSP dataset's import entries as mirror export flows allows us to recover an additional 130,000 non-missing export flows, thereby increasing the number of non-zero observations by about 70 percent.[31] We use this step to also recover services trade flows of two additional countries (Latvia and Lithuania) for which disaggregated output information exists in EUKLEMS but which do not report cross-border trade flows as part of OECD's TiSP dataset.

We perform additional checks to ensure that the trade data are consistent across all levels of service categories. Since EBOPS is a hierarchical classification, it is a logical requirement to ensure that any value reported at the heading level corresponds to the sum of its constituent subheadings. Starting at the most disaggregated level and working upwards, heading entries are imputed from subheading sums either (i) when the higher-level entry is missing while the lower-level sum is not, or (ii) whenever the sum of lower-level entries exceeds the value reported at the heading level. These adjustments to the OECD TiSP dataset ensure its internal consistency and help recover additional observations.

Even though the majority of OECD countries already accounts for a large share of global cross-border service trade (74 percent of world exports and 69 percent of world imports, based on 28 OECD members in 2007), we attempt to maximize coverage of global trade flows by augmenting the OECD TiSP data with information from the "United Nations International

[31] For within-OECD trade, the original export flow is always retained even if a matching mirror flow would be found to exist.

Trade in Services Database" as published by the United Nations Department of Economic and Social Affairs, Statistics Division (UNSD). The UN services trade data are broken down by EBOPS category and partner country, starting with the year 2000, on an annual basis. The UNSD receives data and metadata from National Statistical Offices, Central Banks and the Statistical Office of the European Communities; all values are in US dollars. The UN dataset is subjected to the same procedure for checking internal consistency across EBOPS levels.[32] Only originally reported export flows are used, no mirroring is performed on UN data.

Since OECD's TiSP constitutes our preferred data source, the UN data serves to augment the dataset only in instance when the corresponding OECD observation is missing. This implies that mirror OECD flows take precedence over original UN exports even if an exact match exists. An additional 120,000 observations can be gained by updating missing OECD data with UN data.[33]

Production Data. Annual production data for services sectors are obtained from the "EU KLEMS Growth and Productivity Accounts: November 2009 Release" as updated in March 2011. The EU KLEMS Database provides for one of the most detailed sectoral breakdowns available. Coverage comprises mostly of OECD members which corresponds closely to the source for cross-border services trade data. The raw data consist of "gross output at current basic prices" in millions of local currency units. All gross output (GO) values are converted into current USD using official exchange rates taken from Eurostat. We use data covering 2000-2007 as EU KLEMS series currently extend only up to 2007. As noted above, availability of services production data predetermines the dimensions of our

[32] Amongst other things, the hierarchical consistency check serves to level out heterogeneous reporting habits across countries. For instance, the United States happens to report bilateral trade in 'Telecommunications services' only at the subheading level whereas the heading entry 'Communications Services' is missing in the raw (unprocessed) data; performing the consistency check as described above allows us to retain this information which would otherwise likely have been lost.

[33] The majority of those–or 93,000 observations–that appear as missing in the TiSP data can be updated from the UN database, whereas 20 percent consist of 'new' entries in the sense that the respective country pair–year–EBOPS combination did not exist in the OECD data. Both additions underscore the usefulness of drawing on both datasets.

sample to 28 countries, 12 sectors, and 8 years over the period 2000-2007, even though the gravity model estimations in section 4 use trade data for an additional eight countries.[34]

Production data is reported according to the NACE Rev.1 classification (Statistical Classification of Economic Activities in the European Communities), which is derived from ISIC. Most of the 28 countries report services production data at the NACE division level, yet three countries report with less sectoral detail (Australia, Canada, and the United States). In order to estimate the gravity model, NACE output data need to be concorded to the trade classification for services, which was done based on the "Correspondence between ISIC Categories for Foreign Affiliates (ICFA) and Extended Balance of Payments Services Classification (EBOPS)" as published in Annex IV of the UN's Manual on Statistics of International Trade in Services. The concordance required modifications, for instance when the correspondence table is more detailed than what is reported in the EU KLEMS database, and/or when a NACE category would need to be mapped onto multiple EBOPS codes. Some sectors are inherently difficult to concord to trade categories, reflecting the fact that their output is unlikely to be tradable, e.g. real estate activities, sewage and sanitation activities, or some residual categories. These sectors do not appear to have much relevance for trade in services and were thus dropped. Table 1 displays the 12 sectors that could successfully be concorded.

Internal Trade and Expenditures. Both variables are calculated from production data in the following way. A country's internal trade for any given sector is calculated by subtracting sectoral exports from gross output. We back out a country's sectoral expenditure data as the sum of imports from all origin countries including itself or, equivalently, gross output less exports plus imports from abroad.

