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

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Abstract

This paper studies the determinants of aggregate bilateral trade in two broad sectors, manufacturing and services. We build a unified theoretical framework that incorporates a demand bias towards services and a difference in the degree of national product differentiation between the two sectors. Demand bias implies two non-standard bilateral trade determinants: per capita income and income inequality in the importing country. Differences in national product differentiation yield a higher elasticity of bilateral trade in manufactures for the exporting country's economic size than the trade in services. Our empirical model also includes two non-standard trade-cost variables: a measure of internet penetration and virtual proximity (the number of bilateral hyperlinks). The results support our unified model's predictions and illustrate that virtual proximity—thus far ignored in most gravity models—is a strong predictor of aggregate trade in both services and manufacturing. We also find that physical distance is an important determinant of bilateral trade in manufacturing and services, even while controlling for virtual proximity.

Keywords: Trade in Services, 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 has focused on studying international trade in goods or manufacturing. Nevertheless, international trade in services has grown faster than trade in manufacturing in recent decades. The global share of exports of services in total exports increased from 9% in 1970 to more than 20% in 2014 (Loungani et al., 2017). It reached 24% in 2019. Between 2005 and 2019, while total trade (measured by adding exports and imports) in goods rose from $10 trillion to $18.8 trillion (i.e., an 88% increase), trade in services increased from $2.5 trillion to nearly $6 trillion, an increase of 140% (UNCTAD, 2021).[1]

However, the existing literature on bilateral trade in services is relatively modest compared to the extensive list of papers that apply gravity models to study international trade in manufacturing. Besides well-known data limitations on trade in services, there are at least two other reasons for this scarcity of studies. 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 focus on trade in services separately: the same general principles and insights derived for trade in goods should apply to services trade.[2] This is only partially true. Because international trade in services and manufacturing have significantly different natures, they can respond differently to standard trade determinants, such as distance or the country's GDP.

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 importance 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 various authors, e.g., 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 diverse samples (different sets of countries and 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 these differences. We address this by formulating a unified theoretical framework that delivers gravity equations for the two types of trade flows. The model allows us to explore and understand systematic differences between how various factors affect trade in services *vis-à-vis* trade in manufacturing—which the existing literature has not explored. Instead of directly postulating a gravity equation similar to goods/manufacturing trade, we theoretically distinguish be-

[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 global trade (World Trade Organization, 2015). One of the main drawbacks of using the Mode 3 service trade is limited data availability.

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

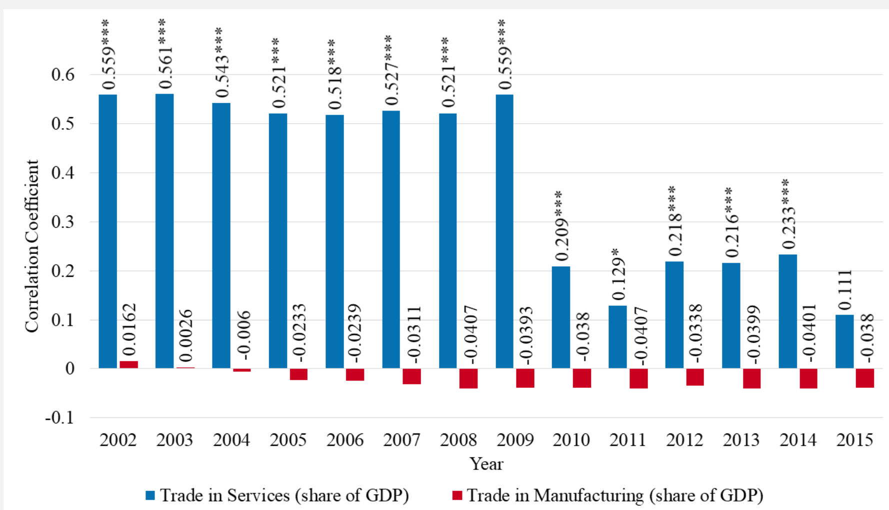
[3]Choi (2010) followed up Freund and Weinhold (2002) by working with a much larger data set and a much wider period and reached the same conclusion that internet penetration is an important determinant of service trade.

tween manufacturing and service products based on their innate characteristics and then derive gravity equations, guiding the ensuing empirical specifications and predictions.

We explore two inherent dimensions in which services are distinguished from manufacturing. *Demand Bias:* Compared to manufacturing, 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). Surprisingly, however, the general theoretical and empirical implications of this demand bias towards trade in goods/manufacturing vis-à-vis services are less analyzed and understood. Lewis et al. (2019) is an important exception. The paper examines how such structural change—what we call demand bias at the global level—has impacted the global openness of trade in manufacturing and services. Our paper contributes to this literature by studying how the nature of bilateral trade in the two product categories differs with respect to their income-elasticity.

Preliminary evidence of how demand bias towards services shows up in the international trade basket is depicted in Figure 1. 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. The correlation coefficients are positive and statistically significant for trade in services every year from 2002 to 2015, while the correlation coefficients are close to zero and statistically insignificant for manufacturing trade. These results illustrate a stronger association between a country's income level and trade in services compared to trade in manufacturing.

Figure 1: **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]

The attention to *Demand Bias* is not new in the gravity literature (see, Fieler (2011)). Nevertheless, it has not been brought forth to differentiate between trade in the two product categories. It has two theoretical implications. First, the 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 the total income or GDP of the importer country (Markusen, 2013). Second, the 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 the incorporation of Armington elasticity is not new. Nevertheless, there is little emphasis on the *differences* of national product differentiation across the two product groups and what they imply towards international bilateral trade in the two sectors.

We include these two features together in a unified framework as a theoretical innovation and one of the paper's main contributions. We find that while *Demand Bias* affects the importing-country scale effects on bilateral trade, differences in *National Product Differentiation* dictate the effects of exporting-country scale effects. More precisely, relative to bilateral trade in manufactures, trade in services is more elastic with respect to the importing country's income per capita and less elastic with respect to the exporting country's GDP. These differences are theoretically derived in section 2.4 and subsequently supported by our empirical findings.

The side-by-side estimation of gravity equations for aggregate trade in manufacturing and services contributes to the understanding and interpretation of the similarities and dissimilarities between them, contrasting with the existing empirical literature that focuses separately on 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. Almost any firm selling goods or services is likely to have used the internet in the modern internet era. 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). Instead of using country-wise measures for internet use, Hellmanzik and Schmitz (2015) find that the number of *bilateral* internet links is a significant determinant of audiovisual services trade. Following them, we also incorporate this measure of virtual proximity in our analysis.

Our empirical specifications incorporate internet penetration and the measure of virtual proximity to assess their importance as determinants to trade in services and manufacturing. We find that virtual proximity is a significant determinant of bilateral aggregate trade in both product groups. It substantially reduces the role of physical distance and scale variables such as the GDP and income

[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.

[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.

per capita. We find 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 severe omitted-variable bias in estimating gravity relations.

2 Theory

The world economy consists of many countries (N) 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 numeraire good achieves three purposes:

(i) Since these endowments vary (exogenously) across countries, the size of the labor force is not necessarily inversely related to per capita income; therefore, they can be seen as "independent" or separate variables affecting the volume of trade.

(ii) Such modeling of the numeraire good implies an endogenous wage rate. As will be seen later, it serves two roles in the model. It enables us 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.

(iii) The intra-country endowment distribution of the numeraire good allows for an exogenous source of wealth and income inequality.

The trading countries are indexed by i or j (source and destination country respectively). Country i is endowed with L_i households, each owning one unit of labor. Sectors are denoted by $z = \{m, s\}$.

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. At the center of our theory lies a four-tier generalization of Dixit-Stiglitz specifications that reveal these differences in a transparent way:

(i) outer tier on the choice of manufactures-services basket c_j and the numeraire good,

(ii) middle-tier 1 over the allocation of c_j into the baskets of manufactures (c_{mj}) and services (c_{sj}),

(iii) middle-tier 2 on the choice among country-specific manufactures (c_{mij}) and services (c_{sij}),

(iv) and the inner-tier across varieties of manufacturing ($c_{mij}(u)$) (services, $c_{sij}(u)$) within the country-specific baskets of manufactures (services).

The demand bias results from non-homotheticity in the middle tier 1 of the preference structure, while the middle tier 2 features national product differentiation across countries. We summarize the notations used in Table 1.

Table 1: Summary of the Notations

Notation	Description
c_j	Household consumption in country j of a basket of manufacturing and services.
P_j	Price of this basket in country j.
c_{mj} [c_{sj}]	Household consumption in country j of the manufactures [services] composite consisting of varieties produced in all trading countries.
P_{mj} [P_{sj}]	Price in country j of the manufactures [services] composite consisting of varieties produced in all trading countries.
c_{mij} [c_{sij}]	Household consumption in country j of the manufacturing [services] composite consisting of varieties produced in country i only.
P_{mij} [P_{sij}]	Price in country j of the manufacturing [services] composite consisting of varieties produced in country i only.
$c_{mij}(u)$ [$c_{sij}(u)$]	Household consumption in country j of a manufacturing [service] variety u produced in country i.
$p_{mij}(u)$ [$p_{sij}(u)$]	Price in country j 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_{mij} [τ_{sij}]	The iceberg transportation/communication cost of shipping or sending a manufacturing [service] variety from country i to country j.
Ω_{mij} [Ω_{sij}]	Mass of manufacturing [services] varieties which are produced in country i and sold in country j.
$\bar{q}_{0j}$	Household endowment of the numeraire good in country j.
y_j	Household income in country j, which includes the value of the numeraire good endowment.

2.1.1 Outer-Tier Tastes

The outer-tier tastes are defined over the numeraire good 0 (c_{0j}) and the manufacturing-services basket (c_j). The utility function is log-linear: $v_j = \beta_0 \ln c_{0j} + \beta \ln c_j$, where $\beta_0 > 0, \beta > 0, \beta_0 + \beta = 1$. This is maximized with respect to the budget constraint, $c_{0j} + P_j c_j = y_j$. The demand functions are:

$$c_{0j} = \beta_0 y_j; \qquad c_j = \beta \frac{y_j}{P_j}. \tag{1}$$

Let $e_j \equiv P_j c_j = \beta y_j$ denote the expenditure on the overall basket of manufacturing and services.

2.1.2 Middle-Tier 1 Tastes: Non-Homothetic CES

This is where the demand-bias is introduced through non-homotheticity, modeled *a la* Fieler (2011), Matsuyama (2015) and Comin et al. (2017). Our specifications mirror Matsuyama (2015) and Comin et al. (2017). Following Comin et al. (2017), we call it non-homothetic CES. Let the manufacturing-services basket, c_j, be a function of a manufacturing composite, c_{mj}, and a services composite, c_{sj}, defined implicitly by the equation:

$$\sum_{z\in(m,s)} c_j^{\frac{\theta_z-\eta}{\eta}} c_{zj}^{\frac{\eta-1}{\eta}} = 1. \tag{2}$$

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. (2) returns the standard Dixit-Stiglitz function over manufacturing and services. We impose the following parametric restrictions:

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

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

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]

The household problem is to choose c_{mj} and c_{sj} that maximize c_j, subject to the "utility constraint" (2) and the budget constraint:

$$P_{mj}c_{mj} + P_{sj}c_{sj} = e_j, \tag{3}$$

As shown in Appendix A, this optimization leads to the following expressions of the overall manufacturing-services basket, the price of this basket and the manufacturing and services baskets separately.

$$c_j = \Xi\Big(\underset{-}{P_{mj}}, \underset{-}{P_{sj}}, \underset{+}{e_j}\Big) \tag{4a}$$

$$P_j^{1-\eta} = \sum_{z\in(m,s)} P_{zj}^{1-\eta} c_j^{\theta_z - 1} \tag{4b}$$

$$c_{zj} = \left(\frac{P_{zj}}{e_j}\right)^{-\eta} \left[\Xi\left(P_{mj}, P_{sj}, e_j\right)\right]^{\theta_z - \eta}, \; z = m, s. \tag{4c}$$

In Appendix B we prove the following two results.

