Dark costs, missing data: shedding some light on services trade

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Abstract

We develop a method to project missing sectoral services output and trade. For OECD countries, projected and observed output data match well. The basis is a structural gravity model to estimate barriers to services trade across sectors, countries and time. The model fits well and reveals key differences across service sectors. Border barriers fall over time but unevenly. Inferred border barriers are fitted to national geography, technology, income and endowments, and institutional determinants. The fitted model including fitted border barriers is used to project missing internal or bilateral trade flows, aggregating to projected output.

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1 Introduction

Trade costs in services are covered in darkness. Opaque regulations characterize trade in professional and financial services, a sharp contrast to the tariffs and quotas on goods trade and a partial contrast to goods quality regulations with measurable costs. Hard to measure transport costs in services trade, such as the costs of electronically delivering business services, contrast with well-defined freight rates for moving physical goods. Services trade and output are less well measured than physical goods trade, and data are often missing. The missing data hamper attempts to infer services trade costs from trade flows and especially hinder examining the role services trade plays in the wider national and global economies. This paper makes progress on both understanding services trade costs and methods using the estimated costs to project missing services trade and output data.

First, the inclusion of intra-national services trade data in our estimations enables us to recover a rich pattern of border barriers to services trade, varying by country, sector, and over time. Second, we study the determinants of the barriers to services trade by decomposing their impact into four country-specific components including geography, technology, income and endowments, and infrastructure. Thus, from a methodological perspective, ours is the first study to offer an analysis of the impact of a rich set of national/country-specific characteristics on international trade within the structural gravity model. Third, the good fit properties of the structural gravity model encourage its application to projection of missing (or suspect) data on bilateral and internal services trade. We test the output projection method using trade and output data from OECD countries. The results suggest that projection is reasonably reliable, opening the way to supplementing sparse observable data with projected values for developing countries. Finally, an overall conclusion suggested by our results is that the structural gravity model works well with sectoral data on cross-border services trade.

We start by estimating a gravity model, described in Section 2.1, for 12 service sectors and 28 countries. For that purpose, we construct a database combining information on services trade and production, respectively, covering the period 2000 to 2007. The broad sectoral and geographical coverage of bilateral services trade flows well as the inclusion of intra-national trade sets this dataset apart from those used in previous gravity estimations. The construction of the data set, the data sources, and comparisons with alternative services trade datasets are described in Section 4 and in Supplementary Appendix B.

We offer benchmark gravity estimates for sectoral cross-border services trade.[1] Gravity works well with sectoral services data: most estimates are significant with expected signs and reasonable magnitudes. We document some similarities but also some important differences in estimated coefficients of standard gravity variables between goods and services and across services sectors, respectively. For example, we show the effects of distance to vary across services sectors, plausibly from having relatively less of an impact in Professional Business, Transportation, and Research services to being a very significant friction in Travel, Insurance or Construction services. Other traditionally strong predictors for goods trade such as contiguity, language or legal system also have more nuanced effects on services trade, which depend on the particular sector. For example, the strongest impact of sharing a common official language that we obtain is in the categories of Travel, Insurance and Audiovisual services, respectively. In addition, we document a strong effect of EU membership for most kinds of services trade for newer EU members. These results are presented in Section 5.1.

The second key empirical output of the paper is a multi-dimensional set of *relative* border barrier estimates by sector, country, and year for cross-border services trade. Inference of border barriers is drawn from comparison of internal trade to cross-border trade, all else equal. Estimated border barriers thus reflect the cost of cross-border trade relative to the

[1]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 traveling 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 for example Christen and Francois (2010). Our estimates of trade barriers should be interpreted accordingly.

cost of internal trade.[2] Border barriers in services trade are, on average, large and significant, but they vary widely within each of the three dimensions of our sample. Across countries, our estimates reveal that economic size reduces border barriers in services trade. Across sectors, border barriers vary in an intuitive way such that the frictions are found to be low for Travel, Transportation and Communication services and high for Financial or Audiovisual services. Over time, border barriers in services trade on average have fallen for almost all sectors in our sample. The two exceptions are Construction and Audiovisual services. In addition, we find that the decrease in the border effects varies considerably across the services categories. The analysis of border effects in international services trade appears in Section 5.2.

The third main contribution of the paper is an empirical analysis of the *country-specific* determinants of the border barriers in services trade. In order to perform the analysis, we group a series of suitable proxies into four intuitive categories including (i) geography, (ii) technology, (iii) income and endowments, and (iv) institutions. We view the econometric estimates of the national characteristics on international trade as 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 and reasonable magnitudes. For instance, we find that distance is an impediment to domestic trade whereas concentration of economic activity within a country promotes international trade relative to domestic trade. Our estimates suggest that better communications technology (proxied for with measures for fixed and mobile telephone density) facilitates international services trade. We also establish strong links between income and labor endowments and international trade. Finally, we offer evidence that stronger institutions promote international trade relative to domestic trade. The analysis on the impact of national determinants on international trade is presented in Section 6.1.

The fourth main contribution of the paper is the projection method for generating miss-

[2] As defined in the theory section 2.1, the border effects that we recover are measured by the coefficient on an indicator variable for *internal* trade flows. This is interpreted as the effect on relative (internal to cross-border) trade volume variation of relative (internal to cross-border) trade cost variation.

ing services output. We derive and implement a procedure to recover missing output data. The ability to consistently predict border effects is a necessary condition for successfully recovering potentially missing output data. The theory underpinning this method is introduced in Section 2.2, where we capitalize on the additive property of the PPML estimator, documented by Arvis and Shepherd (2013) and Fally (2015), which ensures a perfect match between the structural gravity terms and the corresponding directional fixed effects in order to recover missing sectoral services output data.

The availability of disaggregated output information in our dataset enables us to conduct various benchmarking exercises to evaluate the accuracy of the novel procedure. We conclude that the projection method works well, and are able to characterize in detail the accuracy of predictions across countries and sectors (Section 6.2). 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 frictions 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. We leave such extensions for future work.

We are not the first to use the gravity model to explain patterns of services trade. The model has been previously used to 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; Walsh, 2006; Lennon et al., 2009) and to estimate the effect on US services imports of Internet penetration in partner countries (Freund and Weinhold, 2004). Head et al. (2008) develop a gravity-like model of the market for international services which they use to estimate significant but declining distance effects for four broad categories of "offshorable" services. Breinlich and Criscuolo (2011) use UK data to offer a series of stylized facts for firms that engage in international trade in services. They show that firm-level heterogeneity is a key feature of services trade and find similarities between services and goods trade at the firm level. They conclude that existing heterogeneous firm models for goods trade could be a good starting point for explaining trade in services as well.[3] We complement these studies by estimating structural gravity for sectoral services trade with an alternative sample and by applying the latest econometric developments in the related literature (e.g., controlling for the multilateral resistances and employing the PPML estimator). However, the most novel component of our analysis in relation to the existing literature is the introduction of intra-national trade flows. This adjustment enables us (i) to obtain sectoral estimates of border effects in services trade, (ii) to study their determinants, and (iii) to combine theory and empirics in order to recover missing output information. Anderson et al. (2014), in their methodologically-related study of barriers to Canada's inter-provincial and international services trade, also employ employ intra-provincial trade. However, even though they are able to control for intra-provincial borders, the authors do not study their determinants and they do not attempt to predict missing output data.

Finally, from a methodological perspective, our analysis of the national determinants of international borders in services trade is related to Heid et al. (2017) and Beverelli et al. (2017). Heid et al. (2017) is a methodological paper that demonstrates that the addition of international trade flows enables identification of the impact of non-discriminatory trade policies and country-specific variables within a structural gravity model with importer and exporter fixed effects. These authors demonstrate the validity of their methods in the case of MFN tariffs and time-to-export. Beverelli et al. (2017) apply the methods of Heid et al. (2017) to identify the impact of national institutional quality on international trade. We make two contributions in relation to these studies. First, the analysis in Heid et al. (2017) and Beverelli et al. (2017) are based on manufacturing data while our focus is on services. Second, we complement these studies by identifying the simultaneous impact of a series of country-specific characteristics on international trade. Specifically, we offer evidence that national geography, technology, income and endowments, and institutions all play significant

[3] In a more remotely related study, Miroudot et al. (2012) provide evidence linking lower international trade costs with higher productivity in services sectors. We refer the reader to Ethier and Horn (1991) and Mattoo et al., eds (2007) for informative surveys of the literature.

roles in explaining international borders in services trade.

2 Theoretical Foundations

This section starts with a brief review of the theoretical gravity model of trade, which will guide our empirical analysis of services trade flows. In addition, we capitalize on the structural properties of the gravity model to propose a procedure for projecting gross output when such information is missing or suspect.

2.1 The Structural Gravity Model: A Brief Review

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:[4]

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

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

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

Here, X_{ij}^k denotes 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

[4]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), Head and Mayer (2014), Costinot and Rodriguez-Clare (2014) and Yotov et al. (2016) review the literature on the theoretical foundations and extensions of gravity.

services class k.[5] 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)-(18) translates into a simple econometric specification.[6] 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 exponential form:

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

where Z^k is a vector of trade cost and activity/size variables, and β^k is the vector of corresponding trade elasticities with respect to the various components of Z^k. Specification (4) leads directly to an estimable equation of the form

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

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 $\tau_{ij}^k \equiv {t_{ij}^k}^{1-\sigma} \leq 1$ is a trade cost factor representing

[5] While our theory allows for sector-specific elasticities of substitution, we will not be able to identify those parameters separately since we do not have data on any direct price shifter, e.g. tariffs, for services trade. Thus, as is standard in the gravity literature, the gravity estimates on all trade cost covariates in our regressions include the elasticities of substitution.

[6] Time subscripts are omitted in this section to simplify notation but are spelled out in equation (14) below.

the effect of gravity forces that reduce bilateral trade between i and j in sector k, X_{ij}^k. ϵ_{ij}^k 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}^k, the intra-country trade cost for each sector k.

2.2 Structural Gravity with Missing Output Data

The identification of intra-country trade costs τ_{ii}^k requires sectoral output data to derive internal trade flows. Hence, limited data on sectoral output constitutes an important problem, for unfettered use of the structural gravity model requires the full set of intra-national and international trade flows for all countries. An important contribution of this study is to show and test 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 and their structural gravity expressions, respectively, in order to recover the required information. Equation (4) provides a structural interpretation of the exporter and importer fixed effects in equation (5), respectively, for each sector:

$$x_i^k = \exp(\eta_i^k) = (\Pi_i^k)^{\sigma_k - 1} Y_i^k, \quad \forall i > 0, \tag{6}$$

$$m_j^k = \exp(\theta_j^k) = (P_j^k)^{\sigma_k - 1} E_j^k, \quad \forall j > 0, \tag{7}$$

Variables Y_i^k, E_j^k, Π_i^k and P_j^k are as defined above, and η_i^k, θ_j^k denote the empirically estimated exporter-/importer fixed effects, respectively. In practice, the fixed effects are estimated relative to a base country so, for example, m_0^k and x_0^k are not estimated.[7] For the base country, we assume that Y_0^k is observed, from which E_0^k is inferred as 'apparent consumption'

[7]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 sets of fixed effects are perfectly collinear when the constant vector is also included.

deducting exports and adding imports to Y_0^k. A normalization of the set of P^k's and Π^k's is required in any case, so it is natural to choose $P_0^k = 1$ (see Anderson and Yotov, 2010a).[8]

Fally (2015) shows that the fixed effects estimated with PPML are exactly consistent with the theoretical values from (6)-(7). 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), (6) and (7) thus implies:

$$(P_j^k)^{\sigma_k-1}(\Pi_i^k)^{\sigma_k-1} = \chi^k Y^k \frac{x_i^k m_j^k}{E_j^k Y_i^k} \qquad \forall\, i, j. \tag{8}$$

Slightly transform the system of multilateral resistances from structural gravity (equations 17 and 18):

$$1 \;=\; \sum_j \tau_{ij}^k (P_j^k)^{\sigma_k-1}(\Pi_i^k)^{\sigma_k-1}\frac{E_j^k}{Y^k} \qquad \forall\, i, \tag{9}$$

$$1 \;=\; \sum_i \tau_{ij}^k (P_j^k)^{\sigma_k-1}(\Pi_i^k)^{\sigma_k-1}\frac{Y_i^k}{Y^k} \qquad \forall\, j. \tag{10}$$

Substitute (8) into (9) and (10) to obtain:

$$\widetilde{Y^k}_i \;=\; \chi^k x_i^k \sum_j \tau_{ij}^k m_j^k \qquad \forall\, i \tag{11}$$

$$\widetilde{E^k}_j \;=\; \chi^k m_j^k \sum_i \tau_{ij}^k x_i^k \qquad \forall\, j. \tag{12}$$

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

System (11)-(12) yields fitted values for output and expenditures, respectively.[9] World output $\widetilde{Y}^k = \chi^k \sum_{i>0} x_i^k \sum_j \tau_{ij}^k m_j^k + Y_0^k$ is obtained by summing over all countries $i \in I$ in equation (11). These two equations represent a core result because they show how output (and expenditure) can be obtained so long as all quantities on the right-hand side of (11) and (12) are identified. The principal challenge to implementing this system of equations is to obtain an estimate of intra-national trade costs $\hat{\tau}_{ii}^k$ in the absence of Y_i^k. We present a solution in Section 6, which delivers a strong fit between predicted and true output.

