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

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Abstract

This paper studies how and why the bilateral trades in manufacturing and services differ in their response to changes in the determinants – both theoretically and empirically. 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 product groups. Estimation results support the theoretical predictions. The empirical model includes, among others, two non-standard trade-cost variables: a measure of internet penetration and virtual proximity (the number of bilateral hyperlinks). An important finding is that virtual proximity—thus far ignored in most gravity models—is a strong predictor of aggregate trade in both services and manufacturing. Also, physical distance is an important determinant of bilateral trade in manufacturing and services, even while controlling for virtual proximity.

Keywords: Trade in Services, Trade in Manufacturing, Gravity Model, Nonhomotheticity, Product Differentiation, Virtual Proximity
JEL Classification: D11, F12, F14, 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. However, international trade in services has grown faster than trade in manufacturing in recent decades. The global share of exports of services in total exports 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, 2022).[1] Despite the significant decrease in the volume of trade in goods and services in 2020 due to the global pandemic, 2021 already saw a recovery of both types of trade to their prepandemic trends (UNCTAD, 2022).

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 services trade, there are at least two other reasons for this. First, the increase of the share of the service sector in international trade is a relatively recent phenomenon—evidently far more recent than the famous paradigm of trade in wine and clothes, stylized by David Ricardo more than two centuries ago. Second, there is a broad perception that there is no need to 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, as products, services and manufacturing have significantly different characteristics, international trade in them may respond differently to same trade determinants, like 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 GDP per capita 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 subsectors of the service sector and the services sector as a whole have been estimated by various authors, for example, Freund and Weinhold (2002), Grünfeld and Moxnes (2003), Marvasti and Canterbery (2005), Kimura and Lee (2006), Walsh (2008), Head et al. (2009), Hanson and Xiang (2011), Culiuc (2014), Hellmanzik and Schmitz (2015, 2016), and Anderson et al. (2018).

While the literature encompasses different estimation techniques, and diverse samples including different sets of countries, time periods, explanatory variables, it does not bring to the fore the differences in how trade in the two categories responds to changes in the common 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. In doing so, we explore two inherent dimensions in which manufacturing and services discern themselves.
Demand Bias: Compared to services, the demand for manufacturing is more income-inelastic. This is

[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 the limited availability of data.

[2] For instance, see Lee and Lloyd (2002).

[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.

standard in the literature on structural change 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 shown in Figure 1. Part (a) graphs the expected positive correlations between per capita GDP and the total trade in manufacturing and services across the 177 countries and over 2010-2020. However, part (b) shows the correlations between per-capita GDP and the *share* of respective trade in the GDP, which is not apparent. Here the correlation is postive for trade in services, but negative (and relatively small) for trade in manufacturing for every year from 2010 to 2020. These results support the demand-bias hypothesis.

Another fundamental difference between the two categories of trade is with respect to their *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]

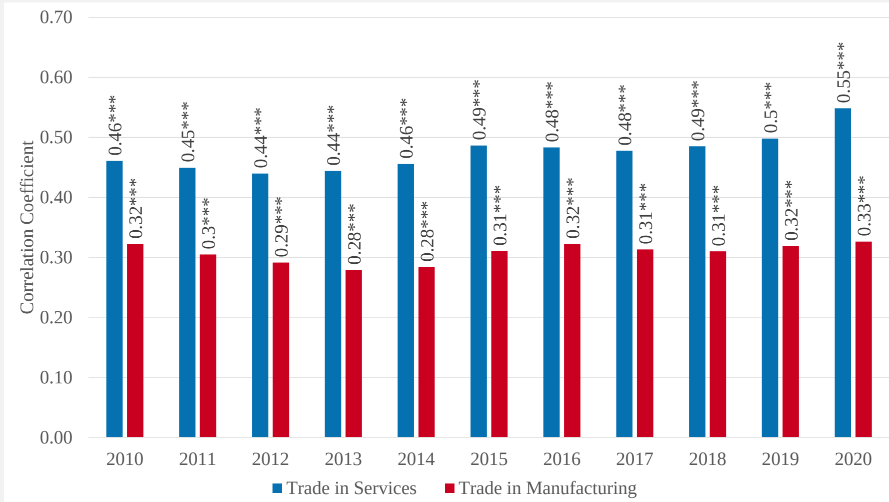
The attention to *Demand Bias* is not new in the gravity literature (see, Fieler (2011)). But it has not been applied to differentiate trade in the two product categories. It has two theoretical implications. First, the per capita income and population size of the importer country would have different 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. Yet, there is virtually no emphasis in the existing literature placed on the *differences* of national product differentiation between the two product groups and what they imply toward international bilateral trade in the two product groups.

We bring these two features together in a unified theoretical framework and consider it as a main contribution of this paper. 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.

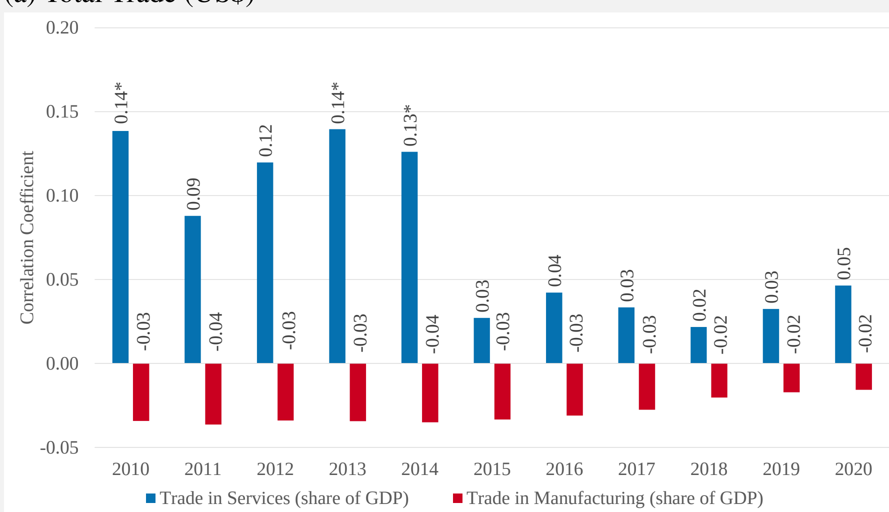
[4]We invoke the term "national product differentiation" *a la* Head and Ries (2001).

[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. Regardless 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, the elasticities average to 3.02 and 2.35 for manufacturing and service products, and for GTAP, these are 2.89 and 2.35, respectively.

Figure 1: **Cross-country Correlation: GDP per capita and International Trade in Manufacturing and Services in GDP**



(a) Total Trade (US$)



(b) Total Trade as a Share of 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 in each category.
Statistical Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The next contribution lies in side-by-side estimation of gravity equations for aggregate trade in manufacturing and services to better understand and interpret the similarities and dissimilarities between them. This is in contrast to the existing empirical literature that focuses separately on manufacturing and services, or some important segments of them.

A hightlight of our empirical exercise is the incorporation of internet penetration and, in particular, virtual proximity. 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). Virtual proximity refers to bilateral internet links. Hellmanzik and Schmitz (2015) find that the number of *bilateral* internet links is a significant determinant of audiovisual services trade. This relatively novel idea is extended to study *aggregate* trade in services and manufacturing.

We find that virtual proximity is not only a significant determinant of bilateral aggregate trade in both product groups, it substantially lowers the marginal effects of physical distance and scale variables like the GDP and income per capita on bilateral trade. A strong implication is that virtual proximity is crucial in understanding trade costs and trade flows in both manufactures and services. Its exclusion entails, in our view, a severe omitted-variable bias in estimating gravity relations.

