Determinants of Bilateral Trade in Manufacturing and Services: A Unified Approach*

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Abstract

Gravity models have been extensively used as workhorse models to study the determinants of international trade. While most of the literature has focused on trade in manufacturing, a recent literature has emerged that uses gravity models to study international trade in services. Despite showing that gravity equations are well suited to studying trade in services, there is little research on the systematic differences and specificities when using gravity models for each type of trade. This paper addresses this by studying the determinants of aggregate bilateral trade in services *vis-à-vis* manufacturing. The main objective is to understand the systematic differences between services and manufacturing trade that are borne out empirically. In doing so, we derive a joint theory that brings out "systematic" differences in response to scale and trade cost variables between trade in manufacturing and services. We build a unified theoretical framework that incorporates a *demand bias* towards services and a difference in *national product differentiation* between the two sectors. The *demand bias* yields larger income elasticities for trade in services compared to trade in manufacturing, and differences in *national product differentiation* produce a higher elasticity of bilateral trade in manufactures for the exporting country's size than in services. We show that the model predictions find support on traditional gravity equation estimates using various specifications and estimation approaches. We also investigate the role of virtual proximity and internet infrastructure in international trade in manufactures and services. We find that virtual proximity is a strong predictor of aggregate trade in services and manufacturing.

Keywords: Trade in Services, Trade in Manufacturing, Gravity Model, National Product Differentiation, Non-Homothetic Tastes, Internet, Virtual Proximity
JEL Classification: D11, D43, F12, F19, L80

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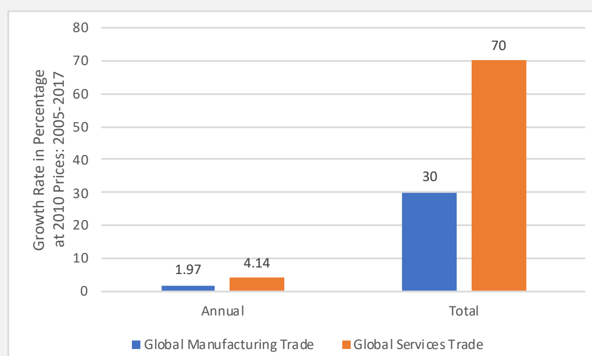
1 Introduction

Learning the determinants of bilateral trade by estimating gravity equations is an essential part of the vast and growing empirical literature on international trade. Most of it study trade in goods or manufacturing. However, international trade in services has grown faster than trade in manufacturing in recent decades. The global share of exports of services in total exports has increased from 9% in 1970 to more than 20% in 2014 (Loungani et al., 2017).[1] Between 2005 and 2016, while total trade (measured by adding exports and imports) in goods rose from $10 trillion to $16 trillion (i.e., a 60% increase), that in services increased from $2.5 trillion to nearly $5 trillion, an increase of almost 100% (UNCTAD, 2018). *Vis-à-vis* trade in manufacturing, our calculations using our collected sample of countries yield that, between 2005 and 2017, at 2010 US prices, the total global manufacturing trade grew at an annual rate of 1.97% while that of commercial services was about 4.14%. During this period, global trade in services increased by 70% while manufacturing grew by 30%. Figure 1 illustrate these differences in global international trade between services and manufacturing.

The existing literature on bilateral trade in services is relatively modest compared to the extensive list of papers that apply gravity models to trade in manufacturing. Besides well-known data limitations on trade in services, there are at least two other reasons for this. First, the increase of the share of the service sector in international trade is a relatively recent phenomenon—evidently far more recent than the famous paradigm of trade in wine and clothes, stylized by David Ricardo more than two centuries ago. Second, there is a broad perception that there is no need to distinguish trade in services from trade in manufacturing: the same general principles and insights derived for trade in goods should directly apply to services trade.[2] This is however partially true. There *are* important differences between manufacturing and services, which may reflect in different responses of trade from common determinants. Therefore, a better understanding of the determinants of bilateral trade in services *vis-à-vis* manufacturing is necessary.

Figure 1: **Growth of Global Trade: Goods and Manufactures versus Services**

(a) UNCTAD (2018)



(b) Source: Own Calculations

[1]Aggregate service trade data typically includes cross-border trade in services only. However, services trade via commercial affiliates (Mode 3) constitutes at least half of all trade in services. If we include Mode 3 service trade, the share of trade in services jumps to more than 40% of total trade (World Trade Organization, 2015). Unfortunately, the availability of Mode 3 service trade data is limited.

[2]For instance, see Lee and Lloyd (2002) for a detailed discussion about the implications of including international trade in services to observed levels of total intra-industry trade.

The formal empirical literature on the determinants of trade in services began with the estimation of multilateral trade, e.g., Francois (2001), Freund and Weinhold (2002) and Francois et al. (2003). While Francois (2001) and Francois et al. (2003) estimated import demand for services with per capita GDP and population as explanatory variables, Freund and Weinhold (2002) were the first to show the significance of internet penetration — as a trade cost-reducing agent — in explaining trade in services.[3] Gravity equations of *bilateral* trade in various sub-sectors of the service sector and the services sector as a whole have been estimated by authors, including Freund and Weinhold (2002), Grünfeld and Moxnes (2003), Marvasti and Canterbery (2005), Kimura and Lee (2006), Walsh (2008), Head et al. (2009), Hanson and Xiang (2011), Culiuc (2014), Hellmanzik and Schmitz (2015, 2016) and Anderson et al. (2018). While the literature encompasses different samples (different sets of countries or periods), including different sets of explanatory variables and estimation techniques, it does *not* bring to fore the differences in how trade in the two categories responds to changes in the explanatory variables, and, importantly, how to interpret the differences. The current paper aims to fill this void (at least partially).

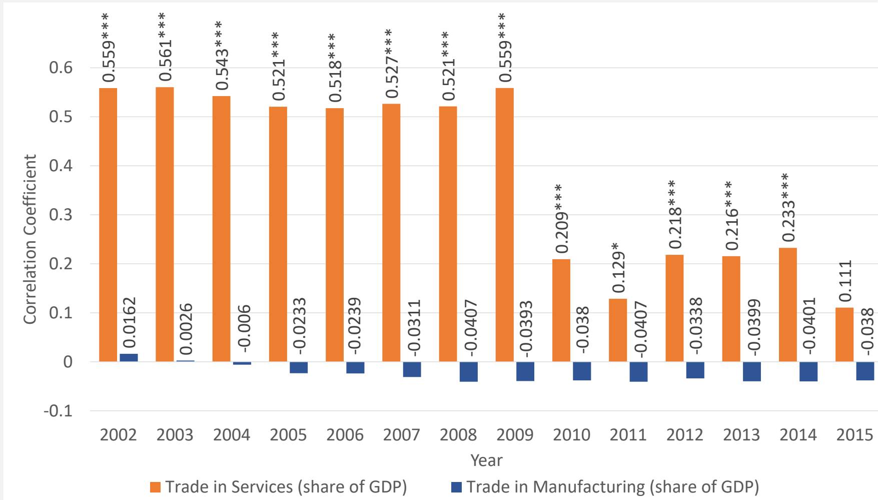
To do this, we first formulate a unified theoretical framework that delivers gravity equations for the two types of trade flows and allows us to explore and understand systematic differences between how various factors affect trade in services *vis-à-vis* trade in manufacturing. The model theoretically distinguishes between manufacturing and service products based on some of their innate characteristics and derive gravity equations, which guide the ensuing empirical specifications and expectations from them. We explore two dimensions that distinguish services from manufacturing.

Demand Bias: Compared to manufactures, the demand for services is more income-inelastic. This is standard in the structural-change literature, with a long history and empirical backing, e.g., Kuznets (1957), Fuchs (1968), Kongsamut et al. (2001), Matsuyama (2009), Boppart (2014), and Comin et al. (2017). Somewhat surprisingly, however, the general theoretical and empirical implications of this demand bias towards trade in goods/manufactures vis-à-vis services are less analyzed and understood. Lewis et al. (2019) is an important exception. It examines how such structural change — what we call demand bias at the global level — has impacted the overall global openness of trade in manufactures and services. Our endeavor in this paper is oriented towards understanding how the nature of bilateral trade in the two product categories differs.

Preliminary evidence of how demand bias towards services is reflected in the international trade basket is depicted in Figure 2. It graphs the simple correlation between per capita GDP and the manufacturing and services total trade as *shares* of GDP across the 177 countries in our sample. We observe that the correlation coefficient is positive and statistically significant for trade in services for every year over 2002-2015. However, for manufacturing trade, the correlation coefficients are close to zero and statistically insignificant.

[3] Choi (2010) followed up Freund and Weinhold (2002) by working with a much larger data set and a much wider period and reached the same conclusion that internet penetration is an important determinant of service trade.

Figure 2: **Cross-country Correlation: Per Capita GDP and the Shares of International Trade in Manufacturing and Services in GDP**



Note: The variables are constructed using our data and sample of countries. Total trade is calculated as the sum of total exports and imports of each category to other countries in the sample.
Statistical Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Differences in National Product Differentiation: The Armington elasticity of import demand for services is smaller than that for manufacturing – equivalent to services being more nationally differentiated than manufacturing.[4] Relatively less known notwithstanding, it derives from available empirical estimates: see Bilgic et al. (2002) and Donnelly et al. (2004).[5]

What we call *Demand Bias* is not, *per se*, new in the gravity literature (see, for instance, Fieler (2011)). But it has not been brought forth to differentiate between trade in the two product categories. It has two theoretical implications. First, per capita income and population size of the importer country would have different impacts on bilateral trade and should enter as separate regressors — instead of just total income or GDP of the importer country (Markusen, 2013). Second, within-country income distribution would matter since the demand for a product basket is not unitarily elastic with respect to income. Our contribution lies in delineating how these implications may differentially impact trade in manufacturing and trade in services. Likewise, *National Product Differentiation* through incorporation of Armington elasticity is not new. But, little effort has been made to understand its implication towards bilateral trade in the two sectors.

We consider pulling these two features together as a theoretical innovation. We find that while *Demand Bias* affects the importing-country scale effects on bilateral trade, differences in *National*

[4] We invoke the term "national product differentiation" *a la* Head and Ries (2001).

[5] In their review paper, Bilgic et al. (2002) present different regional and national studies that estimate Armington elasticities in the context of the U.S. for traded commodities and services. For commodities, they range from 1.5 to 3.5, while for services, they vary between 0.2 and 2.0. Irrespective of the methodology used, services generally have lower Armington elasticities than manufacturing products. Donnelly et al. (2004) presents Armington elasticities for selected industries in the U.S. for the USITC and GTAP CGE models. For the former, elasticities average out to be 3.02 and 2.35 for manufacturing and services products, and, for GTAP, these are 2.89 and 2.35, respectively.

Product Differentiation dictate the effects of exporting-country scale effects. More precisely, relative to bilateral trade in manufactures, that in services is more elastic with respect to per capita income of the importing country and less elastic with respect to the GDP of the exporting country. These differences are derived in section 2.4, and, subsequently supported by our empirical results.

The side-by-side estimation of gravity equations for aggregate trade in manufacturing and that in services contributes towards understanding and interpreting the similarities and dissimilarities between them, contrasting with the existing empirical literature that focuses on either manufacturing, services, or some important segments of them.

In studying the determinants of international trade in services and manufacturing, this paper also sheds light on the importance of internet penetration and virtual proximity. In the modern internet era, almost any kind of business dealing with goods or services is likely to have used the internet. It is natural to speculate that internet use would significantly lower trade costs for *both* goods and services. Starting with Freund and Weinhold (2002), internet use has been recognized as an important factor in reducing trade costs, particularly, for services.[6] As expected, internet use is found as a significant determinant of trade in services — particularly that of a country as an exporter, not as an importer (Freund and Weinhold, 2002, Page 240). Instead of using country-wise internet use, in their study of audiovisual services trade, Hellmanzik and Schmitz (2015) find that the number of *bilateral* internet links is a significant determinant of such trade. Following them, we also incorporate this variable and interpret it as a measure of *virtual proximity*.

Our empirical section incorporates internet penetration and virtual proximity and we find that, in particular, virtual proximity is a significant determinant of bilateral aggregate trade in both product groups. Indeed, it substantially reduces the role of physical distance and scale variables such as GDP and per capita income. We find suggestive evidence that the elasticity with respect to virtual proximity is higher for trade in services relative to manufacturing. Our results also show that the exporter country's internet penetration is an essential determinant for trade in services even after controlling for virtual proximity. However, we do not find sufficient evidence to support internet penetration as a determinant of trade in manufacturing. In sum, our empirical analysis implies that virtual proximity is crucial in understanding trade costs and trade flows in both manufactures and services in modern times. Its exclusion, we argue, entails a serious omitted-variable issue in estimating gravity relations.

Section 2 lays out our theoretical model of trade with non-homothetic preferences that incorporates *demand bias* and differences in *national product differentiation*, leading to gravity equations for aggregate trade in manufacturing and aggregate trade in services in a unified framework. Section 3 describes the data and outlines the empirical strategy. Empirical results are presented in Section 4. Robustness checks and sensitivity analyses are undertaken in Section 5. Section 6 concludes.

2 Theory

The world economy consists of N countries and three traded goods: namely, services (s), manufacturing (m), and a numeraire good (0). Manufacturing and services are differentiated and produced by a primary factor, labor. Each household has a given endowment of good 0, which is homogeneous and cannot be produced. The presence of a fixed-endowment numeraire good achieves two purposes. Since these endowments vary (exogenously) across countries, the size of the labor force is not necessarily inversely related to per capita income. Furthermore, such modeling of the numeraire good

[6]The authors use the number of the top-level domain names in a country as a measure of internet use, whereas Choi (2010) has used internet penetration (number of users per 100 or 1,000 people) as the measure of the same.

implies an endogenous wage rate, which serves two roles in the model. It enables to (a) assess the effect of the cost of production in the exporter country on the value of bilateral trade and (b) reveal the role of the Armington elasticity in determining how the total income of an exporter country may affect bilateral trade. The trading countries are indexed by i, k or r. Country i is endowed with L_i households, each owning one unit of labor.

2.1 Tastes

Households have identical tastes across countries and within countries. For ease of notation and better exposition, we initially assume that all households in a country have the same endowment of good 0. This is relaxed in section 2.5.

Demand bias and differences in national product differentiation are incorporated via preferences. A four-tier generalized version of Dixit-Stiglitz specifications reveal these differences in a transparent way: outer tier on choice of manufactures-cum-services basket c_r and the numeraire good, middle-tier 1 over the allocation of c_r into the baskets of manufactures (c_{mr}) and services (c_{sr}), middle-tier 2 on the choice of country-specific manufactures (c_{mir}) and services (c_{sir}) and the inner-tier on varieties of manufacturing ($c_{mir}(u)$) and services ($c_{sir}(u)$) within the respective country-specific basket. Various notations are summarized in Table 1.

Table 1: Notations

c_r:	household consumption in country r of a basket of manufacturing and services
P_r:	price of this basket in country r
c_{mr} [c_{sr}]:	household consumption in country r of the manufactures [services] composite consisting of varieties produced in all trading countries
P_{mr} [P_{sr}]:	price in country r of the manufactures [services] composite consisting of varieties produced in all trading countries
c_{mir} [c_{sir}]:	household consumption in country r of the manufacturing [services] composite consisting of varieties produced in country i only
P_{mir} [P_{sir}]:	price in country r of the manufacturing [services] composite consisting of varieties produced in country i only
$c_{mir}(u)$ [$c_{sir}(u)$]:	household consumption in country r of a manufacturing [service] variety u produced in country i
$p_{mir}(u)$ [$p_{sir}(u)$]:	price in country r of a manufacturing [service] variety u produced in country i
$p_{mi}(u)$ [$p_{si}(u)$]:	the FOB price of a manufacturing [service] variety u produced in country i
$q_{mi}(u)$ [$q_{si}(u)$]	output of a firm in the manufacturing [service] sector of country i
τ_{mir} [τ_{sir}]:	the iceberg transportation/communication cost of shipping or sending a manufacturing [service] variety from country i to country r
Ω_{mir} [Ω_{sir}]:	mass of manufacturing [services] varieties which are produced in country i and sold in country r
$\bar{q}_{0r}$	household endowment of the numeraire good in country r
y_r:	household income in country r, which includes the value of the numeraire good endowment.