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

As a corollary of Result 1, we obtain

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

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

[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 $\eta - \theta_s = \frac{(\theta_s - 1)(\theta_s - \theta_m)}{1 + \theta_m - \theta_s} > 0 \Rightarrow \eta > \theta_s > \theta_m > 0$.

2.1.3 Middle-Tier 2 Tastes

Differences between manufacturing and service in terms of the degree of *national product differentiation* are incorporated in this tier. The overall (sub) utility from consuming manufacturing (services) depends on manufacturing (services) baskets produced at home and imported from different countries.

$$c_{zj} = \left(\sum_{i=1}^{N} c_{zij}^{\frac{\epsilon_z - 1}{\epsilon_z}} \right)^{\frac{\epsilon_z}{\epsilon_z - 1}}, \ z = m, s. \tag{5}$$

Here ϵ_m and ϵ_s denote the respective Armington elasticities that define *national product differentiation*. The critical assumption is that

Assumption 1.

$$\epsilon_m > \epsilon_s > 1, \tag{6}$$

meaning that services are more *nationally differentiated* than manufacturing. Expression (5) leads to the middle-tier demand functions:

$$c_{zij} = \left(\frac{P_{zij}}{P_{zj}} \right)^{-\epsilon_z} c_{zj}, \tag{7a}$$

$$\text{where } P_{zj}^{1-\epsilon_z} \equiv \sum_{i=1}^{N} P_{zij}^{1-\epsilon_z}. \tag{7b}$$

with P_{zj} being the price index in country j of the good $z = \{m, s\}$ composite consisting of varieties produced in all trading countries.

2.1.4 Inner-Tier Tastes

These are given by the standard Dixit-Stiglitz specifications for country-specific manufacturing and services consumption baskets: $c_{zij} = \left(\int_{u \in \Omega_{zij}} c_{zij}(u)^{\frac{\sigma_z - 1}{\sigma_z}} du \right)^{\frac{\sigma_z}{\sigma_z - 1}}$.

Assumption 2.

$$\sigma_z > 1; \quad \sigma_z > \epsilon_z. \tag{8}$$

The elasticity of substitution among within-country varieties exceeds one and it is larger than the elasticity of substitution over country-specific baskets—for both manufacturing and services.[9]

To focus on the differences in the degree of *national product differentiation*, we simplify and assume $\sigma_m = \sigma_s = \sigma$, i.e., within-country elasticity of substitution among manufacturing varieties is same as that among service varieties. Thus,

$$c_{zij} = \left(\int_{u \in \Omega_{zij}} c_{zij}(u)^{\frac{\sigma - 1}{\sigma}} du \right)^{\frac{\sigma}{\sigma - 1}}. \tag{9}$$

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

Specifications (5) and (9) are a generalization of Ardelean and Lugovskyy (2010). The composite (9) leads to the demand functions:

$$c_{zij}(u) = \left(\frac{p_{zij}(u)}{P_{zij}}\right)^{-\sigma} c_{zij} = \left(\frac{p_{zi}(u)\tau_{zij}}{P_{zij}}\right)^{-\sigma} c_{zij}, \tag{10}$$

where $p_{zij}(u) = p_{zi}(u)\tau_{zij}$, while $p_{zi}(u)$ is the FOB price of a variety of good z produced in country i and $\tau_{zij} \geq 1$ is the iceberg transport cost per unit: the amount that need to be shipped from country i for one unit of good z to arrive in the destination country j. The respective price indices in the importing country j bear the expressions:

$$P_{zij}^{1-\sigma} = \int_{u\in\Omega_{zij}} p_{zij}(u)^{1-\sigma} du = \int_{u\in\Omega_{zij}} \left(p_{zi}(u)\tau_{zij}\right)^{1-\sigma} du. \tag{11}$$

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, $l_{zi}(u) = \alpha + q_{zi}(u)$, $\alpha > 0$, $z = m, s$, where the units of manufacturing and services are normalized such that the variable labor coefficient is the unity in both sectors. In this paper, we abstract from firm heterogeneity—obviously important; this is kept in mind for follow-up research. The market structure is monopolistic competition in 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:

$$p_{zi}(u) = \frac{\sigma w_i}{\sigma - 1}, \quad p_{zij}(u) = \frac{\sigma w_i \tau_{zij}}{\sigma - 1}, \tag{12}$$

implying

$$\begin{aligned} P_{zij} &= \frac{\sigma w_i \tau_{zij}}{\sigma - 1} \cdot \Omega_{zij}^{-\frac{1}{\sigma-1}}; \quad \frac{p_{zij}(u)}{P_{zij}} = \Omega_{zij}^{\frac{1}{\sigma-1}}; \\ P_{zj} &= \frac{\sigma}{\sigma - 1} \left(\sum_{i=1}^{N} \left(w_i \tau_{zij}\right)^{1-\epsilon_z} \Omega_{zij}^{\frac{1-\epsilon_z}{1-\sigma}} \right)^{\frac{1}{1-\epsilon_z}} \\ \frac{P_{zij}}{P_{zj}} &= \frac{w_i \tau_{zij} \Omega_{zij}^{\frac{1}{1-\sigma}}}{\left(\sum_{i=1}^{N} \left(w_i \tau_{zij}\right)^{1-\epsilon_z} \Omega_{zij}^{\frac{1-\epsilon_z}{1-\sigma}} \right)^{\frac{1}{1-\epsilon_z}}}, \end{aligned} \tag{13}$$

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

$$\begin{aligned} \pi_{zij}(u) &= L_j p_{zij}(u) c_{zij}(u) - w_i \underbrace{\tau_{zij} L_j c_{zij}(u)}_{\substack{\text{output shipped} \\ \text{to country } j}} = L_j c_{zij}(u) \left[p_{zij}(u) - w_i \tau_{zij}\right] \\ &= \frac{L_j c_{zij}(u) w_i \tau_{zij}}{\sigma - 1} > 0. \end{aligned} \tag{14}$$

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

$$\Omega_{zij} = \Omega_{zi}, \tag{15}$$

where Ω_{zi} is the mass of varieties of j produced in country i, with $z = m, s$.[10] The total variable profit of a firm that produces variety u is the sum of its variable profits made across all trading countries:

$$\pi_{zi}(u) = \sum_{j=1}^{N} \pi_{zij}(u) = \frac{w_i \sum_j L_j c_{zij}(u)\tau_{zij}}{\sigma - 1} = \frac{w_i q_{zi}(u)}{\sigma - 1}. \tag{16}$$

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

2.3 World Trading Equilibrium

Formally, given the preferences, the endowment of the numeraire good ($\bar{q}_{0j}$), the supply of labor (L_j) for each trading country, and the bilateral trade costs τ_{zij} for each pair of trading countries, the *world trading equilibrium* is a vector

$$\{w_j^*, \Omega_{mj}^*, \Omega_{sj}^*, P_{mj}^*, P_{sj}^*, c_{mj}^*, c_{sj}^*, c_j^*, e_j^*\}, \text{ such that}$$

(a) $P_j^* = e_j^*/c_j^*$; and the vector is consistent with
(b1) $2N$ price-indexes (13) 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

$$e_j = \beta(w_j + \bar{q}_{0j}) \tag{17}$$

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:

$$\alpha\sigma\left(\Omega_{mj} + \Omega_{sj}\right) = L_j; \tag{18}$$

(b6) $2N$ world market-clearing condition for manufactures and services produced:

$$\alpha(\sigma - 1) = \frac{w_i^{-\epsilon_j} \Omega_{zi}^{-\frac{\sigma-\epsilon_z}{\sigma-1}}}{\left(\sum_{j=1}^{N} \left(w_j \tau_{zij}\right)^{1-\epsilon_z} \Omega_{zj}^{\frac{\epsilon_z - 1}{\sigma - 1}}\right)^{\frac{\epsilon_z}{\epsilon_z - 1}}} \cdot \sum_{j=1}^{N} L_j c_{zj} \tau_{zij}^{-(\epsilon_z - 1)} \quad z = m, s. \tag{19}$$

where the left-hand side is the supply for each variety of manufacturing or services (equal to $\alpha(\sigma - 1)$, the equilibrium firm-level output) and the right-hand side is the world demand for that variety in addition to the amount lost due to international trade costs.[11] ■

[10] This will change if there were firm heterogeneity and positive fixed costs of operating in foreign country.
[11] Eq. (19) is derived in Appendix C.

We now derive expressions for wages and the equilibrium number of varieties produced in each country, which will be used to derive and interpret the gravity equations. Turn to eq. (19) and define

$$\chi_{zi} \equiv \frac{\sum_{j=1}^{N} L_j c_{zj} \tau_{zij}^{-(\epsilon_z - 1)}}{\alpha(\sigma-1)\left(\sum_{j=1}^{N}\left(w_j \tau_{zij}\right)^{1-\epsilon_z} \Omega_{zj}^{\frac{\epsilon_z - 1}{\sigma - 1}}\right)^{\frac{\epsilon_z}{\epsilon_z - 1}}} \cdot \quad z = m, s. \tag{20}$$

Substituting the expression above back into (19) and rearranging, we obtain $\Omega_{zi} = \chi_{zi} w_i^{-\frac{(\sigma-1)\epsilon_z}{\sigma-\epsilon_z}}$. In turn, substitute this into the full employment condition (18):

$$\alpha\sigma\left(\chi_{mi} w_i^{-\frac{(\sigma-1)\epsilon_m}{\sigma-\epsilon_m}} + \chi_{si} w_i^{-\frac{(\sigma-1)\epsilon_s}{\sigma-\epsilon_s}}\right) = L_i \Rightarrow w_i = w_i\left(\underset{+}{\chi_{mi}}, \underset{+}{\chi_{si}}, \underset{-}{L_i}\right). \tag{21}$$

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

$$\Omega_{zi} = \chi_{zi} \cdot \left[w_i\left(\chi_{mi}, \chi_{si}, L_i\right)\right]^{-\frac{(\sigma-1)\epsilon_z}{\sigma-\epsilon_j}}. \tag{22}$$

The last two equations lead to another result.

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

The negative relation between the size of a country and wages follows from eq. (21). Eq. (22) implies a positive relationship between size and the mass of varieties produced in a trading country.