2 Theory

The world economy consists of many countries (N) and three traded goods: services (s), manufacturing (m), and a numeraire good (0). Manufacturing and services are differentiated and produced by a primary factor, labor. We interpret this as effective labor, which is the working population (labor force) augmented by the skill content (*a la* Copeland and Taylor (1994) among many others.)

Each household has a given endowment of good 0. It is homogeneous and cannot be produced. The presence of a numeraire good implies an endogenous wage rate (per unit of effective labor). As will be seen, it serves two roles: (a) assess the effect of the cost of production in the exporter country on the value of bilateral trade and (b) reveal the role of the Armington elasticity in determining how the total income of an exporter country may affect bilateral trade.

The trading countries are indexed by i or j (source and destination country respectively). Country i is endowed with H_i identical households, each owning ρ_i units of effective labor (skill content), both exogenous. We may interpret H_i as the population of country i. By definition, $L_i \equiv H_i\rho_i$ is the total endowment of effective labor in country i. Production sectors are distinguished by $z = \{m, s\}$.

2.1 Tastes

Households have identical tastes across and within countries. *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 transparently:
(i) an outer tier on the choice of the manufacturers-services basket c_j and the numeraire good,
(ii) a middle-tier 1 over the allocation of c_j into the baskets of manufactures (c_{mj}) and services (c_{sj}),
(iii) a middle-tier 2 on the choice among country-specific manufactures (c_{mij}) and services (c_{sij}),
(iv) and an 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 nonhomotheticity in the middle tier 1, while middle-tier 2 features national product differentiation across countries. Table 1 summarizes the notations.

Table 1: Summary of the Notations

[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 a measure of the same.

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

These 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 satisfying 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 grand basket of manufacturing and services.

2.1.2 Middle-Tier 1 Tastes: Nonhomothetic CES

This is where demand bias is introduced *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 nonhomothetic 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 nonhomotheticity, (R1) states that the difference between them is not supposed to be very large. This ensures normality of both goods.[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 $\eta > 1$, while (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 leads to the expressions for 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 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 *demand bias* toward 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

The differences between manufacturing and service in terms of the degree of *national product differentiation* are introduced in this tier. The 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 needs 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. Firm-level labor requirement is given by $l_{zi}(u) = \alpha + q_{zi}(u)$, $\alpha > 0$, $z = m, s$. The units of manufacturing and services are normalized such that the variable labor coefficient is the unity in both sectors. We abstract from firm heterogeneity—obviously important; this is kept in mind for follow-up research. The market structure is monopolistic competition in both production sectors and perfect competition in the numeraire sector. An individual firm in either production sector faces a constant price elasticity of demand for its variety in each trading country. Let w_i be the wage per unit of effective labor in country i. It is important to observe that w_i is not observable and not equal to the wage rate per unit of labor ($= w_i\rho_i$). Henceforth, for lack of better words, we will call it the *unadjusted wage*.

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

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

Here, Ω's are the respective masses 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:

$$\pi_{zij}(u) = H_j p_{zij}(u) c_{zij}(u) - w_i \underbrace{\tau_{zij} H_j c_{zij}(u)}_{\substack{\text{output shipped} \\ \text{to country } j}} = H_j c_{zij}(u)\left[p_{zij}(u) - w_i\tau_{zij}\right]$$

$$= \frac{H_j c_{zij}(u) w_i \tau_{zij}}{\sigma - 1} > 0. \tag{14}$$

Because the variable profit is positive in every market, each firm in either sector located in any country sells a positive amount in all trading countries. We have

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

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

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

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

2.3 World Trading Equilibrium

Formally, given the preferences, the endowment of the numeraire good ($\bar{q}_{0j}$), the supply of (effective) 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.8), 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:

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

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 be different 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 unadjusted wage rate 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

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

Substituting the expression above 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 unadjusted-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 economy size (more effective labor) is associated with lower unadjusted wage rate and larger number of varieties.

The negative relation between economy size and unadjusted wage follows from eq. (21). Eq. (22) implies a positive relationship between the economy size and the equilibrium mass of varieties.

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

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

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

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

The above expression 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 positioned *vis-à-vis* one another depending on the equilibrium configuration of global as well as country-specific variables.

Following Anderson and van Wincoop (2003), we interpret χ_{mi} and χ_{si} as multilateral resistance facing an exporting country i, while P_{mj} and P_{sj} as those facing an importing country j. From (24),

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

On the right-hand side of (24), the term $H_j y_j^{\eta}$ is a direct consequence of nonhomothetic tastes, which implies 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 *total* income of the importing country to capture its effect, as is standard in the gravity literature. Nonhomotheticity 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 nonhomothetic tastes form the microfoundations beneath differentiating between the population and per capita income of a country as an importer, there is no basis for differentiating between them for a country as an exporter. Only the economy size matters. This is via the $w_i(\cdot; L_i)$ in (24).

Multiplying both sides of eq. (21) with w_i, it can be readily derived that w_i is negatively related to $w_i L_i$ (total labor income). Since X_{ij} falls in w_i, it increases with the total labor income. Thus, as long as total labor income is positively related to total income inclusive of the value of the numeraire good, bilateral trades in both manufacturing and services increase with total income of a country as an exporter. This is hardly surprising. However, since the absolute value of the exponent of w_i in (24) is increasing in ϵ_z and $\epsilon_m > \epsilon_s$, we have a major result, which is not obvious or apparent:

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

Intuitively, compared to services, lesser *national product differentiation* of manufacturing implies more elastic import demand for it. In equilibrium, manufacturing production and exports are less governed by world demand and more by the supply side. Hence, 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 difference in the degree of *National Production Differentiation* is thus the key 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 higher 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) with 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

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

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

The last expression is the overall price index in country j covering manufacturing and services.[12]

2.5 A Summary

Our theoretical model predicts that bilateral trade in both manufacturing and services increases with the exporting country's economy size as well as with the importing country's population and per capita income separately. In what follows, economy size will be proxied by GDP.[13] Moreover, bilateral trade declines with bilateral trade costs, as one would expect. Three main results summarize how our model differs from a standard gravity model.

Result A: The elasticity of bilateral trade with respect to the exporter's GDP is greater for manufacturing than for services.

Result B: The elasticity of bilateral trade with respect to 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 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 extraneous variables and considerations are absent in our model. For example, our model does not incorporate how wealth could affect aggregate consumption and bilateral trade.

Result C: In absolute terms, the trade-cost elasticity of bilateral trade is greater for manufacturing than for services.

These implications that lend themselves to empirical testing are intuitively reasoned after Results 6, 5 and 7 respectively. The demand-bias assumption underlies *Result B*, while *Results A* and *C* are driven by the differences in the national product differentiation.[14]

[12] 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.

[13] In our model, for any country i, L_i is related one-to-one with $w_i L_i$, the total labor earnings—which, in turn, are expected to be positively correlated with GDP.

[14] Note that openness to trade may depend on the economy's size and per capita income. This is an extensive margin

3 Empirics

The current section discusses our empirical analysis to quantify the dependence of aggregate bilateral trade on country-specific characteristics and bilateral trade costs, with particular attention to the differences in the relative importance of these variables in international trade in manufacturing and services. This is indeed our prime motivation.