Outer-Tier Tastes: log-linear

$$\text{Utility Function:} \quad v_r = \beta_0 \ln c_{0r} + \beta \ln c_r, \ \beta_0 > 0; \beta > 0; \beta_0 + \beta = 1 \tag{1}$$

$$\text{Budget:} \quad c_{0r} + P_r c_r = y_r$$

$$\text{Demand Functions:} \quad c_{0r} = \beta_0 y_r; \quad c_r = \beta \frac{y_r}{P_r}. \tag{2}$$

Middle-Tier 1 Tastes; Non-Homothetic CES

$$\text{Utility Function:} \quad \sum_{j \in (m,s)} c_r^{\frac{\theta_j - \eta}{\eta}} c_{jr}^{\frac{\eta - 1}{\eta}} = 1. \tag{3}$$

$$0 < \theta_m < \theta_s < 1 + \theta_m \tag{R1}$$

$$\eta > \max\left\{1, \frac{\theta_m}{1 - \theta_s + \theta_m}\right\} \tag{R2}$$

$$\text{Budget:} \quad P_{mr} c_{mr} + P_{sr} c_{sr} = e_r \equiv P_r c_r = \beta y_r \tag{4}$$

$$\text{Demand Functions:} \quad c_{jr} = \left(\frac{P_{jr}}{e_r}\right)^{-\eta} \left[\varXi\left(P_{mr}, P_{sr}, e_r\right)\right]^{\theta_j - \eta} \tag{5}$$

$$\text{Expression of } c_r\text{:} \quad c_r = \varXi\left(\underset{-}{P_{mr}}, \underset{-}{P_{sr}}, \underset{+}{e_r}\right) \tag{6}$$

$$\text{Expression of } P_r\text{:} \quad P_r^{1-\eta} = \sum_{j \in (m,s)} P_{jr}^{1-\eta} c_r^{\theta_j - 1}. \tag{7}$$

Middle-Tier 2 Tastes, Dixit-Stiglitz

$$\text{Utility Function:} \quad c_{jr} = \left(\sum_{i=1}^{N} c_{jir}^{\frac{\epsilon_j - 1}{\epsilon_j}}\right)^{\frac{\epsilon_j}{\epsilon_j - 1}}, \ j = m, s \tag{8}$$

$$\text{Budget:} \quad \sum_{i=1}^{N} P_{jir} c_{jir} = c_{jr}, \ j = m, s \tag{9}$$

$$\text{Demand Functions:} \quad c_{jir} = \left(\frac{P_{jir}}{P_{jr}}\right)^{-\epsilon_j} c_{jr}, \ j = m, s, \ \text{where } P_{jr}^{1-\epsilon_j} \equiv \sum_{i=1}^{N} P_{jir}^{1-\epsilon_j}, \ j = m, s. \tag{10}$$

Inner-Tier Tastes, Dixit-Stiglitz

$$\text{Utility Function:} \quad c_{jir} = \left(\int_{u \in \Omega_{jir}} c_{jir}(u)^{\frac{\sigma - 1}{\sigma}} du\right)^{\frac{\sigma}{\sigma - 1}}, \ \sigma > 1, \ j = m, s \tag{11}$$

$$\text{Budget:} \quad \int_{u \in \Omega_{jir}} p_{jir}(u) c_{jir}(u) = c_{jir}, \ j = m, s \tag{12}$$

$$\text{Demand Functions:} \quad c_{jir}(u) = \left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma} c_{jir} = \left(\frac{p_{ji}(u)\tau_{jir}}{P_{jir}}\right)^{-\sigma} c_{jir}, \ j = m, s \tag{13}$$

$$\text{where } P_{jir}^{1-\sigma} \equiv \int_{u \in \Omega_{jir}} p_{jir}(u)^{1-\sigma} du = \int_{u \in \Omega_{jir}} \left(p_{ji}(u)\tau_{jir}\right)^{1-\sigma} du, \ j = m, s. \tag{14}$$

Demand bias is introduced in middle-tier 1 preferences. It is modeled *a la* Fieler (2011), Matsuyama (2015) and Comin et al. (2017). Unlike Gorman tastes, the parameter η measures the *constant* elasticity of substitution between manufacturing and services. Note that, if $\theta_m = \theta_s = 1$, eq. (3) returns the standard Dixit-Stiglitz function over manufacturing and services.

While $\theta_m \neq \theta_s$ is a necessary condition for non-homotheticity, (R1) states that the difference between them are not supposed to be very large. This ensures normality of both goods (see Appendix B for a proof).[7] However, the magnitudes of θ_m and θ_s can still be large or small: they may exceed or fall short of unity. (R2) implies $\eta > 1$ and (R1) and (R2) together imply

$$\eta > \theta_s > \theta_m > 0.$$[8]

In Appendix B we prove that,

Result 1. Both manufacturing and service bundles are normal goods, i.e., given P_{jr}, $dc_{jr}/dc_r > 0$. Furthermore, the income elasticities of demand for manufacturing and services are respectively less and greater than unity.

As a corollary of Result 1,

Result 2. At given price indices P_{mr} and P_{Sr}, the quantities demanded for manufacturing and that for services are respectively a strictly concave and a strictly convex function of income; thus, the respective Engel curves are strictly concave and strictly convex.

Results 1 and 2 formally characterize the *demand bias* towards services. However, an increase per capita income (y_r) has a proportionate effect on the aggregate expenditure on the numeraire good and that on the manufacturing-services basket.

In middle-tier 2 preference, ϵ_m and ϵ_s denote the respective Armington elasticities that define national product differentiation. The critical assumption is that

Assumption 1.

$$\epsilon_m > \epsilon_s > 1, \tag{15}$$

meaning that services are more *nationally differentiated* than manufacturing.

We further assume that the substitutability among within-country varieties exceeds that among between-country varieties for both manufacturing and services, i.e.,

Assumption 2.

$$\sigma > \epsilon_j \quad \text{for } j = m, s. \tag{16}$$[9]

To highlight national production differentiation differences, we have presumed that substitutability between within-country varieties is same between manufacturing and services.[10]

[7] Normality of the service bundle is assured under less restrictive assumptions. But normality of manufacturing is not because, if the demand bias toward services is too large, as nations get larger, they may shift their purchases so heavily toward services that manufacturing becomes an inferior good.

[8] If $\theta_s \leq 1$, it is easy to show that $\eta > \theta_s > \theta_m > 0$. Suppose $\theta_s > 1$. Then (R2) implies $\eta - \theta_s = \frac{(\theta_s-1)(\theta_s-\theta_m)}{1+\theta_m-\theta_s} > 0 \Rightarrow \eta > \theta_s > \theta_m > 0$.

[9] Ardelean (2009) provides empirical evidence supporting this assumption for manufacturing.

[10] Otherwise, a more general version of (11) is:

$$c_{jir} = \left(\int_{u \in \Omega_{jir}} c_{jir}(u)^{\frac{\sigma_j - 1}{\sigma_j}} du \right)^{\frac{\sigma_j}{\sigma_j - 1}}, \ j = m, s.$$

2.2 The Supply Side

The technology in each production sector obeys increasing returns to scale and is the same across countries. In terms of the labor requirement, $l_{ji}(u) = \alpha + q_{ji}(u)$, $\alpha > 0$, $j = m, s$, where the units of manufacturing and services are normalized such that the variable labor coefficient is the unity in both sectors. We abstract from firm heterogeneity — obviously important; but this is kept in mind for follow-up research. The market structure is monopolistic competition production sectors m and s, and, perfect competition in the numeraire sector. An individual firm in either production sector faces constant price elasticity of demand for its variety in each trading country. Hence the price markup over marginal cost is constant:

$$p_{ji}(u) = \frac{\sigma w_i}{\sigma - 1}, \quad p_{jir}(u) = \frac{\sigma w_i \tau_{jir}}{\sigma - 1}, \tag{17}$$

implying

$$\begin{aligned} P_{jir} &= \frac{\sigma w_i \tau_{jir}}{\sigma - 1} \cdot \Omega_{jir}^{-\frac{1}{\sigma-1}}; \quad \frac{p_{jir}(u)}{P_{jir}} = \Omega_{jir}^{\frac{1}{\sigma-1}}; \\ P_{jr} &= \frac{\sigma}{\sigma - 1} \left(\sum_{i=1}^{N} \left(w_i \tau_{jir} \right)^{1-\epsilon_j} \Omega_{jir}^{\frac{1-\epsilon_j}{1-\sigma}} \right)^{\frac{1}{1-\epsilon_j}} \\ \frac{P_{jir}}{P_{jr}} &= \frac{w_i \tau_{jir} \Omega_{jir}^{\frac{1}{1-\sigma}}}{\left(\sum_{i=1}^{N} \left(w_i \tau_{jir} \right)^{1-\epsilon_j} \Omega_{jir}^{\frac{1-\epsilon_j}{1-\sigma}} \right)^{\frac{1}{1-\epsilon_j}}}, \end{aligned} \tag{18}$$

where Ω's are the respective mass of varieties produced and sold. In sector j of country i, the variable (operating) profit made by firm u in country r has the expression:

$$\pi_{jir}(u) = L_r p_{jir}(u) c_{jir}(u) - w_i \underbrace{\tau_{jir} L_r c_{jir}(u)}_{\text{output shipped to country } r} = L_r c_{jir}(u) \left[p_{jir}(u) - w_i \tau_{jir} \right] = \frac{L_r c_{jir}(u) w_i \tau_{jir}}{\sigma - 1} > 0. \tag{19}$$

Since the variable profits are positive in each market, each firm in either sector located in any country sells in all trading countries:

$$\Omega_{jir} = \Omega_{ji}, \tag{20}$$

where Ω_{ji} is the mass of varieties of j produced in country i, $j = m, s$.[11] The total variable profit of a firm that produces variety u is given by the sum of its variable profits made across all N countries:

$$\pi_{ji}(u) = \sum_{r=1}^{N} \pi_{jir}(u) = \frac{w_i \sum_r L_r c_{jir}(u) \tau_{jir}}{\sigma - 1} = \frac{w_i q_{ji}(u)}{\sigma - 1}. \tag{21}$$

where, recall that $q_{ji}(u)$ is the output of a firm located in sector j of country i. Fixed costs are αw_i. Hence free entry-exit and zero-profits imply $q_{ji}(u) = \alpha(\sigma - 1)$. Not surprisingly, the equilibrium firm-level output is constant and the same across all countries, and, it implies $l_{ji}(u) = \alpha\sigma$.

[11] This will change if there were firm heterogeneity and positive fixed costs of operating in foreign country.

2.3 World Trading Equilibrium

Formally, given the preferences, the endowment of the numeraire good ($\bar{q}_{0r}$) and the supply of labor (L_r) for each trading country as well as bilateral trade costs τ_{jir} for each pair of trading countries, the *world trading equilibrium* is a vector $\{w^*_r, \Omega^*_{mr}, \Omega^*_{sr}, P^*_{mr}, P^*_{sr}, c^*_{mr}, c^*_{sr}, c^*_r, e^*_r\}$, such that
(a) $P^*_r = e^*_r/c^*_r$; and the vector is consistent with the
(b1) $2N$ price-index expressions (18) for manufacturing and services bundles separately for each country;
(b2) $2N$ demand functions (A.6) for manufacturing and services bundles separately for each country;
(b3) N demand functions

$$e_r = \beta(w_r + \bar{q}_{0r}) \tag{22}$$

for the manufacturing-services basket, one for each country;
(b4) N expenditure-share adding up conditions (A.6), one for each country;
(b5) N full-employment conditions, one for each country:

$$\alpha\sigma\left(\Omega_{mr} + \Omega_{sr}\right) = L_r; \tag{23}$$

(b6) $2N$ world market-clearing condition for each variety of manufactures and services produced in each country:

$$\alpha(\sigma-1) = \frac{w_i^{-\epsilon_j}\Omega_{ji}^{-\frac{\sigma-\epsilon_j}{\sigma-1}}}{\left(\sum_{r=1}^{N}\left(w_r\tau_{jir}\right)^{1-\epsilon_j}\Omega_{jr}^{\frac{\epsilon_j-1}{\sigma-1}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot \sum_{r=1}^{N} L_r c_{jr}\tau_{jir}^{-(\epsilon_j-1)} \qquad j = m, s. \tag{24}$$

where the left-hand side is the supply for each variety of manufacturing or services (equal to the equilibrium firm-level output $\alpha(\sigma-1)$) and the right-hand side is the world demand for it plus the amount lost in transit.[12] ■

We shall now derive expressions for the wage rate and the equilibrium number of varieties produced in each country, which will be used in deriving the gravity equations — and interpreting them. Turn to eq. (24) and define

$$\chi_{ji} \equiv \frac{\sum_{r=1}^{N} L_r c_{jr}\tau_{jir}^{-(\epsilon_j-1)}}{\alpha(\sigma-1)\left(\sum_{r=1}^{N}\left(w_r\tau_{jir}\right)^{1-\epsilon_j}\Omega_{jr}^{\frac{\epsilon_j-1}{\sigma-1}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot \qquad j = m, s. \tag{25}$$

Substituting the above back into (24) and rearranging, $\Omega_{ji} = \chi_{ji} w_i^{-\frac{(\sigma-1)\epsilon_j}{\sigma-\epsilon_j}}$. In turn, substitute this into the full employment condition (23) and obtain:

$$\alpha\sigma\left(\chi_{mi}w_i^{-\frac{(\sigma-1)\epsilon_m}{\sigma-\epsilon_m}} + \chi_{si}w_i^{-\frac{(\sigma-1)\epsilon_s}{\sigma-\epsilon_s}}\right) = L_i \Rightarrow w_i = w_i\left(\underset{+}{\chi_{mi}}, \underset{+}{\chi_{si}}, \underset{-}{L_i}\right). \tag{26}$$

This is an implicit wage function. Next, using this, we obtain an expression for the equilibrium number of varieties produced in each country:

$$\Omega_{ji} = \chi_{ji} \cdot \left[w_i\left(\chi_{mi}, \chi_{si}, L_i\right)\right]^{-\frac{(\sigma-1)\epsilon_j}{\sigma-\epsilon_j}}. \tag{27}$$

Eqs. (26) and (27) formalize the following result that is expected:

[12] Equation (24) is derived in Appendix (C).

Result 3. Larger countries are associated with lower wage rate and larger number of varieties.

2.4 Gravity Equations

Following the standard approach in the literature, let the bilateral trade flows be measured by the fob value of the gross exports at the destination country. Let X_{jir} denote this, where j is the sector/good (manufacturing or services), i the exporting country and r the importing or the destination country. We have X_{jir} = # of varieties of good j produced in country i × country r's expenditure on each variety at the fob price. Various substitutions lead to two expressions of the gravity relation for each product group m and s:

$$X_{jir} = \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_j-1} \chi_{ji}^{\frac{\epsilon_j-1}{\sigma-1}} \left[w_i\left(\chi_{mi},\chi_{si},L_i\right)\right]^{-\frac{\sigma(\epsilon_j-1)}{\sigma-\epsilon_j}} \left(\frac{\tau_{jir}}{P_{jr}}\right)^{-\epsilon_j} \left(L_r c_{jr}\right). \tag{28}$$

$$= \boxed{A_j \cdot L_r y_r^{\eta} \cdot \frac{\tau_{jir}^{-\epsilon_j}}{P_{jr}^{\eta-\epsilon_j} \cdot \chi_{ji}^{\frac{1-\epsilon_j}{\sigma-1}}} \cdot \frac{\left[w_i\left(\chi_{mi},\chi_{si},L_i\right)\right]^{-\frac{\sigma(\epsilon_j-1)}{\sigma-\epsilon_j}}}{\left[\Xi(P_{mr},P_{sr},\beta y_r)\right]^{\eta-\theta_j}}}, \text{ where } A_j \equiv \beta^{\eta}\left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_j-1}.\text{[13]} \tag{29}$$

Eq. (29) is closer to a standard-looking gravity equation than is eq. (28).

Worth-emphasizing, a gravity equation like (29) is a cross-sectional relationship, showing how bilateral exports among various pairs of trading countries are positioned *vis-à-vis* one another depending on the equilibrium configuration of global as well as country-specific variables. Following Anderson and van Wincoop (2003), we can interpret χ_{mi} and χ_{si} as multilateral resistance facing the exporting country i, while P_{mr} and P_{sr} as those facing the importing country r. It follows directly from (29) that

Result 4. Bilateral trade in either good depends on multilateral resistance facing the exporting country and the importing country in both sectors.

Non-homotheticity of tastes implies:

(i) In the right-hand-side of (29), the term $L_r y_r$ does not, on its own, capture the income effect of the importing country. That is, bilateral trade is not merely a function of total income, divided multiplicatively into the population and per capita income (Fieler, 2011).

(ii) While bilateral trade is proportional to the size of the population, it is not so with respect to per capita income.

In view of (28) and Result 1,

Result 5. Bilateral trade of either good is unitarily elastic with respect to the importing country's population size, while the importing country per capita income elasticity of bilateral trade in manufacturing is less than unity, and that in services exceeds unity.

This follows from the *demand bias* assumption. Higher income elasticity of demand for services than for manufactures translates into a higher elasticity of bilateral trade in services with respect to the per capita income of a country as an importer.

[13] Expression (28) is derived in Appendix D. Two further substitutions from section 2.1, namely, $e_r = \beta y_r$ and the expression of c_{jr} in (5), leads to (29).

While non-homothetic tastes form the micro-foundations beneath differentiating between size and per capita income of a country as an importer, there is no basis for considering the exporting country's size and per capita income as independent determinants of bilateral trade. Only the overall size matters, represented through the $w_i(\cdot; L_i)$ function. Since the absolute value of the exponent of w_i in (29) is increasing in ϵ_j and $\epsilon_m > \epsilon_s$, it follows that

Result 6. The elasticity of the bilateral trade with respect to the size of the exporting country is greater for manufacturing than for services.

Hence, bilateral trade is *not* unitarily elastic with respect to the exporting-country size. Furthermore, the magnitude of the exporting country's size effect depends on the Armington elasticities. Multiplying both sides of equation (26) with w_i, it can be readily derived that w_i is negatively related to $w_i L_i$. Thus, bilateral trade is positively related to total labor income; and, if total labor income is positively related to total income inclusive of the value of the numeraire good, bilateral trade increases with total income.

Intuitively, compared to services, lesser *national product differentiation* of manufacturing implies more elastic import demand for it. In equilibrium, manufacturing production and exports are less governed by world demand and more by the supply side. Therefore, manufacturing trade is more sensitive to changes in the total endowment of resources of the exporting country, that is, the size of the exporter country. The differences in *national production differentiation* underpins Result 6. Also, note in (29) that the elasticity of bilateral trade with respect to trade cost depends on the Armington elasticity or the national product differentiation, *not* the elasticity of substitution between intra-country varieties. This brings us to the result on trade-cost elasticities, which is a direct implication of Armington elasticity for manufacturing being higher than that for services.

Result 7. The international trade cost elasticity of bilateral trade is higher, in absolute terms, to manufacturing than is for services.[14]

2.5 Inequality within Countries

So far, our model has permitted across-country heterogeneity. Because the demand function for each product category is nonlinear with respect to (per capita) income due to Demand Bias, the income distribution within the importer country *per se* would impact the aggregate demand for products from different countries, including its own.

Mitra and Trindade (2005) have articulated a model of trade in food, a necessity, and manufacturing, a luxury, (rather than manufacturing and services) with non-homotheticity and a demand bias toward manufacturing relative to food. However, non-homotheticity is postulated, not on preferences

[14] We may want to compare the gravity equation (29) to the standard case where tastes are homothetic and there is no difference in the national product differentiation between manufacturing and services. Hence the only difference between the two commodities lies in their respective trade costs, while the substitution elasticity among within-country varieties exceeds that between across-country varieties for both product groups. Accordingly, if $\theta_m = \theta_s = 1$, and, $\epsilon_m = \epsilon_s = \epsilon$, the gravity equations in (29) reduce to

$$X_{jir} = A' \cdot (w_i L_i) \cdot (L_r y_r) \cdot \frac{\chi_{ji}^{\frac{\epsilon-1}{\sigma-1}}}{\alpha\sigma \sum_{j\in(m,s)} \chi_{ji}} \cdot \frac{\tau_{jir}^{-\epsilon}}{P_{jr}^{\eta-\epsilon} P_r^{-(\eta-1)}}, \text{ where } A' \equiv \beta \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon-1} \text{ and } P_r \equiv \left(\sum_{j\in(m,s)} P_{jr}^{-(\eta-1)}\right)^{-\frac{1}{\eta-1}}.$$

Notice that bilateral trade of both manufacturing and services are unitarily elastic with respect to size of the importing country and the exporting country.

directly, but in terms of the share of expenditure of food and manufacturing being a function of total expenditure.[15] The theoretical hypothesis is that an increase in income inequality in terms of a mean-preserving spread of per capita income within a country would increase this ratio. The same intuition extends to our model. It follows readily from Result 2 that, all else the same, as an importer, a country with a higher income inequality will have less bilateral trade in manufacturing and more bilateral trade in services.