2.4 Gravity Equations

Following the standard practice, let the bilateral trade flows be measured by the FOB value of the gross exports at the destination country, denoted by X_{zij}. Recall that z denotes the sector/good (manufacturing or services), i the exporting/origin country, and j the importing/destination country. We have X_{zij} = # of varieties of good z produced in the country $i \times$ country j's expenditure on each variety at the FOB price. Various substitutions (see Appendix D) lead to

$$X_{zij} = \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_z - 1} \chi_{zi}^{\frac{\epsilon_z - 1}{\sigma - 1}} \left[w_i\left(\chi_{mi}, \chi_{si}, L_i\right)\right]^{-\frac{\sigma(\epsilon_z - 1)}{\sigma - \epsilon_z}} \left(\frac{\tau_{zij}}{P_{zj}}\right)^{-\epsilon_z} \left(L_j c_{zj}\right). \tag{23}$$

This is the gravity relation. A couple of further substitutions, namely, using $e_j = \beta y_j$ and the expression of c_{zj} namely, (4c) from section 2.1, leads from (23) to (24) below. For good $z = m, s$,

$$\boxed{X_{zij} = A_j \cdot L_j y_j^{\eta} \cdot \frac{\tau_{zij}^{-\epsilon_z}}{P_{zj}^{\eta-\epsilon_z} \cdot \chi_{zi}^{\frac{1-\epsilon_z}{\sigma-1}}} \cdot \frac{\left[w_i\left(\chi_{mi}, \chi_{si}, L_i\right)\right]^{-\frac{\sigma(\epsilon_z-1)}{\sigma-\epsilon_z}}}{\left[\Xi(P_{mj}, P_{sj}, \beta y_j)\right]^{\eta-\theta_z}}}, \text{ where } A_z \equiv \beta^{\eta}\left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_z - 1}. \tag{24}$$

The expression above is closer to a familiar-looking gravity equation. Worth emphasizing, a gravity equation like (24) is a cross-sectional relationship, showing how bilateral exports among various pairs of trading countries are compared *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 interpret χ_{mi} and χ_{si} as multilateral resistance facing the exporting country i, while P_{mj} and P_{sj} as those facing the importing country j. From (24), Result 4. Bilateral trade in either good depends on multilateral resistance facing the exporting country and the importing country in both sectors.

In the right-hand-side of (24), the term $L_j y_j^{\eta}$ is a direct consequence of non-homothetic tastes, implying that the population and income per capita of the importer country matter to bilateral trade and with different elasticities. Therefore, it does not suffice to simply use the importing country's income to capture its effect, as it is standard in the gravity literature. Non-homotheticity implies that bilateral trade is a function of the population and income per capita of the importer country (Fieler, 2011). Moreover, bilateral trade is proportional to the importer's population, while it is not proportional to per capita income. In view of (23) and Result 1,

Result 5. Bilateral trade of either good is unitarily elastic with respect to the importing country's population size, while the elasticity with respect to the importing country's income per capita 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.

While non-homothetic tastes form the micro-foundations beneath differentiating between the 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. To exporters, only their overall size matters, represented through the $w_i(\cdot; L_i)$ function. Since the absolute value of the exponent of w_i in (24) is increasing in ϵ_z 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.

Result 6 states that 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 (21) with w_i, it can be readily derived that w_i is negatively related to $w_i L_i$. Hence 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.

Now we turn the attention to the role of differences in the degree of national product differentiation. 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. 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 the *National Production Differentiation* is the key feature underlying Result 6.

Another distinguishing feature of the gravity equations (24) is that unlike those based on the standard Dixit-Stiglitz preferences that assume the elasticity of substitution between intra-country and inter-country varieties to be the same, 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—a direct implication of Armington elasticity for manufacturing being larger than that for services.

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

We may want to compare the gravity equation (24) to the standard case where tastes are homothetic, and there is no difference in the national product differentiation between manufacturing and services. In the standard case, 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 we use $\theta_m = \theta_s = 1$, and, $\epsilon_m = \epsilon_s = \epsilon$, the gravity equations (24) reduce to

$$X_{zij} = A' \cdot (w_i L_i) \cdot (L_j y_j) \cdot \frac{\chi_{zi}^{\frac{\epsilon-1}{\sigma-1}}}{\alpha\sigma \sum_{z\in(m,s)} \chi_{zi}} \cdot \frac{\tau_{zij}^{-\epsilon}}{P_{zj}^{\eta-\epsilon} P_j^{-(\eta-1)}}, \text{ where} \tag{25}$$

$$A' \equiv \beta \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon-1} \quad ; \quad P_j \equiv \left(\sum_{z\in(m,s)} P_{zj}^{-(\eta-1)}\right)^{-\frac{1}{\eta-1}} .$$

The last expression is the overall price index in country j covering manufacturing and services.

Note that, under homothetic preferences, bilateral trade is again proportional to the importing country's total income. However, the economy's total income is *not* equal to the total factor income in our model, bilateral trade is proportional to the exporting country's total factor income, but *not* with respect to its total income. Bilateral trade in each product sector is influenced by multilateral resistance in both product sectors. Moreover, the trade cost elasticity depends on the degree of national product differentiation, not the elasticity of substitution among domestic varieties.

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 trade model 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 directly, but in terms of the share of expenditure of food and manufacturing being a function of total expenditure. By assumption, that 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 general category of goods without distinguishing between manufactures and food and without the inclusion of services. 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 the country's income per capita. Countries with the same level of income per capita can have strikingly different income inequality levels. 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 result in changes in the *average* per capita income or income inequality or both.

Table 2: Numerical Example: Increase in Inequality via Composition and Its Impact on Aggregate Consumption of Manufacturing and Services

Disposable Income in Dollars	Share of Manufactures in c_j	Share of Services in c_j	Initial Distribution	New Distribution: 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				= $\boxed{-\$20}$

More specifically, consider a change in the composition of the population, specifically leading to less equitable income distribution, i.e., "hollowing out of the middle class," while the total or per capita income remains the same.[12] That is, starting from a given income distribution, let the new distribution 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 distribution of the population, and consequently, 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 to represent a change in inequality, the *compositional effect* is generally neglected. Our numerical 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 income 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 the importing country's population and per capita income separately. Moreover, they decline in response to 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-exporter's GDP elasticity is greater for manufacturing than for services.*

(ii) *The trade elasticity with respect to the importer's per capita income is higher for services than for manufacturing. Our model yields a more specific result: the importing-country per capita income*

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

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 nonessential variables and considerations are absent in 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 that lend themselves to empirical testing are intuitively reasoned after Results 6, 5 and 7 respectively. The demand-bias assumption underlies result (ii), while results (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 this effect's direction is ambiguous theoretically. Hence, the impact of the importer-country inequality on bilateral trade is primarily an empirical issue.

Note that openness to trade may depend on the economy's size and per capita income. This is an extensive margin issue outside of the scope of our theoretical model. Furthermore, our theoretical model does not incorporate manufacturing or services as inputs to production. However, 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 manufacturing or services, and that service inputs are less differentiated than manufactures inputs.

3 Empirical Analysis

This section discusses our empirical strategy to quantify the dependence of aggregate bilateral trade on country-specific characteristics and bilateral trade costs, emphasizing the differences in the relative importance of these variables in international trade in manufacturing and services.

3.1 Variables and Data Sources

We use aggregate bilateral manufacturing trade flows from 2002 to 2015 from the U.N. Comtrade database, United Nations (2018). In compiling the data, preference is given to trade flows reported by the exporting country. We complement the dataset by mirroring the importer country's trade flows whenever the exporter's report is unavailable. 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)".[13] Similar to manufacturing, we accord preference to trade flows as reported by the exporter country. 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 when the corresponding OECD observation is missing.

[13] The EBOPS 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.

The resulting data comprise 177 countries over the period from 2002 to 2015. These countries are listed in Table A1 in Appendix E. We adopt the following notations and definitions for the included variables. Table 3 provides a brief description and data sources of all variables included.

Table 3: Variables, Descriptions and Data Sources

Variable and Notation	Description	Source
Manufacturing Trade (X_{mij})	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_{sij})	Aggregate bilateral services trade flows from 2002 to 2015, 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 current USD.	World Development Indicators. World Bank (2018).
	(b) GDP converted into international dollars using purchasing power parity (PPP) rates.	World Development Indicators. World Bank (2018).
Population (POP)	Total Population in million	World Development Indicators. World Bank (2018).
Capital Stock (CAPITAL)	Capital stock at constant 2017 prices USD)	Penn World Table Feenstra et al. (2015)
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 distr.	(a)Solt (2020) (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).

Notes: This table reports the name, description and source of the variables included in the empirical analyses.

(i) X_{zij}: Following the notation from eq. (24), it represents the total aggregate bilateral exports of sector $z = m, s$ in current US dollars, from country i to country j. This is our dependent variable in the econometric specifications that we describe in section 3.3.

Explanatory variables include GDP, population, GDP per capita, and those affecting bilateral trade costs. In addition, they also include a measure of income inequality, even though the predicted 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.[14]

(ii) GDP_i, POP_j, gdp_j: These represent respectively the total income of the exporting country i, the population of the destination country j, the per capita GDP ($GDP_j \div POP_j$) of the destination country j. This information is from the World Development Indicators, World Bank (2018).

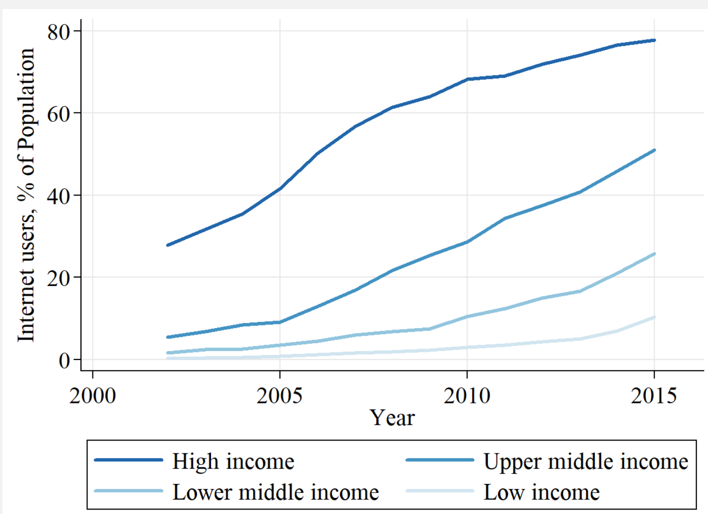
(iii) INQ_j: This is the income inequality measure. We use the GINI coefficient as well as the pre-tax income share of the top 10% and 1% of the population. Information on the GINI coefficient comes from Solt (2020), and that on income shares come from the World Inequality Database (2019).[15]

(iv) DIST_{ij}, BORDER_{ij}, LANG_{ij}, COLN_{ij}: 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.[16]

In addition to the above "standard" explanatory variables (perhaps except for income inequality), we include two variables to capture virtual costs between countries, namely, internet use in a country and the number of bilateral hyperlinks, as determinants of bilateral trade.

(v) INTPEN: It is a measure of internet penetration: the percentage share of a country's population that uses the internet. We use annual data from the World Development Indicators, World Bank (2018), from 2002 to 2015. Figure 2 shows the rapid growth of internet users globally since the early 2000s, while there is a considerable gap in the usage between high- and low-income countries. Internet penetration is viewed as a factor that reduces bilateral trade costs.

Figure 2: **Internet Penetration by Country Income Group**



Note: This figure shows the median country's share of internet users. Income groups are defined from the World Bank classification in 2019.

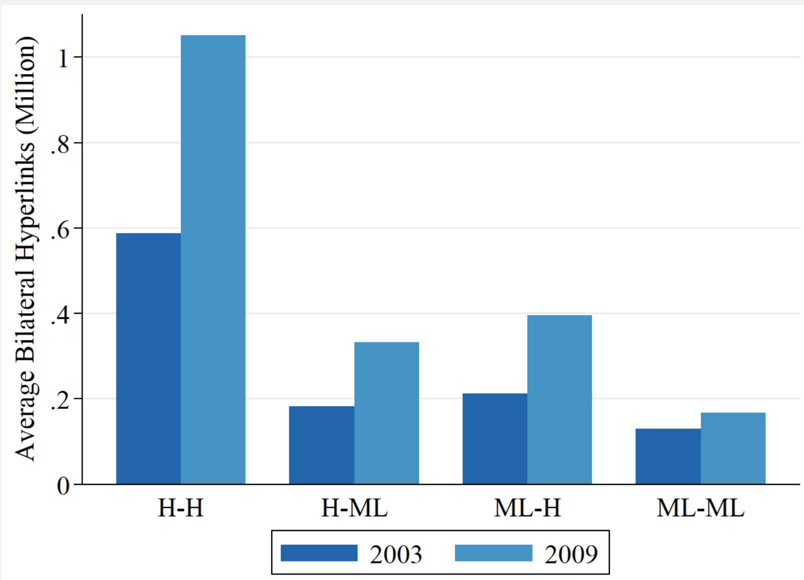
[14]As Dalgin et al. (2008, Page 749) write, "At a minimum, the gravity model must be augmented with income per capita and a measure of the within-country income distribution."

