Dark Costs, Missing Data: Shedding Some Light on Services Trade *

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Abstract

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JEL Classification Codes: F13, F14, F16
Keywords: Gravity, Services Trade, Trade Costs in Services, Home Bias, Border effects.

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Abstract

A structural gravity model is used to estimate barriers to services trade across sectors, countries and time. The standard gravity model works well for services trade. Our estimates reveal similarities between the determinants of goods and services trade, but also point to some differences. Border barriers have generally fallen over time, but unevenly across the services sectors in our sample. We offer novel evidence on the importance of national geography, technology, development and institutions as key determinants of the borders in services trade. We use the estimated model, in combination with gravity theory, to project missing internal or bilateral trade flows, which together constitute sectoral output. For OECD countries, projected and observed output data match well.

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1 Introduction

Trade costs in services are shrouded in darkness. Opaque regulations affect trade in professional and financial services, in contrast to the tariffs and quotas on goods trade. 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. Finally, services trade and output itself are less well measured than physical goods trade, and data are often missing.

This paper sheds some light. First, we demonstrate that the structural gravity model works well with secotral data on services trade. Second, 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. Third, we study the determinants of the barriers to services trade by decomposing their impact into four country-specific components including geography, technology, development 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. Fourth, 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.

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

We start by offering 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 widely across services sectors, plausibly from having little impact in Financial and Research services to being a significant friction in Travel and Construction. Other traditionally strong predictors for goods trade such as contiguity, language or legal system also have more nuanced effects for 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, Communication and Audiovisual services. In addition, we document a strong effect of EU membership for most kinds of services trade. 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 cost of internal trade.[2] Border barriers in services trade are large, significant, and 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,

[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.

[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.

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 the borders in international services trade appear in Section 5.2.

The third main contribution of the paper is an empirical analysis of the *national/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) development 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 larger countries (in terms of internal distance) are more closed to trade, while concentration of economic activity within a country promotes international trade relative to domestic trade. Our estimates suggest that better technology (proxied for with measures for fixed and mobile teledensity), facilitates international services trade. We are particularly excited about this result because, despite the significant interest and intuitive appeal of the relationship between trade and technology in the academic and policy literature, we are not aware of any other study that would identify such links directly within a structural gravity model. We also establish a direct link between economic development and international trade. Our proxies for economic development include GDP per capital as well as shares of labor with secondary and tertiary education. 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 are presented in Section 6.1.

The fourth main contribution of the paper is the projection method for generating missing services output. We derive and implement a novel 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 novel procedure's accuracy. We conclude that the projection method works well, and we are able to characterize in detail the accuracy of predictions across countries and sectors (Section 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 with potentially large payoffs. We leave such extensions for future work.

We are not the first to use the gravity model to explain patterns of services trade. For instance, 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), to estimate the time trend in distance effects (Head et al., 2008), or to estimate the effect on US services imports of Internet penetration in partner countries (Freund and Weinhold, 2004). Breinlich and Criscuolo (2011) use UK data to offer a series of stylized facts for firms that engage in international trade in services. Anderson et al. (2014) estimate the barriers to Canada's inter-provincial and international services trade.[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

[3]In a more remotely related study is 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.

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 the borders in services trade, (ii) to study their determinants, and (iii) to combine theory and empirics in order to recover missing output information.[4]

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) in order 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) is 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, development and institutions all play significant 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.

[4]Anderson et al. (2014) is an exception that also employs intra-provincial trade. However, even though Anderson et al. (2014) 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.

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:[5]

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

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

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

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 services class k.[6] 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

[5] 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.

[6] 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.

incidence of trade costs on the consumers of services k in destination j as if they consumed from a unified world market.

The structural gravity system (1)-(3) translates into a simple econometric specification.[7] 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 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,

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

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.[8] For the base country, we assume that Y_0^k is observed, from which E_0^k is inferred as 'apparent consumption' 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).[9]

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

[8] 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.

[9] 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.

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 2 and 3):

$$\begin{aligned} 1 &= \sum_j \tau_{ij}^k (P_j^k)^{\sigma_k-1}(\Pi_i^k)^{\sigma_k-1}\frac{E_j^k}{Y^k} \qquad \forall\, i, && (9)\\ 1 &= \sum_i \tau_{ij}^k (P_j^k)^{\sigma_k-1}(\Pi_i^k)^{\sigma_k-1}\frac{Y_i^k}{Y^k} \qquad \forall\, j. && (10)\end{aligned}$$

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

$$\begin{aligned} \widetilde{Y^k}_i &= \chi^k x_i^k \sum_j \tau_{ij}^k m_j^k \qquad \forall\, i && (11)\\ \widetilde{E^k}_j &= \chi^k m_j^k \sum_i \tau_{ij}^k x_i^k \qquad \forall\, j. && (12)\end{aligned}$$

System (11)-(12) yields fitted values for output and expenditures, respectively.[10] 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 that delivers a strong fit of output thus fitted with 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

[10] In the Supplementary Appendix 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.

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 not asymptotically unbiased.[11]

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,[12] 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:

[11] 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.

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

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

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.[13] $CURR_{ij,t}$, $LEGAL_{ij,t}$, and $RLGN_{ij}$ denote commonly used bilateral gravity variables for shared currency, common legal system, and common religion, respectively.[14]

$SMCTRY_{ij}$ is an indicator variable for *internal* trade flows, i.e. $SMCTRY_{ij} = 1 \, \forall \, i = j$ and zero otherwise. Thus, $SMCTRY_{ij}$ is an exogenous variable that 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

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

[14] In sensitivity experiments presented in Supplementary Appendix B, we include additional covariates that have been shown to be significant determinants of goods trade. 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 specification for the sake of brevity and expositional clarity. As a further robustness check, we allow the coefficients of standard gravity variables to vary over time as well. This exercise does not reveal any systematic pattern regarding trends in coefficient estimates but confirms that the principal findings discussed in Section 5.1 below remain unchanged; see Tables **??–??** in Supplementary Appendix C.