However, higher or lower income inequality is *not* synonymous with greater or less spread with the same mean. In addition to the spread effect, i.e., the per capita income levels remaining the same, a change in the composition of the population can also result in a change in the *average* per capita income or income inequality or both.

More specifically, consider a change in the composition of the population, specifically leading to a greater polarization, i.e., 'hollowing out of the middle class,' while the total or per capita income remains the same.[16] That is, starting from a given composition, let the new composition have a higher number of relatively richer and a higher number of relatively poorer individuals. How would it impact on aggregate consumption of manufacturing and services? Depending upon the specifics, the directional changes can be positive or negative. Table 2 presents a numerical example, which is self-explanatory. Notice from the last column that there is complete polarization in the new composition of the population, and, hence there is no ambiguity that income distribution has more spread under the new composition of the population. Straightforward computation shows that the average per capita income remains the same between the initial and the new situation, while an increase in inequality in the form of greater polarization leads to an *increase* in the aggregate manufacturing consumption and a *decrease* in services consumption. This is indicative that bilateral trades in manufacturing and services may respectively fall or increase with an increase in inequality in the importing country. This is the opposite of the spread effect.

While the notion of mean-preserving spread is often used represent a change in inequality, the *compositional effect* is generally neglected. Our example illustrates that the composition effect may be quite different from — and indeed the opposite — of the spread effect. Considering both the effects, the overall theoretical implication of inequality on bilateral trade is ambiguous.

2.6 A Summary

Our theoretical model predicts that bilateral trades in both manufacturing and services increase with the exporting country's GDP while increasing with population and per capita income of the importing country separately. Moreover, they decline with respect to the bilateral trade costs. These predictions are hardly surprising. Nonetheless, three main results summarize how our model differs from the standard gravity model.

(i) The trade elasticity with respect to the exporter GDP is greater for manufacturing than for services.

(ii) The trade elasticity in regard to the importer per capita income is higher for services than for manufacturing. Of course, our model yields a more specific result: the importing-country per capita income

[15] By assumption, the share of manufactures increases and that of food falls with the total expenditure, i.e., income elasticity of manufacturing and food are respectively higher and lower than unity. In their empirical work, Dalgin et al. (2008) analyze the effect of income inequality on the ratio of bilateral trade in luxury goods to that in necessary goods within the category of goods in general without distinguishing between manufactures and food and without the inclusion of services.

[16] Income and wealth polarization has been a global phenomenon in recent decades (Hollinger, 2012).

Table 2: Numerical Example. Increase in Inequality in terms of Greater Polarization and Its Impact on Aggregate Consumption of Manufacturing and Services

Disposable Income in Dollars	Share of Manufactures in Manufac-Service Basket	Share of Services in Manufac-Service Basket	Initial Distribution of Population	New Distribution of Population: Complete Polarization
200	0.4	0.6	9	10
100	0.6	0.4	6	0
80	0.8	0.2	5	10
Share of Disposable Income Spent on the Manufacturing-Services Basket				= 0.5
Change in the Aggregate Consumption of Manufactures				= $\boxed{\$20}$
Change in the Aggregate Consumption of Services				= $\boxed{-\$20}$

elasticity of bilateral trade is larger than unity for services and less than unity for manufactures. However, we should not expect such sharpness of theoretical predictions to be borne out empirically since some relevant (extraneous) variables, and considerations are absent our model. For instance, our static model does not incorporate how wealth might affect aggregate consumption and bilateral trade.

(iii) the trade-cost elasticity of trade is larger for manufacturing than for services in absolute terms.

These implications, lending themselves to empirical testing, are intuitively reasoned after Results 6, 5 and 7 respectively. The demand-bias assumption underlies (ii), where (i) and (iii) are driven by the differences in the national product differentiation. Furthermore, within-country inequality in a country as an importer is a determinant of bilateral trade of both product groups but the direction of this effect is ambiguous theoretically. Hence, the impact of the importer-country inequality on bilateral trade is primarily an empirical issue.

Note that openness to trade — which determines products included in the traded basket — may depend on the size and per capita income of the economy. This is an extensive margin issue, which is outside of our theoretical model.[17]

3 Empirical Analysis

This section discusses empirical variables, data sources and our empirical strategy.

3.1 Variables and Data Sources

Aggregate bilateral manufacturing trade flows from 2002 to 2015 are obtained from the U.N. Comtrade database, United Nations (2018). In compiling the data, preference is given to trade flows

[17]Furthermore, our theoretical model does not incorporate manufacturing or services as inputs to production. We argue that the elasticity rankings of bilateral trade with respect to income and per capita income between the two categories of products are likely to hold even if manufacturing and services were used as inputs to production as long as there are no significant differences in factor intensity between the two sectors. There is no compelling reason to suppose that there is a 'producer-demand bias' towards manufactures or services, and, that service inputs are less differentiated than manufactures inputs.

reported by the exporting country. We complement the dataset by mirroring the importer country's trade flows whenever the exporter's report is not available.

For bilateral trade in services, we follow Anderson et al. (2018) and rebuild an integrated dataset of cross-border services trade from 2002 to 2015. Our primary data source is the "OECD Statistics on International Trade in Services: Trade in Services by Partner Country and main service category (EBOPS 2010 classification)".[18] Similar to manufacturing, we accord preference to trade flows as reported by the exporter country as a more reliable measure of bilateral trade. We used the information reported by the importer country whenever the exporting country did not report. Even though most OECD countries already account for a large share of global cross-border service trade, we attempt to maximize the coverage of global trade flows by augmenting the OECD data with information from the U.N. Comtrade database. Since the OECD constitutes our preferred data source, the U.N. data serves to augment the dataset only when the corresponding OECD observation is missing.

The resulting data comprise 177 countries over the period 2002-2015. These countries are listed in Table 15 in Appendix E. We adopt the following notations and definitions for the included variables.

$\boxed{X_{jir}:}$ Following the notation from eq. (29), it represents the total aggregate bilateral exports of sector $j = m, s$ in current US dollars, from country i to country r. This is our dependent variable in the econometric specifications that follow.

Explanatory variables include GDP, population, per capita GDP, and those affecting trade cost. In addition, they also include a measure of inequality, even though the theoretical impact on bilateral trade is ambiguous. It is because if we recognize non-homotheticity, it is only natural to include per capita income and a measure of inequality.[19]

$\boxed{\text{GDP}_i}$, $\boxed{\text{POP}_r}$, $\boxed{\text{gdp}_r}$: These represent respectively the total income of the exporting country i, the population of the destination country r, the per capita GDP (GDP ÷ the population) of the destination country r. This information comes from the World Development Indicators, World Bank (2018).

$\boxed{\text{INQ}_r}$: This is the income inequality measure. We use the GINI coefficient as well as the pre-tax income share of top 10% and 1%. The respective data sources are Frederick Solt, `https://fsolt.org/swiid/` and World Inequality Database (2019).[20]

$\boxed{\text{DIST}_{ir}}$, $\boxed{\text{BORDER}_{ir}}$, $\boxed{\text{LANG}_{ir}}$, $\boxed{\text{COLN}_{ir}}$: These are the bilateral geographical distance and indicator variables for shared borders, for a common language and colonial relation — usual determinants of bilateral trade costs. The information on these variables is obtained from the *Centre D'Estudes Prospectives et d'Informations Internationales*, CEPII's gravity database.[21]

In addition to the above 'standard' explanatory variables (perhaps with the exception of income inequality), we include two variables to capture virtual connectivity between countries, namely, overall internet use in a country and the number of bilateral hyperlinks, as determinants of bilateral trade in both product categories.

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[18] It includes transport (both freight and passengers), travel, communications services (e.g., postal, telephone, and satellite.), construction services, insurance, and financial services, computer and information services, royalties and license fees for the use of intellectual property, other business services (e.g., merchanting, operational leasing, commercial, technical and professional services.), cultural, personal and recreational services, and government services.

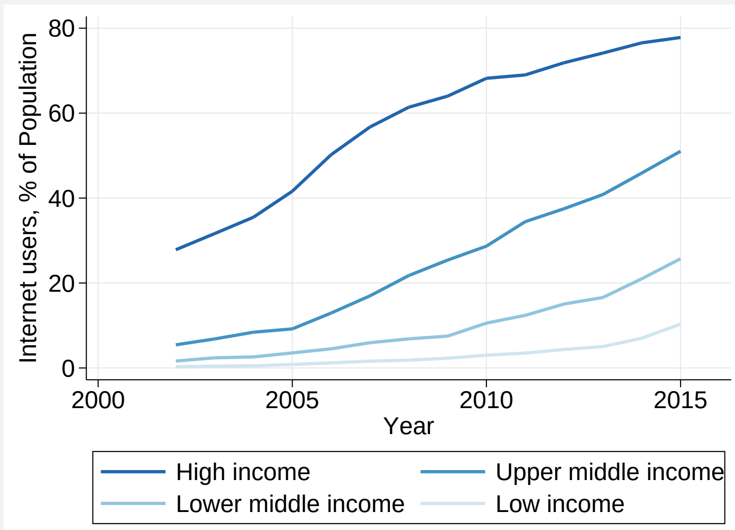
[19] As Dalgin et al. (2008, Page 749) write, "At a minimum, the gravity model must be augmented with income per capita and a measure of the within-country income distribution."

[20] While GINI is a common measure of inequality, income shares of top 1%, 10%, etc. have also been used; see Leigh (2007) and Piketty et al. (2019), among others.

[21] Other bilateral trade cost variables would include, for example, whether the two countries are included in any preferential trading arrangement like a free-trade bloc. However, we do not incorporate them, although we could, since we believe it is unlikely to change the nature of our results. It is arguable that bilateral tariff levels may have significant explanatory power. However, data on it over time is generally lacking (UNCTAD-WTO, 2012, Chapter 3).

INTPEN: It is a measure of internet penetration in a country: the percentage share of a country's population that uses the internet. Annual data is obtained from the World Development Indicators, World Bank (2018), for 2002-2015. Figure 3 shows the rapid growth of internet users globally since the early 2000s, while there still exists a considerable gap in the usage between high- and low-income countries. In explaining bilateral trade, internet penetration is viewed as a factor that reduces bilateral trade costs *vis-à-vis* all trading countries.

Figure 3: **Internet Penetration by Country Income Group, 2002-2015**



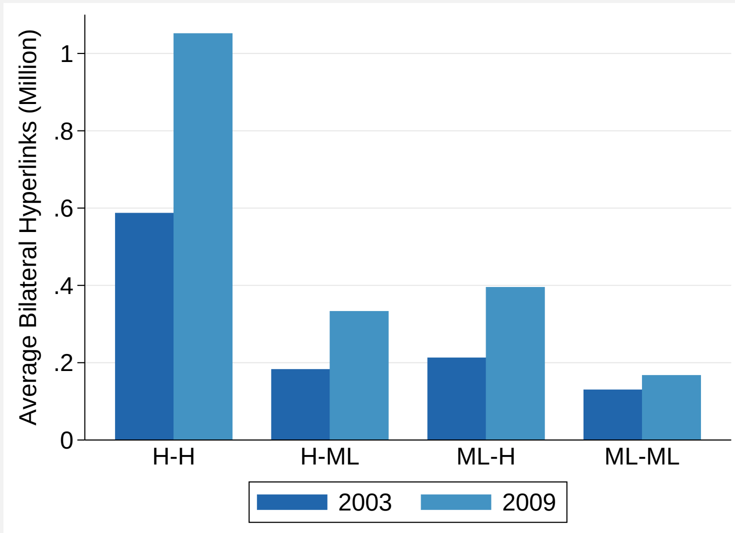
Note: This figure, based on annual data, shows the median country's value of internet users as a share of total population for each income group. The income groups are defined as the World Bank classification in 2019.

BLINK: It captures bilateral information flows over the internet, measured by the number of bilateral inter-domain hyperlinks that internationally connect web pages in two trading countries. In contrast to DIST indicating physical distance, BLINK measures virtual proximity between two trading nations. The data on inter-domain hyperlinks come from two sources. The information on the bilateral hyperlinks in 1998 is obtained from the OECD Communications Outlook 1999 report, available for 29 countries. Our second and primary source of hyperlinks data is Chung (2011), who provides information on bilateral hyperlinks for two years, 2003 and 2009, for 46 and 82 countries, respectively. This data is also used by Hellmanzik and Schmitz (2015).[22]

According to the BLINK measure, the U.S.–U.K. is the pair with the highest number of bilateral hyperlinks for all available years, 1998, 2003, and 2009. Figure 4 illustrates the patterns of BLINK across countries by income level. It presents the average number of hyperlinks between countries of

[22] Bilateral hyperlinks refer to links from websites with domains from a specific origin country to websites with domains in another country. An easy way to measure the bilateral hyperlink between two countries is to use country top-level domains (ccTLD), such as `.us` for the U.S. or `.uk` for the U.K. However, determining the host and source countries for non-national domain names, such as `.org`, `.edu`, or `.com` is a challenging task. Chung (2011) developed an attribution method that allows for identifying the host country of a `.com` domain. This feature makes the data much richer and allows for a more complete and accurate characterization of internet connectivity across countries.

Figure 4: **Bilateral Hyperlinks, 2003 and 2009**



Note: This figure, shows the average number of Bilateral Hyperlinks from and to two sets of countries: High Income (H) and Medium-low (ML) income countries on 2003 and 2009.

different income groups in 2003 and 2009. H represents high-income countries, and ML represents middle or low-income countries. The number of hyperlinks between the two countries is not symmetric. The number of hyperlinks from country A targeting country B is not necessarily the same number of hyperlinks from country B targeting country A. In Figure 4, H-ML represents the average number of hyperlinks from high-income countries to middle or low-income countries, while ML-H represents the average number of hyperlinks from middle or low-income countries to high-income countries. On average, countries have more hyperlinks targeting high-income countries than middle or low-income countries. Figure 4 shows a growth in the average number of hyperlinks between countries from 2003 to 2009, signifying that the world has increased its virtual proximity. Moreover, the virtual proximity has increased more between High-Income countries relative to Medium-Low income countries.

In our estimation we only use 2009 BLINK data that are available for 82 countries, which are listed in Table 16 in Appendix E. We do not use 1998 or 2003 BLINK data since it is available for a very limited number of countries.

BROAD: It is the number of broadband subscriptions in a country in 2003, a measure of a country's information and communication technology infrastructure. It is used as an instrument for BLINK09. The data source is from the World Development Indicators, World Bank (2018).[23]

Table 3 presents the summary statistics of the variables included in this study. Note, in particular, that the mean bilateral trade flow in manufacturing goods in our sample is US$ 296.35 million, which is much larger than the average services flow, US$ 83.3 million. The huge difference partly reflects the larger prevalence of barriers to trade in services compared to that in goods and the fact that service trade data does not include those with commercial presence (Mode 3).

[23]Table 17 in Appendix E provides a summary of all variables included and their sources.

Table 3: Summary statistics

	N	Mean	SD	Min	Max
Trade in manufacturing (US$ Million)	436,128	292.47	3,810.43	0.00	398761.27
Trade in services (US$ Million)	436,128	81.07	1,038.30	0.00	80330.00
GDP (US$ Billion)	2,478	333.04	1,325.81	0.07	18120.71
GDP PPP (US$ Billion)	2,436	467.87	1,589.18	0.14	19820.98
Population (Million)	2,478	37.03	138.36	0.02	1371.22
Internet users (% of population)	2,445	29.96	27.77	0.00	98.20
Broadband Subscriptions in 2003 (Million)	116	86.45	327.92	0.00	2,775.20
Gini index (Disposable income)	1,980	38.64	7.89	23.10	61.60
Top 10^{th} percentile income share	1,463	0.44	0.12	0.22	0.71
Top 1^{st} percentile income share	1,480	0.14	0.06	0.05	0.32
Distance (1000 Km)	31,152	7.93	4.48	0.06	19.90
Shared border (dummy)	31,152	0.02	0.13	0.00	1.00
Common language (dummy)	31,152	0.15	0.36	0.00	1.00
Colonial background (dummy)	31,152	0.01	0.11	0.00	1.00
Bilateral hyperlinks (1998)	794	5,172.62	15,540.01	3.00	212,106.00
Bilateral hyperlinks (2003)	1,824	437,469.96	1,459,996.60	1.00	24,936,200.00
Bilateral hyperlinks (2009)	3,741	593,328.00	2,432,472.77	5.00	48,878,701.00

Notes: This table reports summary statistics for the main variables used in our empirical analyses. The final sample is composed by 177 countries, over the period 2002-2015. Information for bilateral hyperlinks, income inequality measures, and Internet users are not available for all countries in our sample.

3.2 Estimation Strategy

The gravity expressions (29) has constant trade elasticities with respect to bilateral trade costs and the population of the importing country, but not in regard to other determinants. Furthermore, it does not include within-country inequality. A fully structural estimation would require specifying a functional form to capture heterogeneity within a country and numerically solving a highly non-linear general equilibrium system containing across-country and within-country heterogeneities. Instead of this, we tread along the standard path of assuming a constant-elasticity dependence between the explanatory variables on the one hand and bilateral trade on the other, on the presumption that the effects of other higher-order terms are relatively small. In effect, we utilize the theoretical gravity equations (29) as the basis to parametrically specify the estimable equations, which additionally include a measure of within-country income inequality.

Our econometric model contains the standard set of variables included in gravity estimations, such as GDP, per capita GDP, population, and standard bilateral trade cost variables; and, it additionally includes a measure of income inequality for the importer country and two measures of internet use: internet penetration and bilateral hyperlinks.