[15]While the GINI coefficient is a common measure of inequality, income shares of top 1% and 10% of the population have also been used by Leigh (2007) and Piketty et al. (2019), for example.

[16]Other bilateral trade cost variables would include, for example, whether the two countries are included in any preferential trading arrangement. We do not incorporate them since we believe it is unlikely to change the nature of our results.

(vi) 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).[17]

Figure 3: **Bilateral Hyperlinks, 2003 and 2009**



Note: This figure shows the average number of bilateral hyperlinks from and to High Income (H) and Medium-low (ML) income countries on 2003 and 2009.

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 3 illustrates the patterns of BLINK across countries by income level. It presents the average number of hyperlinks between countries of 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 any 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 3, H-ML represents the average number of hyperlinks from high-income countries to middle or low-income countries, while ML-H

[17] Bilateral hyperlinks refer to links from websites with domains from an origin country to websites with domains in another country. An easy way to measure bilateral hyperlinks is to use country top-level domains (ccTLD), such as *.us* for the U.S. or *.uk* for the U.K. However, determining the countries for non-national domain names, such as *.org*, *.edu*, or *.com* is a challenging task. Chung (2011) developed a method that allows the country identification of links with *.com* domain. Hence, this dataset allows for a more complete and accurate characterization of internet connectivity across countries.

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 3 shows an increase in the average number of hyperlinks between countries from 2003 to 2009, suggesting that the world has increased its virtual proximity. Moreover, the virtual proximity has increased faster between high-income countries.

In our estimations, we primarily use 2009 BLINK (denoted by BLINK09) data that are available for 82 countries, which are listed in Table A2 in Appendix E. We do not use 1998 or 2003 BLINK data since it is available for a limited number of countries.

(vii) BROAD03: The number of broadband subscriptions in a country in 2003 is a measure of the information and communication technology infrastructure. We use it as an instrument for BLINK09. The data source is from the World Development Indicators, World Bank (2018).

(viii) CAPITAL: This represent the capital stock at constant 2017 national prices (in million of 2017 US$). We use the capital stock to construct instrumental variable for GDP and GDP per capita. The data is from the Penn World Table, Feenstra et al. (2015).

Table 4 presents the summary statistics of the variables included in this study. 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 considerable 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).

Table 4: Summary statistics

	N	Mean	SD	Min	Max
Trade in manufacturing (US$ Million)	436,128	292.47	3,810.43	0.00	398,761.27
Trade in services (US$ Million)	436,128	81.07	1,038.30	0.00	80,330.00
GDP (US$ Billion)	2,478	333.04	1,325.81	0.07	18,120.71
GDP PPP (US$ Billion)	2,436	467.87	1,589.18	0.14	19,820.98
Population (Million)	2,478	37.03	138.36	0.02	1,371.22
Capital (US$ Billion)	2,282	2,421.35	6,858.98	1.96	71,041.91
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 (24) have constant trade elasticities with respect to bilateral trade costs and the population of the importing country, while other determinants have varying elasticities. 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 use the theoretical gravity equations (24) as the basis to parametrically specify the estimable equations, which additionally include a measure of within-country income inequality. In effect, our econometric model contains the standard set of variables included in gravity estimations like GDP, per capita GDP, population, and standard bilateral trade cost variables, as well as a measure of income inequality for the importer country and two measures of internet use: internet penetration and bilateral hyperlinks.

We have a panel dataset, albeit unbalanced, on bilateral trade, GDP, internet penetration, and other country-wise characteristics from 2002 to 2015. Thus, choosing the traditional panel estimation with fixed effects seems logical for estimating our gravity equations. 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 recommends panel estimation of gravity equation whenever panel data is available. However, we argue that it is not a preferred strategy, at least in our context. Our reasons are as follows.

(1) The gravity relations in eq. (24) reflect a snapshot of how bilateral trade is aligned in a cross-sectional equilibrium among trading countries. They are *not* amenable to a natural interpretation when there is within-country variation over time of an explanatory variable. For example, there is no context or a clear interpretation of how, ceteris paribus, a change *over time* in the importer-country per capita income would 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*."

(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. Nevertheless, 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 would not work. While fixed-effects panel estimation is an attractive method to isolate the impact of trade costs and multilateral resistance, our purposes require a different approach.

(3) Most compelling perhaps is the low within-variation of the gravity variables. In our dataset, the time-varying explanatory variables have relatively small within-variation compared to between-variation. Table 5 records that within-variation accounts for a very modest portion of most variables' total variation, except for internet penetration. This means that fixed-effects panel estimates are likely to wipe out most of the variation of the gravity variables and that we are interested in estimating.

For these reasons, we rely on year-to-year regressions. 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 the bilateral variables and fixed effects. The second stage uses the estimates of fixed effects from the first step as the dependent variable and the country-specific measures as inde-

Table 5: 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.

pendent variables. The second stage does not use fixed-effects.[18] We use Poisson-Pseudo Maximum Likelihood - PPML in both stages (Santos Silva and Tenreyro, 2011). Using a two-stage estimation of the gravity equation is not new in the literature. See for instance, Head and Ries (2008) and Head and Mayer (2014). However, we discuss the two-step estimation procedure in section 3.3 in more detail.

3.3 A Two-Stage PPML Procedure

We begin by translating Equation (24) into the following econometric specification:

$$X_{zij} = \exp(x_{zi} + m_{zj}) \cdot \mathrm{GDP}_i^{\alpha_z} \cdot L_j^{\beta_z} \cdot \mathrm{gdp}_j^{\gamma_j} \cdot \exp(\theta_{zQ}\mathrm{INQ}_j) \cdot \tau_{zij}^{-\epsilon_z} + v_{zij},\ \ \alpha_z, \beta_z, \epsilon_z > 0, \tag{26}$$

where v_{zij}'s are the purely bilateral trade error terms. The terms x_{zi} and m_{zj} 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 GDP per capita of the importing country (L_j and gdp_r) and trade costs τ_{zij}. The population size of the importing country appears multiplicatively linear in (24), 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_{zij} 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 internet penetration and virtual proximity. Although the last two variables are often neglected in gravity estimation, we show that they play an essential role in predicting trade flows in both manufacturing and services. We define the bilateral trade cost:

$$\tau_{zij} = \cdot \exp\Big[\tilde{\theta}_{zD} \ln \mathrm{DIST}_{ij} + \tilde{\theta}_{zB}\mathrm{BORDER}_{ij} + \tilde{\theta}_{zL}\mathrm{LANG}_{ij} + \tilde{\theta}_{zC}\mathrm{COLN}_{ij} + \tilde{\theta}_{zXI}\mathrm{INTPEN}_i + \tilde{\theta}_{zMI}\mathrm{INTPEN}_j + \tilde{\theta}_{zK} \ln \mathrm{BLINK}_{ij}\Big], \tag{27}$$

[18]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 manufacturing or services—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 does not permit an estimation of the coefficients of country-specific observable variables, which are unquestionably relevant to our study.

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

$$\begin{aligned} &\text{Exporting Country: } x_{zi} = A_z + \xi_{zi} \\ &\text{Importing Country: } m_{zj} = B_z + \xi_{zj}, \end{aligned} \tag{28}$$

where ξ_{zi} and ξ_{zj} respectively represent the exporter-country-specific and importer-country-specific error terms. Substituting (27) and (28) into (26),

$$\begin{aligned} X_{zij} = \exp\Big(&A_z + B_z + \xi_{zi} + \xi_{jr} + \alpha_z \ln \mathrm{GDP}_i + \beta_z \ln L_j + \gamma_z \ln \mathrm{gdp}_j + \theta_{zQ}\mathrm{INQ}_j + \theta_{zXI}\mathrm{INTPEN}_i \\ &+ \theta_{zMI}\mathrm{INTPEN}_j + \theta_{zD} \ln \mathrm{DIST}_{ij} + \theta_{zK} \ln \mathrm{BLINK}_{ij} + \theta_{zB}\mathrm{BORDER}_{ij} \\ &+ \theta_{zL}\mathrm{LANG}_{ij} + \theta_{zC}\mathrm{COLN}_{ij}\Big) + v_{zij}, \end{aligned} \tag{29}$$

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. (29) by separating country-specific terms from bilateral terms.

$$\begin{aligned} X_{zij} = \exp\Big(&X_{zi} + M_{zj} + \theta_{zD} \ln \mathrm{DIST}_{ij} + \theta_{zK} \ln \mathrm{BLINK}_{ij} \\ &+\theta_{zB}\mathrm{BORDER}_{ij} + \theta_{zL}\mathrm{LANG}_{ij} + \theta_{zC}\mathrm{COLN}_{ij}\Big) + v_{zij}, \end{aligned} \tag{30}$$

where,

$$\begin{aligned} X_{zi} &\equiv A_z + \alpha_z \ln \mathrm{GDP}_i + \theta_{zXI}\mathrm{INTPEN}_i + \xi_{zi} \\ M_{zr} &\equiv B_z + \beta_z \ln L_j + \gamma_z \ln \mathrm{gdp}_j + \theta_{zQ}\mathrm{INQ}_j + \theta_{zMI}\mathrm{INTPEN}_j + \xi_{zj}. \end{aligned} \tag{31}$$

Our two-stage technique estimates the parameters in eqs. (30) and (31) separately. In the first stage, we employ fixed-effects estimation of (30) by using PPML *a la* Santos Silva and Tenreyro (2006, 2011). The first-stage estimation yields bilateral-trade estimates $\hat{\theta}_{zD}, \hat{\theta}_{zK}, \hat{\theta}_{zB}, \hat{\theta}_{zL}$ and $\hat{\theta}_{zC}$ as well as $\widehat{\exp(X_{zi})}$ and $\widehat{\exp(M_{zj})}$, 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 $\alpha_z, \beta_z, \gamma_z$, among other parameters, are obtained in the second stage, where, in view of (31), $\widehat{\exp(X_{zi})}$ and $\widehat{\exp(M_{zj})}$ are separately regressed against country-specific variables. From their respective definitions,

$$\begin{aligned} &\widehat{\exp(X_{zi})} = \exp(V_{zi} + \xi_{zi}); \quad \widehat{\exp\left(X_{zj}\right)} = \exp\left(V_{zj} + \xi_{zj}\right), \quad \text{where} \\ &V_{zi} \equiv A_z + \alpha_z \ln \mathrm{GDP}_i + \theta_{zXI} \ln \mathrm{INTPEN}_i \\ &V_{zj} \equiv B_z + \beta_z \ln L_j + \gamma_j \ln \mathrm{gdp}_j + \theta_{zQ}\mathrm{INQ}_j + \theta_{zMI} \ln \mathrm{INTPEN}_j. \end{aligned} \tag{32}$$

We estimate the two equations in (32) by PPML.[19,20]

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

$$\exp(u_{zi}) \equiv 1 + \frac{\nu_{zi}}{\sqrt{\exp(V_{zi})}} \qquad \exp(u_{zj}) \equiv 1 + \frac{\nu_{zj}}{\sqrt{\exp\left(V_{zj}\right)}},$$

where ν_{zi} and ν_{zj} are statistically independent of V_{zi} and V_{zj} respectively and $\mathbb{E}(\nu_{zi}) = \mathbb{E}\left(\nu_{zj}\right) = 0$. 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.