3.1 Variables and Data Sources

We use aggregate bilateral manufacturing trade flows from 2010 to 2020 from the U.N. Comtrade database, United Nations (2023). When compiling the data, we follow Anderson et al. (2018) and give preference to trade flows reported by the exporting country as a more reliable trade flow measurement because of the stronger reporting incentives for exporter companies. We complement the data set 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 data set on cross-border services trade from 2010 to 2020. 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)".[15] 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 serve to augment the dataset when the corresponding OECD observation is missing. The resulting data comprise 177 countries during the period from 2010 to 2020. These countries are listed in Table A1 in Appendix E.

In addition to the variables of interest consistent with theory, we add one control variable, namely, an indicator of income inequality. Because the demand function for each product category is nonlinear with respect to (per capita) income due to the Demand Bias, the income distribution within the importer country *per se* would impact the aggregate demand for products from different countries, including its own. This would affect bilateral trade.

Theoretically, allowing within-country heterogeneity and inequality would, in our view, further complicate an already complex theoretical framework. Intuitively however, if we think of an increase in equality in terms of a mean-preserving spread, greater-than-unity elasticity of demand for services and less-than-unity elasticity of demand for manufacturing would suggest bilateral trade in services increasing with inequality and that in manufacturing decreasing with inequality.

Apart from the conventional mean-preserving spread of income, a change in income equality can stem from a *compositional effect* referring to a change in the distribution of *ownership* in the

issue outside 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 GDP and per capita income between the two categories of products are likely to hold even if manufacturing and services were used as input 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 manufacturing inputs.

[15] 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.

factor(s) of production. A previous version of the manuscript (available upon request) demonstrates that this effect may be counter to the mean-preserving effect. Combining the two effects thus implies a theoretically ambiguous impact of inequality on bilateral trade. We infer therefore that it is mainly an empirical issue.

We adopt the following notations and definitions for the included variables, while Table 2 provides a brief description and data sources of all variables included.

(i) X_{zij}: Consistent with 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.

Explanatory variables include GDP, population, GDP per capita, and those affecting bilateral trade costs. Also included is a measure of income inequality.[16]

(ii) GDP_i, POP_j, gdp_j: These represent respectively the economy size 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. We collect this information from the World Development Indicators, World Bank (2023a).

(iii) INQ_j: This is the income inequality measure. We use the GINI coefficient as well as the income share of the top 10% and 1% of the population. Information on the GINI coefficient and on income shares come from the UNU-WIDER (2022).[17]

(iv) DIST_{ij}, BORDER_{ij}, LANG_{ij}, COLN_{ij}, FTA_{ij}: These are the bilateral geographical distance, and indicator variables for shared borders, a common language, colonial relation, and preferential trade agreements—usual determinants of bilateral trade costs.[18] The information on these variables is obtained from *Centre D'Estudes Prospectives et d'Informations Internationales*, CEPII's gravity database.

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

(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 (2023a), from 2010 to 2020. Figure 2 shows the growth of internet users globally over the 2010s, 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.

[16]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."

[17]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.

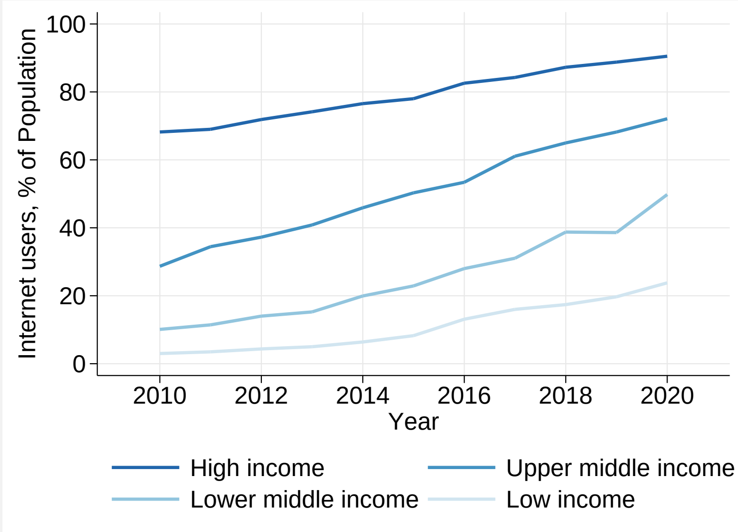
[18]FTA is used in the gravity model by Baier and Bergstrand (2007) and Piermartini and Yotov (2016), among others

Table 2: Variables, Descriptions and Data Sources

Variable and Notation	Description	Source
Manufacturing Trade (X_{mij})	Aggregate bilateral manufacturing trade flows from 2010 to 2020, in millions of current USD.	U.N. Comtrade database, United Nations (2023).
Services Trade (X_{sij})	Aggregate bilateral services trade flows from 2010 to 2020, in millions of current USD.	OECD Statistics and U.N. Comtrade database, United Nations (2023).
Gross Domestic Product (GDP)	(a) Gross domestic product in current USD.	World Development Indicators. World Bank (2023a).
	(b) GDP converted into international dollars using purchasing power parity (PPP) rates.	World Development Indicators. World Bank (2023a).
Population (POP)	Total Population in million	World Development Indicators. World Bank (2023a).
Capital Stock (CAPITAL)	Capital stock at constant 2017 prices USD)	Penn World Table Feenstra et al. (2015)
Income Inequality (INQ)	(a) GINI coefficient (b) Share of income held by the top 10^{th} and 1^{st} percentiles of the income distribution	(a) UNU-WIDER (2022) (b) UNU-WIDER (2022)
Distance (DIST)	Bilateral distance between countries' capitals (in thousands of 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.
Trade Agreement (FTA)	Dummy =1 if the country pair are part of a Trade Agreement	CEPII dataset.
Common border (BORDER)	Dummy =1 if countries share a common border.	CEPII dataset.
Institutional Quality Index (IQI)		Nawaz and Mangla (2021) and World Bank (2023b)
Internet Penetration (INTPEN)	Internet users per 100 people.	World Development Indicators. World Bank (2023a).
Broadband (BROAD)	Fixed subscriptions to high-speed access to the public Internet.	World Development Indicators. World Bank (2023a).
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.

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



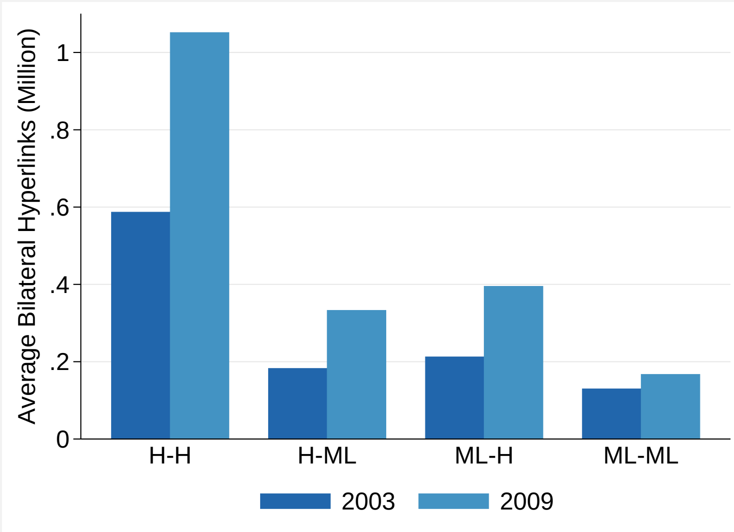
Note: This figure shows the median country's share of internet users. Income groups are defined according to the World Bank classification.