We have a panel data, albeit unbalanced, on bilateral trade, GDP, internet penetration, and other country-wise characteristics from 2002 to 2015. Thus a fixed-effects panel estimation comes to mind as a first instinct. There are prominent examples of panel estimation of trade gravity relations in the literature, e.g., Egger and Pfaffermayr (2003) and Baltagi et al. (2014), among others. Indeed, Yotov et al. (2016) strongly recommend panel estimation of gravity equation whenever panel data is available. However, we respectfully differ and argue that it is not a preferred strategy, at least in our context. Our reasons are as follows.

Table 4: Variance Decomposition of Time-Varying Variables

	Between/Overall Variation (%)	Within/Overall Variation (%)
GDP per capita (log)	94.77	5.23
GDP PPP per capita (log)	97.06	2.94
GDP (log)	96.99	3.01
GDP PPP (log)	98.68	1.32
Population (log)	99.83	0.17
Gini Coefficient	98.34	1.66
Top 10^{th} percentile (Income)	97.09	2.91
Top 1^{st} percentile (Income)	93.25	6.75
Internet Penetration	71.46	28.54

Notes: This table reports the variance decomposition into between and within variation to the country-specific and time-varying variables. The data comprises 177 countries over the 2002–2015 period.

(1) The gravity relations in Equation (29) reflect a snapshot of how bilateral trade is aligned in a cross-sectional equilibrium among trading countries. It is *not* amenable to a natural interpretation when there are within-country variations over time of an explanatory variable. For example, there is no context or a clear interpretation of how a change *over time* in the importer-country per capita income would, all else the same, affect its bilateral trade with another country. To paraphrase Head and Mayer (2014), "All the micro-foundations of gravity that we examined are static models. They provide a derivation for a cross-section but are *questionable bases for panel estimation*" [italics added].

(2) The presence of country-specific or country-time-specific fixed effects does not permit the estimation of the marginal impact of observable country-specific variables like GDP, per capita income, population, or internet use. But, our objective is to estimate and understand the differences in these marginal impacts across trade in manufacturing and trade in services. Non-homothetic preferences do not imply unitary elasticity with respect to scale variables of the exporting or the importing country. Thus taking size-adjusted trade as the dependent variable is not appropriate. While fixed-effects panel estimation serves as an attractive filter to isolate the impact of trade costs and the multilateral resistance — which is important on its own — it is not our sole focus however.

(3) Most compellingly perhaps, in our data set the time-varying explanatory variables have relatively small within-variation compared to between-variation. Table 4 records that within-variation accounts for a very modest portion of most variables' total variation, internet penetration being the sole exception. In the absence of significant within-variations, fixed-effects panel estimates are likely to yield unreliable estimates.

Therefore, we rely on year-to-year regressions. In any given year, the gravity equations contain country-specific determinants (e.g., exporting country GDP) and bilateral determinants (e.g., physical distance and virtual proximity between two countries).

Our primary empirical strategy is a two-step (-stage) approach that uses fixed-effects estimation in the first step only. This yields estimates of the coefficients on bilateral variables. The second-stage estimation involves the estimates of fixed effects from the first step and the observable country-specific variables, but it is not a fixed-effects estimation.[24] PPML is used in each step. To be clear, a two-stage

[24]Not using fixed-effects estimation presumes independence between the country-specific observable and unobservable characteristics. For instance, country-specific policy-induced overall trade restrictions on either manufactures or services

estimation of the gravity equation is not new; see, for instance, Head and Ries (2008) and Head and Mayer (2014). However, we detail our procedure in section 3.3 for the sake of exposition and clarity.

3.3 A Two-Stage PPML Procedure

We begin by translating eq. (29) into the following econometric specification:

$$X_{jir} = \exp(x_{ji} + m_{jr}) \cdot \mathrm{GDP}_i^{\alpha_j} \cdot L_r^{\beta_j} \cdot \mathrm{gdp}_r^{\gamma_j} \cdot \exp(\theta_{jQ}\mathrm{INQ}_r) \cdot \tau_{jir}^{-\epsilon_j} + v_{jir}, \;\; \alpha_j, \beta_j, \epsilon_j > 0, \tag{30}$$

where v_{jir}'s are the purely bilateral trade error terms. The terms x_{ji} and m_{jr} capture the effects of unobservable exporting-country-specific and importing-country-specific variables, including the multilateral resistance terms. The other variables are: GDP of the exporting country (GDP_i), population and per capita GDP of the importing country (L_r and gdp_r) and trade costs τ_{jir}. The population size of the importing country appears multiplicatively linear in (29), because of the assumption of identical households in our theoretical model. Once we depart from this assumption, bilateral trade will not be multiplicatively linear with respect to the population size.

We need to specify the bilateral cost term, τ_{jir} as a function of observables. Following the literature, we adopt a specification that includes traditional variables to characterize bilateral costs such as geographical distance and shared border, and, in addition, internet penetration and virtual proximity. Although the last two variables are often neglected in gravity estimation, we show that they play an important role in predicting trade flows in both manufacturing and services. We define the following bilateral trade cost function:

$$\begin{aligned}\tau_{jir} = \cdot \exp\Big[&\tilde{\theta}_{jD} \ln \mathrm{DIST}_{ir} + \tilde{\theta}_{jB}\mathrm{BORDER}_{ir} + \tilde{\theta}_{jL}\mathrm{LANG}_{ir} + \tilde{\theta}_{jC}\mathrm{COLN}_{ir} \\ &+\tilde{\theta}_{jXI}\mathrm{INTPEN}_i + \tilde{\theta}_{jMI}\mathrm{INTPEN}_r + \tilde{\theta}_{jK} \ln \mathrm{BLINK}_{ir}\Big],\end{aligned} \tag{31}$$

One of the main challenges is to deal with the unobservable exporting-country-specific and importing-country-specific terms x_{ji} and m_{jr}. We assume

$$\begin{aligned}&\text{Exporting Country: } x_{ji} = A_j + \xi_{ji} \\ &\text{Importing Country: } m_{jr} = B_j + \xi_{jr},\end{aligned} \tag{32}$$

where ξ_{ji} and ξ_{jr} respectively represent the exporter-country-specific and importer-country-specific error terms. Substituting (31) and (32) into (30),

$$\begin{aligned}X_{jir} = \exp\Big(&A_j + B_j + \xi_{ji} + \xi_{jr} + \alpha_j \ln \mathrm{GDP}_i + \beta_j \ln L_r + \gamma_j \ln \mathrm{gdp}_r + \theta_{jQ}\mathrm{INQ}_r + \theta_{jXI}\mathrm{INTPEN}_i \\ &+ \theta_{jMI}\mathrm{INTPEN}_r + \theta_{jD} \ln \mathrm{DIST}_{ir} + \theta_{jK} \ln \mathrm{BLINK}_{ir} + \theta_{jB}\mathrm{BORDER}_{ir} \\ &+ \theta_{jL}\mathrm{LANG}_{ir} + \theta_{jC}\mathrm{COLN}_{ir}\Big) + v_{jir},\end{aligned} \tag{33}$$

where $\theta_{jD} \equiv -\tilde{\theta}_{jD}\epsilon_j$, $\theta_{jXI} \equiv -\tilde{\theta}_{jXI}\epsilon_j$, $\theta_{jMI} \equiv -\tilde{\theta}_{jMI}\epsilon_j$, $\theta_{jK} \equiv -\tilde{\theta}_{jK}\epsilon_j$, $\theta_{jB} \equiv -\tilde{\theta}_{jB}\epsilon_j$, $\theta_{jL} \equiv -\tilde{\theta}_{jL}\epsilon_j$, $\theta_{jC} \equiv -\tilde{\theta}_{jC}\epsilon_j$. We further represent eq. (33) by separating country-specific terms from bilateral terms.

$$X_{jir} = \exp\Big(X_{ji} + M_{jr} + \theta_{jD} \ln \mathrm{DIST}_{ir} + \theta_{jK} \ln \mathrm{BLINK}_{ir}$$

— which are not accounted for in our model — may be correlated with observed country-specific variables like GDP or per capita GDP. Nonetheless, relying solely on the fixed-effects estimator goes too far insofar as not permitting an estimation of the coefficients of country-specific observable variables, which are unquestionably relevant to study.

$$+\theta_{jB}\text{BORDER}_{ir} + \theta_{jL}\text{LANG}_{ir} + \theta_{jC}\text{COLN}_{ir}\Big) + v_{jir}, \tag{34}$$

where,

$$\begin{aligned} X_{ji} &\equiv A_j + \alpha_j \ln \text{GDP}_i + \theta_{jXI}\text{INTPEN}_i + \xi_{ji} \\ M_{jr} &\equiv B_j + \beta_j \ln L_r + \gamma_j \ln \text{gdp}_r + \theta_{jQ}\text{INQ}_r + \theta_{jMI}\text{INTPEN}_r + \xi_{jr}. \end{aligned} \tag{35}$$

Our two-stage technique estimates the parameters in eqs. (34) and (35) separately. In the first stage, we employ fixed-effects estimation of (34) by using PPML *a la* Santos Silva and Tenreyro (2006, 2011), a standard approach. The first-stage estimation yields bilateral-trade estimates $\hat{\theta}_{jD}, \hat{\theta}_{jK}, \hat{\theta}_{jB}, \hat{\theta}_{jL}$ and $\hat{\theta}_{jC}$ as well as $\widehat{\exp(X_{ji})}$ and $\widehat{\exp(M_{jr})}$, where the last two estimates measure the sum of the unobservable multilateral resistance effects and the observable country-specific effects. The parameters ϵ_m and ϵ_s are not identified, but whether or not $\epsilon_m > \epsilon_s$ can be verified *a la* Result 6, i.e., from whether or not the estimate of α_m exceeds that of α_s.

Country-specific effects, e.g., estimates of $\alpha_j, \beta_j, \gamma_j$, among other parameters, are obtained in the second stage, where, in view of (35), $\widehat{\exp(X_{ji})}$ and $\widehat{\exp(M_{jr})}$ are separately regressed against country-specific variables. From their respective definitions,

$$\begin{aligned} &\widehat{\exp\left(X_{ji}\right)} = \exp\left(Z_{ji} + \xi_{ji}\right); \quad \widehat{\exp\left(X_{jr}\right)} = \exp\left(Z_{jr} + \xi_{jr}\right), \quad \text{where} \\ &Z_{ji} \equiv A_j + \alpha_j \ln \text{GDP}_i + \theta_{jXI} \ln \text{INTPEN}_i \\ &Z_{jr} \equiv B_j + \beta_j \ln L_r + \gamma_j \ln \text{gdp}_r + \theta_{jQ}\text{INQ}_r + \theta_{jMI} \ln \text{INTPEN}_r. \end{aligned} \tag{36}$$

We estimate the two equations in (36) by PPML.[25] This is different from Head and Mayer (2014), who use generalized least-squares. Both approaches however account for heteroskedasticity issues.

Multilateral resistance terms, adjusted for the constants A_j and B_j, are subsumed in ξ_{ji} and ξ_{jr}, whose estimates are $\widehat{\exp\left(X_{ji}\right)}/\widehat{\exp\left(Z_{ji}\right)}$ and $\widehat{\exp\left(M_{jr}\right)}/\widehat{\exp\left(Z_{jr}\right)}$ respectively. Our procedure essentially differs from the (single-stage) random-intercept model in that it identifies and deals with the exporter and importer-specific effects separately. This is more efficient because the variations in the bilateral-trade-specific error terms do not directly influence the estimated coefficients of observable country-specific factors.

3.4 Endogeneity Issue with BLINK

For the years 2009 to 2015, we use the BLINK data for 2009 – which we refer to as BLINK09. However, the number of bilateral hyperlinks may be affected by bilateral trade, an endogeneity issue due to reverse causality. As shown by Reed (2015), lagging a regressor does not purge the simultaneity and the endogeneity bias.

[25]The multiplicative error terms can be easily transformed into additive ones by defining

$$\exp(u_{ji}) \equiv 1 + \frac{\nu_{ji}}{\sqrt{\exp\left(Z_{ji}\right)}} \qquad \exp(u_{jr}) \equiv 1 + \frac{\nu_{jr}}{\sqrt{\exp\left(Z_{jr}\right)}},$$

where ν_{ji} and ν_{jr} are statistically independent of Z_{ji} and Z_{jr} respectively and $\mathbb{E}\left(\nu_{ji}\right) = \mathbb{E}\left(\nu_{jr}\right) = 0$. The respective conditional means equal the respective conditional variance and thus the resulting moment equations are equally weighted, which facilitates the use of PPML estimation. See (Feenstra, 2016, Chapter 6) for a lucid treatment of the structure of error term under which PPML can be applied.

Endogeneity is a concern as long as BLINK09 is a regressor. We need to instrument it.[26] We consider two instruments for BLINK09. The first is the number of bilateral hyperlinks in 2003 (BLINK03) as do Hellmanzik and Schmitz (2016, 2017). The authors argue that the past values of bilateral hyperlinks are pre-determined, thus unaffected by future shocks to bilateral trade. However, there might still be concerns that this instrument is correlated with unobserved characteristics associated with future bilateral trade flows. Moreover, the 2003 bilateral hyperlinks data is available for only 46 countries, drastically reducing the sample size and potentially raising selection concerns. We, therefore, consider another instrument, constructed from the number of broadband connections that the exporter and the importer countries had internally in 2003. We call it BROAD03, which we interpret as a joint measure of each pair of countries' pre-existing information and communication technology infrastructure. The rationale is that the number of bilateral hyperlinks between two countries would depend, among other factors, on the number of broadband connections in those countries. We define BROAD03 as the product of the number of broadband connections in the two countries in 2003. This has the intuitive property that its magnitude would be small if the number of broadband connections in either country is sufficiently small. Moreover, it is unlikely that BROAD03 would affect current and future bilateral trade on its own, independent of BLINK09. We thus believe that BROAD03 meets the exclusion restriction.

4 Results

In this section, we present the results of our estimates of eqs. (34) and (35). First, we apply our two-stage procedure using data on all 177 countries in our sample for each year in 2002-2015 period. In this 'baseline' specification, we include all explanatory variables except bilateral hyperlinks, BLINK09. In Stage 2 there are two dependent variables: the estimated exporter fixed effects and estimated importer fixed effects on bilateral trade from stage 1 estimation. Stage 2 estimations recover the effects of *observable* country-specific variables. In these regressions, we use nominal GDPs expressed in US$ and GINI coefficient as the measures of size and inequality.[27] The results are reported in Tables 5 and 6 for service trade and trade in manufactures, respectively.

Next, we estimate the same baseline equations (without the BLINK09 variable), while restricting the sample to those 82 countries for whom BLINK09 data is indeed available. The goal is to compare the marginal effects of other variables between the absence and presence of bilateral hyperlinks. The results are presented in Table 7.

Considering the potential endogeneity issues with BLINK09, we proceed with an instrumental variable approach. As discussed earlier, the two instruments under consideration are BLINK03 and BROAD03. To test the validity of our proposed instruments, we first estimate an auxiliary regression (equivalent to a first-stage regression in a standard 2SLS procedure) by OLS:

$$\text{BLINK09}_{ir} = \alpha + \xi_i + \xi_r + \beta \cdot IV_{ir}^{(1)|(2)} + \boldsymbol{\gamma}' \cdot \boldsymbol{V}_{ir} + \epsilon_{ir} \tag{37}$$

where ξ_i and ξ_r represent the exporter and importer fixed effects, respectively; $IV_{ir}^{(1)|(2)}$ represent the two considered instruments; $\boldsymbol{V}_{ir}$ is the set of bilateral variables that include the distance, common border, common language and colonial relationship in the past and ϵ_{ir} is the random term. Table 8

[26] Besides mitigation of endogeneity concerns by instrumenting BLINK09, in the presence of two fixed effects in our model the concerns of the presence of the incidental parameter problem are alleviated too (see Fernández-Val and Weidner (2016)).

[27] Alternative measures of GDP and income inequality are discussed in Section 5.

reports the results for BROAD03 (column 1) and BLINK03 (column 2). The coefficients on the instruments are highly significant and the F–statistics for both are large and significant, reducing concerns for the presence of weak instrument issues.

Between the two instrumental variables, BROAD03 is our preferred choice however. There are three reasons. First, we have data on BROAD03 for a larger sample of countries. Second, Table 8 shows a stronger relationship between BLINK09 and BROAD03 than between BLINK09 and BLINK03. Third, BROAD03 entails less scope for violations of the exclusion restriction relative to BLINK03. Accordingly, given the coefficients from Table 8 in Column (1), we calculate the predicted (log) number of bilateral hyperlinks in 2009. We then estimate the two-stages of the gravity equations, as described in section 3.3, but replacing the log of BLINK09 by its predicted counterpart from eq. (37). Table 9 reports the results. In what follows, we organize our discussion of results around the explanatory variables.

4.1 Exporter's GDP, Importer's Population, and Importer's per capita GDP

The second stage results reported in all four tables show that the exporting country's GDP, the importing country's population, and per capita income are positively associated with bilateral trade for both product groups. This is hardly surprising. But note that the estimated coefficients on these variables are consistent with our theoretical model *in terms of ranking*. The exporter GDP coefficients for manufacturing and services are plotted without BLINK09 being included in Figure 5(a) over the period 2002-2015, while the results with BLINK09 included are illustrated in Figure 5(b) for years 2009 to 2015. With some exceptions, the estimated coefficients are higher for manufacturing than services.

As these coefficients are monotonically related to Armington elasticities, which, in turn, are inversely related to the degree of *product differentiation*, the ranking of the coefficients indirectly supports one of our basic premises that services are more nationally differentiated than manufactures.

Figure 5(c) depicts the coefficients on importer per capita GDP in the specification without BLINK09. The numbers are again consistent with the theory: the elasticities of bilateral trade in services with respect to the importing country per capita GDP are greater, compared to that in manufacturing. Panel (d) depicts the coefficients of importing-country per capita GDP for the period 2009-2015, where BLINK is accounted for. The rankings are clear and agree with theory. The exporter GDP elasticity for manufacturing ranges from 0.36 to 0.64, whereas that for services ranges from 0.38 to 0.57. The importer per capita GDP elasticity for bilateral trade in manufacturing lies in the range 0.38-0.71, whereas for bilateral trade in services, the range is 0.72-0.98.