[20]This is different from Head and Mayer (2014), who use generalized least-squares. Both approaches account for

Multilateral resistance terms, adjusted for the constants A_z and B_z, are subsumed in ξ_{zi} and ξ_{zj}, whose estimates are $\widehat{\exp(X_{zi})}/\widehat{\exp(V_{zi})}$ and $\widehat{\exp\left(M_{zj}\right)}/\widehat{\exp\left(V_{zj}\right)}$ respectively. Our procedure essentially differs from the (single-stage) random-intercept model by identifying 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 Endogenous-Regressor Issues

One of the main concerns in estimating the importance of trade determinants is the potential endogeneity between some variables and the volume of trade. This section describes the potential endogeneity by estimating the coefficients of BLINK09, GDP, and GDP per capita and explains our approach to addressing these issues.

3.4.1 BLINK (Stage 1)

For the years 2009 to 2015, we use the BLINK data for 2009—denoted by BLINK09. However, the number of bilateral hyperlinks may be directly affected by the bilateral trade, raising endogeneity concerns. We address this potential endogeneity by using an instrumental variable approach[21]

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. We, therefore, consider another instrument for BLINK09, 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. To test the validity of our proposed instruments, we first estimate an auxiliary regression by OLS:

$$\text{BLINK09}_{ij} = \alpha + \xi_i + \xi_j + \beta \cdot IV_{ij}^{(1)|(2)} + \boldsymbol{\gamma}' \cdot \boldsymbol{V}_{ij} + \epsilon_{ij} \tag{33}$$

where ξ_i and ξ_j represent the exporter and importer fixed effects, respectively; $IV_{ij}^{(1)|(2)}$ represent the two considered instruments; $\boldsymbol{V}_{ij}$ is the set of bilateral variables that include the distance, common border, common language and colonial relationship in the past and ϵ_{ij} is the random term. Table A3 in Appendix 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.

heteroskedasticity issues.

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

BROAD03 is our preferred choice of the two available instruments for three reasons. First, we have data on BROAD03 for a more extensive set of countries,[22] allowing for a larger sample. Second, as shown in Table A3 in Appendix F, there is 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 A3 in Column (1), we calculate the predicted (log) number of bilateral hyperlinks in 2009, which replace the log of BLINK09 in our two-stage estimation of gravity equations.

3.4.2 GDP and per capita GDP (Stage 2)

Multilateral resistance, which is unobservable and subsumed in the respective error terms, is likely to be simultaneously determined with a country's income or per capita income (Yotov et al., 2016; Piermartini and Yotov, 2016). In order to mitigate this problem, we instrument GDP and per capita GDP. The literature on international trade and growth suggests instruments such as rainfall, latitude, savings rate capital stock (see, for example, Frankel and Romer (1999) and Brueckner and Lederman (2015)). Limiting ourselves to these four candidates as instruments, we note that rainfall may be a significant factor of economic activity for tropical but not non-tropical countries, whereas our sample has both categories of countries. We, therefore, reject rainfall. Latitude (in absolute value) is strongly correlated with GDP as well as per capita GDP. However, a typical first-stage regression of GDP or per capita GDP against latitude with the inclusion of control variables yields the coefficient on latitude statistically insignificant for different years, and the F-statistic is low. Hence it does not pass the instrument relevance test. The same holds for the contemporaneous or one-year lag savings rate, which also leads us to reject it as a valid instrument for GDP and per capita GDP.

In contrast, capital stock and per capita capital stock strongly correlate with GDP and per capita GDP, respectively. Table A4 in Appendix F shows that the estimated coefficients of capital stock are statistically significant for all years in our sample.[23] In addition, the F-statistics are large and significant in all specifications, alleviating concerns that the instrument is weak.

Furthermore, it is unlikely that the lagged capital stock would significantly affect the country-specific component of trade flows on their own, independent of GDP or per capita GDP. Hence exclusion restriction is plausibly met. We, therefore, instrument GDP (respectively per capita GDP) on lagged capital stock (respectively lagged per capita capital stock) in our stage-2 estimation for exporter (respectively importer) country-specific effects.

4 Results

In this section, we present the results of our estimates of eqs. (30) and (32). First, we apply our two-stage procedure using data from all 177 countries in our sample from 2002 to 2015. Bilateral trade is the dependent variable. This baseline specification includes 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 from stage 1 estimation. Stage 2 estimations recover the effects of *observable* country-specific variables. In all these regressions, we use nominal GDPs expressed in US dollar and GINI coefficient as the measure of inequality.[24] The results are reported

[22] We have information on BROAD03 for 69 countries, while BLINK03 is available for 43 countries.

[23] The number of countries matches the number of observations in each specification, as reported in the Table by N.

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

in Tables 6 and 7 for service trade and manufacturing trade, respectively.

Next, we estimate the same baseline equations but restricting the sample to the 82 countries with non-missing observations for the bilateral hyperlinks data. We report two estimations. Tables 8 and 9 present the results without and with the inclusion of BLINK09 (for the same 82 countries for which BLINK09 data is available). The goal is to investigate potential differences in the estimates driven solely by the inclusion of BLINK09.

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

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 manufacturing and services. 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 excluding BLINK09 in Figure 4 (a) over the period from 2002 to 2015, while the results with the inclusion of BLINK09 are illustrated in Figure 4 (b) for years 2009 to 2015. Except for 2002-2004 and 2012, the estimated coefficients are higher for manufacturing than services.

Since the coefficients are monotonically related to Armington elasticities, which are inversely related to the degree of *national product differentiation*, the ranking of the coefficients indirectly supports one of our basic premises that services are more nationally differentiated than manufacturing.

Figure 4(c) depicts the coefficients on the importer's GDP per capita in the specification without BLINK09. The estimates are again consistent with the theory: the elasticities of bilateral trade in services with respect to the importing country's GDP per capita are greater than that in manufacturing. Panel (d) depicts the importing-country GDP per capita coefficients from 2009 to 2015, where BLINK09 is included. The rankings of estimates agree with the theory.

A stark finding is that the coefficients on exporter's GDP, importer's population, and importer's GDP per capita become significantly lower when BLINK09 is included in our specifications. All six panels in Figure 5 illustrate this. BLINK09 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 bias and leads to an over-estimation of coefficients on these variables. This finding underscores that virtual proximity is an essential missing component in the gravity literature, hitherto on estimating 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 the importer's GDP are equal to the coefficients on population, and those of per capita GDP equal the respective coefficients in Tables 6 to 9 minus the respective coefficient of the population. 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 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 might 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.

Table 6: **Trade in Services** - PPML estimates, 2002 to 2015, GDP and per-capita GDP instrumented

	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)	–0.66***	–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	4,500	4,885	5,577	12,433	13,158	14,790	14,875	25,762	31,152	30,976	31,152	30,450	31,152	31,152
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)	0.84***	0.84***	0.83***	0.85***	0.84***	0.85***	0.89***	0.89***	0.84***	0.83***	0.82***	0.83***	0.83***	0.82***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)	(0.10)	(0.09)	(0.08)
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	76	77	76	77	128	142	132	126	117	107	95
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.53***	0.52***	0.53***	0.67***	0.67***	0.71***	0.74***	0.72***	0.73***	0.73***	0.73***	0.75***	0.71***	0.68***
	(0.04)	(0.04)	(0.05)	(0.07)	(0.07)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
Importer GDP per capita (log)	1.60***	1.54***	1.38***	1.35***	1.44***	1.38***	1.26***	1.44***	1.21***	1.23***	1.26***	1.38***	1.41***	1.40***
	(0.23)	(0.26)	(0.21)	(0.24)	(0.22)	(0.20)	(0.19)	(0.19)	(0.16)	(0.16)	(0.18)	(0.17)	(0.15)	(0.13)
Internet Importer	–0.01*	–0.01	–0.00	0.00	–0.00	0.00	0.01	0.00	0.01	0.01	0.01	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)
Importer Gini	0.06***	0.06***	0.06***	0.03	0.03	0.02	0.02	0.02	0.04***	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)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
N	35	34	38	76	77	76	77	128	142	132	126	117	107	95

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

Table 7: **Trade in Manufacturing** - PPML estimates, 2002 to 2015, GDP and per-capita GDP instrumented

	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	30,800	30,800	30,800	30,800	30,800	30,800	30,800	30,800	30,800	30,800	31,152	31,152	31,152	31,152
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)	0.81***	0.82***	0.83***	0.88***	0.90***	0.93***	0.94***	0.90***	0.92***	0.93***	0.92***	0.95***	0.94***	0.91***
	(0.06)	(0.07)	(0.08)	(0.08)	(0.09)	(0.10)	(0.09)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)
Internet Exporter	–0.00	–0.00	–0.00	–0.01	–0.01	–0.01	–0.01	–0.01	–0.00	–0.00	–0.00	–0.01	–0.01	–0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	144	143	144	148	147	150	149	144	142	132	126	117	107	95
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.79***	0.80***	0.81***	0.81***	0.80***	0.79***	0.78***	0.78***	0.79***	0.78***	0.78***	0.78***	0.76***	0.74***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
Importer GDP per capita (log)	0.93***	0.88***	0.89***	0.92***	0.91***	0.89***	0.92***	0.87***	0.92***	0.96***	1.00***	1.10***	1.14***	1.12***
	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.11)	(0.14)	(0.16)	(0.16)	(0.15)	(0.13)
Internet Importer	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)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(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***	0.04***	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	144	143	144	148	147	150	149	144	142	132	126	117	107	95

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

Table 8: PPML estimates with BLINK sample but without BLINK09 as a Regressor, 2009-2015, GDP and per-capita GDP instrumented

	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	3,724	3,741	3,741	3,741	3,741	3,741	3,741	3,696	3,696	3,696	3,741	3,741	3,741	3,741
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***	0.86***	0.85***	0.83***	0.85***	0.85***	0.84***	0.87***	0.89***	0.90***	0.90***	0.92***	0.91***	0.90***
	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.07)	(0.10)	(0.11)	(0.11)	(0.10)	(0.10)	(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	81	81	81	81	81	81	80	80	80	81	81	81	81
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$														
Importer Population (log)	0.74***	0.73***	0.73***	0.74***	0.75***	0.72***	0.70***	0.77***	0.79***	0.79***	0.78***	0.78***	0.77***	0.74***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Importer GDP per capita (log)	1.35***	1.06***	1.07***	1.06***	1.25***	1.26***	1.24***	0.87***	0.92***	0.94***	1.02***	1.09***	1.12***	1.09***
	(0.17)	(0.14)	(0.15)	(0.16)	(0.17)	(0.15)	(0.13)	(0.11)	(0.14)	(0.16)	(0.20)	(0.19)	(0.18)	(0.16)
Internet Importer	0.00	0.01**	0.01**	0.01*	0.00	0.00	0.00	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	0.03	0.05***	0.05***	0.04***	0.04**	0.05***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.05***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
N	75	76	73	72	70	69	61	76	76	73	72	70	69	61

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

Table 9: PPML estimates with BLINK09 as a regressor, 2009-2015, with BLINK09, GDP and per-capita GDP instrumented

	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***	0.44***	0.42***	0.39***	0.42***	0.40***	0.41***	0.62***	0.62***	0.61***	0.35***	0.65***	0.64***	0.65***
	(0.09)	(0.10)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.12)	(0.10)	(0.09)	(0.09)
Internet Exporter	0.01***	0.01***	0.01***	0.01***	0.02***	0.01***	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	68	68	68	68	68	68	68	68	68	68	68	68	68	68
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***	0.48***	0.48***	0.46***	0.24***	0.48***	0.49***	0.50***
	(0.07)	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)
Importer GDP per capita (log)	1.14***	0.80***	0.68***	0.67***	0.83***	0.79***	0.86***	0.57***	0.57***	0.51***	0.33	0.63**	0.65***	0.63**
	(0.19)	(0.16)	(0.18)	(0.20)	(0.22)	(0.24)	(0.23)	(0.13)	(0.15)	(0.19)	(0.23)	(0.25)	(0.25)	(0.25)
Internet Importer	–0.00	0.00	0.01	0.01	0.00	0.00	–0.00	0.00	0.00	0.00	0.00	–0.00	–0.00	–0.00
	(0.01)	(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*	0.03**	0.03*	0.03**	0.03**	0.03*	0.03*
	(0.02)	(0.02)	(0.01)	(0.01)	(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

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

Figure 4: **Coefficients on Exporter GDP and Importer per capita GDP**

(a) No BLINK (b) BLINK09 included

(c) No BLINK (d) BLINK09 included

4.2 Income Inequality

Non-homotheticity in tastes implies that inequality in the importing country may impact bilateral trade. However, our discussion in Section 2.5 does not indicate any clear direction of this effect, making it an empirical issue primarily. Our general finding is that 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, although statistical significance is somewhat weaker. In Table 9, we see that the coefficients on GINI are nearly identical between manufacturing and services.