Gravity Variables. Data on standard gravity variables including distance, common language, common borders, and colonial ties are from CEPII's *Distances* Database. An important advantage of the CEPII *Distances* Database is that it includes population-weighted distances that can be used to calculate consistently both bilateral distances as well as inter-

[34] These countries are Chile, Hong Kong China, Israel, Mexico, Norway, New Zealand, the Russian Federation and Turkey.

nal distances.[35] We use the former in the gravity estimations of international services trade and the latter in our study of the determinants of borders.

Appendix B: Prediction Accuracy and Number of Countries

This robustness check illustrates how the accuracy of projections depends on the share of actual output information that is available for estimating equation (18). The exercise involves estimating output repeatedly for a given country as in section 5.2 but each time based upon an incrementally smaller sample containing output information. We then trace out how the mean and variance of predicted output change as the procedure is run on less and less information (Figure 12). The 90% confidence interval is constructed based on 200 random country samples for each set number of countries ($N = 27, 26, \ldots, 17$) used to predict output; in each case the value of predicted output at the 5th and 95th percentile of the resultant distribution is retained.[36]

The examples of Austria, Belgium, France, Korea, Poland and Germany in the case of Computer services, which are shown in Figure 12, demonstrate two facts that we would expect from this exercise: (1) median inferred output (as a percentage deviation from its true value) is stable as it is consistently estimated even as less information is used to predict it; (2) at the same time, the confidence interval widens as the auxiliary regression is based upon less and less countries. The pattern of loss in accuracy is qualitatively similar across

[35]The CEPII procedure (see Mayer and Zignago (2006) is based on Head and Mayer (2000), using the following formula to generate weighted distances: $d_{ij} = \sum_{k \in i} \frac{pop_k}{pop_i} \sum_{l \in j} \frac{pop_l}{pop_j} d_{kl}$, where pop_k is the population of agglomeration k in trading partner i, and pop_l is the population of agglomeration l in trading partner j, and d_{kl} is the distance between agglomeration k and agglomeration l, measured in kilometers, and calculated by the Great Circle Distance Formula. All data on latitude, longitude, and population is from the World Gazetteer web site.

[36]In Figure 12, a value of zero at the horizontal axis indicates that no country is deliberately discarded from the estimation other than the one whose output is to be predicted out-of-sample. There is no confidence interval in this case (since all 200 random samples are identical), and the point estimate in percentage deviation terms corresponds to the respective country's entry in Table 10.

countries, and does also not vary across years (Figure 13). Unsurprisingly, the patterns differ across sectors but not systematically so (Figures 14 and 15 for Japan). Overall, the results of this robustness exercise are obviously noisy due to small sample size in combination with influential data; however, they do support the notion that the method proposed in section 5.2 is not particularly sensitive to either the amount of data available or individual countries used for out-of-sample prediction.