A stark finding is that the coefficients on exporter GDP, importer population, and per capita importer GDP become significantly lower when BLINK is included in our specifications. All six panels in Figure 6 illustrate this. BLINK tends to increase bilateral trade, and, as Table 10 shows, BLINK09 is positively correlated with all three variables. Thus, the omission of BLINK entails an omitted-variable problem and leads to an over-estimation of coefficients on these variables. This finding underscores that virtual proximity is an important missing component in the literature, hitherto, on the estimation of trade costs of bilateral trade in both manufacturing and services.

We can transform the population, and per capita GDP variables of the importing country into the GDP and the per capita GDP by substituting the log of the population as the log of GDP − log of per capita GDP. Hence, the coefficients of importer's GDP are equal to the coefficients on population, and those of per capita GDP equals the respective coefficients in Tables 5-9 minus the respective coefficient of the population. Notice that in each set of regression, the coefficients on population are smaller than those on per capita GDP. Hence in the (GDP, per capita GDP) space for the importing

Table 5: **Trade in Services** - PPML estimates Year-by-Year Using the 2-Stage Approach (2002 to 2015)

	International Trade in Services (level)													
	(1) 2002	(2) 2003	(3) 2004	(4) 2005	(5) 2006	(6) 2007	(7) 2008	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.66***	–0.65***	–0.64***	–0.64***	–0.67***	–0.69***	–0.68***	–0.69***	–0.64***	–0.61***	–0.62***	–0.63***	–0.66***	–0.64***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.34*	0.28*	0.32*	0.49***	0.37**	0.29*	0.27*	0.26*	0.23	0.24*	0.26*	0.28*	0.15	0.10
	(0.14)	(0.14)	(0.13)	(0.14)	(0.13)	(0.13)	(0.13)	(0.12)	(0.13)	(0.12)	(0.11)	(0.12)	(0.11)	(0.12)
Common language	0.33**	0.39**	0.37***	0.30*	0.37**	0.38**	0.40***	0.39***	0.35***	0.42***	0.37***	0.36***	0.42***	0.43***
	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Colony	0.29*	0.22	0.28*	0.17	0.12	0.12	0.15	0.12	0.40***	0.42***	0.42***	0.31**	0.28**	0.24*
	(0.14)	(0.14)	(0.13)	(0.13)	(0.14)	(0.14)	(0.13)	(0.13)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)
N	4500	4885	5577	12433	13158	14790	14875	25762	31152	30976	31152	30450	31152	31152
R-sq	0.87	0.85	0.86	0.82	0.82	0.82	0.81	0.82	0.83	0.85	0.85	0.84	0.85	0.85
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$														
Exporter GDP (log)	0.85***	0.84***	0.83***	0.85***	0.85***	0.85***	0.89***	0.89***	0.83***	0.82***	0.80***	0.83***	0.83***	0.83***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.07)	(0.08)	(0.07)	(0.08)	(0.09)	(0.09)	(0.11)	(0.09)	(0.09)
Internet Exporter	0.01***	0.01***	0.01***	0.01**	0.01**	0.01**	0.01***	0.01***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	35	34	38	77	80	79	80	132	146	136	130	119	108	96
R-sq	0.98	0.98	0.97	0.93	0.94	0.93	0.91	0.90	0.86	0.84	0.85	0.81	0.86	0.88
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.55***	0.53***	0.53***	0.67***	0.67***	0.70***	0.73***	0.72***	0.73***	0.73***	0.73***	0.75***	0.72***	0.70***
	(0.04)	(0.04)	(0.04)	(0.07)	(0.06)	(0.07)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Importer GDP percap (log)	1.34***	1.28***	1.23***	1.18***	1.29***	1.24***	1.16***	1.26***	1.06***	1.08***	1.10***	1.31***	1.33***	1.28***
	(0.12)	(0.12)	(0.09)	(0.12)	(0.12)	(0.13)	(0.13)	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)	(0.09)	(0.08)
Internet Importer	–0.00	–0.00	–0.00	0.01	0.00	0.00	0.01	0.01	0.02*	0.02**	0.02**	0.01	0.01	0.00
	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)
Importer Gini	0.06***	0.06***	0.06***	0.02	0.02	0.02	0.02	0.02	0.05**	0.04**	0.04*	0.04*	0.05***	0.04**
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
N	35	34	38	77	80	79	80	132	146	136	130	119	108	96
R-sq	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.95	0.95	0.95	0.96	0.95	0.97	0.98

Notes: Robust standard errors are in parentheses. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 6: **Trade in Manufacturing** - PPML estimates Year-by-Year Using the 2-Stage Approach (2002 to 2015)

	International Trade in Manufacturing													
	(1) 2002	(2) 2003	(3) 2004	(4) 2005	(5) 2006	(6) 2007	(7) 2008	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.70***	–0.73***	–0.74***	–0.77***	–0.76***	–0.76***	–0.76***	–0.76***	–0.76***	–0.76***	–0.73***	–0.76***	–0.75***	–0.74***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.70***	0.61***	0.62***	0.57***	0.55***	0.53***	0.51***	0.52***	0.52***	0.51***	0.57***	0.55***	0.56***	0.56***
	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
Common language	0.23**	0.24**	0.23**	0.23*	0.23**	0.30***	0.29***	0.26**	0.23**	0.24**	0.22*	0.27**	0.25**	0.23**
	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
Colony	–0.02	0.01	0.02	0.08	0.07	0.12	0.15	0.16	0.17	0.21	0.17	0.15	0.11	0.08
	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
N	30800	30800	30800	30800	30800	30800	30800	30800	30800	30800	31152	31152	31152	31152
R-sq	0.90	0.89	0.89	0.89	0.88	0.88	0.87	0.87	0.88	0.87	0.88	0.89	0.89	0.90
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$														
Exporter GDP (log)	0.80***	0.81***	0.80***	0.85***	0.88***	0.90***	0.91***	0.88***	0.90***	0.91***	0.90***	0.92***	0.91***	0.89***
	(0.06)	(0.07)	(0.09)	(0.09)	(0.09)	(0.11)	(0.10)	(0.10)	(0.11)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)
Internet Exporter	–0.00	–0.00	–0.00	–0.01	–0.01	–0.01	–0.01	–0.00	–0.00	–0.00	–0.00	–0.01	–0.01	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	148	148	148	153	154	157	156	150	146	136	130	120	108	96
R-sq	0.90	0.87	0.81	0.78	0.78	0.75	0.76	0.75	0.71	0.72	0.75	0.76	0.77	0.77
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.79***	0.80***	0.80***	0.80***	0.80***	0.79***	0.77***	0.78***	0.78***	0.78***	0.78***	0.79***	0.77***	0.74***
	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)
Importer GDP percap (log)	0.91***	0.82***	0.81***	0.85***	0.85***	0.81***	0.80***	0.80***	0.82***	0.86***	0.90***	1.08***	1.11***	1.10***
	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.08)	(0.11)	(0.13)	(0.12)	(0.12)	(0.11)	(0.09)
Internet Importer	0.01	0.01*	0.01*	0.01	0.01	0.01	0.01*	0.01	0.01	0.01	0.00	–0.01	–0.01	–0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.04***	0.05***	0.05***	0.05***	0.05***	0.04***	0.05***	0.05***	0.05***	0.04***	0.05***	0.04***	0.05***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	148	148	148	153	154	157	156	150	146	136	130	120	108	96
R-sq	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.95	0.94	0.93	0.94	0.96	0.97	0.98

Notes: Robust standard errors are in parentheses. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 7: PPML estimates Year-by-Year Using the 2-Stage Approach only the countries with BLINK information but without BLINK09 as a Regressor

	Services							Manufacturing						
	(1) 2009	(2) 2010	(3) 2011	(4) 2012	(5) 2013	(6) 2014	(7) 2015	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.65***	–0.63***	–0.60***	–0.61***	–0.59***	–0.63***	–0.62***	–0.69***	–0.68***	–0.68***	–0.68***	–0.68***	–0.68***	–0.67***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.32**	0.29*	0.33**	0.36**	0.36**	0.23*	0.18	0.61***	0.63***	0.64***	0.68***	0.69***	0.68***	0.69***
	(0.12)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.10)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
Common language	0.38**	0.30**	0.36***	0.31**	0.36***	0.42***	0.42***	0.23*	0.18	0.18	0.18	0.17	0.16	0.14
	(0.12)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)
Colony	0.05	0.36***	0.33***	0.34**	0.25*	0.22*	0.18	0.09	0.10	0.15	0.12	0.08	0.04	0.02
	(0.13)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
N	3724	3741	3741	3741	3741	3741	3741	3696	3696	3696	3741	3741	3741	3741
R-sq	0.83	0.84	0.86	0.86	0.85	0.86	0.87	0.89	0.90	0.90	0.91	0.92	0.92	0.93
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$														
Exporter GDP (log)	0.90***	0.85***	0.84***	0.82***	0.85***	0.85***	0.85***	0.85***	0.87***	0.86***	0.88***	0.89***	0.89***	0.88***
	(0.08)	(0.09)	(0.09)	(0.10)	(0.10)	(0.08)	(0.07)	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.10)	(0.09)
Internet Exporter (log)	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	–0.00	–0.00	–0.00	–0.00	–0.00	–0.00	–0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	80	82	82	81	82	82	82	81	81	81	81	82	82	82
R-sq	0.90	0.86	0.84	0.84	0.83	0.88	0.90	0.71	0.67	0.69	0.72	0.73	0.75	0.76
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.73***	0.73***	0.73***	0.74***	0.75***	0.72***	0.70***	0.76***	0.78***	0.78***	0.78***	0.78***	0.77***	0.74***
	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.04)
Importer GDP percap (log)	1.19***	1.01***	1.01***	1.04***	1.25***	1.25***	1.21***	0.80***	0.79***	0.82***	0.89***	1.05***	1.08***	1.06***
	(0.12)	(0.11)	(0.12)	(0.11)	(0.12)	(0.10)	(0.08)	(0.10)	(0.13)	(0.14)	(0.14)	(0.13)	(0.12)	(0.10)
Internet Importer	0.01	0.02*	0.02**	0.01*	0.00	0.00	0.00	0.01	0.01	0.01	0.00	–0.01	–0.01	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.03	0.05**	0.05***	0.04**	0.04*	0.05***	0.04**	0.04**	0.05**	0.04**	0.04**	0.04**	0.04**	0.05**
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
N	75	76	73	72	70	69	61	76	76	73	72	70	69	61
R-sq	0.96	0.95	0.95	0.96	0.95	0.97	0.98	0.94	0.93	0.93	0.93	0.96	0.96	0.97

Notes: Robust standard errors are in parentheses. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 8: Instrumental Variable Validation: First-Stage Regressions

	Dependent Variable: BLINK09 (log)	
	(1)	(2)
BROAD03 (log)	0.63***	
	(0.02)	
BLINK03 (log)		0.32***
		(0.01)
Distance (log)	–0.35***	–0.20***
	(0.02)	(0.02)
Common border	0.50***	0.26***
	(0.08)	(0.06)
Common language	0.61***	0.17***
	(0.05)	(0.05)
Colony	0.20**	0.06
	(0.07)	(0.06)
N	3,037	1,580
R-sq	0.95	0.96
F-statistic	390.01	435.18
Exporter and Importer FE	✓	✓

countries, the coefficients on per capita GDP remain positive. This is, in essence, similar to Dalgin et al. (2008).

Notice also that, given Table 9, the elasticity of bilateral trade in both manufacturing and services with respect to the size variables, i.e., exporter GDP, importer GDP, and importer GDP per capita, are less than unity. This is consistent with Santos Silva and Tenreyro (2006, page 650), who also noted GDP or per capita GDP elasticity for manufacturing trade to be less than one and argued that this may be due to larger countries tending to be less open. We note another possible reason: the absence of wealth variables that can also affect aggregate consumption and bilateral trade.

4.2 Income Inequality in the Importer Country

As argued in Section 2.5, theoretically, the effect of inequality on bilateral trade is ambiguous. Hence, it is primarily an empirical issue. The coefficient on GINI is positive for both manufacturing and services, i.e., bilateral trade in both product categories is positively associated with income inequality. In Table 9, the coefficients on GINI are positive and nearly identical between manufacturing and services but statistically insignificant for many of the sample years. In sum, our empirical analysis implies that importer-country inequality is not a strong predictor of bilateral trade.

4.3 Overall (Unobservable-) Trade-Cost Elasticity

Our empirical model does not yield point estimates of the overall trade-cost elasticities for either product group. However, the magnitudes of these elasticities are monotonic with respect to the Armington elasticities that rank the elasticities of bilateral trade with respect to the size of a country as an exporter, whose point estimates are indeed available: see Table 9 and Figure 5.

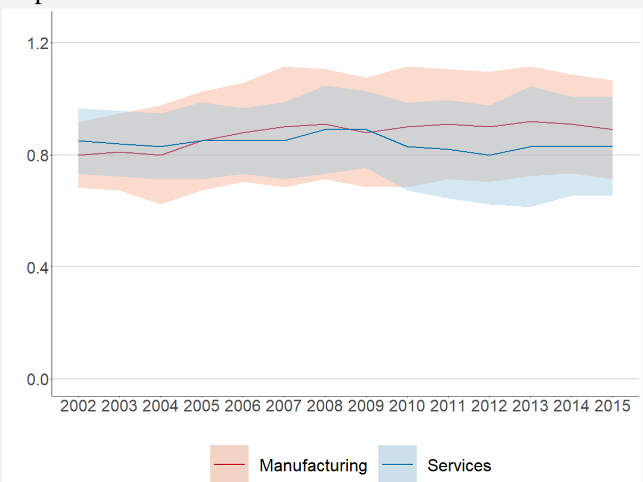
Table 9: Two-stages PPML estimates with BLINK09 instrumented by BROAD03

	Services							Manufacturing						
	(1) 2009	(2) 2010	(3) 2011	(4) 2012	(5) 2013	(6) 2014	(7) 2015	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.53***	–0.51***	–0.48***	–0.49***	–0.47***	–0.50***	–0.49***	–0.60***	–0.59***	–0.58***	–0.52***	–0.58***	–0.58***	–0.58***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.15	0.08	0.13	0.15	0.16	0.04	–0.00	0.48***	0.50***	0.50***	0.46***	0.56***	0.55***	0.56***
	(0.13)	(0.14)	(0.12)	(0.12)	(0.13)	(0.12)	(0.12)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Common language	0.20	0.10	0.17	0.11	0.16	0.19	0.20	0.08	0.03	0.02	–0.08	0.01	–0.00	–0.01
	(0.13)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Colony	–0.05	0.25*	0.22*	0.23*	0.15	0.11	0.08	0.00	0.01	0.03	–0.05	–0.05	–0.07	–0.07
	(0.13)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
BLINK09 (log)	0.32***	0.35***	0.34***	0.35***	0.36***	0.37***	0.36***	0.24***	0.26***	0.27***	0.43***	0.27***	0.26***	0.26***
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
N	3,020	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.83	0.85	0.87	0.86	0.85	0.86	0.87	0.89	0.90	0.90	0.91	0.92	0.92	0.93
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$														
Exporter GDP (log)	0.57***	0.43***	0.41***	0.38***	0.41***	0.40***	0.43***	0.59***	0.59***	0.57***	0.36**	0.63***	0.63***	0.64***
	(0.09)	(0.10)	(0.10)	(0.10)	(0.11)	(0.09)	(0.09)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)
Internet Exporter	0.01***	0.01***	0.01***	0.01***	0.02***	0.01***	0.01***	–0.00	0.00	0.00	0.00	–0.00	–0.00	–0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	68	68	68	68	68	68	68	68	68	68	68	68	68	68
R-sq	0.72	0.59	0.57	0.52	0.52	0.55	0.60	0.54	0.49	0.46	0.25	0.58	0.60	0.63
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.43***	0.33***	0.33***	0.33***	0.36***	0.33***	0.34***	0.47***	0.48***	0.46***	0.24***	0.48***	0.49***	0.49***
	(0.07)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.05)
Importer GDP percap (log)	0.98***	0.82***	0.72***	0.77***	0.88***	0.90***	0.97***	0.54***	0.51***	0.47***	0.38**	0.66***	0.70***	0.71***
	(0.16)	(0.13)	(0.12)	(0.12)	(0.14)	(0.16)	(0.15)	(0.12)	(0.12)	(0.13)	(0.14)	(0.17)	(0.17)	(0.17)
Internet Importer	0.00	0.00	0.01	0.01	0.00	–0.00	–0.01	0.00	0.00	0.00	–0.00	–0.01	–0.01	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.01	0.04	0.04*	0.04*	0.03	0.04**	0.03*	0.04	0.04*	0.03	0.03*	0.03*	0.03	0.04
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	64	66	64	63	61	60	55	65	66	64	63	61	60	55
R-sq	0.80	0.75	0.75	0.77	0.74	0.76	0.80	0.80	0.79	0.73	0.42	0.78	0.82	0.85

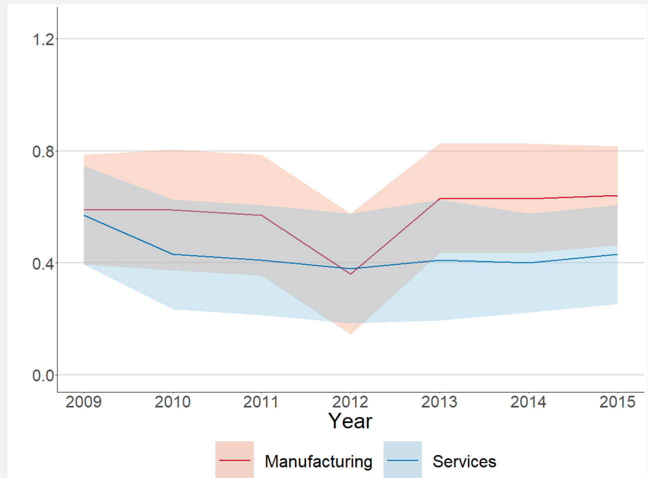
Notes: Robust standard errors are in parentheses. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Figure 5: **Coefficients on Exporter GDP and Importer per capita GDP**