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:

$$X^k_{ij,t} \quad = \quad \exp\{(1 - SMCTRY_{ij})\alpha^{k\prime}\mathbf{Z}_{ij,t} + \sum_i \sum_t \beta^k_{it} SMCTRY_{ij} + \eta^k_{it} + \theta^k_{jt}\} + \epsilon^k_{ij,t}, \qquad \forall\, k. \quad (14)$$

Here η^k_{it} (θ^k_{jt}) 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 $x^k_{i,t} = \exp\{\eta^k_{it}\}$ and $m^k_{j,t} = \exp\{\theta^k_{jt}\}$, 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 trade.[15] 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 with country- 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 services trade across the three main dimensions of our data, namely across sectors, countries, and over time. We present

[15] 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.

the analysis of the border effects in services trade in Section 5.2.[16]

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:[17]

$$X_{ij,t}^{k} = \exp\{(1 - SMCTRY_{ij})\alpha^{k\prime}\mathbf{Z}_{ij,t} + SMCTRY_{ij}\gamma^{k\prime}\mathbf{W}_{it} + \sum_{t}\beta_{t}^{k} SMCTRY_{ij} + \eta_{it}^{k} + \theta_{jt}^{k}\} + \epsilon_{ij,t}^{k}, \qquad \forall\, k. \tag{16}$$

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 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.[18] The second group, *Technology*, includes variables that we expect to pick up the impact of national technologies as they specifically relate to cross-border services trade, and their evolution over time. This group includes fixed-line teledensity ($FLTLDNS$) and mobile phone teledensity ($MPTLDNS$). The third group, *Development*, 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.[19] Finally, the fourth

[16] 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.

[17] 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 $\hat{\beta}_{it}^{k}$, 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.

[18] The idea behind this variable is to capture variation in geographical distribution across countries; for example, in Canada economic activity is clustered in a particular region, namely the border with the US.

[19] 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.

group, *Institutions*, includes the comprehensive "Rule of Law" institutional quality measure ($INSTTNS$) from the Worldwide Governance Indicators (WGI).[20] 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.[21] We develop this analysis in Section 6.1. Second, as country characteristics are commonly observable even when sectoral output is not, specification (16) will admit and 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.[22] In particular, first, we account for the unobservable multilateral resistance terms with directional (source and destination), country-specific, time-varying dummy variables.[23] These country fixed effects also control for output and expenditures. Second, our choice of estimation technique is

[20]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, thus we present results including the PMR indicator as a sensitivity check in the Supplementary Appendix Table XX.

[21]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. (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 development, on international borders.

[22]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.

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

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 most preferred gravity estimates.[24]

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.[25] 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 A, 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

[24]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.

[25]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.

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.[26] 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 of the classification.

Even though the majority of OECD countries already accounts for a large share of global cross-border service trade,[27] 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 instance when the corresponding OECD observation is missing.[28] 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), respec-

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

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

[28]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.

tively. 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 the Supplementary Appendix.

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 for one of the most detailed sectoral breakdowns available. Coverage comprises mostly of OECD members which corresponds closely to the source for cross-border services trade. The raw data consist of "gross output at current basic prices" in millions of local currency units. We use data covering 2000-2007 as EU KLEMS series currently extend only up 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 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 distance, common language, and contiguity are taken from CEPII's *Distances* Database (see Mayer and Zignago, 2011; Head and Mayer, 2000). A very 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 with each other.[29] 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.[30] Additional gravity variables for common currency, common legal 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 ($EFFCTDIST$) 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.

[29] Specifically, distance – both between countries and (internally) within countries – is calculated as $DISTANCE_{ij} = \sum_{k \in i} Pop_k/Pop_i \sum_{l \in j} Pop_l/Pop_j D_{kl}$, 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). All data on latitudes, longitudes, and population are from the World Gazetteer web page. The same procedure is used to construct (consistently) international as well as intra-national distances.

[30] To obtain the main analysis, we rely on the CES population weighted distances from CEPII's database.In addition, in sensitivity experiments, which are included in the Supplementary Appendix, we also employ the simple weighted distances to obtain similar results.

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) find similarities between services and goods trade at the firm level, based upon UK firm-level data. Whilst they characterize the pronounced heterogeneity across services exporters, they conclude that existing (heterogeneous firm) models for goods trade will be a good starting point for explaining trade in services as well. This section demonstrates that the empirical gravity model works well with services trade and 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.[31] 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.

[31] 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.

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. 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, in sectors such as Travel, Construction, Insurance, Merchanting, Leasing and Audio, distance effects are large and highly significant. It appears intuitive that Travel services would exhibit amongst the largest distance effect due to the very nature of this service category. A possible explanation for the large distance estimates in the case of Construction, Insurance, and Leasing is the highly localized nature of activity in these categories. By contrast, distance is less of a friction for Transportation, Financial, and Research services, respectively. 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 estimate positive estimates of the contiguity coefficients for nine out of twelve service categories. However, we obtain significant estimates for only three categories, which include Transportation, Travel, and Leasing. The rationale for significant effects in Transportation and Travel services is intuitive. However, the explanation in the case of Operational Leasing is less obvious but could be related to the particular spatial location of lessors and lessees, respectively. We also obtain one negative and marginally significant estimates of contiguity effects for Merchanting services without being able to offer an explanation for this result. 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. Despite the fact that we obtain positive and significant estimates for only four services categories, we view our findings as intuitive. The four categories with significant estimates are Travel, Communication, Insurance, and Audio services. The significant estimate for communication is intuitive. We attribute the significant language effects in Insurance and Audio services to need for precise communication in these sectors. The effect of speaking the same language is also strong for Travel services. 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 estimates, language appears to exert a stronger effect on services trade than on manufacturing goods trade (Anderson and Yotov, 2010b), which is consistent with the higher requirement for personal interaction and communication in most services.

Interestingly, we obtain negative and significant estimates of the effect of language in Computer and Research 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. The latter is also a possible explanation for the insignificant estimates of the effects of language that we obtain for 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. 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 due to the fact that the benefits from EU membership might have been exhausted among the ‘old’ members while there is much to gain for the 'new' members was confirmed. Specifically, we obtain five significant estimates for the EU impact on trade among 'old' members (and these estimates are actually negative), while nine of the estimates for 'new' members are positive and six of them are statistically significant. A possible explanation for the negative EU estimates for old members in Insurance 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 seems not 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 and significant estimates of the effects of common religion on services trade in four of the services sectors in our sample and negative and significant estimates in two categories, including Computer and Audio services. 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 good economic sense. At the same time, we document important 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.[32] 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 services trade across the three dimensions in our sample.

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 $SMCTRY$ estimates, 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.[33]

[32] 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).

[33] 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.

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. Combined with the fact that border estimates in services trade are positive and significant, 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 the significant fall in services borders is globalization. Second, we note that, with the exception of Construction and Audiovisual services, the borders 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).[34] Finally, our results reveal significant variation in the decrease borders in services trade across the sectors in our

[34]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.