Figure 5: **Coefficients on Exporter GDP, Importer Population and Importer per capita GDP: No BLINK Versus BLINK**

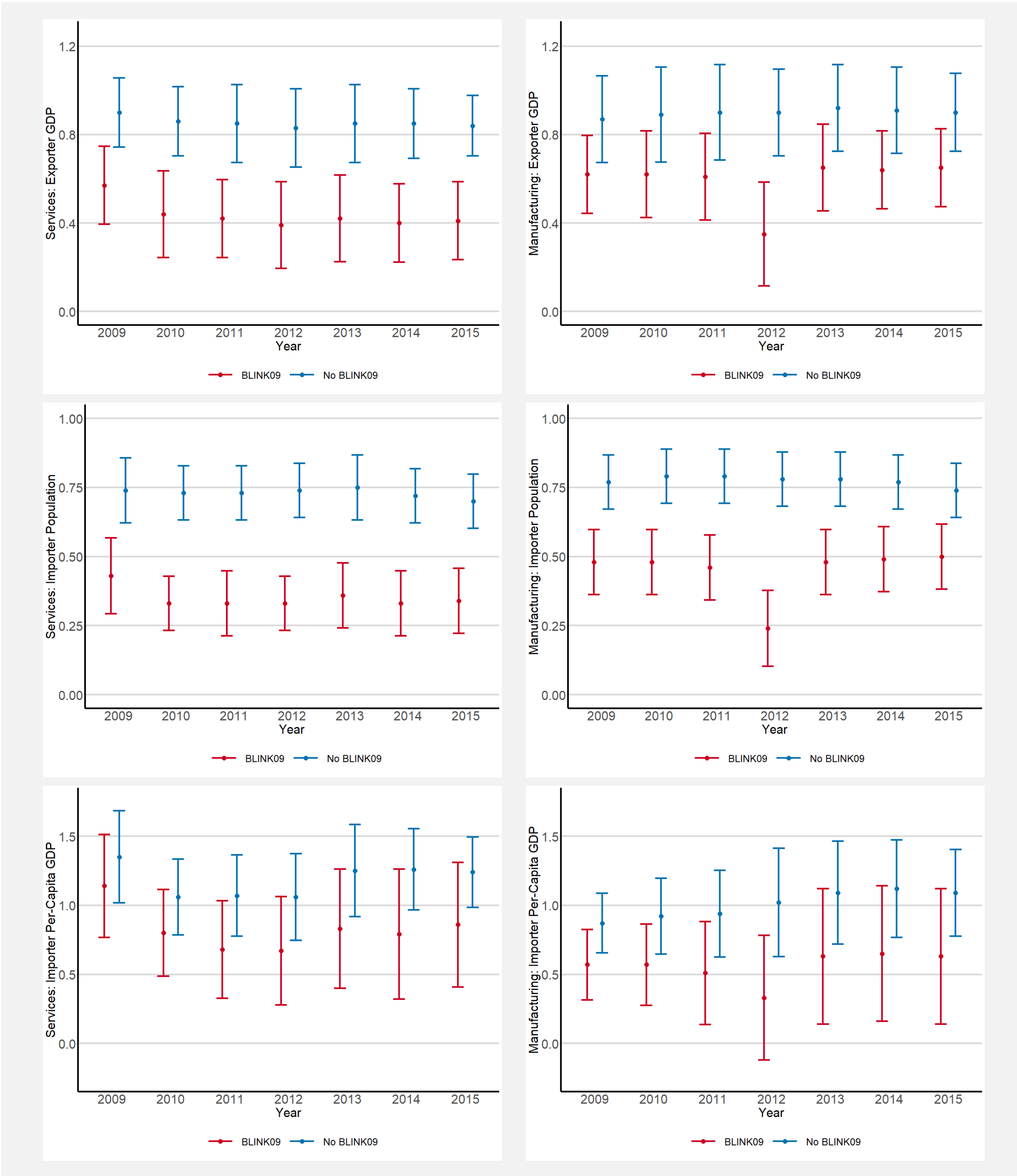


Table 10: Correlations with Bilateral hyperlinks

	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 per capita (log)	0.2526***	0.2678***	0.2740***	0.2736***	0.2667***	0.2646***	0.2725***

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

4.3 Overall Trade-Cost Elasticity

Because overall trade costs are unobservable, our empirical model does not yield point estimates of the overall trade-cost elasticities. 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 4.

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 Result 7. As noted earlier, it indirectly validates our Difference in the National Product Differentiation assumption.

4.4 Observable Trade Costs

Internet Penetration: Tables 6 and 9 show a positive and statistically significant marginal effect of internet usage in the exporter country on international trade of services. However, we do not observe a consistent and statistically significant effect of internet usage in the importer country for trade in services. Moreover, the coefficient for internet usage in both countries is not statistically significant for trade in manufacturing, suggesting that, at the margin, manufacturing trade 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) holds on average across many countries and years for trade in services.

Bilateral Hyperlinks: In contrast to the general use of the 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. Table 9 shows 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 a 3.2 to 3.7% increase in bilateral trade in services.

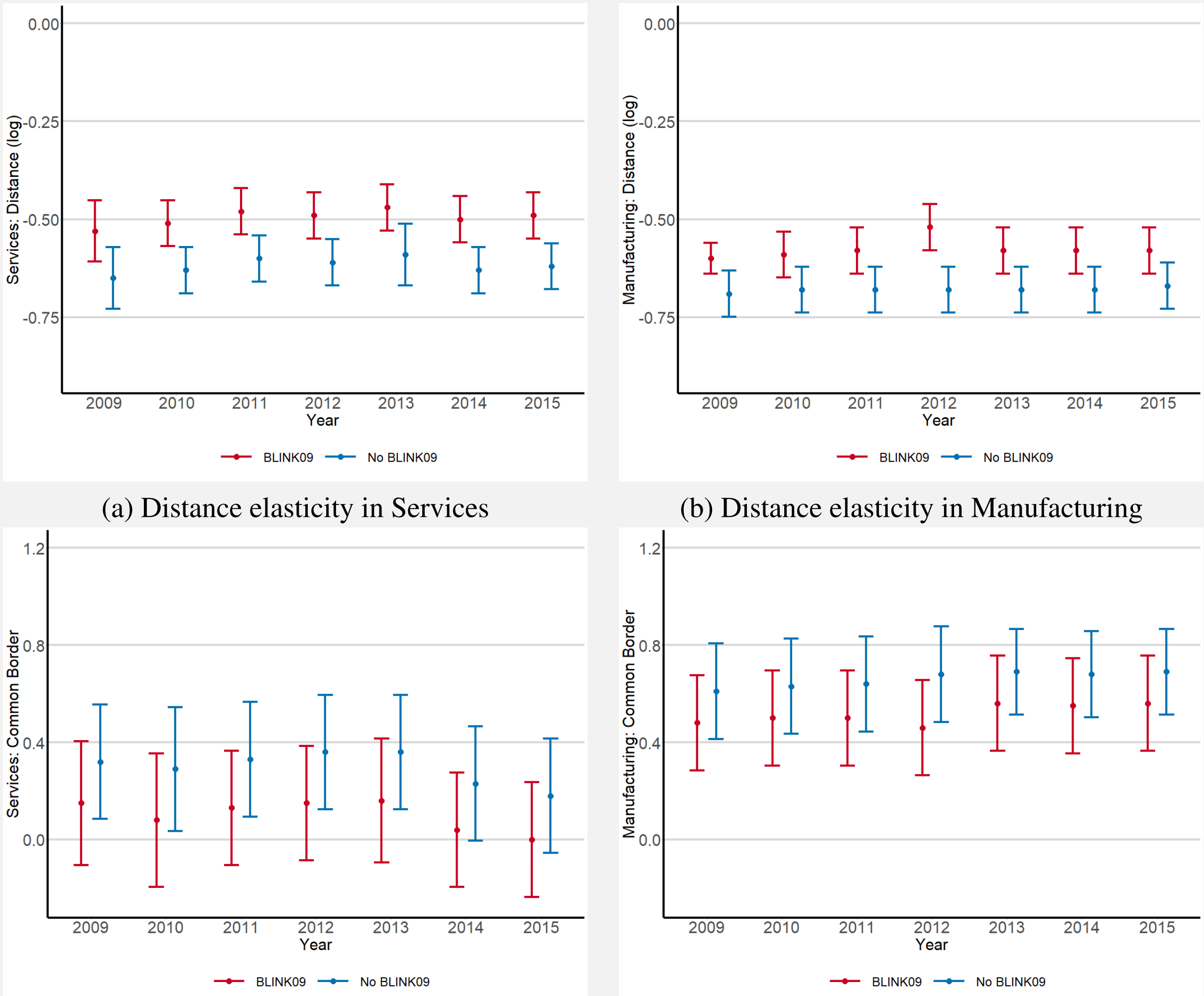
Distance, Common Border, Common Language and Colony, and, Substitution Effects: The coefficients of these standard trade-cost variables bear their expected signs. It is surprising, however, that when BLINK09 is present as a regressor (Table9), the coefficients of common language and colonial relation 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 remains highly significant for trade in both services and manufacturing. As expected, bilateral trade in services is less sensitive to physical distance than manufacturing.

It is interesting to know how the coefficients on these variables change once we account for the virtual proximity variable. Comparing Tables 8 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 6 for distance and common border.