Exporter GDP

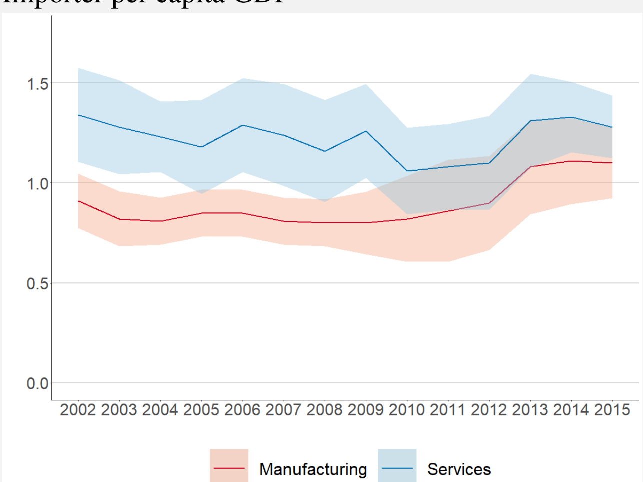


(a) No BLINK

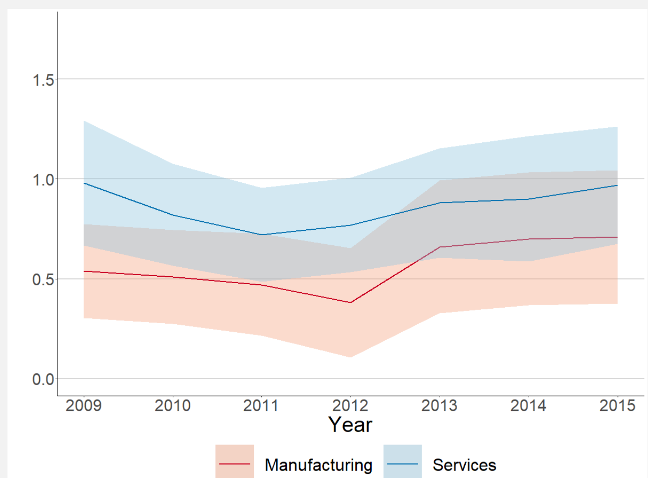


(b) BLINK09 included

Importer per capita GDP



(c) No BLINK



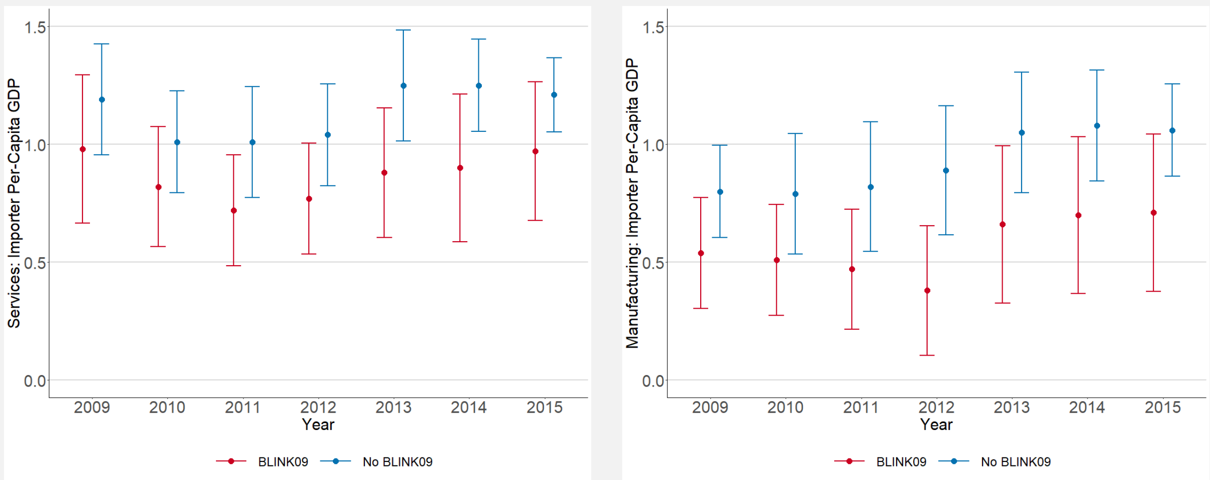
(d) BLINK09 included

The exporting-country GDP elasticity being greater for manufacturing, the Armington elasticity is higher for manufacturing, implying that the trade-cost elasticity of bilateral trade is higher for manufacturing than for services. This is consistent with the theoretical prediction in Result 7. As noted earlier, it indirectly validates our Difference in the National Product Differentiation assumption.

4.4 Observable Trade Costs

Internet Penetration Tables 5 through Table 9 show a positive and statistically significant effect of internet usage in the exporter country on international trade of services. However, we do not observe

Figure 6: **Coefficients on Exporter GDP, Importer Population and Importer per capita GDP**



(a) No BLINK

(b) BLINK09 included

Table 10: Correlations with Bilateral hyperlinks

	Correlation with BLINK09						
	2009	2010	2011	2012	2013	2014	2015
Exporter GDP (log)	0.6259***	0.6278***	0.6288***	0.6244***	0.6223***	0.6204***	0.6219***
Importer Population (log)	0.4287***	0.4270***	0.4252***	0.4236***	0.4219***	0.4202***	0.4187***
Importer GDP percap (log)	0.2526***	0.2678***	0.2740***	0.2736***	0.2667***	0.2646***	0.2725***

Note: *** Denotes statistical significance at 1%.

a consistent and statistically significant effect of internet usage in the importer country for trade in services. Moreover, the coefficients for internet usage in countries both as exporters and importers are not statistically significant for trade in manufacturing, suggesting that, at the margin, trade in manufactures is *not* affected by the *overall* internet usage in either country.

Internet usage is likely to be positively and strongly associated with the number of internet websites in a country, which provides essential information on sellers' products and services in particular. Typically, the producers advertise their products on their websites, reaching potential consumers at home and abroad. Thus, internet usage is expected to reduce trade costs for exporting firms. From the importer country's perspective, its import behavior is not so much affected by the extent of internet use in that country as does the internet use in the countries that export their products.

Freund and Weinhold (2002) is among the first to investigate this empirically, and their finding is somewhat qualified: for trade in services between the U.S. and other countries, internet usage in other countries positively impacts their exports to the U.S. in specific categories of services. More generally interpreted, internet utilization is positively associated with bilateral services exports. In a related paper, Freund and Weinhold (2004) find that internet usage is positively associated with overall export growth. The authors argue that their findings are consistent with a model in which internet use reduces market-specific fixed costs of trade, which are likely to enhance export growth. Our results indicate that the same overall qualitative pattern as in Freund and Weinhold (2002, 2004) hold on average across many countries and years for trade in services.

Bilateral Hyperlinks In contrast to the overall use of internet in a trading country, virtual proximity – captured by BLINK09 – constitutes a strong trade-cost-reducing agent and exerts positive effects on bilateral trade for both services and manufacturing. Observe in Table 9 that the coefficients on the instrumented BLINK09 are positive and statistically significant. Furthermore, bilateral trade in services is more sensitive to virtual proximity compared to manufacturing. On average, a 10% increase in bilateral hyperlinks leads, barring the year 2012, to a 2.4 to 2.7% increase in bilateral trade in manufacturing and 3.2 to 3.7% increase in bilateral trade in services.

Distance, Common Border, Common Language and Colony, and, Substitution Effects The coefficients of these standard trade-cost variables bear their expected signs. It is surprising however that when BLINK09 is included as a regressor, the coefficients of common language and colonial relation generally become statistically insignificant. Moreover, the coefficient on the common border is significant for manufacturing trade but not for trade in services, while physical distance remain highly significant for trade in both services and manufacturing. As expected, compared to manufacturing, bilateral trade in services is less sensitive to physical distance.

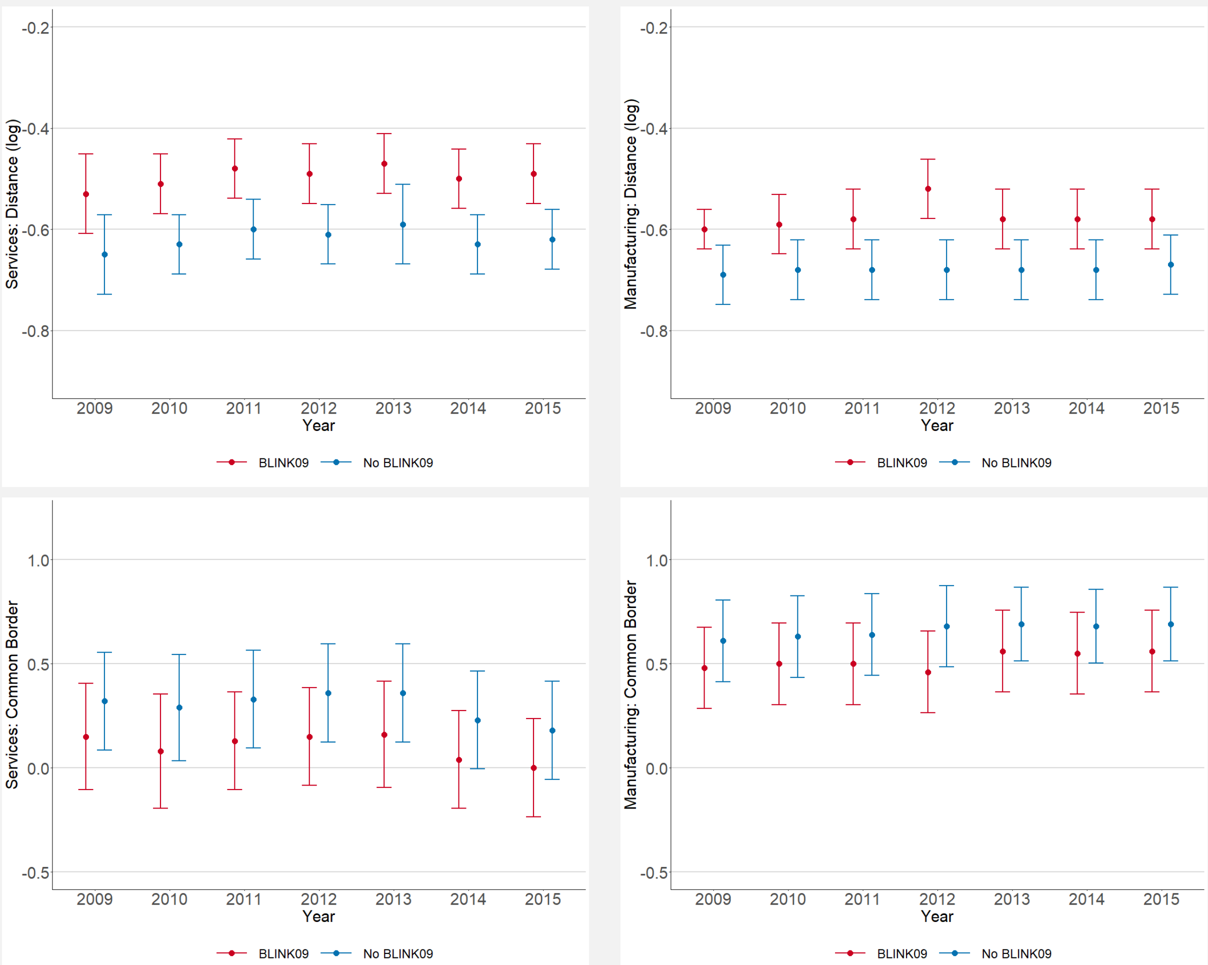
It is of interest to know how the coefficients on these variables change once we account for the virtual proximity variable. Comparing Tables 7 and 9 we observe that, with virtual proximity present as a regressor, the marginal impacts of distance, common border, and common language on trade in both services and manufacturing become smaller in magnitude. This is illustrated in Figure 7 for distance and common border.

The estimates for geographical distance imply that virtual proximity partly substitutes physical proximity. There are two essential points on this finding. First, it does *not* mean that physical proximity is less important than virtual proximity. Indeed, the absolute value of the coefficient on physical distance exceeds the coefficient on virtual proximity for both manufacturing and services.

Second, how does the virtual proximity substitution result relate to the "distance puzzle" *a la*

Brun et al. (2005), Disdier and Head (2008) and Yotov (2012)? Insofar as increasing globalization includes an increasing flow of information between countries through the internet, we may infer from Figure 7(a) that there is no distance puzzle since the partial effect of distance has indeed decreased. The process has presumably begun much before 2009. However, keeping apart the downward shift of the distance coefficient due to virtual proximity, we still see that the physical distance coefficient is remarkably stable from one year to the next. In this sense, the distance puzzle remains. Of course, we know from Yotov (2012) that the key lies in accounting for internal trade and internal distance effect. We believe that if these variables are included, the coefficients on distance will, with the advent of virtual proximity, have a decreasing trend over time, combined with a downward shift.

Figure 7: **Coefficients on Distance and Common Border: BLINK versus No BLINK**



(c) Common Border in Services

(d) Common Border in Manufacturing

5 Robustness

Table 11: Two-stages PPML using PPP GDP (BLINK09 Instrumented by BROAD03)

	Services							Manufacturing						
	(1) 2009	(2) 2010	(3) 2011	(4) 2012	(5) 2013	(6) 2014	(7) 2015	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.53***	–0.51***	–0.48***	–0.49***	–0.47***	–0.50***	–0.49***	–0.60***	–0.59***	–0.58***	–0.52***	–0.58***	–0.58***	–0.58***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.15	0.08	0.13	0.15	0.16	0.04	–0.00	0.48***	0.50***	0.50***	0.46***	0.56***	0.55***	0.56***
	(0.13)	(0.14)	(0.12)	(0.12)	(0.13)	(0.12)	(0.12)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Common language	0.20	0.10	0.17	0.11	0.16	0.19	0.20	0.08	0.03	0.02	–0.08	0.01	–0.00	–0.01
	(0.13)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Colony	–0.05	0.25*	0.22*	0.23*	0.15	0.11	0.08	0.00	0.01	0.03	–0.05	–0.05	–0.07	–0.07
	(0.13)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
BLINK09 (log)	0.32***	0.35***	0.34***	0.35***	0.36***	0.37***	0.36***	0.24***	0.26***	0.27***	0.43***	0.27***	0.26***	0.26***
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
N	3,020	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.83	0.85	0.87	0.86	0.85	0.86	0.87	0.89	0.90	0.90	0.91	0.92	0.92	0.93
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $\widehat{\exp}(X_{ji})$														
Exporter GDP (log)	0.59***	0.46***	0.44***	0.40***	0.42***	0.41***	0.44***	0.64***	0.65***	0.63***	0.41***	0.67***	0.68***	0.70***
	(0.09)	(0.10)	(0.10)	(0.11)	(0.12)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)
Internet Exporter	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.01*	0.01*	0.01*	0.01*	0.01	0.01	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
N	68	68	68	68	68	68	68	68	68	68	68	68	68	68
R-sq	0.74	0.61	0.59	0.54	0.50	0.52	0.53	0.57	0.54	0.50	0.29	0.61	0.62	0.63
Dependent variable: Importer Fixed Effects, $\widehat{\exp}(M_{jr})$														
Importer Population (log)	0.47***	0.38***	0.36***	0.37***	0.41***	0.36***	0.38***	0.50***	0.51***	0.48***	0.27***	0.51***	0.51***	0.52***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.07)	(0.06)	(0.05)	(0.05)
Importer GDP percap (log)	1.14***	0.96***	0.85***	0.90***	1.06***	1.30***	1.46***	0.82***	0.78***	0.75***	0.63***	0.89***	1.09***	1.09***
	(0.23)	(0.18)	(0.17)	(0.17)	(0.21)	(0.21)	(0.17)	(0.16)	(0.15)	(0.16)	(0.16)	(0.20)	(0.22)	(0.24)
Internet Importer	0.01	0.01	0.02**	0.02*	0.01	0.00	-0.00	0.01	0.01	0.00	-0.00	-0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	-0.00	0.03	0.03*	0.03*	0.02	0.03**	0.03**	0.03	0.03*	0.03	0.03	0.03	0.03*	0.04*
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
N	64	66	64	63	61	60	55	65	66	64	63	61	60	55
R-sq	0.79	0.76	0.77	0.77	0.72	0.82	0.85	0.84	0.84	0.78	0.48	0.79	0.85	0.86

Table 12: Second-Stage Estimates: Alternative Measures of Income Inequality (BLINK09 Instrumented by BROAD03)