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 Wholesale services. Finally, we note that Construction and Audiovisual services are the only sectors where the borders in services trade remained statistically unchanged during the period 2000-2006. We also note, however, that most of the border estimates in each of these two sectors is negative. The variation across sectors may indicate either missed opportunities or greater costs of globalization in lagging sectors.

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 specification (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, we only obtain few insignificant estimates (e.g., for Transportation services in Greece and for Leasing and Research in Ireland, among a few others). In addition, we note that all significant border estimates in Table 4 are positive, suggesting the presence of substantial border barriers to services trade. 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 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 6.6. This estimate points to substantial border effects that enormously 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 2.7 and 9.3, the border effects in services are large and they 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 Operational Leasing services, respectively, followed by Finance 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, suggesting low tradability due to the need for face-to-face interaction. At the other extreme, consistent with our priors, by far the lowest border barriers exist in the Travel and Transportation sectors, respectively, followed by Communication services. Overall, the sectoral variation in our border estimates reveals wide but intuitive variation across the service categories, with potentially important policy implications.

The distribution of estimated border effects by country from Table 4 reveals wide variation too. The figure suggests that, on average, the border barriers in services trade are appreciably higher for smaller and less developed economies than for large industrialized countries. With average $SMCTRY$ indexes of more then 10, Slovakia, Latvia and Lithuania exhibit the sample's largest average $SMCTRY$ coefficients, closely followed by Slovenia, Poland and Estonia with average $SMCTRY$ estimates of more then 9. On the other side of the spectrum, we find some of the worlds largest economic powers including Germany, the United States, and the Netherlands. In this group, we also find some smaller but vey integrated economies such as Ireland, Belgium, and Luxembourg.

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. Intuitively, large countries tend to have larger domestic trade relative to international costs, so that their border barrier appears lower when inferred from comparing internal to international trade flows. At the same time, 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 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 country with lower average $SMCTRY$ estimates exhibit 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; however, it exhibits relatively large border effects in Wholesale 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, e.g., 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. Fourth, we find that border effects in services trade have fallen over the period of investigation for all sectors in our sample. Finally, our estimates reveal that the more developed countries in our sample have seen a fall in border effects in services trade while smaller and less developed economies have suffered from an increase in services border barriers.

6 Projecting Missing Output

We now turn to specification (16), which replaces country-specific $SMCTRY$ variables with observable national characteristics. In so doing, 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 compared to goods. Furthermore, to our best knowledge, 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.[35] Recall that national determinants of international borders from vector $\mathbf{W}_{it}$ in equation (16) are grouped in four categories, including *Geography*, *Technology*, *Development* and *Institutions*. Furthermore, in terms of interpretation, we note that estimates on each of the country-specific variables, which we use to replace the country-specific $SMCTRY$ dummies, has a dual interpretation by construction. For example, a negative estimate of the coefficient on a given national characteristic can be interpreted either (i) as promoting intra-national trade relative to international trade or, alternatively, (ii) as decreasing international borders in

[35]These estimates are comparable to the corresponding indexes from Table 2 and are available upon request.

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 estimates, we observe both positive and negative values.[36] However, we do obtain significant estimates of the coefficients on internal distance and on effective internal distance. Nine of the estimates on $INTRADIST$ are positive and four of them are statistically significant, suggesting that, all else equal, larger countries are more closed to trade. Conditional on that, we obtain negative and, in most cases, significant estimates of the impact of effective distance. All estimates on $EFFCTDIST$ are negative and ten of the twelve possible estimates are statistically significant. This results suggests that geographical concentration of economic activity promotes international trade relative to domestic trade.

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 negative and significant estimates that we obtain of the coefficients on $FLTLDNS$ and $MPTLDNS$. Without any exception, all estimates on $FLTLDNS$ are negative and all but one of them are statistically significant. Similarly, all but one of the estimates on $MPTLDNS$, and most of them are statistically significant. We are particularly excited about being able to document a robust direct relationship between technology and trade openness for two rea-

[36] 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.

sons. First, from a practical perspective, despite the significant interest and intuitive appeal of the relationship between trade and technology in the academic and policy literature, we are not aware of any other study that would identify such links directly within a structural gravity model. Second, 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 *Development* 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 ($SCNDRY$, $SKILLD$). Our estimates reveal that economic development is a significant determinant of trade-openness. This is supported by the fact that most of the estimates on each of the three covariates in this group are statistically significant. Our estimates reveal a robust positive relationship between GDP and intra-national trade relative to international trade. Furthermore, in combination with the negative estimates that we obtain on population size, the positive estimates on $LNGDP$ imply an inverse relationship between economic development, measured as GDP per capita and trade openness. This result is consistent with our finding from the previous section that border effects in services trade are larger for less developed nations.

The strong link between development and trade openness is further reinforced by the estimates on the population shares based on education from Table 5. Our estimates suggest that secondary education does not play a very significant role in promoting trade as only four of the estimates on $SCNDRY$ are statistically significant. Pushing inference to the limit, we can interpret the fact that three of the 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.

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 nine 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.[37]

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.

[37]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.

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 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 7). A quantile-quantile 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 $y = x$ line.

Reassuringly, most of the quantiles in Figure 7 line up closely, and the the line is not too dissimilar from the 45 degree line. That said, the fact that the general trend in the Q-Q plot is 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 when output is very large. 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 cross 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 likely 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) 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 7 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 three robustness checks.[38] 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 projects tend to move away from their true values and the variance of such estimates increases (Table 7). However, the incremental deterioration relative to Table 6 seems relatively small even for the case of dropping output information for 7 countries, and so the projections appear to be quite robust.

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

Second, rather than discarding output information, we discard 20% of *international* trade flows randomly from the sample prior to estimating gravity and predicting internal trade. The results in Table 8 show that the predictions are barely affected and thus are exceptionally robust to fewer information that involves other countries. Thirdly, however, 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, though the results can be interpreted as giving an indication of the bias if it was thought that official statistics may suffer from underreporting and thus not capture all trade flows. Table 9 shows that prediction without any country-specific trade flow information renders the predictions appreciably worse off. This is a result of the fact that without international trade, a country's exporter fixed effect is not identified and this hits the prediction accuracy for its internal trade hard.