The estimates for geographical distance imply that virtual proximity partly substitutes physical proximity. There are two implications of 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 6(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 the internal distance effect. We believe that if these dimensions 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 6: **Coefficients on Distance and Common Border: BLINK versus No BLINK**



(a) Distance elasticity in Services

(b) Distance elasticity in Manufacturing

(c) Common Border in Services

(d) Common Border in Manufacturing

5 Robustness

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 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 and second-stage estimates for

Table 11: Two-stages PPML using GDP PPP, with BLINK09 GDP PPP and GDP PPP per-capita instrumented

	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
Second Stage Regressions														
Dependent variable: Exporter Fixed Effects, $ \widehat\exp (X_ji)$														
Exporter GDP PPP (log)	0.59***	0.46***	0.44***	0.41***	0.44***	0.42***	0.44***	0.65***	0.65***	0.64***	0.37***	0.68***	0.68***	0.70***
	(0.09)	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.10)	(0.09)	(0.10)	(0.10)	(0.12)	(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
Dependent variable: Importer Fixed Effects, $ \widehat \exp (M_jr)$														
Importer Population (log)	0.51***	0.38***	0.36***	0.36***	0.40***	0.36***	0.38***	0.49***	0.50***	0.48***	0.25***	0.50***	0.51***	0.52***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)	(0.07)	(0.06)	(0.05)	(0.06)
Importer GDP PPP per capita (log)	1.52***	0.94***	0.79***	0.79***	0.98***	1.03***	1.16***	0.72***	0.71***	0.62***	0.40	0.75***	0.86***	0.85***
	(0.25)	(0.17)	(0.18)	(0.20)	(0.23)	(0.26)	(0.25)	(0.17)	(0.17)	(0.21)	(0.25)	(0.28)	(0.31)	(0.33)
Internet Importer	0.00	0.01**	0.02***	0.02***	0.01*	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	(0.01)	(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	0.03*	0.04***	0.04***	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)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
N	64	66	64	63	61	60	55	65	66	64	63	61	60	55

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

Table 12: Second-Stage Estimates: Alternative Measures of Income Inequality, with BLINK09, GDP and per-capita GDP instrumented

	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***	0.48***	0.48***	0.46***	0.24***	0.48***	0.49***	0.50***
	(0.07)	(0.05)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)
Importer GDP per capita (log)	1.14***	0.80***	0.68***	0.67***	0.83***	0.79***	0.86***	0.57***	0.57***	0.51***	0.33	0.63**	0.65***	0.63**
	(0.19)	(0.16)	(0.18)	(0.20)	(0.22)	(0.24)	(0.23)	(0.13)	(0.15)	(0.19)	(0.23)	(0.25)	(0.25)	(0.25)
Internet Importer	–0.00	0.00	0.01	0.01	0.00	0.00	–0.00	0.00	0.00	0.00	0.00	–0.00	–0.00	–0.00
	(0.01)	(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*	0.03**	0.03*	0.03**	0.03**	0.03*	0.03*
	(0.02)	(0.02)	(0.01)	(0.01)	(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
Panel b: Importer Top 10$\hat{t}h$ percentile of income share														
Importer Population (log)	0.54***	0.38***	0.39***	0.39***	0.44***	0.37***	0.41***	0.53***	0.53***	0.54***	0.33***	0.54***	0.54***	0.51***
	(0.07)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.05)
Importer GDP per capita (log)	0.90***	0.77***	0.62***	0.63***	0.66***	0.77***	0.72***	0.59***	0.58***	0.55***	0.36**	0.64***	0.74***	0.75***
	(0.17)	(0.15)	(0.14)	(0.16)	(0.16)	(0.18)	(0.15)	(0.15)	(0.16)	(0.14)	(0.17)	(0.16)	(0.15)	(0.22)
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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Top 10$\hat{t}h$ percentile of income share	–2.54***	1.29**	1.83***	1.74***	1.46***	1.95***	1.89***	2.00***	1.82***	2.14***	3.13***	2.41***	2.50***	2.40***
	(0.92)	(0.62)	(0.46)	(0.43)	(0.47)	(0.36)	(0.42)	(0.59)	(0.55)	(0.63)	(0.60)	(0.62)	(0.64)	(0.87)
N	48	48	46	46	46	46	43	48	48	46	46	46	46	43
Panel c: Importer Top 1$\hat{s}t$ percentile of income share														
Importer Population (log)	0.54***	0.37***	0.35***	0.36***	0.42***	0.34***	0.39***	0.51***	0.52***	0.52***	0.27***	0.51***	0.51***	0.49***
	(0.07)	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)
Importer GDP per capita (log)	0.93***	0.83***	0.63***	0.62***	0.64***	0.76***	0.73***	0.64***	0.64***	0.56***	0.35*	0.61***	0.71***	0.72***
	(0.17)	(0.16)	(0.14)	(0.16)	(0.16)	(0.19)	(0.17)	(0.17)	(0.18)	(0.16)	(0.18)	(0.18)	(0.17)	(0.27)
Internet Importer	–0.00	0.00	0.01	0.01	0.01	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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Top 1$\hat{s}t$ percentile of income share	–3.12*	2.80***	3.57***	3.52***	2.79***	3.64***	3.49***	2.82**	2.51**	2.76**	5.40***	3.71**	3.81***	3.41*
	(1.78)	(0.99)	(0.75)	(0.73)	(0.90)	(0.72)	(0.87)	(1.23)	(1.14)	(1.36)	(1.44)	(1.44)	(1.46)	(1.96)
N	49	49	46	46	46	46	43	49	49	46	46	46	46	43

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

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 per capita (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

Notes: Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

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 Panel Estimation

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 per capita (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					✓					✓

Notes: Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

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"). Given the challenges specific to our model and the variables we are interested in, there is an additional issue with using panel estimation: there is no available empirical methodology incorporating PPML together with fixed effects *and* instrumental variables for addressing endogeneity.

At the cost of endogeneity bias, Table 14 presents the results from pooled, random-effects, along with various combinations of fixed-effects specifications but without instrumenting BLINK09, GDP or per capita GDP.[25] The panel covers the years 2009-2015, since we use BLINK09 for bilateral hyperlinks that are available only for these years.

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 models disagree with theoretical predictions only in the case of country-pair fixed effects. This is because the between-variation vanishes.[26]

6 Concluding Remarks

This paper aims to understand 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: nonhomothetic tastes with a demand bias towards services and differences in the degree of national product differentiation.

Although the gravity equations for manufacturing and services are separately estimated, they help us 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 GDP per capita. 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.

Another major finding is that virtual proximity is an essential determinant of trade costs of both manufacturing and services, and it 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. For this purpose, 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). Chaney (2008) shows that, in the presence of firm heterogeneity, 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 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 valuable to analyze bilateral trade flows of sub-categories 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, by incorporating the role of FDI in services (Mode 3 of trade in services). Lastly, international trade in services, particularly that of *business services*, can impact economic growth. Exploring the link between service exports on one hand and growth or per capita income on the other will be promising.

[25] For use of panel estimation of gravity equations allowing for fixed effect, see Redding and Venables (2004), Head and Mayer (2014), Anderson and van Wincoop (2003) and Piermartini and Yotov (2016), among many thers.

[26] 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 relationships in the past.

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Appendices

A Derivation of Demand functions for c_j, c_{zj} and P_j

This section presents the derivation of the demand functions for c_j, c_{zj} and P_j, described in eqs. (4a), (4b) and (4c), respectively. Letting γ and μ_r denote the respective Lagrange multipliers, the first-order conditions of Middle tier 1 household optimization with respect to c_j, c_{mj} and c_{sj} are:

$$1 + \gamma \sum_{z\in(m,s)} \frac{\theta_z - \eta}{\eta} c_j^{\frac{\theta_z - 2\eta}{\eta}} c_{zj}^{\frac{\eta-1}{\eta}} = 0 \tag{A.1}$$

$$\gamma \frac{\eta - 1}{\eta} c_j^{\frac{\theta_m - \eta}{\eta}} c_{mj}^{-\frac{1}{\eta}} = \mu_j P_{mj} \tag{A.2}$$

$$\gamma \frac{\eta - 1}{\eta} c_j^{\frac{\theta_s - \eta}{\eta}} c_{sj}^{-\frac{1}{\eta}} = \mu_j P_{sj}. \tag{A.3}$$

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

$$\frac{c_{mj}}{c_{sj}} = c_j^{-(\theta_s - \theta_m)} \left(\frac{P_{mj}}{P_{sj}}\right)^{-\eta}. \tag{A.4}$$

Non-homothetic tastes over manufacturing and services imply that this consumption ratio depends on the overall sub-utility, c_j. 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_{mj} and c_{sj}, adding them and using the utility constraint, we obtain

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

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

$$c_{zj} = \left(\frac{P_{zj}}{e_j}\right)^{-\eta} c_j^{\theta_z - \eta} = \left(\frac{P_{zj}}{P_j}\right)^{-\eta} c_j^{\theta_z} \tag{A.6}$$

$$\frac{P_{zj} c_{zj}}{e_j} = \left(\frac{P_{zj}}{e_j}\right)^{1-\eta} c_j^{\theta_z - \eta} = \left(\frac{P_{zj}}{P_j}\right)^{1-\eta} c_j^{\theta_z - 1}. \tag{A.7}$$

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

$$\sum_{z\in(m,s)} P_{zj}^{1-\eta} c_j^{\theta_z - \eta} = e_j^{1-\eta}. \tag{A.8}$$

which implicitly solves c_j (eq. (4a) in the text).

Plugging back (A.8) into eq. (A.6), we obtain a quasi-reduced-form solution expression of c_{zj} ((4c) in the text). Next, substituting $P_j = e_j/c_j$ into (A.8) yields eq. (4b) in the text.

B Results 1 and 2

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

$$\hat{c}_{zj} = \eta\hat{e}_j - (\eta - \theta_z)\hat{c}_j \tag{A.9}$$

$$\hat{e}_j = \frac{\sum_z \lambda_z(\eta - \theta_z)}{\eta - 1} \cdot \hat{c}_j, \quad \text{where } \lambda_z \equiv \frac{P_{zj}^{1-\eta} c_j^{\theta_z - \eta}}{e_j^{1-\eta}} \in (0, 1). \tag{A.10}$$

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

$$\Lambda_z \equiv \frac{\eta}{\eta - 1}\sum_z \lambda_z(\eta - \theta_z) - (\eta - \theta_z) = \frac{\eta\,(1 + \theta_z - \sum_z \lambda_z\theta_z) - \theta_z}{\eta - 1}$$

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),

$$\hat{c}_{zj} = \Lambda_z\hat{c}_j = \frac{(\eta - 1)\Lambda_z}{\sum_z \lambda_z(\eta - \theta_z)}\hat{e}_j. \tag{A.13}$$

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

$$\nu_{mj} \equiv \frac{\hat{c}_{mj}}{\hat{e}_j} = \frac{\eta\,[1 - \lambda_s\,(\theta_s - \theta_m)] - \theta_m}{\sum_z \lambda_z(\eta - \theta_z)}; \quad \nu_{sj} \equiv \frac{\hat{c}_{sj}}{\hat{e}_j} = \frac{\eta - \theta_s + \eta\lambda_m\,(\theta_s - \theta_m)}{\sum_z \lambda_z(\eta - \theta_z)}. \tag{A.14}$$

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

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

$$\frac{\widehat{\partial c_{mj}/\partial e_j}}{\hat{e}_j} < 0 < \frac{\widehat{\partial c_{sj}/\partial e_j}}{\hat{e}_j}. \tag{A.15}$$

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

$$\frac{\partial c_{zj}}{\partial e_j} = \frac{c_{zj}}{e_j}\nu_{zj},$$

where ν_{zj} is the income elasticity of the z-good basket, implying

$$\frac{\widehat{\partial c_{zj}/\partial e_j}}{\hat{e}_j} = \nu_{zj} - 1 + \frac{\widehat{\nu_{zj}}}{\hat{e}_j}. \tag{A.16}$$