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}^k for goods by destinations j from origin i in k are equal to zero, and outward multilateral resistance Π_i^k is not defined. Understanding that we have $Y_i^k = 0$ in equation (6), all the steps from equations (8)-(12) remain valid, and we can understand that where Π_i^k appears in (8) we may as well set $\Pi_i^k = 0$ because the equation for seller i in sector k 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 in sector k and setting $\hat{Y}_i^k = 0$, we exploit the panel structure and the properties of the PPML estimator to generate consistent estimates of output.

Under the (strong) assumption that structural gravity generates the true data, these generated activity variables $\{\widetilde{Y}_i^k, \widetilde{E}_j^k\}$ are perfectly consistent with the theory. Their expected value (asymptotically) is the true value. In reality, both the fitted values $\widetilde{Y}_i^k$ and the observed values $(Y_i^k)^*$ are measured with error, and the measurement error of the observed values might contaminate the estimates of the τ_{ij}^k's such that the fitted values of (11) and (12) are

[9] In Supplementary Appendix A we offer an alternative presentation for recovering missing output data by focusing on recovering missing intra-national trade flows in the presence of international trade flows and by employing a non-linear solver (e.g., Matlab) instead of relying directly on the PPML estimator. The two procedures deliver identical results. Finally, in the robustness analysis, we test the predictive power of the gravity model when *international* trade data are missing in addition to missing output/intra-national trade data (Supplementary Appendix E, Table 18).

not asymptotically unbiased.[10]

3 Estimating Structural Gravity

In order to obtain an operational econometric gravity specification, we have to model the unobservable bilateral trade frictions τ_{ij}^k from equation (5). Following the vast gravity literature for goods trade,[11] 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 in the following econometric specification:

$$\tau_{ij}^k \quad = \quad \exp\Big[\big(1 - SMCTRY_{ij}\big)\alpha^{k\prime}\mathbf{Z}_{ij,t} + \beta^k SMCTRY_{ij}\Big]. \qquad (13)$$

Vector $\mathbf{Z}_{ij,t}$ includes a series of standard gravity variables, in which $\ln DIST_{ij}$ is the logarithm of bilateral distance between trading partners i and j, $CNTG_{ij}$ captures the presence of a contiguous border between partners i and j, and $LANG_{ij}$ accounts for common official language. Additional variables are intended to capture policy, institutional and cultural forces that determine trade in services. Specifically, EU_OLD_{ij} indicates established (pre-2000) EU membership whereas EU_NEW_{ij} is an indicator for those eight countries in our sample that joined the EU in 2004.[12] $CURR_{ij,t}$, $LEGAL_{ij,t}$, and $RLGN_{ij}$ denote commonly used indicator gravity variables for shared currency, common legal system, and common religion, respectively.[13]

[10]Considering the potentially most problematic contamination issue is somewhat reassuring. The internal trade flows are typically generated as a residual $(X_{ii}^k)^* = (Y_i^k)^* - \sum_{j\neq i}(X_{ij}^k)^*$. The econometric model assumes that the observed bilateral trade flow value is related to the true value by $(X_{ij}^k)^* = X_{ij}^k\epsilon_{ij}^k$ where ϵ_{ij}^k 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 $(X_{ii}^k)^* = (Y_i^k)^* - \sum_{j\neq i}(X_{ij}^k)^*$ is consistent with $(X_{ii}^k)^* = X_{ii}^k\epsilon_{ii}^k$ if and only if $(Y_i^k)^* = \sum_j X_{ij}^k\epsilon_{ij}^k$; that is, there is no additional source of measurement error in the output variables. This is a plausible assumption because statistical practice would normally include such consistency checks. But it is not guaranteed.

[11]We refer the reader to Anderson and van Wincoop (2004) for a survey of trade costs and their modeling in the gravity literature.

[12]These are Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovakia and Slovenia.

[13]In sensitivity experiments presented in Supplementary Appendix D.1, we include additional covariates that have been shown to be significant determinants of goods trade, namely regional trade agreements (RTAs) and bilateral investment treaties (BITs). However, since those variables were generally not significant in the case of services and their introduction did not affect our main estimates, they are excluded from the main

$SMCTRY_{ij}$ is an indicator variable for *internal* trade flows, i.e. $SMCTRY_{ij} = 1 \, \forall \, i = j$ and zero otherwise. Thus, $SMCTRY_{ij}$ picks up all the relevant forces that discriminate between internal and international trade and, all else equal, its estimate β^k should be interpreted as a relative border cost effect. An alternative treatment of international borders in the trade literature is with an indicator variable for international trade flows: $BRDR_{ij} = 1 \, \forall \, i \neq j$ and zero otherwise. The relationship between $SMCTRY_{ij}$ and its more traditional counterpart is straightforward: $SMCTRY_{ij} = 1 - BRDR_{ij}$. Thus, by construction, the estimates of both border dummies' coefficients will be identical in magnitude but with opposite signs. Therefore, the two alternative border-dummy options will deliver identical results. Our choice to use $SMCTRY_{ij}$ is motivated by the focus of our analysis on intra-national trade flows and thus suits better for expositional reasons.

The definition of $SMCTRY_{ij}$ will play a key role in guiding our empirical analysis in three steps. First, we will start with a most-comprehensive econometric specification that includes country-year specific $SMCTRY$ effects for each sector in our sample. In combination with the definition of trade costs from specification (13), and using an appropriate set of fixed effects to control for unobservable multilateral resistance terms, the resulting estimating equation becomes:

$$X_{ij,t}^k = \exp\{(1 - SMCTRY_{ij})\alpha^{k\prime}\mathbf{Z}_{ij,t} + \sum_i \sum_t \beta_{it}^k SMCTRY_{ij} + \eta_{it}^k + \theta_{jt}^k\} + \epsilon_{ij,t}^k, \qquad \forall \, k. \quad (14)$$

Here η_{it}^k (θ_{jt}^k) denotes the set of time-varying exporter (importer) dummies that control for outward (inward) multilateral resistances and countries' output (expenditure) shares in sector k. The relationships between the gravity fixed effects from specification (14) and those from equation (5) are $x_{i,t}^k = \exp\{\eta_{it}^k\}$ and $m_{j,t}^k = \exp\{\theta_{jt}^k\}$, respectively. The purpose and main advantage of specification (14) is that it will deliver benchmark estimates of the effects of the standard gravity covariates (e.g. distance, contiguity, etc.) for international services

specification for the sake of brevity and expositional clarity.

trade.[14] We present and discuss the estimated effects on services trade of standard gravity variables in Section 5.1.

Second, we will estimate a gravity model for each service sector with country-specific and time-specific $SMCTRY$ effects. In combination with the definition of trade costs from specification (13), the resulting structural gravity estimating equation becomes:

$$X^k_{ij,t} = \exp\{(1 - SMCTRY_{ij})\alpha^{k\prime}\mathbf{Z}_{ij,t} + \sum_i \beta^k_i SMCTRY_{ij} + \sum_t \beta^k_t SMCTRY_{ij} + \eta^k_{it} + \theta^k_{jt}\} + \epsilon^k_{ij,t}. \quad (15)$$

The motivation behind specification (15) is that limiting the number of border estimates will enable us to offer a compact analysis of border effects in individual services sectors across countries and over time. We present the analysis of the border effects in services trade in Section 5.2.[15]

Finally, we will replace the country-specific $SMCTRY$ dummy variables from the previous specification with a set of observable country characteristics, denoted by $\mathbf{W}_{it}$. The resulting econometric model becomes:[16]

$$\begin{aligned} X^k_{ij,t} &= \exp\{(1 - SMCTRY_{ij})\alpha^{k\prime}\mathbf{Z}_{ij,t} + SMCTRY_{ij}\gamma^{k\prime}\mathbf{W}_{it} \\ &\quad + \sum_t \beta^k_t SMCTRY_{ij} + \eta^k_{it} + \theta^k_{jt}\} + \epsilon^k_{ij,t}, \qquad \forall\, k. \end{aligned} \quad (16)$$

In order to facilitate exposition, and guided by economic intuition, we group the covariates from vector $\mathbf{W}_{it}$ in four groups. The first group, *'Geography'*, includes an indicator variable for whether a country is landlocked or not ($LANLCKD$), a variable for internal

[14] In addition, the flexible treatment of the $SMCTRY$ effects is consistent with the main argument from recent papers, e.g., Ramondo et al. (2016) and Agnosteva et al. (2014), which demonstrate the importance of allowing for heterogeneous intra-national trade costs.

[15] In an earlier version of this paper, we aggregated the country-time-specific $SMCTRY$ estimates from specification (14) across different dimensions. We thank a referee for suggesting this alternative specification, which has the additional advantage of directly delivering standard errors used to constructed confidence intervals for estimated border effects.

[16] At this point it is worth recalling that the estimated coefficients on $SMCTRY_{ij}$ indicator variables used to identify border effects in specification (14), i.e., the estimates $\hat{\beta}^k_{it}$, should be interpreted as *relative* border effects. As the observable characteristics in $\mathbf{W}_{it}$ replace the $SMCTRY$ dummy variables, a corollary in terms of interpretation is that the effect of each country-specific variable has a dual interpretation in that it can either work towards promoting intra-national trade relative to international trade or, alternatively, decrease international borders in services trade.

distance ($INTRADIST$), and a variable to measure the geographical intensity of economic activity. We call this covariate 'effective distance' ($EFFCTDIST$), and we define it as the ratio of internal distance and country area.[17] The second group, *'Technology'*, includes variables that we expect to pick up the impact of national technologies on cross-border services trade relative to internal trade, and their evolution over time. This group includes fixed-line teledensity ($FLTLDNS$) and mobile phone teledensity ($MPTLDNS$). The third group, *'Income and Endowments'*, includes the logarithm of Gross Domestic Product ($LNGDP$), the logarithm of population ($LNPPLN$) and the endowment (population shares) of labor with completed secondary ($SCBDRY$) and tertiary education ($SKILLD$), respectively.[18] Finally, the fourth group, *'Institutions'*, includes the comprehensive "Rule of Law" institutional quality measure ($INSTTNS$) from the Worldwide Governance Indicators (WGI).[19] Data sources and construction of gravity variables are discussed in the Data section 4 below.

Specification (16) has two advantages in relation to existing specifications of the structural gravity model. First, it will enable us to study the role of national characteristics in vector $\mathbf{W}_{it}$ in explaining variation of relative border barriers. This is a contribution to the trade cost and gravity literature in its own right because our study will be the first to offer estimates of the differential impact of a series of country-specific characteristics on international borders in the presence of a complete set of exporter-time and importer-time fixed effects within a structural gravity model.[20] We develop this analysis in Section 6.1. Second, as country

[17]The idea behind this variable is to capture variation across countries in domestic spatial distribution of economic activity; for example, in Canada economic activity is clustered in a particular region, namely at the border to the US. Regarding terminology, our use of the term 'effective distance' is different from Mayer and Head (2002), who use the same term to denote what we call internal distance ($INTRADIST$). As described in the Data section, we will employ the most preferred measure of Mayer and Head (2002) in order to measure distance in our analysis and we refer the reader to their insightful paper for a detailed discussion on the importance of proper measurement of distance in gravity regressions.

[18]In addition to these variables, we also experimented with physical capital endowment shares. However, due to very high correlation with GDP and Population it is in the current setting not possible to include this variable as a separate regressor.

[19]The OECD's Product Market Regulation (PMR) represents another indicator that captures aspects of domestic regulation that affects internal trade costs for services; however, this variable is not available for all countries in all years. Furthermore, PMR is highly correlated with institutional quality. Therefore, we present results including the PMR indicator as a sensitivity check in Supplementary Appendix Table D.2.