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, and the reason is seen in the crucial role of exporter-time and importer-time fixed effects for out-of-sample predictions. Jim and Aaditya, we think that we should delegate Tables 7, 8 and 9 to the Appendix. What do you think.

The computation of forecast accuracy measures discussed below still needs to be adapted to, and computed for, results from the one-stage approach, or else we drop these statistics. *We further characterize the suitability of the model in equation (**??**) for making projections by reporting a set of standard measures of forecast accuracy (Diebold and Lopez, 1996). The most common overall accuracy measure by far is mean squared error (MSE), reported in*

Table **??** *alongside other commonly used metrics such as Theil's U statistic and the variance ratio (Granger and Newbold, 1976).*[39] *Statistics are disaggregated by country, whereby individual entries denote the country that has been omitted from a given run of equation (***??***) for out-of-sample forecasting. The variance ratio in column (3) is patterned after the familiar R-squared, i.e. low values indicate a small share of residual variance and thus reaffirm the model's good fit. Lastly, column (4) compares the novel procedure's MSE to the one of a simple benchmark model in which internal trade in a particular services sector is projected onto log* aggregate *country GDP. The benchmark model's MSE values are on average 70% higher than in our novel procedure, showing the value added afforded by the border barrier decomposition in section 6.1. A standard decomposition of MSE into the variance of the prediction error and squared bias, respectively, indicates that forecasts are essentially unbiased.*

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.

[39] 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 $\mathrm{Var}(\hat{\varepsilon}_i)/\mathrm{Var}(y_i) = 1 - R^2$, where y is shorthand notation for the log of internal trade (dependent variable) and $\hat{y}$ denotes its fitted value.

7 Conclusion

Structural gravity is applied to model barriers to services trade across many sectors, countries and time based on development of an integrated dataset for services production and trade. Border barriers are flexibly inferred relative to internal costs. 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, development 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 when other trade or production data quality is suspect.

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

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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
DIST	-0.691	-0.945	-0.852	-0.986	-0.902	-0.710
	(0.084)**	(0.080)**	(0.085)**	(0.154)**	(0.194)**	(0.209)**
CNTG	0.304	0.336	0.205	-0.048	0.352	0.132
	(0.139)*	(0.138)*	(0.162)	(0.204)	(0.280)	(0.288)
LANG	0.126	0.647	0.413	0.375	0.863	-0.108
	(0.126)	(0.167)**	(0.240)+	(0.251)	(0.311)**	(0.259)
EU00	-0.516	-0.105	-0.061	-0.406	-1.135	-0.885
	(0.264)+	(0.323)	(0.276)	(0.601)	(0.543)*	(0.570)
EU04	1.309	0.922	1.253	1.474	0.852	0.459
	(0.315)**	(0.316)**	(0.317)**	(0.574)*	(0.711)	(1.101)
CCUR	0.247	0.274	-0.098	-0.655	0.936	0.690
	(0.158)	(0.217)	(0.240)	(0.475)	(0.331)**	(0.389)+
CLEG	-0.036	-0.062	-0.028	-0.231	-0.118	0.262
	(0.093)	(0.123)	(0.155)	(0.194)	(0.201)	(0.215)
CREL	0.491	0.448	0.539	0.543	2.035	1.296
	(0.229)*	(0.288)	(0.311)+	(0.493)	(0.708)**	(0.598)*
N	3135	3110	3135	3135	3124	3124

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
DIST	-0.912	-1.631	-1.039	-0.587	-0.725	-1.535
	(0.142)**	(0.180)**	(0.161)**	(0.122)**	(0.209)**	(0.242)**
CNTG	0.173	-0.361	0.582	0.150	0.365	-0.367
	(0.269)	(0.215)+	(0.266)*	(0.225)	(0.351)	(0.339)
LANG	-1.360	-0.235	-0.273	-0.060	-0.803	0.939
	(0.366)**	(0.314)	(0.374)	(0.247)	(0.419)+	(0.416)*
EU00	-0.218	-2.586	-1.399	-0.061	-1.372	-0.850
	(0.353)	(0.826)**	(0.836)+	(0.421)	(0.459)**	(0.517)
EU04	-0.621	3.367	1.163	0.925	-1.214	-1.808
	(0.477)	(0.894)**	(0.820)	(0.345)**	(0.567)*	(0.618)**
CCUR	0.667	-0.564	0.258	-0.519	0.539	0.617
	(0.282)*	(0.421)	(0.393)	(0.375)	(0.468)	(0.482)
CLEG	0.970	-0.024	-0.173	0.570	1.104	-0.254
	(0.230)**	(0.255)	(0.259)	(0.134)**	(0.195)**	(0.308)
CREL	-1.044	-0.706	0.623	0.009	-0.465	-2.110
	(0.520)*	(0.564)	(0.682)	(0.359)	(0.643)	(0.937)*
N	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
DIST	-0.693	-0.941	-0.858	-0.943	-0.673	-0.353
	(0.084)**	(0.081)**	(0.086)**	(0.163)**	(0.171)**	(0.158)*
CNTG	0.302	0.335	0.176	-0.046	0.555	0.454
	(0.139)*	(0.138)*	(0.163)	(0.209)	(0.258)*	(0.258)$^{+}$
LANG	0.113	0.643	0.410	0.396	0.822	-0.242
	(0.126)	(0.169)**	(0.239)$^{+}$	(0.263)	(0.327)*	(0.267)
EU00	-0.505	-0.066	0.049	-0.109	-0.750	-0.217
	(0.264)$^{+}$	(0.321)	(0.285)	(0.674)	(0.536)	(0.536)
EU04	1.359	0.927	1.242	1.424	1.591	2.269
	(0.307)**	(0.314)**	(0.321)**	(0.585)*	(0.625)*	(0.508)**
CCUR	0.253	0.220	-0.179	-0.867	0.706	0.573
	(0.158)	(0.211)	(0.239)	(0.534)	(0.338)*	(0.385)
CLEG	-0.032	-0.047	0.012	-0.241	-0.077	0.419
	(0.093)	(0.123)	(0.156)	(0.206)	(0.209)	(0.215)$^{+}$
CREL	0.491	0.489	0.595	0.686	2.656	1.685
	(0.230)*	(0.290)$^{+}$	(0.313)$^{+}$	(0.530)	(0.724)**	(0.587)**
SMCTRY_TIME_2	-0.132	-0.120	0.046	0.078	-0.323	0.059
	(0.041)**	(0.080)	(0.059)	(0.077)	(0.280)	(0.120)
SMCTRY_TIME_3	-0.201	-0.132	-0.215	-0.126	-0.999	-0.614
	(0.042)**	(0.090)	(0.090)*	(0.133)	(0.318)**	(0.199)**
SMCTRY_TIME_4	-0.296	-0.158	-0.506	-0.077	-1.032	-0.852
	(0.049)**	(0.094)$^{+}$	(0.102)**	(0.137)	(0.349)**	(0.189)**
N	3135	3110	3135	3135	3124	3124