(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 hyperlink 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).[19]

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 represents the average number of hyperlinks from middle or low-income countries to high-income

[19]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.

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.

countries. On average, countries have more hyperlinks that target 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, 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.[20]

(vii) IQI: This stands for institutional quality index, a measure of soft infrastructure in a country, which may facilitate international trade. IQI is constructed as the simple average of the normalized indicators, obtained from the World Bank (2023b)'s Worldwide Governance Indicators (WGI).[21]

We use the following instrumental variables.

(viii) BROAD03: The number of broadband subscriptions in a country in 2003 is a measure of the information and communication technology infrastructure. This is as an instrument for BLINK09. The data source is from the World Development Indicators World Bank (2023a).

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

Table 3 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 higher prevalence of barriers to trade in services compared to goods and the fact that service trade data do not include those with commercial presence (Mode 3).

[20] BLINK data is available 1998 or 2003, but it is much older and available for a limited number of countries.

[21] The indicators are a) voice and accountability, (b) political stability and absence of violence/terrorism, (c) government effectiveness, (d) regulatory quality, (e) rule of law, and (f) control of corruption.

Table 3: Summary statistics

	N	Mean	SD	Min	Max
Trade in manufacturing (US$ Million)	342,672	360.58	4,808.44	0.00	465,510.78
Trade in services (US$ Million)	342,672	124.00	1,413.39	0.00	106,366.10
GDP (US$ Billion)	1,944	436.14	1,716.60	0.16	21,380.98
GDP PPP (US$ Billion)	1,914	637.57	2,145.07	0.18	24,255.79
Population (Million)	1,947	40.18	147.61	0.02	1,411.10
Internet users (% of Population)	1,825	47.95	29.57	0.25	100.00
Broadband Subscriptions in 2003 (Million)	116	0.87	3.28	0.00	27.65
Gini index	1,719	42.93	10.46	23.21	74.24
Top 10th percentile income share (%)	1,719	33.70	8.67	18.44	62.21
Top 1st percentile income share (%)	1,719	7.87	3.69	2.66	23.92
Institutional Quality Index	1,936	0.56	0.16	0.20	0.89
Distance (1000 Km)	33,242	7.91	4.45	0.06	19.90
Shared Border (dummy)	33,242	0.02	0.12	0.00	1.00
Common Language (dummy)	33,242	0.15	0.35	0.00	1.00
Colonial backgroung (dummy)	33,242	0.01	0.11	0.00	1.00
Trade Agreement (dummy)	32,890	0.17	0.38	0.00	1.00
Bilateral hyperlinks (1998)	794	5,172.62	15,540.01	3.00	212,105.92
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 2010-2020. Information for bilateral hyperlinks, income inequality measures, and Internet users are not available for all countries in our sample.

3.2 Estimation Strategy

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, although unbalanced, on bilateral trade, GDP, Internet penetration, and other country-wise characteristics from 2010 to 2020. 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.

Table 4: Variance Decomposition of Time-Varying Variables

	Between/Overall Variation (%)	Within/Overall Variation (%)
GDP (log)	99.52	0.48
GDP per capita (log)	98.89	1.11
GDP PPP (log)	99.51	0.49
GDP PPP per capita (log)	98.66	1.34
Population (log)	99.93	0.07
Gini Coefficient	98.19	1.81
Share of income (Top 10th percentile)	97.92	2.08
Share of income (Top 1st percentile)	98.15	1.85
Institutional Quality Index	98.54	1.46
Internet Penetration	80.32	19.68

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 2010–2020 period.

(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 per capita income of the importer country 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 such as GDP, per capita income, population, or Internet use. Nevertheless, our objective is to estimate and understand the differences in these marginal impacts between trade in manufacturing and trade in services. Nonhomothetic 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 4 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 independent variables. The second stage does not use fixed effects.[22] We use Poisson-Pseudo Maximum

[22]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. However, relying solely on the fixed effects estimator does not allow an estimation of the coefficients of country-specific observable variables, which are unquestionably relevant to our study.

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). 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:

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

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 is 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.

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

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),

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

where $\theta_{zD} \equiv -\tilde{\theta}_{zD}\epsilon_z$, $\theta_{zXI} \equiv -\tilde{\theta}_{zXI}\epsilon_z$, $\theta_{zMI} \equiv -\tilde{\theta}_{zMI}\epsilon_z$, $\theta_{zK} \equiv -\tilde{\theta}_{zK}\epsilon_z$, $\theta_{zB} \equiv -\tilde{\theta}_{zB}\epsilon_z$, $\theta_{zL} \equiv -\tilde{\theta}_{zL}\epsilon_z$, $\theta_{zC} \equiv -\tilde{\theta}_{zC}\epsilon_z$, and $\theta_{zF} \equiv -\tilde{\theta}_{zF}\epsilon_z$. We further represent eq. (29) by separating country-specific terms from bilateral terms.

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

where,

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

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 $\hat{\theta}_{zD}, \hat{\theta}_{zK}, \hat{\theta}_{zB}, \hat{\theta}_{zL}, \hat{\theta}_{zC}$, and $\hat{\theta}_{zF}$ 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, for example, estimates of α_z, β_z, γ_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,

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

We estimate the two equations in (32) by PPML.[23,24]

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

A main concern in estimating the importance of trade determinants is the endogeneity issue. This section describes this problem in estimating the coefficients on BLINK09, GDP, and GDP per capita and explains our approach to address them.

3.4.1 BLINK (Stage 1)

In our regressions, we use the BLINK data for 2009—denoted by BLINK09. Despite the number of bilateral hyperlinks predating the international trade flows in the estimations, there may still exist

[23]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.

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

endogeneity concerns regarding the potential direct effect of trade volumes on bilateral hyperlinks. We address this potential endogeneity by using an instrumental variable approach[25]

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, because BROAD03 is computed from a country-specific measure, it alleviates the concerns that it is correlated with unobserved bilateral characteristics that affect future bilateral trade. Therefore, we argue that 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.

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,[26] 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,

[25] 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)).

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

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 nontropical countries, whereas our sample has both categories of countries. Therefore, we 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.[27] 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 2010 to 2020. 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 the 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.[28] The results are reported in Tables 5 and 6 for service trade and manufacturing trade respectively.

Next, we estimate the same equations but restricting the sample to the 82 countries with non-missing observations for the bilateral hyperlinks data. Tables 7 and 8 respectively 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 the differences in estimates driven solely by the inclusion of BLINK09.