[20]Heid et al. (2017) demonstrate that the introduction of international trade flows in structural gravity regressions allows for the identification of the effects of non-discriminatory trade policies. Beverelli et al.

characteristics are commonly observable even when sectoral output is not, specification (16) will admit an estimation of international trade costs $\hat{\tau}_{ii}^k$ even when X_{ii}^k is unobserved and, therefore, will enable us to predict missing output data. We demonstrate the effectiveness of our methods to recover missing output data in Section 6.2.

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.[21] In particular, first, we account for the unobservable multilateral resistance terms with directional (source and destination), country-specific, time-varying dummy variables.[22] These country fixed effects also control for output and expenditures. 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, which will enable us to employ PPML directly to recover missing output data. 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 preferred gravity estimates.[23]

(2017) extend the methods of Heid et al. (2017) to identify the impact of national institutions as an important determinant of international trade. We complement these studies by offering estimates of the impact of a series of national characteristics, e.g., geography, technology, and income and endowments, on international borders.

[21]Piermartini and Yotov (2016) offer a detailed discussion of the challenges, solutions, and best-practices for estimations with the structural gravity model. Head and Mayer (2014) offer a thorough survey of the related literature.

[22]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 multilateral resistance terms should be accounted for with exporter-time and importer-time fixed effects in a dynamic gravity setting.

[23]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, 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.

4 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.[24] The limiting factor, which predetermines coverage across countries, sectors and time, is the availability of sectoral services production statistics. This section briefly discusses each data component, and more detailed information is available in Supplementary Appendix B, where we also compare our data with alternative databases.

Trade. The primary source of data on cross-border services trade flows is 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. Note that countries differ in the level of sectoral detail they report to TiSP.

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.[25] We also use mirroring to 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. Additional checks ensure that trade flows are consistent across different levels

[24] 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.

[25] For within-OECD trade, the original export flow is always retained even if a matching mirror flow exists.

of the classification.

Even though the majority of OECD countries already accounts for a large share of global cross-border service trade,[26] 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 Statistics Division. Since OECD's TiSP constitutes our preferred data source, UN data serve to augment the dataset only in instances when the corresponding OECD observation is missing.[27] A substantial number of observations can be gained by updating OECD data with UN data, which underscores the usefulness of drawing on both datasets.

We have compared the novel dataset thus constructed to existing services trade datasets, namely the Francois-Pindyuk Trade in Services dataset, the WTO-UNCTAD-ITC annual trade in commercial services dataset, and the World Input-Output Data (WIOD), respectively. In terms of granularity and other criteria, ours appears to be the most suitable for estimating border barriers and projecting missing output. Details of the comparison and further description of the alternative databases are available in Supplementary Appendix B.2.

Output. 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 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 until 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.

Production data are reported according to the NACE Rev.1 classification. In order to

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

[27]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.

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 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, i.e. 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.

Other Data. Standard gravity variables such as distance, common language and contiguity are taken from CEPII's *Distances* Database (see Mayer and Zignago, 2011; Head and Mayer, 2000). An important advantage of that source for our purposes is its provision of population-weighted distances, which can be used to calculate both bilateral distances as well as intra-national distances in a consistent manner. Specifically, distance—both across and within countries—is calculated as $\left(\sum_{k\in i}(Pop_k/Pop_i)\sum_{l\in j}(Pop_l/Pop_j)D_{kl}^{\theta}\right)^{1/\theta}$, where Pop_k is the population of agglomeration k in exporter i, Pop_l is the population of agglomeration l in importer j, and D_{kl} is the bilateral distance in kilometers between agglomeration k and agglomeration l, using Great Circle Distance formula.[28] To obtain our main results, we capitalize on the findings and recommendations of Mayer and Head (2002) and set $\theta = -1$ (the harmonic mean). In addition, in sensitivity experiments we also employ the arithmetic weighted distance measure from the CEPII database which, following Head and Mayer (2000), is obtained with $\theta = 1$ (results in Supplementary Appendix D.3). In each case, the availability of consistently constructed international and intra-national distances allows us to distinguish between them as determinants of international trade flows and intra-national trade flows, respectively. Additional gravity variables for common currency, common legal

[28] All data on latitudes, longitudes, and population are from the World Gazetteer web page.

system, common religion and RTAs are taken from Head et al.'s gravity dataset (Head et al., 2010).

Finally, the ten observable country characteristics—denoted $\mathbf{W}_{it}$ in section 3—are obtained from four alternative datasets. We use Head et al.'s gravity dataset to get the indicator variable for whether a country is landlocked or not ($LANLCKD$) and to obtain a measure of country areas, which are used to construct the variable for effective distance ($EFFCTDIST$) as the ratio of internal distance and country area. Data on fixed-line teledensity ($FLTLDNS$), mobile phone teledensity ($MPTLDNS$), Gross Domestic Product ($LNGDP$) and population ($LNPPLN$) are from the Worldwide Development Indicators database. Population shares of labor with completed secondary education ($SCBDRY$) and with completed tertiary education ($SKILLD$) are from the Barro-Lee 2016 dataset. Finally, our measure of institutional quality ($INSTTNS$), "Rule of Law", comes from the Worldwide Governance Indicators and the Product Market Regulation (PMR) index is constructed by OECD. Importantly, we note that data on each of the additional ten covariates at the national level are available for a wide range of countries, including developing and developed nations.

5 Gravity Estimation Results

This section presents our main empirical findings as they relate to estimating gravity models and disaggregated border barrier effects for services trade. Subsection 5.1 delivers benchmark estimates for services trade of the effects of standard gravity covariates from the goods gravity literature. Subsection 5.2 offers an analysis of border barriers in services trade across sectors, countries, and over time, respectively.

5.1 Gravity Estimates for Services Trade

Even though trade in services differs from trade in goods in many respects, Breinlich and Criscuolo (2011) conclude that existing (heterogeneous firm) models for goods trade serve as a good starting point for explaining trade in services as well. This section demonstrates that the empirical gravity model works well with services trade. It offers partial equilibrium estimates and a discussion of the effects of standard trade cost variables, including some policy variables, on services trade for each of the sectors in our sample.

In order to obtain estimates of the effects of the standard gravity variables for services trade that are comparable to the corresponding estimates from the goods literature (which usually do not include intra-national trade flows), we rely on our most comprehensive specification (14), which delivers a full set of country-time border effects ($\beta^k_{i,t}$) for each sector in our sample.[29] Thus, the set of border indicator variables corresponds one-for-one to the number of intra-national trade observations in our sample. Sectoral gravity estimates from specification (14) are reported in Table 2 and are obtained with the PPML estimator and standard errors clustered by country pair.

Our estimates reveal that distance represents a significant impediment to trade in services. This is supported by the fact that, without any exception, all estimates of the effect of distance on services trade in Table 2 are negative and statistically significant at any conventional level. In terms of magnitude, with many values close to -1, the estimates of the impact of distance on services trade are comparable to those for goods trade, (see e.g. Head and Mayer, 2014). We also find that the effects of distance on services trade vary (mostly intuitively) across sectors. Thus, for example, distance effects are larger in sectors such as Travel, Construction, Insurance, Merchanting and Audiovisual services than in Transportation, Professional Business, and Research and Development services. The former group still

[29] We treat 'research and development' services (RSRCH) 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.

tend to be relatively localized in nature while digitization and declining communication costs have diminished the importance of distance for the latter group. One possible explanation for the differential impact of distance on services trade could be the presence of fixed costs. As demonstrated by Chaney (2008) and Helpman et al. (2008), the standard gravity model can readily accommodate fixed costs. We expect that in combination with a comprehensive dataset on such barriers to services trade, which is not available to us, a model with fixed costs in services trade will generate novel insights.

We obtain positive estimates of contiguity coefficients for nine out of twelve service categories, but they are significant for only three categories: Transportation, Travel, and Operational Leasing. The rationale for significant effects in Transportation and Travel services is intuitive whilst the explanation in the case of Operational Leasing may be less obvious but could be related to the particular spatial location of lessors and lessees, respectively. Overall, in our view, 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 for example Anderson and Yotov (2010b) and Head and Mayer (2014).

Sharing a common official language facilitates bilateral services trade only in some of the sectors in our sample. We obtain positive and significant estimates in only four services categories; the significant estimate for communication is self-explanatory and the significant language effects in Insurance and Audiovisual services likewise are associated with the need for precise communication in these sectors. A natural explanation for the strong effect of language in Travel services is that, all else equal, people travel more to countries where the same language is spoken. Overall, in sectors that do feature significant language coefficients, the effect appears to be stronger in services trade than in manufacturing goods trade (Anderson and Yotov, 2010b), which is consistent with the higher requirement for personal interaction and communication in most services. Interestingly, we obtain negative and significant language effects in Computer and Research and Development services. A possible explanation for these results is a combination of high-specialization and the establishment of English as a universal language in these sectors in any (non-English speaking) country, which is the likely explanation for the insignificant language coefficients in half of the services sectors in our sample. In sum, the effect of language on services trade seems to be highly sector-specific, and the absence of significant language effects could point to the need for an alternative construction of language-related variables that go beyond common official language (Melitz and Toubal, 2014).

Turning to policy, institutions and cultural variables, respectively, we obtain significant effects of EU membership on services trade. However, the EU impact varies across 'old' vs. 'new' EU members. The estimates from Table 2 confirm our motivation and intuition to allow for differential impact across the two groups because the benefits from EU membership might have been exhausted among the 'old' members while there was much to gain for 'new' members. Specifically, we obtain six significant estimates for the EU impact on trade among 'old' members (and five of these estimates are actually negative), while nine of the estimates for 'new' members are positive and eight of them are statistically significant. A possible explanation for the negative EU estimates for old members in Insurance, Finance and Research is the preponderance of large non-EU services traders such as the US, Japan and Korea. Concurrently, we obtain positive, large and significant estimates for *new* EU members, likely reflecting the redirection of trade towards established EU economies after their 2004 accession.

Sharing a common currency does not seem to be a strong promoter of services trade. We only obtain three positive and significant estimates for sharing a common currency, which are in the categories of Finance, Insurance, and Computers. A possible explanation for the mostly insignificant $CCUR$ estimates is that the EU membership dummies in our specification absorb some of the common currency effect. We obtain strong positive effects of having a common legal system for Computer, Business, and R&D services. The need for clear and compatible regulations that govern economic activity in Business and in R&D

services may explain the results for these sectors. Finally, we obtain positive estimates of the effects of common religion on services trade in eight of the services sectors in our sample and half of them are statistically significant. The single negative and marginally significant estimate of 'Common religion' in the category of Computers. The positive estimates can be explained with the fact that the common religion dummy is presumably picking up the wider effect of culture and trust, features that may be especially important for the exchange of some services.

In sum, the estimates from this section reveal that the structural gravity model performs well with services data. Many of the standard and policy gravity covariates are significant and their estimates make economic sense. At the same time, we document some differences in the effects of standard gravity covariates between goods and services trade as well as significant heterogeneity across the services sectors. Our benchmark results point to avenues for further research and to the need for improvements in modeling trade costs in services.

5.2 On Border Effects in Services Trade

Specification (14) delivers a database of country-time-specific $SMCTRY$ estimates that reveal a significant variation in internal costs. This is an important departure from the existing trade literature that mostly treats countries as point masses.[30] Unfortunately, the very large number of $SMCTRY$ estimates obtained from specification (14) renders a compact presentation of these estimates difficult. Therefore, in this section we employ econometric model (15), which includes separate country and time border effects (β_i^k and β_t^k) that will replace the country-time effects ($\beta_{i,t}^k$) in equation (14). The smaller number of border estimates in (15) enables us to present some key results about the variation of border effects in individual services sectors across countries and over time.

Sectoral gravity estimates from specification (15) are reported in Table 3. In addition to estimates of the standard gravity variables, Table 3 includes time-varying $SMCTRY$ es-

[30] For recent papers that emphasize the importance of proper treatment of intra-national trade costs see Agnosteva et al. (2014) and Ramondo et al. (2016).

timates, which are constrained to be common across countries. As discussed below, these estimates will reflect the impact of globalization in each sector in our sample. In addition, the estimates from Table 3 are obtained with country-specific $SMCTRY$ dummies that will enable us to analyze the variation of services across countries within each sector. The country-specific $SMCTRY$ estimates are omitted from Table 3 but are presented and discussed separately in Table 4. Finally, before proceeding with the discussion of border effects in services trade, we note that most of the estimates of standard gravity variables in Table 3 are very similar to the corresponding indexes from Table 2. This is encouraging because it implies that, for most sectors, the country-and-time $SMCTRY$ dummies effectively replace the corresponding country-time border variables.[31]

We start with a discussion of the evolution of the borders in services trade over time for each sector. This evolution is captured by time $SMCTRY$ estimates in Table 3. Due to perfect collinearity with the country-specific $SMCTRY$ dummies, we are not able to obtain border estimates for each year in our sample. Therefore, we need to drop one of the time $SMCTRY$ dummies in each sector. We chose the reference dummy to be the $SMCTRY$ border effect for 2000, the first year in our sample. Thus, the estimates of all other time border effects should be interpreted as deviations from the average border effect in 2000, and a negative estimate on the time-$SMCTRY$ dummies would indicate a decrease in the borders in services trade, while a positive estimate will reflect an increase in services borders.