	(7) CMPTR	(8) TRADE	(9) OPRNL	(10) BUSIN	(11) RSRCH	(12) AUDIO
DIST	-0.838	-0.546	-0.404	-0.599	-0.726	-0.420
	(0.145)**	(0.234)*	(0.199)*	(0.121)**	(0.207)**	(0.248)$^{+}$
CNTG	0.209	0.076	1.019	0.106	0.271	0.492
	(0.277)	(0.247)	(0.306)**	(0.224)	(0.349)	(0.369)
LANG	-1.251	0.241	-0.347	-0.079	-0.764	1.804
	(0.358)**	(0.330)	(0.350)	(0.244)	(0.391)$^{+}$	(0.419)**
EU00	-0.195	-0.260	-0.307	-0.082	-1.325	1.206
	(0.362)	(0.672)	(0.624)	(0.417)	(0.465)**	(0.582)*
EU04	-0.256	2.129	0.683	0.947	-1.071	0.081
	(0.465)	(0.610)**	(0.637)	(0.335)**	(0.570)$^{+}$	(0.604)
CCUR	0.586	-1.108	0.058	-0.511	0.539	-0.851
	(0.292)*	(0.492)*	(0.420)	(0.365)	(0.454)	(0.495)$^{+}$
CLEG	0.911	0.079	0.027	0.610	1.056	-0.196
	(0.225)**	(0.243)	(0.251)	(0.131)**	(0.187)**	(0.289)
CREL	-0.938	-0.080	0.717	0.076	-0.433	0.046
	(0.541)$^{+}$	(0.562)	(0.669)	(0.364)	(0.628)	(0.739)
SMCTRY_TIME_2	-0.238	0.088	-0.234	-0.170	-0.074	0.435
	(0.081)**	(0.085)	(0.118)*	(0.098)$^{+}$	(0.122)	(0.180)*
SMCTRY_TIME_3	-0.717	-0.266	-0.738	-0.774	-0.280	-0.407
	(0.150)**	(0.118)*	(0.202)**	(0.139)**	(0.178)	(0.276)
SMCTRY_TIME_4	-0.955	-0.491	-0.982	-0.827	-0.819	-0.355
	(0.185)**	(0.137)**	(0.205)**	(0.131)**	(0.201)**	(0.273)
N	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	4.9	2.0	6.4	9.5				10.8					6.7
AUS	4.9	2.0	6.4	9.5				10.8					8.7
AUT	4.2	1.9	5.4	4.9	8.0	9.2	5.2	6.2	8.0	5.4	2.0	9.6	6.0
BEL	3.7	2.7	5.5	6.1	9.2	7.5	3.4	4.8	7.6	4.8	.9*	10.0	5.3
CAN	5.5	4.8	6.8	10.1				9.6					8.6
CZE	6.3	1.3	7.7	9.4	9.4	10.2	7.4	10.1	8.3	7.5	7.2	10.2	8.8
DEU	2.9	1.9	4.4	3.4	5.9	6.9	2.5	4.4	6.6	3.2	.8*	6.7	4.2
DNK	1.7	.9*	7.1	9.3	7.4	11.0	6.2	8.4	6.8	7.1	5.6	10.5	7.8
ESP	4.8	3.0	8.1	8.9	11.1	12.6	8.0	8.8	11.7	7.8	4.8	10.4	8.2
EST	6.0		7.8	8.6	12.4	11.8	7.9	10.7	8.2	8.8	10.6	14.8	9.3
FIN	5.2	4.1	7.4	7.0	10.1	11.5	6.3	6.1	8.3	6.2	5.3	13.8	6.9
FRA	4.1	2.8	6.5	6.4	8.1	10.2	8.3	5.0	7.0	5.7	6.0	7.5	6.2
GBR	2.7	1.7	5.5	7.7	3.9	4.2	5.1	9.2	7.6	5.6	3.3	9.2	6.3
GRC	-1.1*	2.0	5.8	5.8	5.5	11.3	7.0	8.5	8.2	6.3	6.9	9.9	7.1
HUN	6.0		7.0	7.7	10.2	10.6	6.1	8.3	7.5	6.4	4.4	3.6	7.5
IRL	5.0	3.9	6.5	9.2	4.5	6.5	1.6	3.0	1.6*	3.8	1.7*	11.8	6.1
ITA	5.5	3.3	6.1	6.3	7.2	9.3	8.9	5.2	5.9	5.9	6.6		5.9
JPN	3.0	3.4	6.4	5.6	5.3	5.7	8.3	10.5	9.0	7.1	5.9	9.3	7.0
KOR	2.9	2.3	5.2	7.1	8.1	10.6	9.7	8.9	11.1	8.3	10.3	10.1	7.2
LTU	6.5		8.6	11.1	15.0	13.6	9.5	11.9	11.2	9.7	10.2	12.6	10.9
LUX	4.1		3.5	5.6	9.5	3.7	6.1	6.8	7.6	5.5	7.2	10.2	5.1
LVA	5.8	4.3	8.4	9.9	21.2	14.5	9.0	12.2	11.4	9.5	10.7	20.7	11.2
NLD	2.4	1.9	4.3	5.1	8.3	8.5	5.4	5.1	5.7	3.7	2.0	6.2	5.2
POL	5.9		8.1	7.9	11.5	12.3	7.3	11.6	8.7	7.9	8.4	11.1	9.7
PRT	4.9	3.6	7.2	6.7	10.4	12.2	8.8	9.6	12.1	9.6	8.6	15.3	8.6
SVK	10.7	8.0	11.7	12.1	14.4	14.5	11.1	13.2	13.1	11.4	13.3	16.1	12.3
SVN	6.2		8.3	10.1	11.2	13.3	9.1	10.0	6.6	9.5	10.0	12.8	9.9
SWE	4.2	2.1	7.0	8.1	7.2	8.6	6.2	8.1	7.2	5.3	1.7	10.5	6.7
USA	2.6	2.1	4.1	6.6				6.9					5.5
AVRG	4.0	2.7	5.4	7.0	6.6	7.9	7.2	7.8	8.0	6.0	6.0	9.3	6.6