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

The results from the second stage reported in Table 5 to Table 8 show that the exporting country's GDP, the importing country's population, and per capita income are positively associated with bilateral trade in both manufacturing and services. This is hardly surprising, but noteworthy 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), while the results with the inclusion of BLINK09 are illustrated in Figure 4(b). The

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

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

Table 5: **Trade in Services** - PPML estimates, 2010 to 2020, GDP and per-capita GDP instrumented

	International Trade in Services										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020
First Stage Regressions											
Distance (log)	–0.55***	–0.50***	–0.53***	–0.54***	–0.55***	–0.54***	–0.48***	–0.48***	–0.47***	–0.51***	–0.45***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)
Common border	0.21*	0.20*	0.21*	0.16	0.09	0.08	0.16	0.17	0.16	0.14	0.12
	(0.12)	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)
Common language	0.24**	0.34***	0.30***	0.36***	0.39***	0.39***	0.38***	0.37***	0.39***	0.38***	0.44***
	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.10)	(0.11)
Colony	0.57***	0.54***	0.56***	0.50***	0.44***	0.42***	0.38***	0.37***	0.39***	0.31***	0.23**
	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.12)
Trade Agreement	0.46***	0.47***	0.46***	0.42***	0.45***	0.42***	0.48***	0.48***	0.52***	0.35***	0.35***
	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)
N	30,625	30,800	31,152	30,450	31,152	31,152	31,152	31,152	31,152	31,152	30,976
R-sq	0.82	0.84	0.84	0.84	0.85	0.85	0.86	0.86	0.86	0.85	0.86
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions											
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$											
Exporter GDP (log)	0.83***	0.83***	0.81***	0.82***	0.83***	0.83***	0.81***	0.81***	0.80***	0.79***	0.78***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.07)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)
Internet Exporter	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.03***	0.03***	0.03***	0.03***	0.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
N	142	142	142	142	143	144	145	145	136	132	130
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$											
Importer Population (log)	0.76***	0.76***	0.75***	0.76***	0.77***	0.75***	0.76***	0.76***	0.75***	0.73***	0.71***
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Importer GDP percap (log)	1.22***	1.26***	1.36***	1.37***	1.32***	1.31***	1.38***	1.46***	1.54***	1.46***	1.42***
	(0.19)	(0.19)	(0.22)	(0.17)	(0.15)	(0.14)	(0.17)	(0.19)	(0.22)	(0.17)	(0.13)
Internet Importer	0.00	0.00	–0.00	–0.00	–0.00	–0.00	–0.00	–0.01	–0.02	–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	0.03**	0.03**	0.03***	0.02**	0.03**	0.02*	0.02	0.01	0.01	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)
N	142	142	142	142	143	144	145	145	136	132	130

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

Table 6: **Trade in Manufacturing** - PPML estimates, 2010 to 2020, GDP and per-capita GDP instrumented

	International Trade in Manufacturing										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020
First Stage Regressions											
Distance (log)	–0.64***	–0.65***	–0.68***	–0.68***	–0.67***	–0.68***	–0.64***	–0.65***	–0.65***	–0.65***	–0.64***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.40***	0.39***	0.38***	0.40***	0.41***	0.41***	0.46***	0.44***	0.42***	0.44***	0.42***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)
Common language	0.13	0.14*	0.15*	0.14*	0.12	0.13	0.13	0.14*	0.14*	0.18**	0.20**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)
Colony	0.29***	0.31***	0.33***	0.31***	0.28***	0.25**	0.23**	0.24**	0.26***	0.27***	0.26**
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Trade Agreement	0.62***	0.63***	0.58***	0.58***	0.57***	0.53***	0.53***	0.52***	0.56***	0.52***	0.54***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)
N	30,800	31,152	31,152	31,152	31,152	31,152	31,152	31,152	31,152	31,152	31,152
R-sq	0.90	0.90	0.91	0.92	0.92	0.92	0.91	0.90	0.90	0.90	0.90
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions											
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$											
Exporter GDP (log)	0.96***	0.97***	0.99***	0.99***	0.99***	0.97***	0.95***	0.94***	0.94***	0.95***	0.96***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.11)
Internet Exporter	–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)	(0.01)	(0.01)	(0.01)	(0.01)
N	142	142	142	142	143	144	145	145	136	132	130
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$											
Importer Population (log)	0.83***	0.83***	0.81***	0.81***	0.81***	0.77***	0.77***	0.79***	0.80***	0.80***	0.81***
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Importer GDP percap (log)	1.00***	1.06***	1.11***	1.19***	1.16***	1.18***	1.15***	1.00***	0.94***	0.94***	0.89***
	(0.13)	(0.15)	(0.18)	(0.18)	(0.17)	(0.15)	(0.20)	(0.19)	(0.20)	(0.15)	(0.13)
Internet Importer	–0.00	–0.00	–0.00	–0.01	–0.01	–0.01	–0.00	0.00	0.01	0.01	0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.03***	0.03***	0.04***	0.04***	0.04***	0.04***	0.04***	0.03***	0.04***	0.03***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	142	142	142	142	143	144	145	145	136	132	130

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

Table 7: PPML estimates with BLINK sample but without BLINK09 as a Regressor, 2010-2020, GDP and per-capita GDP instrumented

	Services											Manufacturing										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020	(12) 2010	(13) 2011	(14) 2012	(15) 2013	(16) 2014	(17) 2015	(18) 2016	(19) 2017	(20) 2018	(21) 2019	(22) 2020
First Stage Regressions																						
Distance (log)	–0.54***	–0.49***	–0.53***	–0.54***	–0.55***	–0.54***	–0.47***	–0.47***	–0.46***	–0.49***	–0.43***	–0.57***	–0.57***	–0.61***	–0.61***	–0.61***	–0.61***	–0.56***	–0.56***	–0.57***	–0.57***	–0.57***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
Common border	0.26*	0.29*	0.30**	0.23*	0.15	0.15	0.23*	0.23*	0.21*	0.21	0.18	0.47***	0.47***	0.47***	0.49***	0.49***	0.50***	0.57***	0.54***	0.52***	0.57***	0.56***
	(0.13)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)
Common language	0.20	0.30**	0.26*	0.33**	0.36**	0.37***	0.37**	0.36**	0.39***	0.38***	0.43***	0.04	0.04	0.03	0.03	0.01	0.01	0.01	0.02	0.02	0.06	0.06
	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.11)	(0.11)	(0.13)	(0.10)	(0.10)	(0.10)	(0.09)	(0.10)	(0.09)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Colony	0.52***	0.46***	0.48***	0.42***	0.36**	0.34**	0.31*	0.30*	0.33**	0.25*	0.20	0.28**	0.30**	0.32**	0.29**	0.26*	0.24*	0.22*	0.23*	0.24*	0.24*	0.23*
	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.13)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Trade Agreement	0.41**	0.42***	0.40***	0.36**	0.41***	0.37***	0.45***	0.41***	0.48***	0.29**	0.34**	0.69***	0.70***	0.61***	0.63***	0.63***	0.59***	0.61***	0.59***	0.62***	0.56***	0.58***
	(0.13)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)	(0.10)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.09)	(0.09)	(0.09)	(0.07)	(0.08)
N	3,696	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,696	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741	3,741
R-sq	0.83	0.85	0.85	0.85	0.86	0.87	0.87	0.87	0.88	0.87	0.87	0.92	0.92	0.93	0.93	0.93	0.94	0.93	0.92	0.92	0.92	0.92
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions																						
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$																						
Exporter GDP (log)	0.84***	0.85***	0.83***	0.83***	0.85***	0.85***	0.84***	0.84***	0.82***	0.80***	0.80***	0.96***	0.97***	0.98***	0.98***	0.97***	0.95***	0.92***	0.92***	0.92***	0.92***	0.93***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.07)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.10)
Internet Exporter (log)	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.03***	–0.00	–0.00	–0.01	–0.01	–0.01	–0.00	–0.00	–0.00	–0.00	–0.00	–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)
N	79	79	79	79	79	79	80	80	78	77	76	79	79	79	79	79	79	80	80	78	77	76
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$																						
Importer Population (log)	0.76***	0.76***	0.74***	0.75***	0.76***	0.73***	0.75***	0.75***	0.73***	0.72***	0.70***	0.86***	0.85***	0.83***	0.83***	0.84***	0.81***	0.80***	0.83***	0.84***	0.84***	0.85***
	(0.07)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)
Importer GDP percap (log)	1.09***	1.12***	1.20***	1.22***	1.19***	1.18***	1.25***	1.32***	1.38***	1.31***	1.26***	0.93***	0.98***	1.03***	1.12***	1.10***	1.11***	1.09***	0.96***	0.87***	0.89***	0.82***
	(0.18)	(0.19)	(0.21)	(0.17)	(0.16)	(0.15)	(0.19)	(0.20)	(0.23)	(0.17)	(0.13)	(0.16)	(0.18)	(0.22)	(0.21)	(0.20)	(0.18)	(0.27)	(0.29)	(0.30)	(0.22)	(0.19)
Internet Importer	0.01	0.00	0.00	–0.00	0.00	–0.00	–0.00	–0.01	–0.01	–0.01	0.00	–0.00	–0.00	–0.00	–0.01	–0.01	–0.00	–0.00	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)	(0.02)	(0.01)	(0.01)
Importer Gini	0.03**	0.03**	0.03***	0.03**	0.03**	0.02**	0.02**	0.02*	0.02*	0.02**	0.03***	0.02**	0.02**	0.03***	0.03***	0.03***	0.03***	0.03***	0.02**	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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	73	73	73	73	73	74	75	75	74	73	72	73	73	73	73	73	74	75	75	74	73	72