Figure 12: Comparison across COUNTRIES: Computer services, 2000

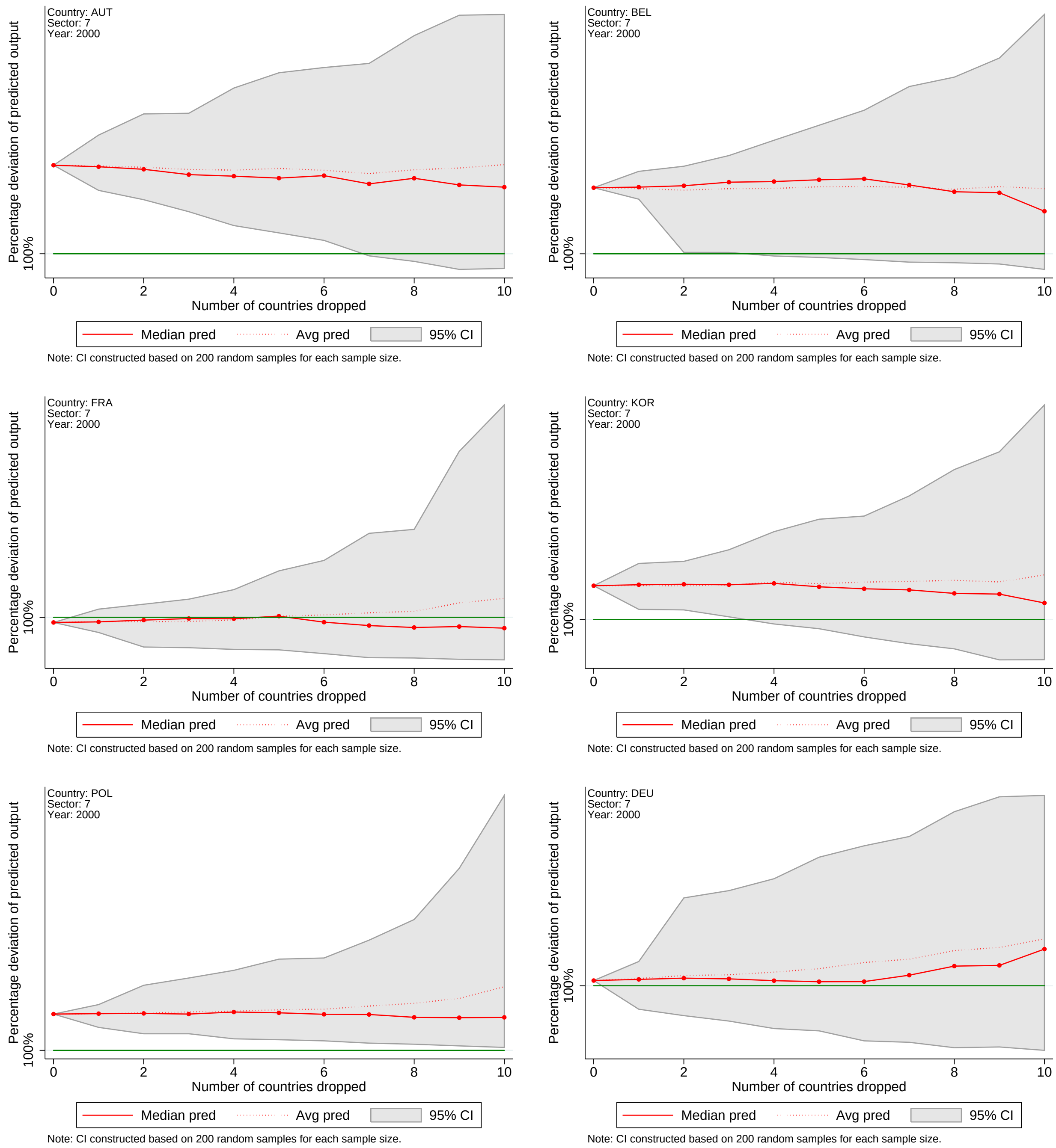


Figure 13: Comparison across YEARS: Australia, Transportation