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	0.837	0.050	-0.496	-0.780	-0.037	-1.347	-1.349	0.174	2.326	0.395	0.434	-2.056
	(0.311)**	(0.375)	(0.352)	(0.462)+	(0.691)	(0.640)*	(0.636)*	(0.459)	(0.696)**	(0.503)	(0.842)	(1.437)
INTRADIST	1.531	0.242	0.577	0.862	-0.734	0.395	0.510	-2.053	-0.480	0.126	0.177	1.482
	(0.301)**	(0.179)	(0.279)*	(0.393)*	(0.437)+	(0.394)	(0.483)	(0.563)**	(0.398)	(0.290)	(0.458)	(0.655)*
EFFCTDIST	-0.355	-0.193	-0.460	-0.755	-0.661	-1.993	-1.168	-1.402	-1.397	-1.210	-0.717	-0.872
	(0.128)**	(0.090)*	(0.099)**	(0.131)**	(0.247)**	(0.227)**	(0.302)**	(0.212)**	(0.323)**	(0.261)**	(0.467)	(0.566)
FLTLDNS	-0.071	-0.047	-0.079	-0.105	-0.135	-0.115	-0.135	-0.130	-0.049	-0.090	-0.106	-0.035
	(0.013)**	(0.016)**	(0.015)**	(0.019)**	(0.024)**	(0.028)**	(0.023)**	(0.017)**	(0.024)*	(0.018)**	(0.023)**	(0.045)
MPTLDNS	-0.002	-0.027	-0.019	-0.009	-0.039	-0.021	-0.045	-0.002	-0.007	-0.021	-0.042	0.054
	(0.005)	(0.006)**	(0.006)**	(0.011)	(0.015)**	(0.013)	(0.012)**	(0.011)	(0.013)	(0.007)**	(0.016)**	(0.021)**
LNGDP	1.084	1.376	1.533	2.167	1.504	0.865	2.985	0.265	-0.103	1.330	2.438	2.817
	(0.141)**	(0.263)**	(0.222)**	(0.290)**	(0.505)**	(0.508)+	(0.402)**	(0.358)	(0.497)	(0.282)**	(0.502)**	(0.753)**
LNPPLN	-1.652	-1.635	-1.889	-3.066	-1.527	-1.648	-3.888	0.233	0.148	-1.786	-2.858	-4.386
	(0.197)**	(0.386)**	(0.325)**	(0.410)**	(0.825)+	(0.695)*	(0.526)**	(0.503)	(0.711)	(0.477)**	(0.692)**	(0.992)**
SKILLD	-0.075	-0.055	-0.105	-0.030	-0.110	-0.107	-0.184	-0.091	0.106	-0.045	-0.113	-0.028
	(0.009)**	(0.014)**	(0.014)**	(0.022)	(0.050)*	(0.037)**	(0.056)**	(0.019)**	(0.047)*	(0.031)	(0.055)*	(0.069)
SCNDRY	-0.000	-0.013	-0.003	0.004	0.074	0.113	-0.008	0.044	0.013	0.006	-0.024	-0.053
	(0.007)	(0.008)	(0.010)	(0.013)	(0.019)**	(0.021)**	(0.014)	(0.016)**	(0.018)	(0.011)	(0.021)	(0.031)+
INSTITNS	-1.067	-1.226	-0.978	-1.763	-0.377	-1.273	-2.410	0.530	-0.724	-1.686	-4.193	-4.105
	(0.333)**	(0.271)**	(0.418)*	(0.557)**	(0.836)	(0.760)+	(0.609)**	(0.563)	(0.612)	(0.453)**	(0.829)**	(1.163)**
SMCTRY_TIME_2	-0.192	-0.234	-0.034	-0.060	-0.508	0.121	-0.483	0.126	-0.134	-0.295	-0.234	0.103
	(0.044)**	(0.083)**	(0.065)	(0.126)	(0.285)+	(0.130)	(0.091)**	(0.114)	(0.142)	(0.089)**	(0.166)	(0.210)
SMCTRY_TIME_3	-0.285	-0.397	-0.325	-0.793	-1.789	-0.992	-1.496	-0.300	-0.879	-1.210	-0.604	-1.022
	(0.079)**	(0.135)**	(0.168)+	(0.272)**	(0.388)**	(0.282)**	(0.199)**	(0.211)	(0.290)**	(0.175)**	(0.284)*	(0.334)**
SMCTRY_TIME_4	-0.486	-0.590	-0.788	-0.898	-1.928	-1.327	-1.724	-0.629	-1.148	-1.319	-1.169	-0.988
	(0.081)**	(0.145)**	(0.151)**	(0.273)**	(0.408)**	(0.320)**	(0.260)**	(0.225)**	(0.303)**	(0.181)**	(0.268)**	(0.400)*
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.