	Services							Manufacturing						
	(1) 2009	(2) 2010	(3) 2011	(4) 2012	(5) 2013	(6) 2014	(7) 2015	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
Panel a: Importer Gini Coefficient														
Importer Population (log)	0.43***	0.33***	0.33***	0.33***	0.36***	0.33***	0.34***	0.47***	0.48***	0.46***	0.24***	0.48***	0.49***	0.49***
	(0.07)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.05)
Importer GDP percap (log)	0.98***	0.82***	0.72***	0.77***	0.88***	0.90***	0.97***	0.54***	0.51***	0.47***	0.38**	0.66***	0.70***	0.71***
	(0.16)	(0.13)	(0.12)	(0.12)	(0.14)	(0.16)	(0.15)	(0.12)	(0.12)	(0.13)	(0.14)	(0.17)	(0.17)	(0.17)
Internet Importer	0.00	0.00	0.01	0.01	0.00	–0.00	–0.01	0.00	0.00	0.00	–0.00	–0.01	–0.01	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.01	0.04	0.04*	0.04*	0.03	0.04**	0.03*	0.04	0.04*	0.03	0.03*	0.03*	0.03	0.04
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	64	66	64	63	61	60	55	65	66	64	63	61	60	55
R-sq	0.80	0.75	0.75	0.77	0.74	0.76	0.80	0.80	0.79	0.73	0.42	0.78	0.82	0.85
Panel b: Importer Top 10^{th} percentile of income share														
Importer Population (log)	0.54***	0.39***	0.39***	0.40***	0.44***	0.37***	0.42***	0.52***	0.53***	0.54***	0.32***	0.54***	0.54***	0.51***
	(0.07)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)
Importer GDP percap (log)	0.91***	0.85***	0.74***	0.77***	0.77***	0.89***	0.98***	0.57***	0.55***	0.51***	0.30*	0.65***	0.74***	0.71***
	(0.17)	(0.13)	(0.12)	(0.13)	(0.13)	(0.15)	(0.16)	(0.10)	(0.12)	(0.12)	(0.12)	(0.13)	(0.12)	(0.13)
Internet Importer	–0.00	–0.00	0.01	0.01	0.01	–0.00	–0.01	0.00	0.00	0.01	0.01	0.00	–0.00	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Top 10^{th} percentile of income share	–2.53**	1.22	1.73***	1.64***	1.42**	1.95***	2.14***	2.02**	1.87**	2.18**	3.18***	2.40***	2.50***	2.36**
	(0.94)	(0.65)	(0.46)	(0.43)	(0.50)	(0.40)	(0.39)	(0.65)	(0.63)	(0.69)	(0.63)	(0.65)	(0.64)	(0.72)
N	48	48	46	46	46	46	43	48	48	46	46	46	46	43
R-sq	0.80	0.75	0.78	0.79	0.77	0.76	0.77	0.83	0.83	0.87	0.70	0.89	0.90	0.79
Panel c: Importer Top 1^{st} percentile of income share														
Importer Population (log)	0.54***	0.37***	0.36***	0.37***	0.42***	0.34***	0.40***	0.51***	0.52***	0.51***	0.26***	0.51***	0.51***	0.48***
	(0.07)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.05)	(0.06)
Importer GDP percap (log)	0.94***	0.85***	0.71***	0.74***	0.75***	0.86***	0.96***	0.60***	0.58***	0.51***	0.27*	0.62***	0.69***	0.64***
	(0.17)	(0.12)	(0.12)	(0.13)	(0.13)	(0.15)	(0.16)	(0.10)	(0.11)	(0.12)	(0.13)	(0.15)	(0.14)	(0.14)
Internet Importer	–0.00	–0.00	0.01	0.01	0.01	–0.00	–0.01	–0.00	–0.00	0.00	0.01	–0.00	–0.00	–0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Top 1^{st} percentile of income share	–3.12	2.76**	3.40***	3.28***	2.68**	3.60***	3.89***	2.87*	2.64*	2.85	5.55***	3.70*	3.82*	3.25*
	(1.80)	(1.03)	(0.76)	(0.77)	(0.96)	(0.78)	(0.81)	(1.32)	(1.23)	(1.51)	(1.61)	(1.56)	(1.52)	(1.59)
N	49	49	46	46	46	46	43	49	49	46	46	46	46	43
R-sq	0.80	0.77	0.78	0.80	0.77	0.76	0.75	0.83	0.84	0.84	0.62	0.85	0.87	0.72

Table 13: Second-Stage Random Effects PPML (BLINK09 instrumented by BROAD03

	Services							Manufacturing						
	(1) 2009	(2) 2010	(3) 2011	(4) 2012	(5) 2013	(6) 2014	(7) 2015	(8) 2009	(9) 2010	(10) 2011	(11) 2012	(12) 2013	(13) 2014	(14) 2015
First Stage Regressions														
Distance (log)	–0.53***	–0.51***	–0.48***	–0.49***	–0.47***	–0.50***	–0.49***	–0.60***	–0.59***	–0.58***	–0.52***	–0.58***	–0.58***	–0.58***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.15	0.08	0.13	0.15	0.16	0.04	–0.00	0.48***	0.50***	0.50***	0.46***	0.56***	0.55***	0.56***
	(0.13)	(0.14)	(0.12)	(0.12)	(0.13)	(0.12)	(0.12)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Common language	0.20	0.10	0.17	0.11	0.16	0.19	0.20	0.08	0.03	0.02	–0.08	0.01	–0.00	–0.01
	(0.13)	(0.11)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Colony	–0.05	0.25*	0.22*	0.23*	0.15	0.11	0.08	0.00	0.01	0.03	–0.05	–0.05	–0.07	–0.07
	(0.13)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)
BLINK09 (log)	0.32***	0.35***	0.34***	0.35***	0.36***	0.37***	0.36***	0.24***	0.26***	0.27***	0.43***	0.27***	0.26***	0.26***
	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
N	3,020	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.83	0.85	0.87	0.86	0.85	0.86	0.87	0.89	0.90	0.90	0.91	0.92	0.92	0.93
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions (Random Intercepts PPML) $\exp\left(X_{ji} + M_{jr}\right)$ **as dependent variable**														
Exporter GDP (log)	0.66***	0.37***	0.35***	0.34***	0.36***	0.37***	0.38***	0.72***	0.69***	0.65***	0.38***	0.66***	0.67***	0.69***
	(0.1)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)	(0.08)
Internet Exporter (log)	0.01**	0.01**	0.01**	0.01**	0.02**	0.01**	0.01*	0.01*	0.01*	0.01	0.01*	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Population (log)	0.44***	0.35***	0.33***	0.33***	0.36***	0.35***	0.41***	0.56***	0.55***	0.48***	0.27***	0.50***	0.52***	0.52***
	(0.1)	(0.09)	(0.10)	(0.10)	(0.11)	(0.10)	(0.11)	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.1)	(0.11)
Importer GDP percap (log)	0.83***	0.77***	0.55*	0.59**	0.66**	0.62**	0.77***	0.59**	0.52**	0.35	0.22	0.39	0.45	0.46*
	(0.27)	(0.26)	(0.28)	(0.28)	(0.32)	(0.30)	(0.30)	(0.24)	(0.24)	(0.26)	(0.27)	(0.29)	(0.28)	(0.28)
Internet Importer (log)	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Importer Gini	0.01	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Intercept	–36.02***	–26.65***	–24.35***	–24.48***	–26.61***	–25.61***	–27.71***	–33.74***	–33.00**	–30.12***	–19.93***	–31.44***	–31.68***	–32.32***
	(3.88)	(3.62)	(3.63)	(3.60)	(3.86)	(3.76)	(3.80)	(3.35)	(3.30)	(3.35)	(3.51)	(3.48)	(3.48)	(3.54)
N	2,932	2,957	2,911	2,885	2,799	2,766	2,639	2,932	2,957	2,911	2,885	2,799	2,766	2,639
Exporters	69	69	69	69	69	69	69	69	69	69	69	69	69	69
Importers	65	66	64	63	61	60	55	65	66	64	63	61	60	55

5.1 Alternative Measures of GDP and Income Inequality

Like other gravity models, our theoretical and empirical models do not account for non-tradable sectors. Keeping this in mind, we consider GDPs measured by PPP. Corresponding estimates are displayed in Table 11. We notice that the results are similar to those in our baseline model, except for a weaker evidence of the hypothesis that, compared to bilateral trade in manufacturing, bilateral trade in services is more sensitive to changes in the per capita income of the importing country.

We also consider alternative measures of income inequality, namely, the pre-tax income share by the top 10 or 1 percentile of the income distribution. Panels (b) and (c) of Table 12 report the estimates of the coefficients on importer-country specific regressors. (The first-stage estimates and the second-stage estimates for the exporting-country-specific regressors remain unchanged.) For comparison, panel (a) reproduces the estimates using GINI, reported earlier in Table 9. Overall, the results are similar across the different measures for within-country income inequality. More inequality is associated with more bilateral trade in both manufacturing and services. The estimates of the coefficients on other variables are comparable to our baseline model.

5.2 Random Intercept Model

Although we have argued in favor of our two-stage procedure, for the sake of comparison, we examined an alternative two-stage approach that relies on the random-intercept PPML estimator in the second stage, as proposed by (Prehn et al., 2015). That is, we run the first-stage fixed effect PPML with bilateral explanatory variables only (as earlier), but in the second stage, we estimate the coefficients on the observable country-specific regressors of both exporting and importing countries *jointly*. The exponential of the sum of the exporter- and importer- fixed effects estimated from the first-stage regression is the (single) dependent variable in the second-stage estimation. The results are reported in Table 13. The coefficient estimates for the bilateral explanatory variables are the same as in our baseline results (see Table 9).

Observe additionally that the coefficients on country-specific variables are generally close to those in our baseline approach, except for the marginal impact of importing-country per capita GDP on bilateral trade in manufacturing. The coefficients on some years are not significantly different from zero. Generally speaking, the qualitative patterns remain fairly robust.

5.3 Panel Estimation

In section 3.2, we argued against panel estimation because of the small within-variation of most country-specific regressors. However, the results from panel estimation might still be of interest, considering that a significant part of the existing literature has adopted panel estimation for gravity models (despite the cautionary note by Head and Mayer (2014) on "questionable bases for panel estimation"). We present the results from the panel covering the years 2009-2015, since we use BLINK09 for bilateral hyperlinks.

Table 14 presents the results from pooled, random-effects, and various combinations of fixed-effects specifications. Notice that the predicted patterns on the impact of exporter GDP and importer per capita GDP are generally borne out from the pooled, exporter-year, importer-year, and country-pair random effects. Exporter-year and importer-year fixed effects do not yield estimates of country-specific variables due to perfect multicollinearity. The panel estimation model do not agree with

Table 14: PPML Panel Estimates (2009-2015)

	Services					Manufacturing				
	Pooled	FE	RE	FE	RE	Pooled	FE	RE	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distance (log)	-0.51***	-0.55***	-0.55***	–	-0.65***	-0.55***	-0.63***	-0.63***	–	-0.76***
	(0.04)	(0.03)	(0.01)		(0.03)	(0.06)	(0.03)	(0.01)		(0.03)
Common border	0.04	0.20	0.21***	–	0.09	0.80***	0.60***	0.60***	–	0.32***
	(0.15)	(0.11)	(0.03)		(0.13)	(0.22)	(0.09)	(0.02)		(0.12)
Common language	0.64***	0.19	0.22***	–	0.79***	0.28	0.06	0.06***	–	0.47***
	(0.13)	(0.10)	(0.03)		(0.10)	(0.19)	(0.09)	(0.02)		(0.09)
Colony	0.18	0.21*	0.21***	–	0.48***	-0.38*	0.02	0.02	–	0.09
	(0.11)	(0.10)	(0.03)		(0.12)	(0.17)	(0.11)	(0.02)		(0.11)
Bilateral hyperlinks (2009)	0.24***	0.40***	0.37***	–	0.28***	0.26***	0.29***	0.28***	–	0.31***
	(0.05)	(0.05)	(0.02)		(0.02)	(0.05)	(0.04)	(0.01)		(0.02)
Exporter GDP (log)	0.54***	–	0.35***	0.07	0.47***	0.56***	–	0.54***	0.51***	0.52***
	(0.06)		(0.04)	(0.12)	(0.03)	(0.08)		(0.04)	(0.05)	(0.02)
Internet Exporter	0.01***	–	0.01***	0.01***	0.02***	-0.01*	–	0.00	-0.00	0.00*
	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)
Importer Population (log)	0.44***	–	0.34***	2.28***	0.42***	0.48***	–	0.45***	0.70	0.41***
	(0.06)		(0.05)	(0.53)	(0.03)	(0.08)		(0.04)	(0.46)	(0.02)
Importer GDP percap (log)	0.78***	–	0.66***	0.64***	0.78***	0.46**	–	0.46***	0.57***	0.55***
	(0.12)		(0.11)	(0.09)	(0.05)	(0.17)		(0.10)	(0.06)	(0.03)
Internet Importer	0.01**	–	0.00	0.01**	0.01**	0.01*	–	0.01	0.00	0.00
	(0.00)		(0.01)	(0.00)	(0.00)	(0.00)		(0.01)	(0.00)	(0.00)
Importer Gini	0.05***	–	0.03***	0.01	0.02***	0.07***	–	0.03***	0.06***	0.04***
	(0.01)		(0.01)	(0.02)	(0.01)	(0.02)		(0.01)	(0.01)	(0.00)
N	20454	20454	20454	16746	20454	20454	20410	20454	20324	20454
R-sq	0.69	0.75	0.41	0.80	0.58	0.73	0.85	0.52	0.89	0.67
Exporter–Year FE		✓					✓			
Importer–Year FE		✓					✓			
Exporter–Year RE			✓					✓		
Importer–Year RE			✓					✓		
Country Pair FE				✓					✓	
Country Pair RE					✓					✓

theoretical predictions only when including country-pair fixed effects, in which case the between-variation vanishes.[28]

6 Potential Extensions and Concluding Remarks

This paper aims at understanding the differences and similarities between determinants of aggregate bilateral trade in manufactures and services and introduces virtual proximity as an essential observable trade-cost-reducing factor for international trade in both sectors. We have articulated a model where two characteristics differentiate between manufacturing and services as distinct sectors: non-homothetic tastes with a demand bias towards services and differences in the degree of national product differentiation. These considerations imply that bilateral trade in either sector will be influenced, besides respective trade costs, by the exporting country's GDP and importing country's population and per capita GDP separately.

Although the gravity equations for manufactures and services are separately estimated, they help us to understand and interpret the similarities and differences in the magnitudes of the marginal effect of an explanatory variable across two product groups in light of our theoretical predictions. Compared to manufacturing, bilateral trade in services is expected to be less sensitive to changes in exporting-country GDP and more sensitive to variations in the importing country's per capita GDP. Moreover, bilateral trade in both categories of products would be dependent on income inequality in the importing country. These predictions are generally supported by the empirical evidence presented. Our model reveals that trade cost elasticities are functions of the degree of national product differentiation, not the elasticity of substitution among domestic varieties. Another major finding is that virtual proximity is an essential factor influencing trade costs of both manufacturing and services, and it significantly reduces the role of physical distance and language differences.

Some extensions that have the potential of offering further insights come to mind. First and foremost, we wish to include data on intra-national trade, which will enable us to estimate border effects and bilateral trade costs relative to domestic trade costs. We plan to use the International Trade and Production Database for Estimation (ITPD-E) from Borchert et al. (2020). Second and as noted earlier, there is considerable firm heterogeneity among service industries in their participation in international markets (Breinlich and Criscuolo, 2011). Recall a key implication of firm heterogeneity toward the gravity relation, due to Chaney (2008), that is, the elasticity of bilateral trade with respect to trade cost is governed by the spread of productivity across firms, not the elasticity of substitution over varieties in consumption. We speculate that both the Armington elasticity and the spread of productivity will determine the trade cost elasticity. Third, in the light of Hellmanzik and Schmitz (2015) and Anderson et al. (2018), it will be useful and interesting to analyze bilateral trade flows of different components of both manufactures and services — particularly, the role of trade costs, which, in part, are impacted by internet use and virtual proximity. Fourth, it will be interesting to model other attributes that distinguish goods and services. For instance, the proximity between providers and users is a hallmark of many services. Recognition of this in the context of trade in services will bring into play the role of FDI in services: Mode 3 of trade in services termed as 'commercial presence.' Lastly, international trade in services conjures up its role, particularly that of *business services*, in the growth of national economies. Exploring the link between service exports and growth or per capita income will be promising.

[28] The country-pair fixed-effects are a typical solution when the researcher is not interested in the time-invariant variables that are pair-specific, such as distance and colonial relationship in the past.

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Appendices

A Derivation of Demand functions for c_r, c_{jr} and P_r: Eqs. (6), (5) and (7)

Letting γ and μ_r denote the respective Lagrange multipliers, the first-order conditions of Middle tier 1 household optimization with respect to c_r, c_{mr} and c_{sr} are:

$$1 + \gamma \sum_{j \in (m,s)} \frac{\theta_j - \eta}{\eta} c_r^{\frac{\theta_j - 2\eta}{\eta}} c_{jr}^{\frac{\eta-1}{\eta}} = 0 \tag{A.1}$$

$$\gamma \frac{\eta - 1}{\eta} c_r^{\frac{\theta_m - \eta}{\eta}} c_{mr}^{-\frac{1}{\eta}} = \mu_r P_{mr} \tag{A.2}$$

$$\gamma \frac{\eta - 1}{\eta} c_r^{\frac{\theta_s - \eta}{\eta}} c_{sr}^{-\frac{1}{\eta}} = \mu_r P_{sr}. \tag{A.3}$$

Dividing (A.2) by (A.3),

$$\frac{c_{mr}}{c_{sr}} = c_r^{-(\theta_s - \theta_m)} \left(\frac{P_{mr}}{P_{sr}} \right)^{-\eta}. \tag{A.4}$$

Non-homothetic tastes over manufacturing and services imply that this consumption ratio depends on the overall sub-utility, c_r. Given $\theta_s > \theta_m$, the higher the sub-utility, the higher is the services to manufacturing consumption ratio, capturing demand-bias towards services. Multiplying (A.2) and (A.3) respectively by c_{mr} and c_{sr}, adding them and using the utility constraint, we obtain

$$e_r = \frac{\gamma}{\mu_r} \cdot \frac{(\eta - 1)}{\eta}. \tag{A.5}$$

Substituting this back into (A.2) and (A.3), eliminating γ and μ_r, and defining the price of the manufactures-services bundle as $P_r \equiv e_r / c_r$ give the respective demand functions and expenditure shares:

$$c_{jr} = \left(\frac{P_{jr}}{e_r} \right)^{-\eta} c_r^{\theta_j - \eta} = \left(\frac{P_{jr}}{P_r} \right)^{-\eta} c_r^{\theta_j} \tag{A.6}$$

$$\frac{P_{jr} c_{jr}}{e_r} = \left(\frac{P_{jr}}{e_r} \right)^{1-\eta} c_r^{\theta_j - \eta} = \left(\frac{P_{jr}}{P_r} \right)^{1-\eta} c_r^{\theta_j - 1}. \tag{A.7}$$

Expenditure shares add up to unity, i.e.,

$$\sum_{j \in (m,s)} P_{jr}^{1-\eta} c_r^{\theta_j - \eta} = e_r^{1-\eta}. \tag{A.8}$$

which implicitly solves c_r (eq. (6) in the text).

Plugging back (A.8) into eq. (A.6), we obtain a quasi-reduced-form solution expression of c_{jr} ((5) in the text). Next, substituting $P_r = e_r / c_r$ into (A.8) yields eq. (7) in the text.