The results from Table 3 lead to four notable conclusions with respect to the evolution of border effects for services trade over time. First, the services border barriers have fallen significantly between 2000 to 2006. This is supported by the large number of negative and significant time-$SMCTRY$ estimates in Table 3. In fact, out of the thirty-six possible time border estimates (12 sectors $\times$ 3 time periods), we only obtain one positive and significant sector-time border effect (for Audiovisual services in 2002). Our broad interpretation for

[31] Insurance and Finance are two sectors for which we observe quantitative differences in the gravity estimates. These differences suggest that in these sectors there are potentially important country-time effects that have been omitted from our specification.

the significant fall in services border effects is globalization. Second, we note that, with the exception of Construction and Audiovisual services, border effects in services trade have fallen for all sectors in our sample. A possible explanation for the insignificant 'globalization' effects in Construction, and Audiovisual services is that these sectors are among the industries with most pronounced localized service activities.

Third, we see that globalization forces have affected services borders in some sectors continuously throughout the whole period of investigation (e.g., Transportation, Computer, Leasing, and Business services), while other sectors have been affected only in particular periods (e.g. Communication, Wholesale, and Research services).[32] Finally, our results reveal significant variation in the decrease in border effects in services trade across the sectors in our sample. Based on the $SMCTRY$-time estimates for 2006, which by construction capture the total impact of globalization during the period of investigation, we see that the sectors that experience the largest fall in borders include Insurance, Finance, Computers and Leasing services. On the other side of the spectrum, the sectors that experienced the least decrease in services borders include Transportation, Travel, Communication, and Merchanting/Wholesale Trade services.

Next, we discuss the variation of the border effects across sectors and across countries. Table 4 reports $SMCTRY$ estimates for each sector and for each country in our sample, which are obtained from estimable equation (15). For brevity, we do not report standard errors in Table 4. Instead, we use one asterisk (*) to mark the *insignificant* border estimates. As can be seen from the table, the vast majority of the border estimates that we obtain across sectors and across countries are positive and statistically significant, suggesting the presence of substantial border barriers to services trade. However, we do obtain some insignificant as well as some negative border estimates, which we discuss in more detail below. Finally, in order to facilitate presentation, we use intra-national sales as weights to construct weighted-average $SMCTRY$ indexes for each sector, which are reported in the bottom row of Table

[32] This variation in the impact of globalization over time across sectors may be useful to identify specific policy tools that have been effective in liberalizing services trade within particular sectors.

4, and for each country, which are reported in the last column of Table 4. The average $SMCTRY$ estimate across all countries and all sectors in our sample, reported in the bottom right corner of Table 4 is 2.31. This estimate points to substantial border effects that deflect 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.

Turning to the sectoral variation of our border estimates, we note that, with average values between -3.4 and 6.9, the border effects in services vary widely across sectors. We believe much of the variation in the sectoral estimates is due to high concentration of some service categories in certain developed parts of the world. The largest border effects are observed in Audiovisual and Financial services, respectively, followed by Operational Leasing and Merchanting services. The large estimates for Finance correspond to the fact that an overwhelming share of banking services are produced and consumed domestically. These findings are consistent with the results from Jensen and 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, thereby suggesting low tradability due to the need for face-to-face interaction. At the other extreme, consistent with our priors, by far the lowest (and in fact negative) border barriers exist in the Travel and Transportation sectors, respectively, followed by Communication services. Overall, the variation in border estimates across sectors is considerable, with potentially important policy implications for sectors with large estimates.

The distribution of estimated border effects across countries also reveals wide variation. Without any exception, the average country-specific border effects from the right-most column in Table 4 are positive. Furthermore, our estimates suggest that, on average, the border barriers in services trade are appreciably higher for smaller and less developed economies than for large industrialized countries. With average $SMCTRY$ indexes of more then 8, Slovakia and Latvia exhibit the sample's largest average $SMCTRY$ coefficients, closely followed by Lithuania, Slovenia, Poland and Estonia with average $SMCTRY$ estimates of more then 6. At the other end of the spectrum, we find some of the world's largest economic powers including the United States and Germany, followed by Italy, France, and the Netherlands. 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. On related note, Coughlin and Novy (2016) demonstrate the existence of border effect heterogeneity that arises solely because aggregation across space increases the relative cost of trading within borders. As a result, larger countries appear to exhibit smaller border effects. The inverse relationship we document here presumably reflects both forces.

While the differences in the border effects in services trade that we just discussed across sectors and across countries are pretty robust on average, there are also instances in which countries with high average $SMCTRY$ estimates exhibit low border effects in particular sectors, and conversely also countries with low average $SMCTRY$ estimates exhibiting high border effects in particular sectors. For example, Ireland is among the countries with the lowest average $SMCTRY$ estimates overall; however, it has one of the largest border effects in Travel services. Similarly, Great Britain is also among the countries with relatively low average $SMCTRY$ estimates overall but exhibits relatively large border effects in Merchanting and Audiovisual services. Most of the countries with the largest $SMCTRY$ estimates experience large border effects across all sectors, although we do see some exceptions with lower borders in specific sectors, for instance Poland in Computer services. The fact that we find only few instances of country-sector specific combinations that deviate from the average estimates across countries and across sectors implies that most of the border determinants in services trade are country and sector specific (as opposed to country-sector specific). We reinforce this argument in the next section.

The analysis of border effects in services trade in this section can be summarized as follows. First we find that the 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. Finally, we find that border effects in services trade have fallen over the period of investigation for all sectors in our sample.

6 Projecting Missing Output

We now turn to specification (16), which replaces country-specific $SMCTRY$ variables with observable national characteristics. The objectives and contributions of this section are twofold. First, the empirical results in Section 6.1 will add to our understanding of the forces that shape frictions between internal and border-crossing services trade flows. This is an interesting question in itself because, as demonstrated earlier, border effects in services trade are substantial and services now represent a larger share of GDP in the developed world than goods. We believe our study is the first to offer direct estimates of the differential impact of a series of national characteristics on international trade relative to intra-national trade. Second, as we show in Section 6.2, the ability to consistently predict border effects is a *necessary and sufficient* condition for successfully recovering missing output data, which may be valuable for many purposes.

6.1 National Determinants of Trade Openness in Services Trade

Estimation results based on specification (16) for each sector in our sample are reported in Table 5. For brevity, we omit from Table 5 estimates of standard gravity covariates.[33] Recall that national determinants of international borders from vector $\mathbf{W}_{it}$ in equation (16) are grouped in four categories, including *'Geography'*, *'Technology'*, *'Income and Endowments'*, and *'Institutions'*. Furthermore, we note that the estimates on each of the country-specific variables, which we use to replace the country-specific $SMCTRY$ dummies, have a dual interpretation by construction. For example, a negative estimate of the coefficient on a

[33] These estimates are comparable to the corresponding indexes from Table 2 and are available in Supplementary Appendix Table 16.

given national characteristic can be interpreted either (i) as dampening intra-national trade relative to international trade or, alternatively, (ii) as decreasing international borders in services trade.

We start the analysis with a discussion of the covariates in the *'Geography'*, which include an indicator variable for whether a country is landlocked or not ($LANLCKD$), a variable for internal distance ($INTRADIST$), and our measure of effective internal distance ($EFFCTDIST$), defined as the ratio of internal distance and country area. Our results do not reveal a systematic pattern as to whether being landlocked has a significant impact on borders and intra-national trade relative to intra-national trade. Only half of the estimates on ($LANLCKD$) are significant and, among the significant ones, we observe both positive and negative values.[34] However, coefficients on internal distance and effective internal distance are generally significant. Nine of the estimates on $INTRADIST$ are negative and three of them are statistically significant, suggesting that—all else equal—distance is an impediment to domestic trade. The two positive and significant $INTRADIST$ estimates are in Transportation and Audiovisual services, respectively. At the same time, we find that geographical concentration of economic activity promotes international trade relative to domestic trade since the impact of effective distance is mostly negative (eleven coefficients) and six of them are statistically significant. Canada is a good example.

Next, we turn to the covariates in the *'Technology'* category, which include fixed-line teledensity ($FLTLDNS$) and mobile phone teledensity ($MPTLDNS$). The estimates from Table 5 suggest that better technology in the sense of digital infrastructure facilitates international services trade. This relationship is robust and is reflected in the consistently negative and significant estimates that we obtain of the coefficients on $FLTLDNS$ and $MPTLDNS$. Our estimates suggest a causal relationship between technology and international trade and our findings are complementary to the results from Portes and Rey (2005)

[34]We note that, unlike previous gravity studies that have constructed bilateral indexes to measure whether being landlocked affects international trade, our specification allows identification of the impact of landlockedness as a country-specific characteristic.

who show that cross border equity flows are enhanced by density of telephone calls. From a methodological perspective, and building on the analysis from Heid et al. (2017), we were able to identify the impact of national technologies, which is a *country-specific* variable, on trade within a structural gravity model in the presence of a complete set of importer-time and exporter-time fixed effects.

The next category of national determinants of services trade borders is *'Income and Endowments'*, and here we include the logarithm of Gross Domestic Product ($LNGDP$), the logarithm of population ($LNPPLN$), and the endowment with human capital as proxied by secondary and tertiary education ($SCNDRY$, $SKILLD$).[35] Our estimates reveal that income and endowments are significant determinants of trade openness. This is supported by the fact that most of the estimates on each of the four covariates in this group are statistically significant. Our estimates reveal a positive relationship between GDP and intra-national trade relative to international trade. At the same time, conditional on income, the negative and significant estimates on $LNPPLN$ suggest that population size is inversely related to international borders.

Turning to the impact of endowment with human capital, the estimates on the population shares based on education from Table 5 suggest that secondary education does not play a very significant role in promoting trade as only three of the estimates on $SCNDRY$ are statistically significant. Pushing inference to the limit, we can interpret the fact that the three significant estimates are positive as an indicator that less developed countries are more closed. Turning to the estimates on $SKILLD$, which measures the share of population with tertiary education, we see a clearer and more consistent picture. All but one of the estimates of the coefficients on $SKILLD$ are negative and the majority of them are statistically significant, thus suggesting that countries with higher shares of skilled workers, i.e., more developed countries, are more open to international trade.

[35] As mentioned earlier, in addition to these variables, we also experimented with physical capital endowment shares. However, due to very high correlation with GDP and Population it is in the current setting not possible to include this variable as a separate regressor.

Finally, we turn to the impact of institutions, which are represented in our model by the comprehensive "Rule of Law" institutional quality measure ($INSTTNS$) from the Worldwide Governance Indicators (WGI). All but one of the estimates on $INSTTNS$ are negative and eight of the eleven negative estimates are statistically significant. Thus, our estimates reveal a strong negative relationship between institutional quality and the size of border barriers in sectoral services trade. Alternatively, the negative and significant estimates on $INSTTNS$ can be interpreted as in indicator that strong national institutions promote international trade (relative to intra-national trade). This result is consistent with the findings of Beverelli et al. (2017), who estimate a positive impact of national institutions within a similar structural gravity setting, and it complements the results from a series of studies, e.g., Anderson and Marcouiller (2002), Yu et al. (2015), and Álvarez, Barbero, Rodríguez-Pose and Zofío (2018) who construct bilateral institutional indexes in order to study the link between institutions and international trade.[36]

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 and reasonable magnitudes. We view these results as particularly encouraging as none of the regressors employed in the main specification relies on sectoral production data, which opens up the possibility of obtaining satisfactory out-of-sample predictions at the sectoral level. These predictions, in turn, are crucial for the success of the novel method for recovering missing sectoral output for services trade, which we implement and test next.