Figure 1: QQ-Plot of Output projection

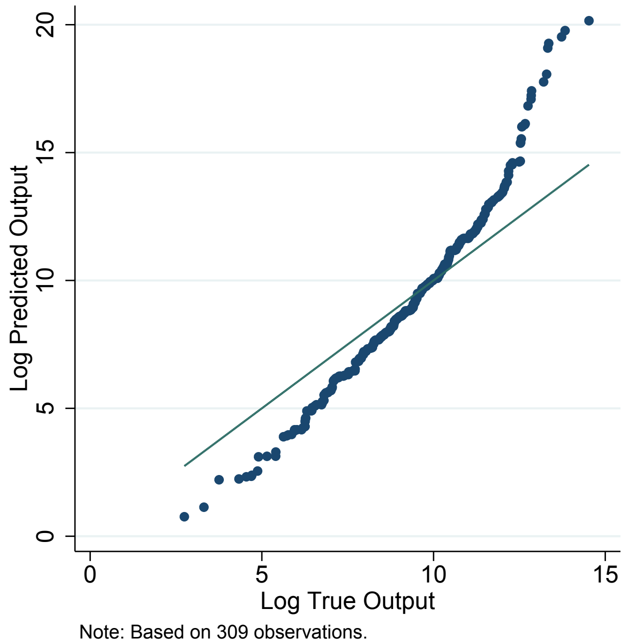

Figure 2: Predicted output percentage deviations and CI

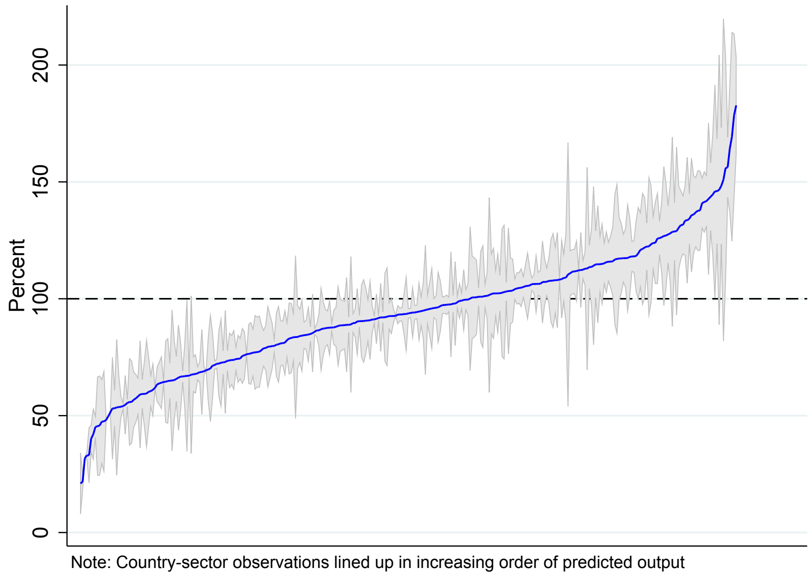

Table 7: Log output prediction (percentage deviation)

		Panel A			Panel B			Panel C		
	Num	Avg Pred	CI		Avg Pred	CI		Avg Pred	CI	
	Sec	Drop: 1	lower	upper	Drop: 4	lower	upper	Drop: 7	lower	upper
AUS	5	104.5	97.0	112.0	108.7	100.4	117.0	109.4	101.1	117.7
AUT	12	114.5	108.0	121.1	124.9	118.2	131.7	130.1	122.4	137.9
BEL	12	100.3	95.4	105.2	94.8	90.4	99.3	92.2	87.9	96.4
CAN	5	95.9	88.5	103.4	102.8	94.6	111.1	111.9	102.3	121.6
CZE	12	102.3	96.0	108.5	98.5	92.5	104.5	100.4	94.0	106.9
DEU	12	105.7	101.9	109.4	99.0	95.7	102.3	97.7	94.3	101.0
DNK	12	73.6	70.2	77.0	74.0	70.6	77.4	74.2	70.6	77.7
ESP	12	85.0	80.3	89.6	80.5	77.0	84.0	81.1	77.4	84.8
EST	11	38.5	33.6	43.4	30.3	25.3	35.2	28.6	23.2	34.0
FIN	12	89.2	82.7	95.7	95.0	87.7	102.4	95.1	88.0	102.3
FRA	12	94.1	91.0	97.2	99.7	96.1	103.4	96.5	93.3	99.8
GBR	12	95.0	91.0	99.0	92.5	88.7	96.3	92.5	88.8	96.2
GRC	12	114.2	101.8	126.7	104.7	91.3	118.1	117.9	98.2	137.6
HUN	12	113.1	106.8	119.4	109.3	103.2	115.4	124.0	114.9	133.0
IRL	12	107.1	102.6	111.6	106.2	101.4	110.9	104.5	99.7	109.3
ITA	11	133.7	126.8	140.5	136.7	130.0	143.4	141.9	134.4	149.3
JPN	12	111.9	107.1	116.7	99.9	95.6	104.1	101.4	97.2	105.6
KOR	12	72.0	68.4	75.6	70.7	67.2	74.2	71.6	67.8	75.5
LTU	12	62.0	57.7	66.3	61.3	57.4	65.3	60.6	56.3	65.0
LUX	12	95.8	89.9	101.7	94.1	88.4	99.9	91.9	86.3	97.5
LVA	12	66.3	62.5	70.1	69.5	64.9	74.0	70.0	65.2	74.9
NLD	12	110.3	105.7	115.0	110.9	106.6	115.3	108.5	103.9	113.0
POL	12	89.2	84.7	93.6	86.8	82.4	91.2	89.1	84.2	93.9
PRT	12	78.9	72.7	85.2	87.0	78.1	95.9	90.5	79.9	101.2
SVK	12	62.1	57.2	66.9	59.3	55.0	63.5	57.9	52.8	63.0
SVN	12	70.0	65.6	74.3	73.0	68.2	77.8	70.3	65.7	74.9
SWE	12	103.1	96.8	109.4	104.5	98.5	110.6	98.0	91.8	104.2
USA	5	128.5	120.4	136.6	125.2	117.2	133.3	128.1	119.6	136.5

Notes: This table reports the results from a robustness experiment related to our methods to predict missing output data. Specifically, we compare the average predictions per country across three specifications. First, in Panel A, we obtain replications after discarding internal trade information for one country at a time. These results correspond to our main results from Table 6. Next, in Panels B and C, we construct missing output after randomly dropping three and six of the countries in our sample, 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. See text for more details.