B Results 1 and 2

Eqs. (A.6) and (A.8) imply,

$$\hat{c}_{jr} = \eta \hat{e}_r - (\eta - \theta_j) \hat{c}_r \tag{A.9}$$

$$\hat{e}_r = \frac{\sum_j \lambda_j (\eta - \theta_j)}{\eta - 1} \cdot \hat{c}_r, \quad \text{where } \lambda_j \equiv \frac{P_{jr}^{1-\eta} c_r^{\theta_j - \eta}}{e_r^{1-\eta}} \in (0, 1). \tag{A.10}$$

and $\hat{x}$ is percentage change in variable x. Eliminating $\hat{e}_r$ and using $\lambda_m + \lambda_s = 1$, we get $\hat{c}_{jr} = \Lambda_j \hat{c}_r$, where

$$\Lambda_j \equiv \frac{\eta}{\eta - 1} \sum_j \lambda_j(\eta - \theta_j) - (\eta - \theta_j) = \frac{\eta\left(1 + \theta_j - \sum_j \lambda_j \theta_j\right) - \theta_j}{\eta - 1}$$

implying

$$\Lambda_s = \frac{\eta - \theta_s + \eta\lambda_m (\theta_s - \theta_m)}{\eta - 1} > 0 \text{ as long as } \eta > \theta_s > \theta_m \tag{A.11}$$

$$\begin{aligned} \Lambda_m &= \frac{\eta\,[1 - \lambda_s (\theta_s - \theta_m)] - \theta_m}{\eta - 1} \\ &> \frac{\eta\,(1 - \theta_s + \theta_m) - \theta_m}{\eta - 1} \\ &> 0 \text{ in view of (R2).} \end{aligned} \tag{A.12}$$

This proves normality.

Next, using (A.10),

$$\hat{c}_{jr} = \Lambda_j \hat{c}_r = \frac{(\eta - 1)\Lambda_j}{\sum_j \lambda_j(\eta - \theta_j)} \hat{e}_r. \tag{A.13}$$

Substituting the expressions of Λ_j into the above, we obtain the respective income elasticity expressions of the manufacturing and services baskets:

$$\nu_{mr} \equiv \frac{\hat{c}_{mr}}{\hat{e}_r} = \frac{\eta\,[1 - \lambda_s (\theta_s - \theta_m)] - \theta_m}{\sum_j \lambda_j(\eta - \theta_j)}; \quad \nu_{sr} \equiv \frac{\hat{c}_{sr}}{\hat{e}_r} = \frac{\eta - \theta_s + \eta\lambda_m (\theta_s - \theta_m)}{\sum_j \lambda_j(\eta - \theta_j)}. \tag{A.14}$$

In view of (R1) and (R2), it is easy to show that $\nu_{mr} < 1 < \nu_{sr}$. Furthermore, at given prices, $\widehat{P_{mr} c_{mr}}/\hat{y}_r < 1 < \widehat{P_{sr} c_{sr}}/\hat{y}_r$.

Concavity and convexity are implied by whether the second derivative is negative or positive. It is sufficient thus to show that

$$\frac{\partial c_{mr}/\partial e_r}{\hat{e}_r} < 0 < \frac{\partial c_{sr}/\partial e_r}{\hat{e}_r}. \tag{A.15}$$

In general, for $j = m, s$,

$$\frac{\partial c_{jr}}{\partial e_r} = \frac{c_{jr}}{e_r} \nu_{jr},$$

where ν_{jr} is the income elasticity of the j-good basket, implying

$$\frac{\widehat{\partial c_{jr}/\partial e_r}}{\hat{e}_r} = \nu_{jr} - 1 + \frac{\widehat{\nu_{jr}}}{\hat{e}_r}. \tag{A.16}$$

Thus the second derivative is a function of income elasticity and the change in income elasticity ν_{jr}. Recall that

$$\nu_{mr} < 1 < \nu_{sr}$$

and the elasticity expressions are given in (A.14).

Referring to (A.14), ν_{jr} is a function of λ_m or λ_s (as $\lambda_m + \lambda_s = 1$). In turn, λ_m or λ_s is a function of e_r via (A.10). The changes in λ_m or λ_s as well as ν_{mr} and ν_{sr} are given by

$$\begin{aligned} d\lambda_m &= [-(\eta - \theta_m)\,\hat{c}_r + (\eta - 1)\hat{e}_r]\,\lambda_m = -\frac{\lambda_m \lambda_s(\eta - 1)(\theta_s - \theta_m)}{\sum_j \lambda_j(\eta - \theta_j)} \hat{e}_r. \\ \frac{\widehat{\nu_{mr}}}{\hat{e}_r} &= \frac{(\eta - \theta_m)\,(\eta - 1)\,(\theta_s - \theta_m)}{\{\eta[1 - \lambda_s(\theta_s - \theta_m)] - \theta_m\}[\sum_j \lambda_j(\eta - \theta_j)]} \cdot \frac{d\lambda_m}{\hat{e}_r} \end{aligned} \tag{A.17}$$

$$
\begin{aligned}
&= -\frac{\lambda_m \lambda_s (\eta-\theta_m)(\eta-1)^2(\theta_s-\theta_m)^2}{\{\eta[1-\lambda_s(\theta_s-\theta_m)]-\theta_m\}[\sum_j \lambda_j(\eta-\theta_j)]^2} < 0 && \text{(A.18)}\\
\frac{\widehat{\nu_{sr}}}{\hat{e}_r} &= \frac{(\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)}{[\eta-\theta_s+\eta\lambda_m(\theta_s-\theta_m)][\sum_j \lambda_j(\eta-\theta_j)]}\cdot\frac{d\lambda_m}{\hat{e}_r}\\
&= -\frac{\lambda_m \lambda_s (\eta-\theta_s)(\eta-1)^2(\theta_s-\theta_m)^2}{[\eta-\theta_s+\eta\lambda_m(\theta_s-\theta_m)][\sum_j \lambda_j(\eta-\theta_j)]^2} < 0. && \text{(A.19)}
\end{aligned}
$$

In view of (A.16), $\nu_{mr} < 1$ and $\widehat{\nu_{mr}} < 0$ imply that

$$
\frac{\widehat{\partial c_{mr}/\partial e_r}}{\hat{e}_r} < 0, \tag{A.20}
$$

proving the first inequality in (A.15), which pertains to the manufacturing basket.

Turning to the services basket,

$$
\frac{\widehat{\partial c_{sr}/\partial e_r}}{\hat{e}_r} = \nu_{sr} - 1 + \frac{\widehat{\nu_{sr}}}{\hat{e}_r} = \underset{+}{\frac{(\eta-1)\lambda_m(\theta_s-\theta_m)}{\sum_j \lambda_j(\eta-\theta_j)}} + \underset{-}{\frac{\widehat{\nu_{sr}}}{\hat{e}_r}}. \tag{A.21}
$$

The sign of $\frac{\partial c_{sr}/\partial e_r}{\hat{e}_r}$ is not clear from (A.21).

Substituting (A.19) into (A.21) and rearranging terms yield

$$
\begin{aligned}
&\frac{[\eta-\theta_s+\eta\lambda_m(\theta_s-\theta_m)][\sum_j \lambda_j(\eta-\theta_j)]^2}{\lambda_m(\eta-1)(\theta_s-\theta_m)}\cdot\frac{\partial c_{sr}/\partial e_r}{\hat{e}_r}\\
&= [\eta-\theta_s+\eta\lambda_m(\theta_s-\theta_m)]\left[\sum_j \lambda_j(\eta-\theta_j)\right] - \lambda_s(\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\
&= [\eta(1+\theta_s-\theta_m)-\theta_s-\eta\lambda_s(\theta_s-\theta_m)]\,[\eta-\theta_m-\lambda_s(\theta_s-\theta_m)] - \lambda_s(\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\
&> [\eta(1+\theta_s-\theta_m)-\theta_s-\eta(\theta_s-\theta_m)]\,[\eta-\theta_m-(\theta_s-\theta_m)] - (\eta-\theta_s)(\eta-1)(\theta_s-\theta_m) && \text{(A.22)}\\
&= (\eta-\theta_s)^2 - (\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\
&= (\eta-\theta_s)[\eta(1-\theta_s+\theta_m)-\theta_m] > 0 \text{ in view of (R2).} && \text{(A.23)}
\end{aligned}
$$

Note that the expression preceding (A.22) declines with λ_s. Hence it is greater than the expression in (A.22), where we have made the substitution $\lambda_s = 1$. We thus have

$$
\frac{\partial c_{sr}/\partial e_r}{\hat{e}_r} > 0
$$

that proves the second inequality in (A.15).

C Derivation of Eq. (24)

The equilibrium firm output of any particular variety of manufactures or services equals $\alpha(\sigma-1)$ (see section 2.2). This must match with the world demand for it plus the amount lost in transit, $\sum_{r=1}^{N} L_r c_{jir}(u)\tau_{jir}$. Using this equality and substitutions based on (A.6), (10), (13) and (18),

$$
\begin{aligned}
\alpha(\sigma-1) &= \sum_{r=1}^{N} L_r c_{jir}(u)\tau_{jir} = \sum_{r=1}^{N} L_r \left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma} c_{jir}\tau_{jir}\\
&= \sum_{r=1}^{N} L_r \left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma}\left(\frac{P_{jir}}{P_{jr}}\right)^{-\epsilon_j} c_{jr}\tau_{jir}
\end{aligned}
$$

$$= \sum_{r=1}^{N} L_r \frac{\left(w_i \tau_{jir}\right)^{-\epsilon_j} \Omega_{ji}^{-\frac{\sigma-\epsilon_j}{\sigma-1}}}{\left(\sum_{r=1}^{N} \left(w_r \tau_{jir}\right)^{1-\epsilon_j} \Omega_{jr}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot c_{jr} \tau_{jir}$$

$$= \frac{w_i^{-\epsilon_j} \Omega_{ji}^{-\frac{\sigma-\epsilon_j}{\sigma-1}}}{\left(\sum_{r=1}^{N} \left(w_r \tau_{jir}\right)^{1-\epsilon_j} \Omega_{jr}^{\frac{\epsilon_j-1}{\sigma-1}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot \sum_{r=1}^{N} L_r c_{jr} \tau_{jir}^{-(\epsilon_j-1)} \qquad j = m, s. \tag{A.24}$$

The last expression is the right-hand side of eq. (24).

D Derivation of the Gravity Eq. (28)

We have

$$\begin{aligned}
X_{jir} &= \text{\# of varieties of good } j \text{ produced in country } i \times \text{country } r\text{'s expenditure on each variety at fob price} \\
&= \Omega_{ji} \times \left[L_r p_{ji}(u) c_{jir}(u)\right] \\
&= L_r \Omega_{ji} p_{ji}(u) \left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma} c_{jir}, \text{ using (13)} \\
&= L_r \Omega_{ji} p_{ji}(u) \cdot \Omega_{jir}^{-\frac{\sigma}{\sigma-1}} \cdot \left(\frac{P_{jir}}{P_{jr}}\right)^{-\epsilon_j} c_{jr}, \text{ using (10) and (18)} \\
&= L_r \cdot \frac{\sigma w_i}{\sigma-1} \cdot \Omega_{ji}^{-\frac{1}{\sigma-1}} \left[\frac{w_i \tau_{jir} \Omega_{ji}^{\frac{1}{1-\sigma}}}{\left(\sum_{i=1}^{N} \left(w_i \tau_{jir}\right)^{1-\epsilon_j} \Omega_{ji}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{1}{1-\epsilon_j}}}\right]^{-\epsilon_j} c_{jr}, \text{ using (17), (18) and (20)} \\
&= \frac{\sigma}{\sigma-1} w_i^{-(\epsilon_j-1)} \Omega_{ji}^{\frac{\epsilon_j-1}{\sigma-1}} \frac{\tau_{jir}^{-\epsilon_j}}{\left(\sum_{i=1}^{N} \left(w_i \tau_{jir}\right)^{1-\epsilon_j} \Omega_{ji}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot L_r c_{jr} \\
&= \frac{\sigma}{\sigma-1} w_i^{-(\epsilon_j-1)} \Omega_{ji}^{\frac{\epsilon_j-1}{\sigma-1}} \frac{\tau_{jir}^{-\epsilon_j}}{\left(\frac{\sigma-1}{\sigma} P_{jr}\right)^{-\epsilon_j}} \cdot L_r c_{jr} \text{ using (18)} \\
&= \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_j-1} \chi_{ji}^{\frac{\epsilon_j-1}{\sigma-1}} \left[w_i \left(\chi_{mi}, \chi_{si}, L_i\right)\right]^{-\frac{\sigma(\epsilon_j-1)}{\sigma-\epsilon_j}} \left(\frac{\tau_{jir}}{P_{jr}}\right)^{-\epsilon_j} \left(L_r c_{jr}\right), \text{ using (27).}
\end{aligned}$$

The very last expression is same as (28).

E The List of Countries included in the Sample and The List of Variables with Their Sources

Table 15: List of Countries in the Complete Sample

Afghanistan	Dominica	Lesotho	St. Vincent and the Grenadines
Albania	Dominican Rep.	Libya	Samoa
Algeria	Ecuador	Lithuania	San Marino
Andorra	Egypt	Luxembourg	Sao Tome and Principe
Angola	El Salvador	Macao	Saudi Arabia
Antigua and Barbuda	Equatorial Guinea	Madagascar	Senegal
Argentina	Estonia	Malawi	Seychelles
Armenia	Ethiopia	Malaysia	Sierra Leone
Australia	Fiji	Maldives	Singapore
Austria	Finland	Mali	Slovakia
Bahamas	France	Malta	Slovenia
Bahrain	FS Micronesia	Marshall Isds	Solomon Isds
Bangladesh	Gabon	Mauritania	South Africa
Barbados	Gambia	Mauritius	Spain
Belarus	Georgia	Mexico	Sri Lanka
Belgium	Germany	Mongolia	Sudan
Belize	Ghana	Morocco	Suriname
Benin	Greece	Mozambique	Swaziland
Bhutan	Greenland	Myanmar	Sweden
Bolivia	Grenada	Namibia	Switzerland
Bosnia Herzegovina	Guatemala	Nepal	Tajikistan
Botswana	Guinea	Netherlands	TFYR of Macedonia
Brazil	Guinea-Bissau	New Zealand	Thailand
Brunei Darussalam	Haiti	Nicaragua	Togo
Bulgaria	Honduras	Niger	Tonga
Burkina Faso	Hong Kong	Nigeria	Trinidad and Tobago
Burundi	Hungary	Norway	Tunisia
Cabo Verde	Iceland	Oman	Turkey
Cambodia	India	Pakistan	Turkmenistan
Cameroon	Indonesia	Palau	Uganda
Canada	Iran	Panama	Ukraine
Central African Rep.	Ireland	Papua New Guinea	United Arab Emirates
Chad	Israel	Paraguay	United Kingdom
Chile	Italy	Peru	United Rep. of Tanzania
China	Jamaica	Philippines	Uruguay
Colombia	Japan	Poland	USA
Comoros	Jordan	Portugal	Uzbekistan
Congo	Kazakhstan	Qatar	Vanuatu
Costa Rica	Kenya	Rep. of Korea	Viet Nam
Côte d'Ivoire	Kiribati	Rep. of Moldova	Yemen
Croatia	Kuwait	Romania	Zambia
Cyprus	Kyrgyzstan	Russian Federation	Zimbabwe
Czechia	Lao PDR	Rwanda	
Denmark	Latvia	Saint Kitts and Nevis	
Djibouti	Lebanon	Saint Lucia	

Table 16: List of the 82 Countries with Bilateral Hyperlink information Available for 2009

Algeria	Egypt	Kuwait	Saudi Arabia
Angola	El Salvador	Libya	Singapore
Argentina	Estonia	Malaysia	Slovakia
Australia	Finland	Mexico	Slovenia
Austria	France	Morocco	South Africa
Bahrain	Germany	Netherlands	Spain
Bangladesh	Greece	Nicaragua	Sudan
Belarus	Guatemala	Nigeria	Sweden
Belgium	Hong Kong	Norway	Switzerland
Brazil	Honduras	Oman	Thailand
Cameroon	Hungary	Pakistan	Tunisia
Canada	India	Panama	Turkey
Chile	Indonesia	Paraguay	Ukraine
China	Iran	Peru	United Arab Emirates
Colombia	Ireland	Philippines	United Kingdom
Costa Rica	Israel	Poland	Uruguay
Côte d'Ivoire	Italy	Portugal	USA
Czechia	Japan	Qatar	Viet Nam
Denmark	Jordan	Rep. of Korea	Yemen
Dominica	Kazakhstan	Romania	
Ecuador	Kenya	Russian Federation	

Table 17: Variables, Descriptions and Sources

Variable and Notation	Description	Source
Manufacturing Trade (X_{mir})	Aggregate bilateral manufacturing trade flows from 2002 to 2015, in millions of current USD.	U.N. Comtrade data base, United Nations (2018).
Services Trade (X_{sir})	Aggregate bilateral services trade flows from 2002 to 2016, in millions of current USD.	OECD Statistics and U.N. Comtrade data base, United Nations (2018).
Gross Domestic Product (GDP)	(a) Gross domestic product in billions of current USD. (b) Gross domestic product converted into international dollars using purchasing power parity (PPP) rates.	World Development Indicators. World Bank (2018). World Development Indicators. World Bank (2018).
Population (POP)	Total Population in million	World Development Indicators. World Bank (2018).
Per Capita GDP (gdp)	GDP ÷ Population	
Income Inequality (INQ)	(a) GINI coefficient of disposable income (b) Share of pre-tax national income held by the top 10^{th} and 1^{st} percentiles of the income distribution	(a)Frederick Solt, https://fsolt.org/swiid/ (b) World Inequality Database (2019)
Distance (DIST)	Bilateral distance between countries' capitals (in '000 kilometers).	CEPII dataset.
Common border (BORDER)	Dummy =1 if countries share a common border.	CEPII dataset.
Common language (LANG)	Dummy =1 if countries have the same official or primary language.	CEPII dataset.
Colonial Relationship (COLN)	Dummy =1 if the pair of countries have ever been in a colonial relationship.	CEPII dataset.
Internet Penetration (INTPEN)	Internet users per 100 people.	World Development Indicators. World Bank (2018).
Broadband (BROAD)	Fixed subscriptions to high-speed access to the public Internet.	World Development Indicators. World Bank (2018).
Bilateral hyperlinks 1998 (BILINK98)	Bilateral hyperlink data for 1998.	OECD Communications Outlook 1999.
Bilateral hyperlinks 2003 (BILINK03)	Number of inter-domain hyperlinks from .xx to .yy and vice versa in 2003.	Chung (2011) and Hellmanzik and Schmitz (2015).
Bilateral hyperlinks 2009 (BILINK09)	Bilateral inter-domain hyperlinks for 2009 with uniquely identified host country of .com domain.	Chung (2011) and Hellmanzik and Schmitz (2015).