6.2 Predicting Missing Output

This section derives and empirically implements a procedure for projecting gross output when such information is missing or suspect. The availability of output information for the 28 OECD countries in our sample allows us to evaluate the accuracy of the procedure. Amongst other uses, output projections are useful in extracting estimates of multilateral resistance

[36]See Beverelli et al. (2017) for a recent review of the methods to identify the impact of institutions on international trade and for a summary of the related literature.

from the origin and destination fixed effects estimates that are not paired with observed outputs and expenditures. Multilateral resistances in turn are useful for comparative static experiments and welfare evaluation. In comparative statics, it is rates of change (differences in logs) of multilateral resistances and welfare that matter, so the accuracy of projected log output indicates that comparative statics can be plausibly performed using projections of missing output data.

Following on from the theoretical exposition in Section 2.2, output predictions are generated in four steps:

(i) Mimicking the case as if output information was not available for a given country, discard internal trade flow for one country and estimate specification (16). As a result, the associated country-specific $SMCTRY$ coefficient is not identified; however, the time-varying $SMCTRY$ coefficients are identified, as are the country's exporter-time and importer-time fixed effects, respectively, since we retain *international* trade flows;

(ii) Obtain out-of-sample predicted values for internal trade of the country for which this information had been dropped in the previous step. A maintained assumption in doing so is that country characteristics in $\mathbf{W}_{it}$ are observable, and the associated coefficient vector γ' is identified from other countries' internal trade flows;

(iii) Combine predicted internal trade with that country's total border-crossing trade to obtain a point estimate and standard errors for predicted log output;

(iv) Repeat steps (i)-(iii) for each country and for each sector in our sample, collecting values of projected log output in each case. We report the accuracy of projected log output as appropriate to applications of gravity to comparative static exercises where rates of change are the focus.

We start to assess the "goodness of fit" of our projections by comparing the distributions of log predicted and log actual output, respectively. We do so by plotting quantiles of each distribution against each other (Figure 1). A quantile–quantile (Q–Q) plot to compare two samples can be viewed as a non-parametric approach to comparing their underlying distributions, and is generally regarded as a more powerful approach to do this than histograms. If the two distributions being compared are linearly related, the points in the Q–Q plot will approximately lie on a line, though not necessarily on the $y = x$ ray.

Reassuringly, most of the quantiles in Figure 1 line up closely, and the line is not too dissimilar from the 45 degree line. The fact that the general trend in the Q–Q plot is slightly steeper than the 45 degree line indicates that the distribution of predicted log output is more dispersed than the distribution of actual log values. The Q–Q plot shows that the projection methods works quite well for a wide range of the log output distribution, but that the distribution of the predictions exhibits heavier tails, which in particular reflects a tendency to overpredict large outputs and under predict small outputs. 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.

It is convenient to express values of predicted log output as percentage deviations from their corresponding actual values, so that 100% would denote a perfect prediction. The full range of predictions in percentage deviation terms by country and sector is shown in Table 6. It is encouraging to note that in many instances predicted log output falls within ±10 percentage points of its true value; for many countries including small ones the predictions are close to 100%, and the confidence intervals (not shown) are reasonably tight.

Some systematic deviations across countries by size are apparent. For instance, output for small economies such as Estonia, Lithuania, Luxembourg or Latvia appears to be mostly underpredicted, whereas output for the United States is overpredicted. There are also fluctuations in accuracy across sectors, which are likely to reflect the density and/or quality of reported trade flows. For instance, Transportation services trade flows (Sector 1) are both plentiful and straightforwardly measured, and as a result, predictions are generally close to

100%. By contrast, trade in Audiovisual services (Sector 12), for example, is much sparser and also more difficult to measure; hence, predictions exhibit a wider dispersion around the benchmark. The relatively poorer performance of our prediction method for Audiovisual services is consistent with the relatively poor performance of the standard gravity model for this sector. On the whole, though, we take these results as evidence of the novel procedure's ability to deliver satisfactory results even when no output information at all is available for a given country-sector combination. In order to gauge margins of error, we use the delta method to construct 95% confidence intervals (CI) around average predictions of log output by country. Figure 2 conveys the full picture of percentage deviations, in increasing order of magnitude, and their associated confidence intervals.

It is intuitive, and is indeed reflected in the results discussed thus far, that the accuracy of output predictions is a function of the quality and amount of data that is available for estimation prior to out-of-sample predictions. In order to comprehensively illustrate the sensitivity of our novel procedure with respect to data input, we conduct a set of three robustness checks.[37]

First, we discard internal trade information not only for the country for which output is to be projected, but in addition for another three and six randomly drawn countries, respectively. This is akin to a situation in which output information is not available for 15% or 25% of the countries in a sample at hand. The results show that, predictably, the point estimates of log output tend to move away from their true values and the variance of such estimates increases (see Table 17 of the Supplementary Appendix). However, the incremental deterioration relative to predictions in Table 6 seems relatively small even for the case of dropping output information for seven countries, and so the projections appear to be quite robust.[38]

Second, rather than discarding output information, we discard 20% of *international* trade

[37]Each of the following three robustness exercises involves 336 estimations as each of the 28 countries is evaluated one-by-one, and each of those estimations are repeated for each of the 12 sectors.

[38]Results are available from the Online Appendix (Table 17). Likewise, full results tables for the other two robustness exercises are also contained in the Online Appendix (Tables 18 and 19, respectively).

flows randomly from the sample prior to estimating gravity and predicting internal trade. This scenario leaves the predictions essentially unaffected and thereby shows that projections are exceptionally robust to fewer information that involves other countries (see Table 18 of the Supplementary Appendix).

Third, we discard *all* export flows of a given country (ie. its internal *and* border-crossing trade) prior to estimating the gravity model and predicting out-of-sample that country's entire output. This is perhaps unrealistically demanding in that international trade statistics are usually available.[39] That said, the case of no country-specific trade flow information whatsoever renders the predictions appreciably worse off (see Table 19 of the Supplementary Appendix). This is a result of the fact that without international trade, a country's exporter-time fixed effect is not identified and this hits the prediction accuracy for its internal trade hard. Because services trade data are sparser for smaller countries, we establish a clear link between incremental losses in prediction accuracy and country size (Figure 3).

From this set of robustness checks we infer two regularities: first, generally speaking the projection of log output works robustly even when less and less information is fed into the estimation. Given the sparsity of the services trade flow matrix in the first instance, this is an important and reassuring result. Second, there is a pecking order: the procedure copes well with less information on internal and international trade flows for other countries, but the availability of international trade flows is salient for satisfactory results. The reason is the crucial role of exporter-time and importer-time fixed effects for out-of-sample predictions.

We further characterize the suitability of the model in equation (16) for making projections by reporting a set of standard measures of forecast accuracy (Diebold and Lopez, 1996). The most widely used measure by far of overall accuracy is mean squared error (MSE), reported in Table 7 alongside other commonly used metrics such as Theil's U statistic and the variance ratio (Granger and Newbold, 1976), respectively.[40] The statistics in Table 7 refer to

[39] The results could be interpreted as giving an indication of the bias entailed by official statistics that would suffer from underreporting and thus not capture all trade flows.

[40] Theil's U is defined as $U = \sum_i (y_i - \hat{y}_i)^2 / \sum_i (y_i)^2$; the variance ratio is simply $\text{Var}(\hat{\varepsilon}_i)/\text{Var}(y_i) = 1 - R^2$, where y is shorthand for the log of internal trade (dependent variable) and $\hat{y}$ denotes its fitted value.

predictions of internal trade flows only. Recall that the underpinning gravity estimations encompass both internal and international trade flows; however, a close fit for border-crossing observations would not be informative about the accuracy of our projection method for internal trade. Statistics are disaggregated by country, whereby individual entries denote the country that has been omitted from a given run of equation (16) for out-of-sample forecasting. We note that the smallest MSE value obtains if the United States is omitted from the estimation. This can be explained by the fact that—at least in manufacturing—the US exhibits unusually low Constructed Home Bias, defined as $CHB_i = \left(\frac{t_{ii}}{\Pi_i P_i}\right)^{1-\sigma}$, see Anderson and Yotov (2010a); we conjecture that the same is likely true in services as well. Values for the Theil index and the variance ratio (which is patterned after the familiar R-squared) are very low, thereby suggesting that nearly all of the variance of actual internal trade is explained. Lastly, in column (4) we compare the MSE from a simple benchmark model, which projects internal trade in a particular services sector solely onto log aggregate GDP, with our novel procedure's MSE as reported in column (1). The benchmark model's MSE values are between 150-230% higher than the ones of our specification, showing the value added afforded by the border barrier decomposition in Section 6.1.

Overall, we conclude that our methods to recover missing output data based upon structural gravity restrictions deliver reasonable results. Log output figures thus estimated are close to their true values for large parts of the log output range, even though the procedure is prone to overpredicting (underpredicting) in the extreme upper (lower) tail of the output distribution. The procedure's good performance in a situation in which no production data at all is available is particularly appealing because outside OECD countries output statistics are hard to come by. Whilst the decomposition of border barriers that underpins these predictions draws on structural gravity theory, its empirical implementation, which we show works very well for OECD countries, can be suitably adapted for the specifics of other (developing) country samples. We also demonstrate the method's robustness in terms of data requirements – not surprisingly predictions tend to be better in instances (eg. sectors) with more trade flow observations, but projection accuracy holds up quite well even when the procedure is run on less and less data.

7 Conclusion

Structural gravity is applied to model barriers to cross-border services trade across many sectors, countries and time based on the development of an integrated dataset for services production and trade. Border barriers are flexibly inferred relative to internal costs. The gravity model works well with sectoral services trade data. In addition to confirming some results from the goods gravity literature, we also document some new insight and nuances that are specific to services trade. 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 find that border barriers have generally fallen over time but unevenly across services sectors.

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 geography, technology, income and endowments, and institutions as key 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 in instances when the quality of other trade or production data 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.

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References

Agnosteva, Delina E., James E. Anderson, and Yoto V. Yotov, "Intra-national Trade Costs: Measurement and Aggregation," *NBER Working Paper No. 19872*, 2014. ΩÁlvarez et al.

Álvarez, Inmaculada C., Javier Barbero, Andrés Rodríguez-Pose, and José L. Zofío, "Does Institutional Quality Matter for Trade? Institutional Conditions in a Sectoral Trade Framework," *World Development*, 2018, *103*, 72–87.

Anderson, James E., "A Theoretical Foundation for the Gravity Equation," *American Economic Review*, 1979, *69* (1), 106–116.

Anderson, James E. and Douglas Marcouiller, "Insecurity And The Pattern Of Trade: An Empirical Investigation," *The Review of Economics and Statistics*, May 2002, *84* (2), 342–352.

Anderson, James E. and Eric van Wincoop, "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, 2003, *93* (1), 170–192.

Anderson, James E., Catherine A. Milot, and Yoto V. Yotov, "How Much Does Geography Deflect Services Trade? Canadian Answers," *International Economic Review*, 08 2014, *55*, 791–818.

Anderson, J.E., "The Gravity Model," *Annual Review of Economics*, 2011, *3*, 133–160.

_ **and E. van Wincoop**, "Trade Costs," *Journal of Economic Literature*, 2004, *42* (3), 691–751.

_ **and Yoto V. Yotov**, "The Changing Incidence of Geography," *American Economic Review*, 2010, *100* (5), 2157–2186.

_ **and** _ , "Specialization: Pro- and Anti-Globalizing, 1990-2002," *NBER Working Paper No. 16301*, 2010.

Armington, P.S., "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers*, 1969, *16*, 159–176.

Arvis, Jean-Francois and Ben Shepherd, "The Poisson Quasi-Maximum Likelihood Estimator: A Solution to the "Adding up" Problem in Gravity Models," *Applied Economics Letters*, April 2013, *20* (6), 515–519.

Baier, Scott L. and Jeffrey H. Bergstrand, "Do Free Trade Agreements Actually Increase Members' International Trade?," *Journal of International Economics*, 2007, *71* (1), 72–95.

Baldwin, R.E. and D. Taglioni, "Gravity for Dummies and Dummies for Gravity Equations," *NBER Working Paper No. 12516*, 2006.

Beverelli, Cosimo, Alexander Keck, Mario Larch, and Yoto V. Yoto, "Institutions, Trade and Development: A Quantitative Analysis," Manuscript 2017.

Breinlich, Holger and Chiara Criscuolo, "International trade in services: A portrait of importers and exporters," *Journal of International Economics*, July 2011, *84* (2), 188–206.

Chaney, Thomas, "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, 2008, *98* (4), 1707–1721.