Table 8: Log output prediction without any trade flows

ISO	TRNSP	TRAVL	CMMCN	CSTRN	INSUR	FINCE	CMPTR	TRADE	OPRNL	BUSIN	RSRCH	AUDIO
AUS	103.7	113.1	121.6	96.3	.	.	.	98.7	.	.	.	.
AUT	116.1	121.9	120.4	132.9	153.0	95.5	101.5	99.4	94.5	109.1	119.4	48.1
BEL	94.0	99.8	94.5	99.5	73.9	97.5	142.5	96.8	78.1	104.5	153.2	114.8
CAN	90.7	91.5	104.0	82.3	.	.	.	98.8	.	.	.	.
CZE	104.2	105.9	87.1	83.8	114.4	116.1	91.4	117.0	93.0	104.0	96.8	76.7
DEU	93.7	93.0	100.5	113.6	97.9	117.5	148.5	110.0	89.9	114.3	136.0	79.7
DNK	112.2	108.8	80.5	76.5	82.9	40.2	62.0	64.9	64.6	71.6	61.9	73.5
ESP	97.6	98.1	75.5	70.9	66.3	71.4	67.7	67.7	59.7	86.8	98.5	90.5
EST	93.4	.	61.6	80.9	51.6	52.2	-43.9	52.8	84.7	80.3	-75.5	-5.2
FIN	89.1	91.0	77.7	101.4	51.8	70.8	140.3	104.3	126.8	117.8	97.5	77.3
FRA	101.8	106.4	91.8	90.5	88.4	86.8	65.8	101.2	106.0	96.4	67.3	132.0
GBR	98.1	98.2	91.0	75.3	116.0	115.1	80.9	80.8	94.9	90.1	87.5	103.1
GRC	124.0	110.0	88.7	94.4	111.6	63.5	138.2	130.5	122.4	134.3	137.4	109.3
HUN	96.3	106.2	86.9	90.6	93.6	106.1	92.1	114.9	143.4	112.7	152.2	180.8
IRL	85.4	91.4	85.4	68.9	128.9	121.3	145.7	109.9	127.4	121.5	142.3	85.5
ITA	119.0	106.9	145.4	141.4	181.1	143.7	101.1	134.2	145.4	127.1	140.1	.
JPN	105.9	101.9	106.6	121.4	142.4	157.2	98.5	94.0	112.6	101.9	117.1	83.2
KOR	92.3	97.9	90.7	81.1	59.7	64.5	29.6	81.2	76.1	85.9	31.8	48.4
LTU	93.5	108.2	65.7	58.6	21.9	40.2	58.7	51.6	49.7	74.0	32.5	114.8
LUX	96.2	112.2	116.3	113.0	92.7	114.2	69.4	68.6	69.6	87.3	76.3	129.1
LVA	97.6	94.1	77.0	71.2	49.6	78.6	91.7	70.7	45.0	85.0	66.1	-24.5
NLD	102.9	101.6	119.6	106.8	87.9	80.1	89.6	115.6	132.6	116.9	108.5	147.8
POL	97.4	106.2	84.5	103.8	78.1	88.1	98.3	77.6	74.5	92.8	74.4	71.5
PRT	89.3	97.7	88.9	101.2	63.1	63.7	99.9	104.2	54.2	73.2	60.2	60.9
SVK	72.9	66.8	57.8	67.4	61.0	70.9	66.6	60.4	48.6	75.3	63.0	19.5
SVN	91.2	104.9	77.3	65.0	58.1	57.9	50.1	64.3	88.6	69.3	55.4	52.6
SWE	93.1	98.6	81.5	99.9	81.5	90.2	90.2	83.3	113.5	108.9	175.7	74.6
USA	126.2	117.9	138.1	139.7	.	.	.	131.1	.	.	.	.

Notes: This table offers a robustness analysis for the predictive success of the gravity model by discarding 20% of *international* trade flows randomly from the sample prior to estimating gravity and predicting internal trade. See text for more details on the prediction procedure.

Table 9: Log output prediction without any trade flows

ISO	TRNSP	TRAVL	CMMCN	CSTRN	INSUR	FINCE	CMPTR	TRADE	OPRNL	BUSIN	RSRCH	AUDIO
AUS	141.3	139.0	153.4	140.1	.	.	.	150.9	.	.	.	.
AUT	174.8	180.3	187.0	169.2	256.6	152.9	208.5	166.3	200.1	183.4	237.9	127.6
BEL	137.6	168.9	169.4	154.5	162.5	142.6	207.7	133.4	165.8	159.8	249.3	217.3
CAN	124.7	122.6	150.8	129.5	.	.	.	136.2	.	.	.	.
CZE	185.1	178.7	190.3	157.0	258.1	240.3	217.9	188.7	275.0	204.1	282.1	206.4
DEU	114.9	119.5	134.7	122.2	126.1	145.6	178.4	132.4	127.0	141.6	176.6	137.9
DNK	147.4	171.1	165.8	146.5	173.5	149.0	164.3	121.9	158.1	148.5	156.2	205.0
ESP	133.2	122.8	142.4	120.3	132.3	132.2	163.6	120.4	157.3	149.5	241.7	183.4
EST	196.2	.	229.7	219.5	303.2	270.4	293.0	178.7	321.4	251.6	363.0	373.6
FIN	155.1	165.6	176.8	176.4	180.9	183.2	224.8	167.0	252.3	202.2	198.9	242.3
FRA	127.5	134.8	137.6	111.2	127.1	122.5	121.6	114.8	144.6	131.5	103.5	187.6
GBR	113.1	116.7	123.8	104.5	124.4	121.2	111.8	110.0	136.5	118.7	123.7	158.0
GRC	164.9	158.9	166.1	151.3	221.4	161.2	296.7	196.7	270.8	232.5	315.2	276.8
HUN	188.1	181.0	188.7	162.8	251.2	222.3	215.3	189.3	283.2	208.2	297.0	268.3
IRL	152.1	154.7	174.0	157.1	174.1	158.5	191.7	150.0	212.8	187.8	268.4	275.4
ITA	153.0	134.1	181.1	163.5	210.5	186.7	167.5	139.1	184.8	173.5	221.1	.
JPN	115.0	118.4	132.5	123.2	154.5	159.7	139.8	123.2	157.5	147.3	169.6	125.8
KOR	117.6	133.4	136.0	115.7	126.3	96.2	135.0	133.0	227.0	156.6	114.9	154.5
LTU	211.1	237.9	231.7	214.4	303.5	293.3	316.2	187.1	346.8	264.0	598.1	392.4
LUX	194.8	240.1	235.2	205.5	119.7	146.7	138.5	153.6	216.1	191.1	191.5	356.1
LVA	217.5	253.2	249.4	219.5	382.2	317.5	338.6	212.0	327.2	270.5	495.5	317.1
NLD	137.5	151.1	165.5	140.7	157.0	130.5	151.8	144.9	176.6	157.6	183.0	221.3
POL	158.8	167.8	172.6	146.6	199.1	202.5	218.6	153.0	222.1	186.4	246.9	198.6
PRT	152.2	159.2	184.9	154.5	176.8	142.1	245.1	183.5	177.2	178.3	256.4	247.8
SVK	147.4	141.5	156.0	135.9	191.4	174.6	196.6	122.2	176.0	170.7	228.9	162.2
SVN	190.0	229.6	228.0	186.0	265.2	246.8	274.3	162.8	397.9	206.2	286.7	277.9
SWE	133.4	149.3	150.4	147.9	155.9	171.0	147.5	126.8	203.6	166.8	215.4	206.4
USA	101.6	88.2	99.0	101.6	.	.	.	86.2	.	.	.	.

Notes: This table offers a robustness analysis for the predictive success of the gravity model by discarding 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. See text for more details on the prediction procedure.