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

Table 8: PPML estimates with BLINK09 as a regressor, 2010-2020, with BLINK09, GDP and per-capita GDP instrumented

Services

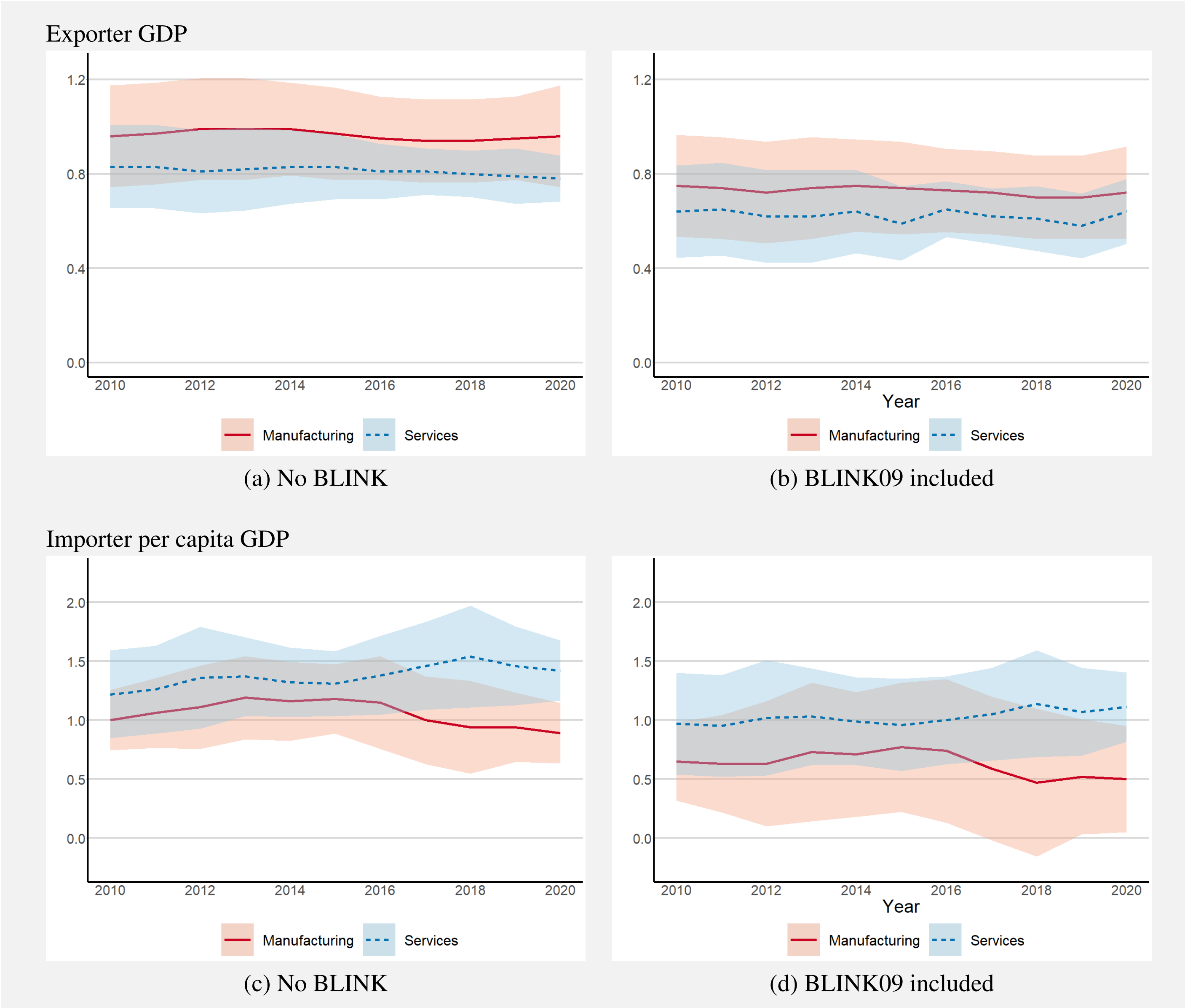
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020
First Stage Regressions											
Distance (log)	−0.50***	−0.45***	−0.48***	−0.49***	−0.50***	−0.47***	−0.41***	−0.41***	−0.40***	−0.43***	−0.38***
	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.15	0.18	0.19	0.13	0.05	0.03	0.12	0.11	0.09	0.09	0.08
	(0.14)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)
Common language	0.12	0.22*	0.16	0.24*	0.26*	0.24*	0.26*	0.24*	0.27*	0.25*	0.34**
	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.11)	(0.11)	(0.13)
Colony	0.45***	0.39***	0.40***	0.35**	0.29*	0.27*	0.26*	0.24*	0.28*	0.19	0.15
	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.13)
Trade Agreement	0.35*	0.37**	0.35**	0.31**	0.36**	0.32**	0.41***	0.37***	0.43***	0.24*	0.29**
	(0.14)	(0.13)	(0.12)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.11)
BLINK09 (log)	0.17***	0.17***	0.18***	0.17***	0.17***	0.22***	0.18***	0.21***	0.20***	0.21***	0.16***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.05)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)
N	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.84	0.86	0.85	0.85	0.86	0.87	0.87	0.87	0.88	0.87	0.87
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions											
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji}})$											
Exporter GDP (log)	0.64***	0.65***	0.62***	0.62***	0.64***	0.59***	0.65***	0.62***	0.61***	0.58***	0.64***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.09)	(0.08)	(0.06)	(0.06)	(0.07)	(0.07)	(0.07)
Internet Exporter (log)	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	0.02***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
N	67	67	67	67	67	67	67	67	66	65	64
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr}})$											
Importer Population (log)	0.57***	0.58***	0.55***	0.56***	0.58***	0.50***	0.57***	0.53***	0.53***	0.51***	0.55***
	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)
Importer GDP percap (log)	0.97***	0.95***	1.02***	1.03***	0.99***	0.96***	1.00***	1.05***	1.14***	1.07***	1.11***
	(0.22)	(0.22)	(0.25)	(0.21)	(0.19)	(0.20)	(0.19)	(0.20)	(0.23)	(0.19)	(0.15)
Internet Importer	0.00	0.01	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)
Importer Gini	0.03**	0.03**	0.03**	0.03**	0.03*	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)	(0.01)	(0.01)	(0.01)	(0.01)
N	62	62	62	62	62	63	63	63	63	62	61