Cheng, I-Hui and Howard J. Wall, "Controlling for Heterogeneity in Gravity Models of Trade and Integration," *Federal Reserve Bank of St. Louis Review*, 2005, *87* (1), 49–63.

Christen, Elisabeth M. and Joseph F. Francois, "Modes of Delivery in Services," CEPR Discussion Paper DP7912, Centre for Economic Policy Research July 2010.

Costinot, Arnaud and Andres Rodriguez-Clare, "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, 2014.

Coughlin, Cletus C. and Dennis Novy, "Estimating Border Effects: The Impact of Spatial Aggregation," *Federal Reserve Bank of St. Louis Working Paper 2016-006A*, April 2016.

Diebold, Francis X. and Jose A. Lopez, "Forecast evaluation and combination," *Chapter 8 in The Handbook of Statistics, Editors: G.S. Maddala and C.R. Rao*, 1996, *14*, 241–268.

Eaton, Jonathan and Samuel Kortum, "Technology, Geography and Trade," *Econometrica*, 2002, *70* (5), 1741–1779.

Eichengreen, Barry and Douglas A. Irwin, "The Role of History in Bilateral Trade Flows," NBER Working Papers 5565, National Bureau of Economic Research, Inc May 1996.

Ethier, W. J. and H. Horn, "Services in International Trade," *in E. Helpman and A. Razin (eds.), INTERNATIONAL TRADE AND TRADE POLICY*, 1991.

Fally, Thibault, "Structural Gravity and Fixed Effects," *Journal of International Economics,* forthcoming, doi:10.1016/j.jinteco.2015.05.005, 2015.

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

Freund, Caroline L. and Diana Weinhold, "The effect of the Internet on international trade," *Journal of International Economics*, 2004, *62*, 171–189.

Granger, Clive W.J. and Paul Newbold, "Forecasting transformed series," *Journal of the Royal Statistical Society B*, 1976, *38*, 189–203.

Head, Keith and Thierry Mayer, "Non-Europe: The magnitude and causes of market fragmentation in the EU," *Review of World Economics (Weltwirtschaftliches Archiv)*, June 2000, *136* (2), 284–314.

Head, Keith and Thierry Mayer, "Gravity Equations: Workhorse, Toolkit, and Cookbook," Chapter 3 in the Handbook of International Economics Vol. 4, eds. Gita Gopinath, Elhanan Helpman, and Kenneth S. Rogoff, Elsevier Ltd., Oxford, 2014, pp. 131–195.

Head, Keith, Thierry Mayer, and John Ries, "How remote is the offshoring threat?," *European Economic Review*, 2008, *53* (4), 429–444.

_ , _ , and _ , "The erosion of colonial trade linkages after independence," *Journal of International Economics*, 2010, *81* (1), 1–14.

Heid, Benedikt, Mario Larch, and Yoto V. Yoto, "Estimating the Effects of Non-discriminatory Trade Policies within Structural Gravity Models," CESifo Working Paper Series 6735, CESifo Group Munich 2017.

Helpman, Elhanan, Marc Melitz, and Yona Rubinstein, "Trading Partners and Trading Volumes," *Quarterly Journal of Economics*, 2008, *123* (2), 441–487.

Jensen, Bradford J. and Lori Kletzer, "Tradable Services: Understanding the Scope and Impact of Services Outsourcing," *Institute for International Economics Working Paper*, 2005, *05-9.*

Kimura, Fukunari and Hyun-Hoon Lee, "The Gravity Equation in International Trade in Services," *Review of World Economics*, April 2006, *142* (1), 92–121.

Lejour, Arjan and Jan-Willem de Paiva Verheijden, "Services trade with Canada and the European Union," CPB Discussion Paper 42, CPB Netherlands Bureau for Economic Policy Analysis 2004.

Lennon, Carolina, Daniel Mirza, and Giuseppe Nicoletti, "Complementarity of Inputs across Countries in Services Trade," *Annals of Economics and Statistics*, 2009, *93-94*, 161–182.

Mattoo, Aaditya, Robert Stern, and Gianni Zanini, eds, *A Handbook of International Trade in Services*, Oxford University Press, 2007.

Mayer, Thierry and Keith Head, "Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade," *Working Papers*, 2002, *2002-01.*

_ **and Soledad Zignago**, "Notes on CEPII's Distances Measures: The GeoDist Database," *CEPII Working Paper 2011 - 25*, 2011.

Melitz, Jacques and Farid Toubal, "Native language, spoken language, translation and trade," *Journal of International Economics*, 2014, *93* (2), 351–363.

Miroudot, Sébastien, Jehan Sauvage, and Ben Shepherd, "Trade costs and productivity in services sectors," *Economics Letters*, 2012, *114* (1), 36–38.

Olivero, Maria Pia and Yoto V. Yotov, "Dynamic Gravity: Endogenous Country Size and Asset Accumulation," *Canadian Journal of Economics*, 2012, *45* (1), 64–92.

Piermartini, Roberta and Yoto V. Yotov, "Estimating Trade Policy Effects with Structural Gravity," *WTO Working Paper ERSD-2016-10*, 2016.

Portes, Richard and Helene Rey, "The determinants of cross-border equity flows," *Journal of International Economics*, March 2005, *65* (2), 269–296.

Ramondo, Natalia, Andrs Rodrguez-Clare, and Milagro Saboro-Rodrguez, "Trade, Domestic Frictions, and Scale Effects," *American Economic Review*, 2016, *106* (10), 3159–84.

Santos Silva, João M.C. and Silvana Tenreyro, "The Log of Gravity," *Review of Economics and Statistics*, 2006, *88* (4), 641–658.

_ **and** _ , "Further Simulation Evidence on the Performance of the Poisson Pseudo-Maximum Likelihood Estimator," *Economics Letters*, 2011, *112* (2), 220–222.

Tharakan, P.K.M., Ilke Van Beveren, and Tom Van Ourti, "The Determinants of India's Software Exports and Goods Exports," *The Review of Economics and Statistics*, 2005, *87* (4), 776–780.

Trefler, Daniel, "The Long and Short of the Canada-U.S. Free Trade Agreement," *American Economic Review*, 2004, *94* (4), 870–895.

Walsh, Keith, "Trade in Services: Does Gravity Hold? A Gravity Model Approach to Estimating Barriers to Services Trade," The Institute for International Integration Studies Discussion Paper Series, IIIS November 2006.

Waugh, Michael E., "International Trade and Income Differences," *American Economic Review*, 2010, *100* (5), 2093–2124.

Yotov, Yoto V., Roberta Piermartini, Jos-Antonio Monteiro, and Mario Larch, *An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model*, Geneva, Switzerland: United Nations and World Trade Organization, 2016.

Yu, Shu, Sjoerd Beugelsdijk, and Jakob de Haan, "Trade, Trust and the Rule of Law," *European Journal of Political Economy*, 2015, *37*, 102–115.

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

Notes: This table describes the sectors in our sample. Column (1) includes sector IDs, which are used in the text. Column (2) offers description of each sector. Column (3) includes the short labels that we use in the text for each sector. Finally, columns (4) and (5) list the Extended Balance of Payments Services Classification (EBOPS) codes and corresponding levels. See main text and Supplementary Appendix for more details on sectoral coverage and concordances.

Table 2: Services Gravity, 2000-2006, Country-Time Borders.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE
Log Distance	-0.6911***	-0.9454***	-0.8519***	-0.9857***	-1.0795***	-0.8713***
	(0.084)	(0.080)	(0.085)	(0.154)	(0.096)	(0.093)
Contiguity	0.3042**	0.3365**	0.2052	-0.0479	0.2465	0.0589
	(0.139)	(0.138)	(0.162)	(0.204)	(0.232)	(0.220)
Same Language	0.1264	0.6469***	0.4127*	0.3748	0.8291***	-0.1531
	(0.126)	(0.167)	(0.240)	(0.251)	(0.314)	(0.262)
Established EU member	-0.5160*	-0.1051	-0.0606	-0.4055	-1.5696***	-1.3102***
	(0.264)	(0.323)	(0.276)	(0.601)	(0.475)	(0.479)
New EU member	1.3086***	0.9222***	1.2526***	1.4737**	1.3952**	1.5112**
	(0.315)	(0.316)	(0.317)	(0.574)	(0.602)	(0.625)
Common currency	0.2466	0.2743	-0.0982	-0.6551	1.0244***	0.7723**
	(0.158)	(0.217)	(0.240)	(0.475)	(0.324)	(0.388)
Common legal system	-0.0355	-0.0622	-0.0277	-0.2312	-0.1455	0.2194
	(0.093)	(0.123)	(0.155)	(0.194)	(0.203)	(0.214)
Common religion	0.4915**	0.4479	0.5390*	0.5428	1.9827***	1.3149**
	(0.229)	(0.288)	(0.311)	(0.493)	(0.693)	(0.592)
Observations	3135	3110	3135	3135	3124	3124

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
Log Distance	-0.9179***	-0.9636***	-0.9039***	-0.5873***	-0.7724***	-1.2414***
	(0.120)	(0.089)	(0.089)	(0.122)	(0.200)	(0.116)
Contiguity	0.1701	-0.1087	0.6821***	0.1501	0.3266	-0.2516
	(0.261)	(0.201)	(0.260)	(0.225)	(0.346)	(0.274)
Same Language	-1.3553***	0.1513	-0.4214	-0.0604	-0.8107*	1.4776***
	(0.366)	(0.290)	(0.371)	(0.247)	(0.419)	(0.415)
Established EU member	-0.2422	-1.2598**	-1.2213*	-0.0610	-1.4539***	-0.0047
	(0.343)	(0.633)	(0.683)	(0.421)	(0.455)	(0.470)
New EU member	-0.5793	2.6249***	0.8076	0.9246***	-1.2013**	-0.9331
	(0.483)	(0.709)	(0.714)	(0.345)	(0.567)	(0.585)
Common currency	0.6630**	-0.8653*	0.2597	-0.5190	0.5524	-0.0257
	(0.281)	(0.466)	(0.394)	(0.375)	(0.469)	(0.449)
Common legal system	0.9646***	0.0121	-0.0256	0.5698***	1.1009***	-0.3078
	(0.230)	(0.237)	(0.263)	(0.134)	(0.197)	(0.294)
Common religion	-1.0091*	-0.2925	0.4435	0.0087	-0.4672	-0.5943
	(0.517)	(0.511)	(0.672)	(0.359)	(0.645)	(0.827)
Observations	3066	3135	3121	3124	3064	3012

Notes: This table reports PPML panel gravity estimates for Services trade, 2000-2006, based on Specification (14). Dependent variable: service exports. Poisson PML estimation with std.err. (in parentheses) clustered at country-pair level. Full sets of exporter-year and importer-year fixed effects included but not reported. The specifications allow for country-year specific SMCTRY coefficient estimates (not shown). Significance levels: * $p < 0.10$, ** $p < .05$, *** $p < .01$. See text for more details.