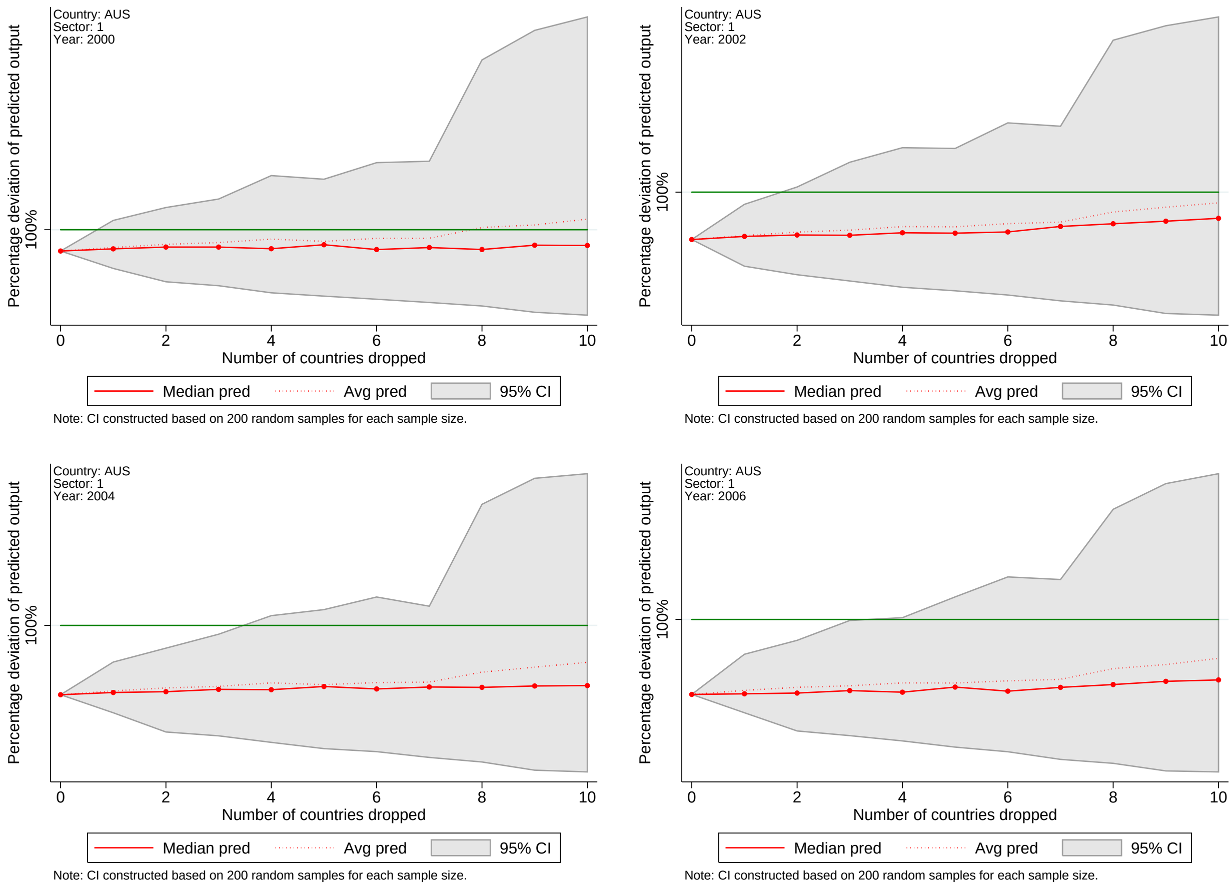


Figure 14: Comparison across SECTORS (I): Japan, 2000

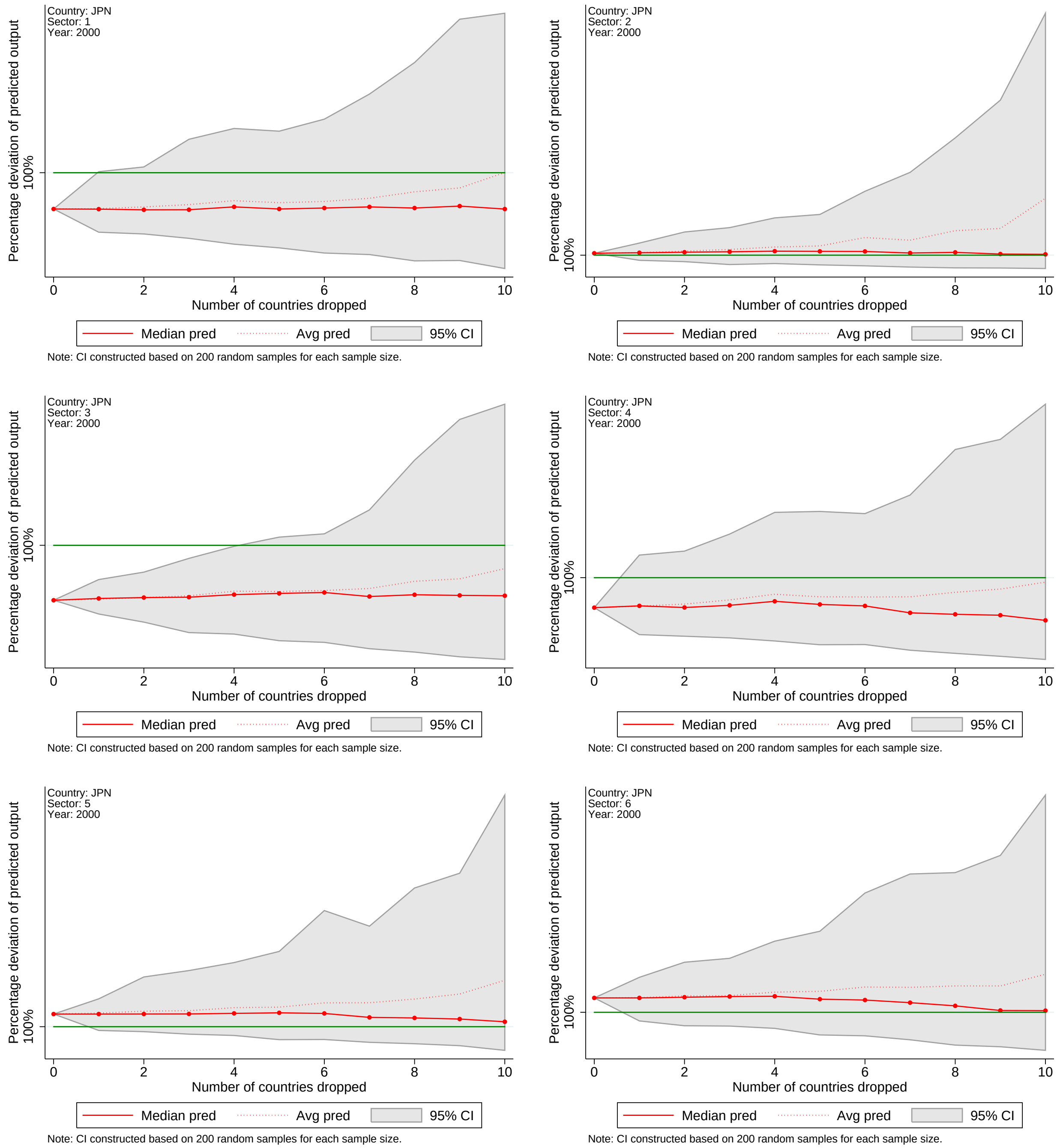


Figure 15: Comparison across SECTORS (II): Japan, 2000