Manufacturing

	(12) 2010	(13) 2011	(14) 2012	(15) 2013	(16) 2014	(17) 2015	(18) 2016	(19) 2017	(20) 2018	(21) 2019	(22) 2020
First Stage Regressions											
Distance (log)	−0.50***	−0.50***	−0.54***	−0.55***	−0.54***	−0.54***	−0.51***	−0.51***	−0.50***	−0.51***	−0.51***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common border	0.35***	0.34***	0.33***	0.36***	0.37***	0.38***	0.46***	0.43***	0.40***	0.44***	0.44***
	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Common language	−0.08	−0.09	−0.11	−0.10	−0.11	−0.11	−0.10	−0.09	−0.11	−0.07	−0.06
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Colony	0.20	0.21*	0.22*	0.20	0.18	0.17	0.16	0.17	0.18	0.18	0.18
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)
Trade Agreement	0.64***	0.64***	0.55***	0.58***	0.58***	0.55***	0.57***	0.55***	0.58***	0.51***	0.54***
	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)
BLINK09 (log)	0.20***	0.22***	0.24***	0.22***	0.21***	0.21***	0.18***	0.19***	0.22***	0.21***	0.20***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
N	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.92	0.92	0.93	0.93	0.93	0.94	0.93	0.92	0.92	0.92	0.92
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions											
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji}})$											
Exporter GDP (log)	0.75***	0.74***	0.72***	0.74***	0.75***	0.74***	0.73***	0.72***	0.70***	0.70***	0.72***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Internet Exporter (log)	−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)
N	67	67	67	67	67	67	67	67	66	65	64
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr}})$											
Importer Population (log)	0.61***	0.58***	0.53***	0.57***	0.60***	0.58***	0.61***	0.63***	0.62***	0.62***	0.67***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)	(0.06)	(0.06)
Importer GDP percap (log)	0.65***	0.63***	0.63**	0.73**	0.71***	0.77***	0.74**	0.59*	0.47	0.52**	0.50**
	(0.17)	(0.21)	(0.27)	(0.30)	(0.27)	(0.28)	(0.31)	(0.31)	(0.32)	(0.25)	(0.23)
Internet Importer	0.00	0.00	0.00	−0.00	−0.00	−0.00	0.00	0.01	0.02	0.01	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Importer Gini	0.02*	0.02*	0.03**	0.03**	0.02*	0.02**	0.02*	0.02	0.02	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	62	62	62	62	62	63	63	63	63	62	61

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 GDP per capita**



(a) No BLINK

(b) BLINK09 included

(c) No BLINK

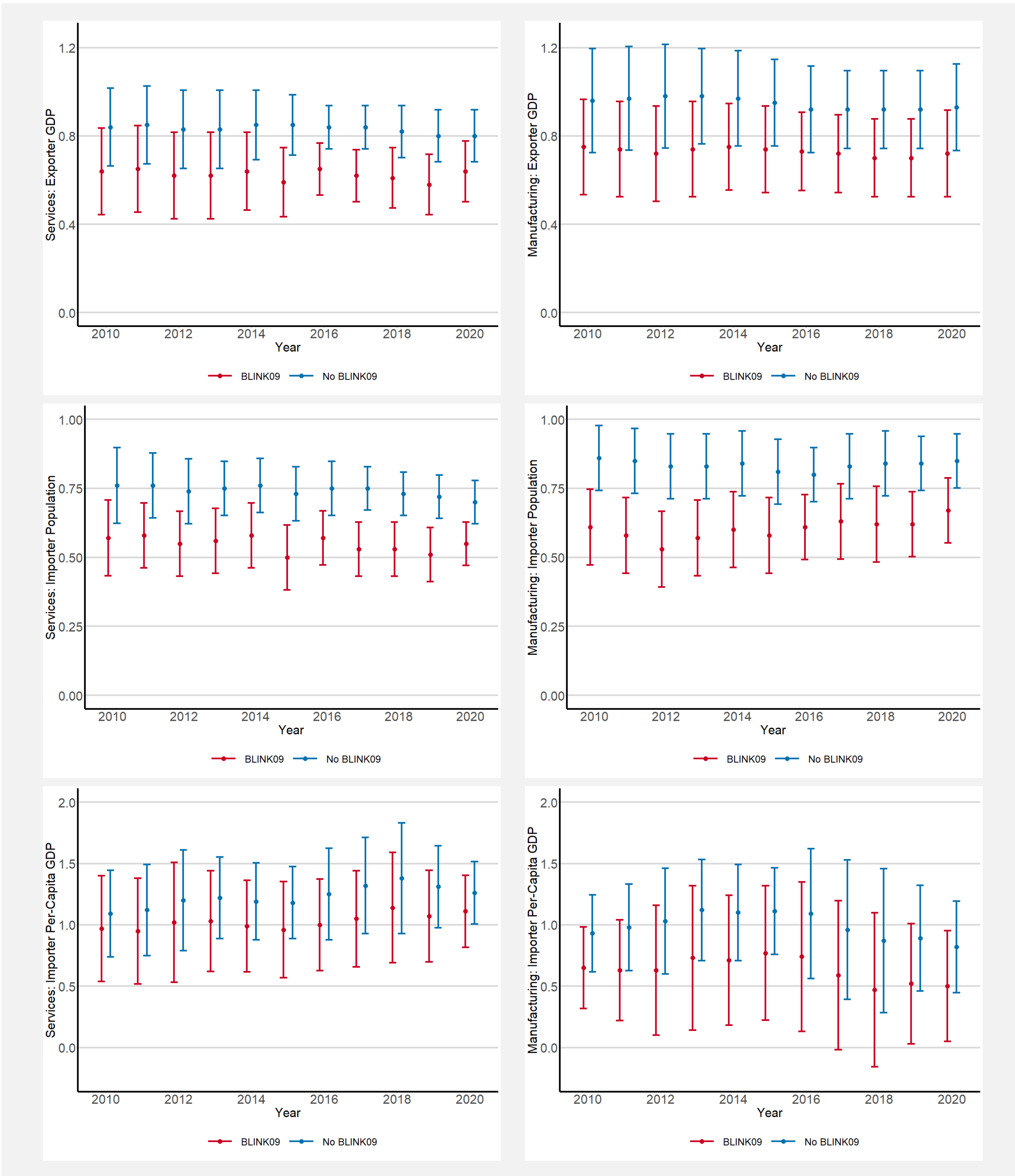
(d) BLINK09 included

estimated coefficients are higher for manufacturing than services, consistent with *Result A* (same as Result 6).

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, *Result B*: 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 in the specifications

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



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 9 shows, BLINK09 is positively correlated with all three variables. Thus, the omission of BLINK entails an omitted-variable bias and leads to an overestimation of coefficients on these variables. This finding underscores that virtual proximity is an essential, yet hithero a missing component in the gravity literature on estimating trade costs of bilateral trade in both manufacturing and services.

Table 9: Correlations with Bilateral hyperlinks

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Exporter GDP (log)	0.6265***	0.6269***	0.6231***	0.6207***	0.6185***	0.6206***	0.6239***	0.6232***	0.6266***	0.6210***	0.6199***
Importer Population (log)	0.4264***	0.4248***	0.4234***	0.4215***	0.4195***	0.4176***	0.4159***	0.4144***	0.4131***	0.4119***	0.4108***
Importer GDP percap (log)	0.2632***	0.2674***	0.2680***	0.2614***	0.2589***	0.2675***	0.2744***	0.2738* **	0.2739***	0.2584* **	0.2578***

Note: * Denotes statistical significance at 0.1%.