Table 3: Services Gravity, 2000-2006, Country and Time Borders.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE
Log Distance	-0.6926***	-0.9406***	-0.8584***	-0.9435***	-0.6730***	-0.3531**
	(0.084)	(0.081)	(0.086)	(0.163)	(0.171)	(0.158)
Contiguity	0.3024**	0.3355**	0.1761	-0.0463	0.5549**	0.4544*
	(0.139)	(0.138)	(0.163)	(0.209)	(0.258)	(0.258)
Same Language	0.1134	0.6432***	0.4103*	0.3965	0.8222**	-0.2416
	(0.126)	(0.169)	(0.239)	(0.263)	(0.327)	(0.267)
Established EU member	-0.5054*	-0.0659	0.0492	-0.1086	-0.7507	-0.2166
	(0.264)	(0.321)	(0.285)	(0.674)	(0.536)	(0.536)
New EU member	1.3588***	0.9267***	1.2417***	1.4239**	1.5917**	2.2691***
	(0.307)	(0.314)	(0.321)	(0.585)	(0.625)	(0.508)
Common currency	0.2533	0.2203	-0.1792	-0.8671	0.7064**	0.5728
	(0.158)	(0.211)	(0.239)	(0.534)	(0.338)	(0.385)
Common legal system	-0.0321	-0.0474	0.0117	-0.2412	-0.0774	0.4186*
	(0.093)	(0.123)	(0.156)	(0.206)	(0.209)	(0.215)
Common religion	0.4914**	0.4891*	0.5948*	0.6862	2.6554***	1.6854***
	(0.230)	(0.290)	(0.313)	(0.530)	(0.724)	(0.587)
SMCTRY (2002)	-0.1322***	-0.1198	0.0458	0.0776	-0.3225	0.0589
	(0.041)	(0.080)	(0.059)	(0.077)	(0.280)	(0.120)
SMCTRY (2004)	-0.2013***	-0.1324	-0.2151**	-0.1259	-0.9991***	-0.6144***
	(0.042)	(0.090)	(0.090)	(0.133)	(0.318)	(0.199)
SMCTRY (2006)	-0.2965***	-0.1577*	-0.5055***	-0.0767	-1.0322***	-0.8518***
	(0.049)	(0.094)	(0.102)	(0.137)	(0.349)	(0.189)
Observations	3135	3110	3135	3135	3124	3124

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
Log Distance	-0.8376***	-0.5464**	-0.4037**	-0.5991***	-0.7264***	-0.4203*
	(0.145)	(0.234)	(0.199)	(0.121)	(0.207)	(0.248)
Contiguity	0.2093	0.0755	1.0193***	0.1056	0.2709	0.4922
	(0.277)	(0.247)	(0.306)	(0.224)	(0.349)	(0.369)
Same Language	-1.2513***	0.2414	-0.3471	-0.0787	-0.7644*	1.8045***
	(0.358)	(0.330)	(0.350)	(0.244)	(0.391)	(0.419)
Established EU member	-0.1952	-0.2597	-0.3069	-0.0821	-1.3252***	1.2060**
	(0.362)	(0.672)	(0.624)	(0.417)	(0.465)	(0.582)
New EU member	-0.2560	2.1290***	0.6826	0.9469***	-1.0707*	0.0810
	(0.465)	(0.610)	(0.637)	(0.335)	(0.570)	(0.604)
Common currency	0.5857**	-1.1076**	0.0578	-0.5107	0.5394	-0.8515*
	(0.292)	(0.492)	(0.420)	(0.365)	(0.454)	(0.495)
Common legal system	0.9111***	0.0786	0.0273	0.6099***	1.0555***	-0.1965
	(0.225)	(0.243)	(0.251)	(0.131)	(0.187)	(0.289)
Common religion	-0.9377*	-0.0804	0.7167	0.0756	-0.4329	0.0456
	(0.541)	(0.562)	(0.669)	(0.364)	(0.628)	(0.739)
SMCTRY (2002)	-0.2377***	0.0882	-0.2339**	-0.1703*	-0.0739	0.4351**
	(0.081)	(0.085)	(0.118)	(0.098)	(0.122)	(0.180)
SMCTRY (2004)	-0.7169***	-0.2655**	-0.7384***	-0.7737***	-0.2798	-0.4072
	(0.150)	(0.118)	(0.202)	(0.139)	(0.178)	(0.276)
SMCTRY (2006)	-0.9548***	-0.4914***	-0.9816***	-0.8271***	-0.8194***	-0.3554
	(0.185)	(0.137)	(0.205)	(0.131)	(0.201)	(0.273)
Observations	3066	3135	3121	3124	3064	3012

Notes: This table reports PPML panel gravity estimates for Services trade, 2000-2006, based on Specification (15). Dependent variable: service exports. Poisson PML estimation with std.err. (in parentheses) clustered at country-pair level. Full sets of exporter-year and importer-year fixed effects included but not reported. The specifications allow for country specific SMCTRY coefficient estimates (not shown). Significance levels: * $p < 0.10$, ** $p < .05$, *** $p < .01$. See text for more details.

Table 4: Country-sector-specific Border Estimates for Services, 2000-2006.

ISO	TRNSP	TRAVL	CMMCN	CSTRN	INSUR	FINCE	CMPTR	TRADE	OPRNL	BUSIN	RSRCH	AUDIO	AVRG
AUS	.1*	-4.6	.4*	2.9*				6.9					3.4
AUT	.7*	-2.8	1.1*	.2*	4.6	7.4	.9*	3.4*	5.9	2.4	-1.7*	7.5	2.6
BEL	.8*	-1.3	1.9	2.2*	6.3	6.0	-.1*	2.5*	5.9	2.3	-2.1*	8.2	2.6
CAN	.5*	-2.1	.5*	3.2				5.6					3.2
CZE	2.9	-3.4	3.4	4.6	6.0	8.4	3.2	7.3	6.3	4.5	3.6	8.1	5.3
DEU	-1.1*	-3.5	-.5*	-2*	2.1*	4.9	-2.2	1.3*	4.3	-.2*	-3.3	4.3	0.6
DNK	-1.6	-3.6	3.0	4.8	4.2	9.4	2.3*	5.8	4.9	4.3	2.2*	8.5	4.7
ESP	.5*	-2.8	2.8	3.1	7.0	10.4	2.8	5.5	9.2	4.1	.4*	7.8	3.8
EST	2.7		3.7	4.2	9.2	10.1	4.0	8.1	6.3	5.9	7.2	12.9	6.1
FIN	1.6	-.9*	2.9	2*	6.5	9.6	1.8*	3.2*	6.1	3.0	1.5*	11.6	3.3
FRA	0*	-2.8	1.3*	.7*	4.1	8.1	3.3	1.7*	4.6	2.1	1.6*	5.0	2.3
GBR	-1.1*	-3.3	.9*	2.6*	.3*	2.3*	.6*	6.3	5.5	2.3	-.6*	7.0	2.7
GRC	-4.5	-2.6	1.6	1.2*	2.2*	9.5	2.9	5.8	6.2	3.3	3.3	7.9	3.6
HUN	2.6		2.9	3.1	6.9	8.9	2.1	5.7	5.6	3.5	.8*	1.5*	4.4
IRL	1.8	-.5*	2.5	4.8	1.4*	4.9	-2.3*	.5*	-.3*	1.1*	-1.7*	9.8	2.8
ITA	1.3*	-2.3	.9*	.6*	3.2	7.2	3.9	1.9*	3.5	2.3	2.2*		1.9
JPN	-1.1*	-2.2	1.3*	0*	1.3*	3.6	3.3	7.2	6.6	3.5	1.6*	6.8	3.0
KOR	-.6*	-2.4	.9*	2.3	4.7	8.8	5.5	6.1	9.0	5.3	6.7	8.0	3.6
LTU	3.1		4.4	6.5	11.7	11.9	5.4	9.2	9.2	6.7	6.6	10.5	7.6
LUX	2.0		.9*	2.7	7.5	2.6	3.6	5.2	6.4	3.7	5.1	8.9	3.5
LVA	2.6	-.1*	4.4	5.5	18.1	12.8	5.1	9.7	9.5	6.7	7.3	18.7	8.1
NLD	-.6*	-2.2	.5*	1*	5.3	6.9	1.7*	2.7*	3.9	1*	-1.2*	4.4	2.3
POL	2.1		3.4	2.7	7.8	10.3	2.7	8.6	6.5	4.6	4.4	8.8	6.1
PRT	1.2*	-1.5	2.6	1.7*	6.8	10.4	4.3	6.6	10.0	6.4	4.8	13.1	4.9
SVK	7.2	3.3	7.4	7.4	11.0	12.7	6.9	10.5	11.1	8.4	9.7	14.0	8.8
SVN	3.3		4.7	6.1	8.4	11.8	5.6	7.7	4.9	7.0	6.9	11.1	7.1
SWE	.3*	-3.2	2.2	2.8	3.5	6.6	1.5*	5.0	4.9	2*	-2.4*	8.1	2.9
USA	-2.6	-5.0	-2.4	-.5*				2.8*					0.0
AVRG	-0.3	-3.4	-0.2	1.1	2.8	5.9	2.5	4.4	5.7	2.7	1.9	6.9	2.31

Notes: This table reports country-specific and sector-specific estimates of the borders in services trade, 2000-2006. Countries appear in rows and sectors appear in columns. The estimates are obtained from Specification (15) together with the gravity estimates from Table 3. Corresponding standard errors and confidence intervals are constructed and available by request but omitted here for brevity. Instead, all insignificant estimates are marked with '*'. The last column of the table reports domestic-sales-weighted averages across sectors. Similarly, the last row of the table reports domestic-sales-weighted averages across countries. See text for more details.

Table 5: Panel PPML Gravity Estimates: Services, 2000-2006, SMCTRY Proxies.

	(1) TRNSP	(2) TRAVL	(3) CMMCN	(4) CSTRN	(5) INSUR	(6) FINCE	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
LNDLCKD	0.698	-0.070	-0.712	-0.969	-0.123	-1.439	-1.407	0.053	2.314	0.342	0.457	-2.244
	(0.307)*	(0.386)	(0.355)*	(0.445)*	(0.700)	(0.643)*	(0.643)*	(0.454)	(0.693)**	(0.500)	(0.825)	(1.377)
EFFCTDIST	-0.094	0.167	-0.062	-0.397	-0.398	-1.686	-0.740	-1.161	-1.144	-0.868	-0.361	-0.514
	(0.132)	(0.092)+	(0.101)	(0.134)**	(0.247)	(0.231)**	(0.286)**	(0.215)**	(0.332)**	(0.260)**	(0.448)	(0.490)
INTRADIST	1.113	-0.260	-0.076	0.254	-1.135	-0.022	-0.070	-2.498	-0.800	-0.325	-0.261	1.168
	(0.290)**	(0.175)	(0.280)	(0.390)	(0.437)**	(0.372)	(0.486)	(0.560)**	(0.393)*	(0.279)	(0.469)	(0.628)+
FLTLDNS	-0.072	-0.046	-0.084	-0.108	-0.137	-0.115	-0.140	-0.134	-0.051	-0.093	-0.111	-0.037
	(0.013)**	(0.016)**	(0.015)**	(0.020)**	(0.025)**	(0.029)**	(0.022)**	(0.017)**	(0.024)*	(0.018)**	(0.023)**	(0.043)
MPTLDNS	-0.001	-0.028	-0.017	-0.008	-0.039	-0.020	-0.043	-0.002	-0.006	-0.020	-0.040	0.059
	(0.005)	(0.006)**	(0.007)**	(0.011)	(0.015)*	(0.014)	(0.011)**	(0.011)	(0.013)	(0.007)**	(0.016)*	(0.020)**
LNGDP	1.163	1.513	1.627	2.258	1.583	0.929	2.901	0.287	-0.153	1.282	2.368	2.686
	(0.136)**	(0.259)**	(0.216)**	(0.281)**	(0.498)**	(0.500)+	(0.402)**	(0.344)	(0.488)	(0.274)**	(0.502)**	(0.711)**
LNPPLN	-1.736	-1.802	-1.971	-3.136	-1.608	-1.712	-3.778	0.229	0.220	-1.716	-2.789	-4.235
	(0.194)**	(0.383)**	(0.322)**	(0.402)**	(0.817)*	(0.685)*	(0.520)**	(0.488)	(0.695)	(0.459)**	(0.684)**	(0.940)**
SKILLD	-0.074	-0.054	-0.103	-0.029	-0.102	-0.097	-0.170	-0.090	0.117	-0.034	-0.101	-0.026
	(0.009)**	(0.014)**	(0.014)**	(0.022)	(0.051)*	(0.037)**	(0.057)**	(0.019)**	(0.047)*	(0.030)	(0.055)+	(0.068)
SCNDRY	0.003	-0.010	0.003	0.009	0.077	0.115	-0.001	0.049	0.017	0.012	-0.019	-0.050
	(0.007)	(0.008)	(0.010)	(0.013)	(0.019)**	(0.021)**	(0.014)	(0.016)**	(0.019)	(0.011)	(0.021)	(0.031)
INSTTNS	-0.996	-1.125	-0.854	-1.644	-0.313	-1.241	-2.245	0.621	-0.673	-1.584	-4.019	-4.058
	(0.331)**	(0.266)**	(0.430)*	(0.557)**	(0.828)	(0.756)	(0.603)**	(0.567)	(0.606)	(0.449)**	(0.848)**	(1.119)**
SMCTRY_TIME_2	-0.191	-0.237	-0.037	-0.066	-0.517	0.119	-0.476	0.129	-0.126	-0.284	-0.222	0.113
	(0.045)**	(0.085)**	(0.066)	(0.131)	(0.284)+	(0.133)	(0.090)**	(0.115)	(0.141)	(0.088)**	(0.166)	(0.208)
SMCTRY_TIME_3	-0.322	-0.452	-0.379	-0.860	-1.857	-1.057	-1.551	-0.332	-0.904	-1.249	-0.643	-0.999
	(0.081)**	(0.139)**	(0.176)*	(0.277)**	(0.385)**	(0.284)**	(0.198)**	(0.208)	(0.284)**	(0.170)**	(0.282)*	(0.320)**
SMCTRY_TIME_4	-0.534	-0.663	-0.859	-0.984	-2.006	-1.400	-1.782	-0.665	-1.164	-1.357	-1.207	-0.962
	(0.083)**	(0.147)**	(0.156)**	(0.276)**	(0.404)**	(0.320)**	(0.257)**	(0.222)**	(0.296)**	(0.175)**	(0.265)**	(0.386)*
N	3135	3110	3135	3135	3124	3124	3066	3135	3121	3124	3064	3012

Notes: This table reports PPML panel gravity estimates for Services trade, 2000-2006, based on Specification (16). Dependent variable: service exports. Poisson PML estimation with std.err. (in parentheses) clustered at country-pair level. Full sets of exporter-year and importer-year fixed effects included but not reported. All specifications also include standard gravity variables, whose estimates are omitted for brevity but are available by request. Significance levels: * $p < 0.10$, ** $p < .05$, *** $p < .01$. See text for more details.