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

$$\nu_{mj} < 1 < \nu_{sj}$$

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

Referring to (A.14), ν_{zj} 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_j via (A.10). The changes in λ_m or λ_s as well as ν_{mj} and ν_{sj} are given by

$$d\lambda_m = \left[-(\eta-\theta_m)\,\hat{c}_j + (\eta-1)\hat{e}_j\right]\lambda_m = -\frac{\lambda_m\lambda_s(\eta-1)(\theta_s-\theta_m)}{\sum_z \lambda_z(\eta-\theta_z)}\hat{e}_j. \tag{A.17}$$

$$\begin{aligned}\frac{\widehat{\nu_{mj}}}{\hat{e}_j} &= \frac{(\eta-\theta_m)\,(\eta-1)\,(\theta_s-\theta_m)}{\{\eta[1-\lambda_s(\theta_s-\theta_m)]-\theta_m\}[\sum_z \lambda_z(\eta-\theta_z)]}\cdot\frac{d\lambda_m}{\hat{e}_j}\\ &= -\frac{\lambda_m\lambda_s\,(\eta-\theta_m)\,(\eta-1)^2\,(\theta_s-\theta_m)^2}{\{\eta[1-\lambda_s(\theta_s-\theta_m)]-\theta_m\}[\sum_z \lambda_z(\eta-\theta_z)]^2} < 0\end{aligned} \tag{A.18}$$

$$\begin{aligned}\frac{\widehat{\nu_{sj}}}{\hat{e}_j} &= \frac{(\eta-\theta_s)\,(\eta-1)\,(\theta_s-\theta_m)}{[\eta-\theta_s+\eta\lambda_m\,(\theta_s-\theta_m)][\sum_z \lambda_z(\eta-\theta_z)]}\cdot\frac{d\lambda_m}{\hat{e}_j}\\ &= -\frac{\lambda_m\lambda_s\,(\eta-\theta_s)\,(\eta-1)^2\,(\theta_s-\theta_m)^2}{[\eta-\theta_s+\eta\lambda_m\,(\theta_s-\theta_m)][\sum_z \lambda_z(\eta-\theta_z)]^2} < 0.\end{aligned} \tag{A.19}$$

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

$$\frac{\widehat{\partial c_{mj}/\partial e_j}}{\hat{e}_j} < 0, \tag{A.20}$$

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

Turning to the services basket,

$$\frac{\widehat{\partial c_{sj}/\partial e_j}}{\hat{e}_j} = \nu_{sj} - 1 + \frac{\widehat{\nu_{sj}}}{\hat{e}_j} = \underbrace{\frac{(\eta-1)\lambda_m(\theta_s-\theta_m)}{\sum_z \lambda_z(\eta-\theta_z)}}_{+} + \underbrace{\frac{\widehat{\nu_{sj}}}{\hat{e}_j}}_{-}. \tag{A.21}$$

The sign of $\frac{\partial c_{sj}/\partial e_j}{\hat{e}_j}$ is not clear from (A.21).

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

$$\begin{aligned}&\frac{[\eta-\theta_s+\eta\lambda_m\,(\theta_s-\theta_m)][\sum_z \lambda_z(\eta-\theta_z)]^2}{\lambda_m(\eta-1)(\theta_s-\theta_m)}\cdot\frac{\partial c_{sj}/\partial e_j}{\hat{e}_j}\\ &= [\eta-\theta_s+\eta\lambda_m\,(\theta_s-\theta_m)]\left[\sum_z \lambda_z(\eta-\theta_z)\right] - \lambda_s(\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\ &= [\eta(1+\theta_s-\theta_m)-\theta_s-\eta\lambda_s\,(\theta_s-\theta_m)]\,[\eta-\theta_m-\lambda_s(\theta_s-\theta_m)] - \lambda_s(\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\ &> [\eta(1+\theta_s-\theta_m)-\theta_s-\eta(\theta_s-\theta_m)]\,[\eta-\theta_m-(\theta_s-\theta_m)] - (\eta-\theta_s)(\eta-1)(\theta_s-\theta_m) \qquad \text{(A.22)}\\ &= (\eta-\theta_s)^2 - (\eta-\theta_s)(\eta-1)(\theta_s-\theta_m)\\ &= (\eta-\theta_s)[\eta\,(1-\theta_s+\theta_m)-\theta_m] > 0 \text{ in view of (R2).} \qquad \text{(A.23)}\end{aligned}$$

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

$$\frac{\partial c_{sj}/\partial e_j}{\hat{e}_j} > 0$$

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

C Derivation of Eq. (19)

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, $\sum_{j=1}^{N} L_j c_{zij}(u)\tau_{zij}$. Using this equality and substitutions based on (A.6), (7a), (10) and (13),

$$\begin{aligned}
\alpha(\sigma-1) &= \sum_{j=1}^{N} L_j c_{zij}(u)\tau_{zij} = \sum_{j=1}^{N} L_j \left(\frac{p_{zij}(u)}{P_{zij}}\right)^{-\sigma} c_{zij}\tau_{zij} \\
&= \sum_{j=1}^{N} L_j \left(\frac{p_{zij}(u)}{P_{zij}}\right)^{-\sigma} \left(\frac{P_{zij}}{P_{zj}}\right)^{-\epsilon_z} c_{zj}\tau_{zij} \\
&= \sum_{j=1}^{N} L_j \frac{\left(w_i\tau_{zij}\right)^{-\epsilon_z} \Omega_{zi}^{-\frac{\sigma-\epsilon_z}{\sigma-1}}}{\left(\sum_{j=1}^{N}\left(w_j\tau_{zij}\right)^{1-\epsilon_z} \Omega_{zj}^{\frac{1-\epsilon_z}{1-\sigma}}\right)^{\frac{\epsilon_z}{\epsilon_z-1}}} \cdot c_{zj}\tau_{zij} \\
&= \frac{w_i^{-\epsilon_z}\Omega_{zi}^{-\frac{\sigma-\epsilon_z}{\sigma-1}}}{\left(\sum_{j=1}^{N}\left(w_r\tau_{zij}\right)^{1-\epsilon_z} \Omega_{zj}^{\frac{\epsilon_z-1}{\sigma-1}}\right)^{\frac{\epsilon_z}{\epsilon_z-1}}} \cdot \sum_{j=1}^{N} L_j c_{zj}\tau_{zij}^{-(\epsilon_z-1)} \quad z = m, s. \qquad \text{(A.24)}
\end{aligned}$$

The last expression is the right-hand side of eq. (19).

D Derivation of the Gravity Equation (23)

We have

$$\begin{aligned}
X_{zij} &= \#\text{ of varieties of good } z \text{ produced in country } i \times \text{country } j\text{'s expenditure on each variety at fob price} \\
&= \Omega_{zi} \times \left[L_j p_{zi}(u) c_{zij}(u)\right] \\
&= L_j\Omega_{zi}p_{zi}(u)\left(\frac{p_{zij}(u)}{P_{zij}}\right)^{-\sigma} c_{zij}, \text{ using (10)} \\
&= L_j\Omega_{zi}p_{zi}(u)\cdot\Omega_{zij}^{-\frac{\sigma}{\sigma-1}}\cdot\left(\frac{P_{zij}}{P_{zj}}\right)^{-\epsilon_z} c_{zj}, \text{ using (7a) and (13)} \\
&= L_j \cdot \frac{\sigma w_i}{\sigma-1}\cdot\Omega_{zi}^{-\frac{1}{\sigma-1}}\left[\frac{w_i\tau_{zij}\Omega_{zi}^{\frac{1}{1-\sigma}}}{\left(\sum_{i=1}^{N}\left(w_i\tau_{zij}\right)^{1-\epsilon_z}\Omega_{zi}^{\frac{1-\epsilon_z}{1-\sigma}}\right)^{\frac{1}{1-\epsilon_z}}}\right]^{-\epsilon_z} c_{zj}, \text{ using (12), (13) and (15)} \\
&= \frac{\sigma}{\sigma-1}w_i^{-(\epsilon_z-1)}\Omega_{zi}^{\frac{\epsilon_z-1}{\sigma-1}}\frac{\tau_{zij}^{-\epsilon_z}}{\left(\sum_{i=1}^{N}\left(w_i\tau_{zij}\right)^{1-\epsilon_z}\Omega_{zi}^{\frac{1-\epsilon_z}{1-\sigma}}\right)^{\frac{\epsilon_z}{\epsilon_z-1}}}\cdot L_jc_{zj} \\
&= \frac{\sigma}{\sigma-1}w_i^{-(\epsilon_z-1)}\Omega_{zi}^{\frac{\epsilon_z-1}{\sigma-1}}\frac{\tau_{zij}^{-\epsilon_z}}{\left(\frac{\sigma-1}{\sigma}P_{zj}\right)^{-\epsilon_z}}\cdot L_jc_{zj} \text{ using (13)} \\
&= \left(\frac{\sigma-1}{\sigma}\right)^{\epsilon_z-1}\chi_{zi}^{\frac{\epsilon_z-1}{\sigma-1}}\left[w_i\left(\chi_{mi},\chi_{si},L_i\right)\right]^{-\frac{\sigma(\epsilon_z-1)}{\sigma-\epsilon_z}}\left(\frac{\tau_{zij}}{P_{zj}}\right)^{-\epsilon_z}\left(L_jc_{zj}\right), \text{ using (22).}
\end{aligned}$$

The very last expression is same as (23).

E LIST OF COUNTRIES INCLUDED IN THE SAMPLE

Table A1: 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 A2: 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	

F Instrumental Variable Validation Regressions

Table A3: Instrumental Variable Validation: Strength of BROAD03 as an IV for BLINK09

	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	✓	✓

Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A4: Instrumental Variable Validation: Strength of Capital Stock as an IV for GDP

	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
Dependent variable: GDP (log)														
Lagged Capital Stock (log)	0.87***	0.88***	0.89***	0.91***	0.93***	0.94***	0.95***	0.93***	0.96***	0.96***	0.97***	0.97***	0.98***	0.99***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Internet Exporter	0.02***	0.02***	0.02***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01**
	(0.00)	(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	145	144	145	149	147	151	149	144	142	132	126	117	107	95
R-sq	0.92	0.93	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.94
F-statistic	825.03	923.88	1027.12	1148.95	1312.3	1483.25	1537.38	1310.34	1323.49	1141.57	1125.33	1096.66	838.24	690.61
Dependent variable: GDP per capita (log)														
Lagged Capital Stock per capita (log)	9.99***	9.27***	8.78***	8.66***	8.31***	6.92***	5.65***	5.92***	5.19***	4.51***	4.50***	4.22***	4.69***	4.94***
	(1.20)	(1.25)	(1.21)	(1.16)	(1.15)	(1.08)	(0.93)	(0.88)	(0.88)	(0.79)	(0.72)	(0.71)	(0.71)	(0.71)
Importer Population (log)	–0.09***	–0.08**	–0.07**	–0.06**	–0.05*	–0.04	–0.03	–0.01	0.00	0.02	0.02	0.02	0.04	0.04
	(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)
Internet Importer	0.04***	0.04***	0.04***	0.04***	0.03***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***
	(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)
Importer Gini	0.03***	0.03***	0.03***	0.03***	0.03***	0.03***	0.02**	0.03***	0.03***	0.03***	0.03***	0.03***	0.02***	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)
N	145	144	145	149	147	151	149	144	142	132	126	117	107	95
R-sq	0.79	0.80	0.81	0.81	0.81	0.84	0.84	0.87	0.88	0.90	0.91	0.91	0.91	0.90
F-statistic	132.8	143.1	150.08	157.79	155.83	189.12	194.17	241.45	242.01	287.5	298.62	295.36	259.89	208.07

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