Table 6: Log output prediction (benchmark 100%)

ISO	TRNSP	TRAVL	CMMCN	CSTRN	INSUR	FINCE	CMPTR	TRADE	OPRNL	BUSIN	RSRCH	AUDIO
AUS	105.7	112.9	115.7	96.3	.	.	.	92.0	.	.	.	.
AUT	118.1	122.3	118.3	133.5	155.9	90.8	128.0	113.6	114.8	111.6	119.5	48.1
BEL	94.3	99.6	94.5	96.9	73.8	91.4	137.7	95.6	80.5	102.3	148.3	89.0
CAN	91.1	92.0	108.9	87.0	.	.	.	100.6	.	.	.	.
CZE	104.6	105.0	88.0	84.1	117.1	117.9	100.6	116.0	122.4	105.4	100.1	66.2
DEU	94.1	93.9	99.6	115.1	97.9	111.8	141.7	107.7	90.6	113.6	125.8	75.8
DNK	112.4	107.3	78.0	77.2	79.5	40.2	66.7	64.9	64.1	71.6	61.9	59.3
ESP	97.4	99.2	78.9	76.6	66.8	72.2	88.8	72.2	63.8	87.6	114.2	102.1
EST	93.7	.	65.7	84.2	51.4	53.1	.	53.8	84.7	79.8	.	.
FIN	89.6	90.4	78.8	108.4	45.8	53.5	127.0	108.0	116.8	107.7	77.1	67.5
FRA	101.2	104.1	92.6	88.7	88.6	80.9	67.7	101.2	103.5	94.7	68.1	137.7
GBR	97.3	97.3	92.6	76.4	114.9	120.9	82.3	81.2	92.1	89.6	87.7	107.8
GRC	123.9	107.2	88.4	97.6	112.9	55.9	146.6	126.9	128.6	121.3	110.4	150.9
HUN	95.4	106.3	87.4	90.3	102.9	102.3	90.5	114.7	144.6	110.9	128.9	182.7
IRL	84.9	91.8	84.4	68.7	126.3	114.8	137.0	111.7	127.5	117.3	133.6	87.2
ITA	118.1	104.4	140.9	141.4	178.5	146.0	102.3	131.5	135.8	128.8	142.7	.
JPN	106.4	102.4	104.8	123.9	143.6	156.2	100.9	94.9	109.0	106.3	121.9	73.0
KOR	92.7	99.1	94.1	80.4	57.4	64.4	33.1	85.3	81.0	85.9	31.7	59.1
LTU	93.3	108.2	67.8	64.5	21.7	42.0	59.3	53.7	45.5	73.5	33.0	83.6
LUX	96.0	112.2	117.2	102.6	92.7	117.4	69.4	68.6	64.8	86.5	76.3	146.0
LVA	97.9	93.3	76.9	83.2	49.6	74.4	103.3	71.4	45.2	79.8	56.8	.
NLD	103.1	100.9	117.4	105.5	95.9	75.5	88.7	117.4	131.6	115.9	108.0	164.3
POL	96.2	106.3	87.6	103.3	79.6	83.7	107.2	83.0	92.3	93.5	77.3	60.2
PRT	88.9	97.6	90.7	93.5	65.2	60.5	101.6	100.9	54.1	74.2	67.0	53.1
SVK	72.8	67.1	58.2	73.8	70.2	66.9	72.6	61.0	47.5	74.3	59.4	21.0
SVN	91.2	106.4	73.6	69.7	55.8	54.6	65.1	63.4	87.7	69.0	55.5	47.5
SWE	93.2	98.5	84.5	99.5	83.5	100.6	90.4	86.5	123.3	112.3	169.3	95.2
USA	125.9	115.8	134.2	136.0	.	.	.	130.4	.	.	.	.

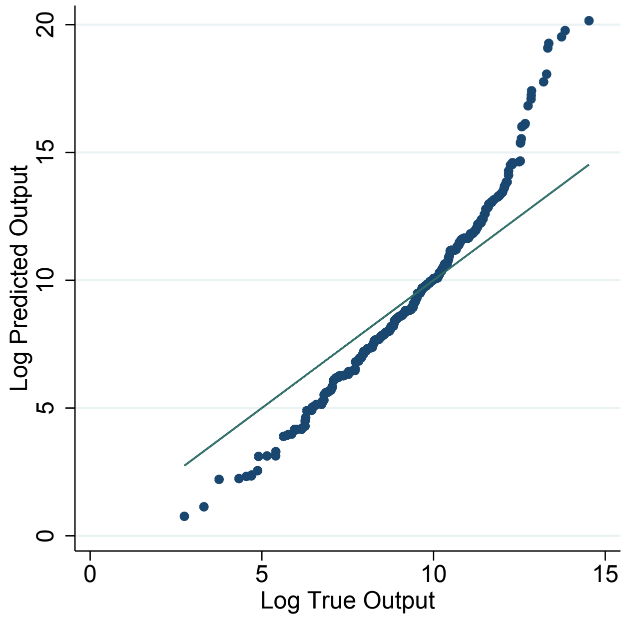
Notes: This table reports predicted log output as percentage deviations from their corresponding actual values for each sector and country in our sample. Thus, by construction, a 100% would denote a perfect prediction. See text for more details on the predictions procedures.

Table 7: Predictive Evaluation for Internal Trade

	(1) MSE	(2) Theil	(3) VarR	(4) Δ MSE (%)
AUS	42077.2	0.000197	0.000261	184.7
AUT	39267.8	0.000189	0.000252	214.3
BEL	39404.6	0.000178	0.000237	193.0
CAN	36017.8	0.000186	0.000247	212.5
CZE	41872.0	0.000197	0.000263	186.2
DEU	38069.3	0.000137	0.000176	145.5
DNK	38876.4	0.000183	0.000244	204.5
ESP	40828.6	0.000195	0.000258	196.2
EST	42075.2	0.000196	0.000262	187.4
FIN	41151.4	0.000194	0.000259	185.2
FRA	38044.4	0.000213	0.000284	216.3
GBR	38812.6	0.000164	0.000212	220.8
GRC	39216.0	0.000193	0.000259	194.8
HUN	42102.0	0.000192	0.000257	224.4
IRL	39530.6	0.000190	0.000253	194.0
ITA	37991.3	0.000193	0.000248	225.2
JPN	40223.4	0.000253	0.000328	226.7
KOR	38710.0	0.000162	0.000210	228.7
LTU	42227.4	0.000197	0.000264	186.9
LUX	41437.4	0.000183	0.000244	197.0
LVA	42347.2	0.000198	0.000265	184.9
NLD	39170.6	0.000171	0.000226	228.9
POL	42035.7	0.000197	0.000262	187.6
PRT	42748.8	0.000198	0.000265	186.4
SVK	37830.9	0.000194	0.000253	159.2
SVN	42238.3	0.000198	0.000265	187.1
SWE	40760.0	0.000178	0.000236	193.9
USA	24807.7	0.000215	0.000291	152.3
Total	39638.4	0.000191	0.000253	196.6

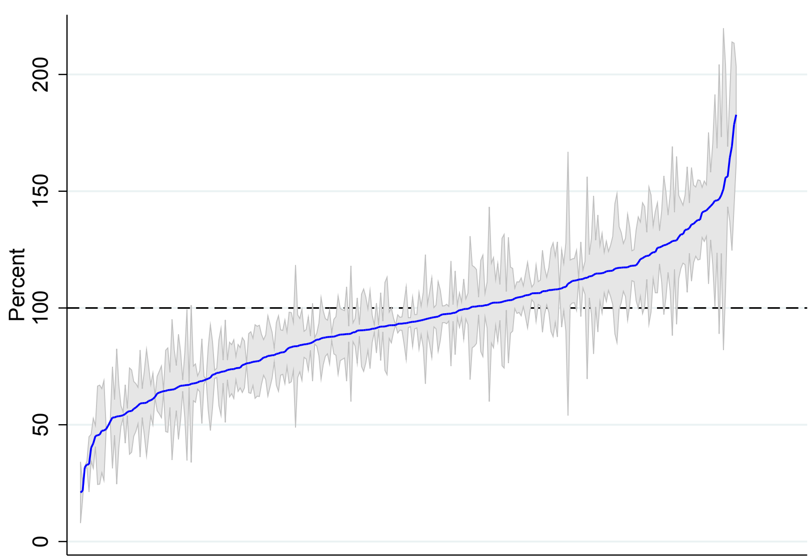
Notes: 'MSE' denotes respective estimation's mean squared error; 'Theil' denotes Theil's U statistic; 'VarR' denotes variance ratio; 'Δ MSE' denotes the ratio in percentage terms of MSE of a reduced benchmark model relative to the full model's MSE as reported in column 1. See text for further details.

Figure 1: QQ-Plot of Output Projection



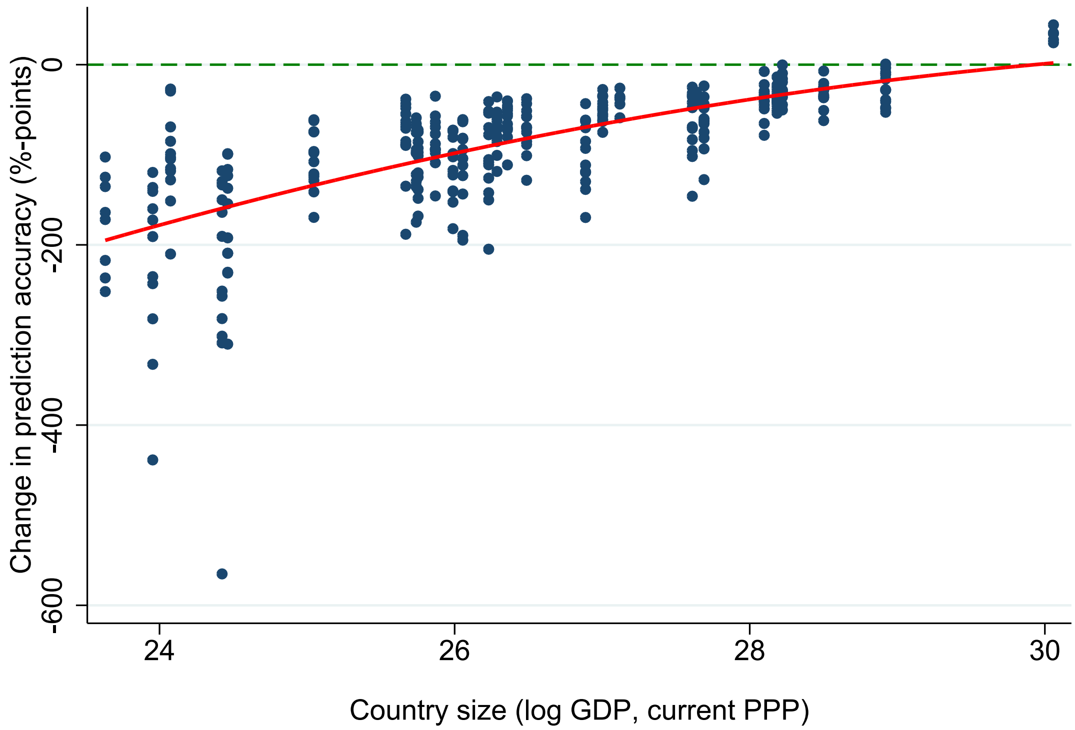
Note: Based on 309 observations.

Figure 2: Predicted Output Percentage Deviations and CI



Note: Country-sector observations lined up in increasing order of predicted output

Figure 3: Prediction Accuracy for Log Output with No Information on Export Flows



Note: Correlation coefficient = .77 (p-value: 0). Red line is quadratic fitted trend.