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 of population, and those of per capita GDP equal the respective coefficients in Tables 5 to 8 minus the respective coefficient of the population. In the majority of the estimated regressions, the population coefficients are smaller than those of 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).[29]

Note also that, given Table 8, the elasticity of bilateral trade in manufacturing with respect to the size variables, that is, 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 that the GDP or GDP per capita elasticities for manufacturing trade are less than one and argued that this could be due to larger countries tending to be less open. Another possible reason is the absence of wealth variables that can also affect aggregate consumption and bilateral trade.

4.2 Income Inequality

Nonhomotheticity in tastes implies that inequality in the importing country may impact bilateral trade. 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 the statistical significance is somewhat weaker. In Table 8, we see that the coefficients on GINI are nearly identical between manufacturing and services.

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

[29]Note that, in Table 8, the years after 2017 for the manufacturing sector showed coefficients for GDP per capita smaller than that for the population, implying a potential non-positive coefficient for GDP per capita when applying the transformation. This pattern change can be partially explained by the decrease in the volume of manufacturing trade in those years (UNCTAD, 2022)

respect to 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 8 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 C*, same as Result 7. As noted earlier, it indirectly validates our Difference in the National Product Differentiation assumption.

4.4 Observable Trade Costs

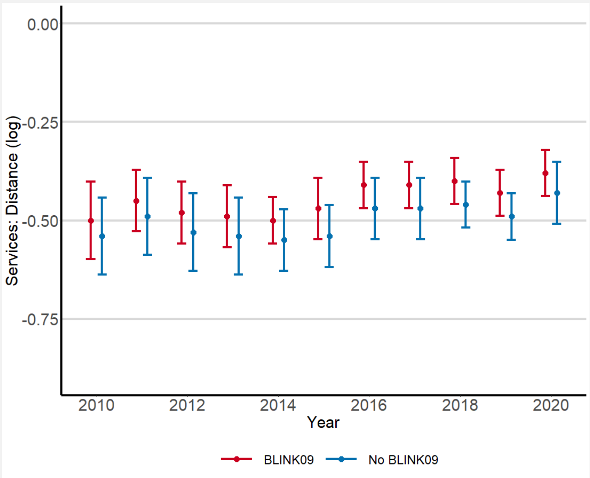
Internet Penetration: Tables 5, 7 and 8 show a positive and statistically significant marginal effect of internet usage in the exporter country on international trade of services. However, we do not observe a consistent and statistically significant effect of internet usage in the importer country for trade in services. Furthermore, the coefficients of internet usage in both exporting and importing countries are statistically insignificant 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, 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.

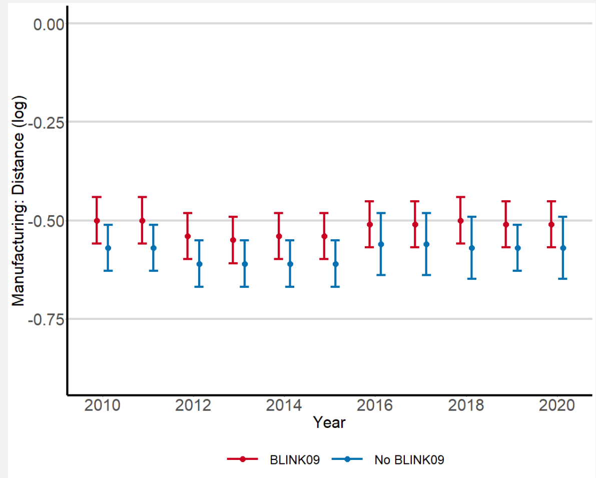
Freund and Weinhold (2002) is among the first to investigate this empirically, and their finding is somewhat qualified: for trade in services between the U.S. and other countries, internet usage in other countries positively impacts their exports to the U.S. in specific categories of services. More generally interpreted, the use of the internet 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 8 shows that the coefficients on the instrumented BLINK09 are positive and statistically significant. Furthermore, bilateral trade in both services and manufacturing show a similar level of sensitivity to virtual proximity. On average, a 10% increase in bilateral hyperlinks leads to a 1.9 to 2.4% increase in bilateral trade in manufacturing and a 1.6 to 2.2% increase in bilateral trade in services.

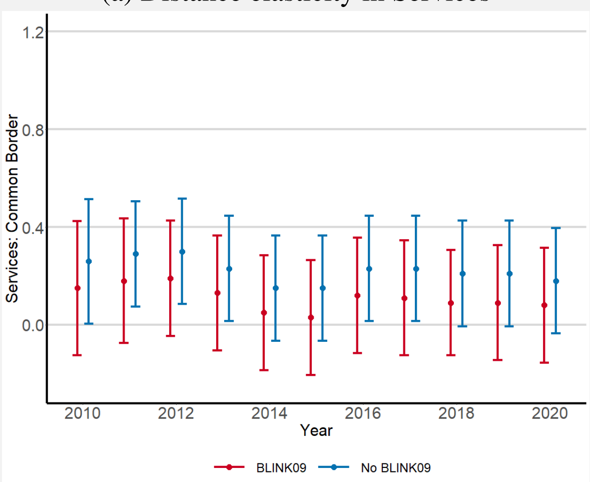
Figure 6: **Coefficients on Distance and Common Border: BLINK versus No BLINK**



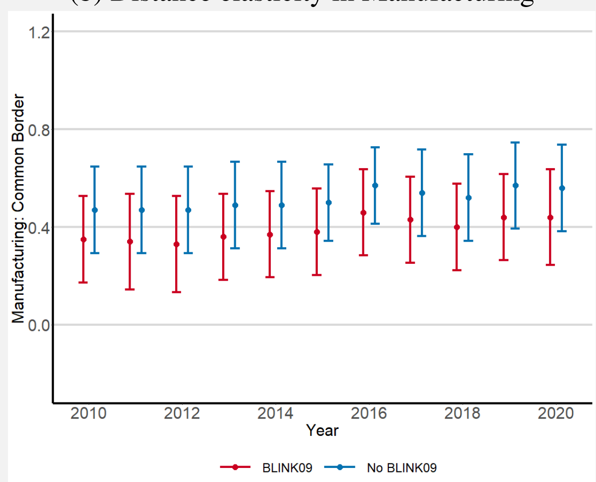
(a) Distance elasticity in Services



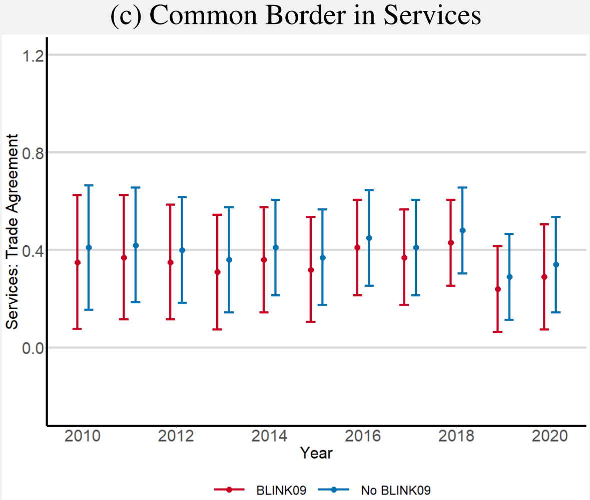
(b) Distance elasticity in Manufacturing



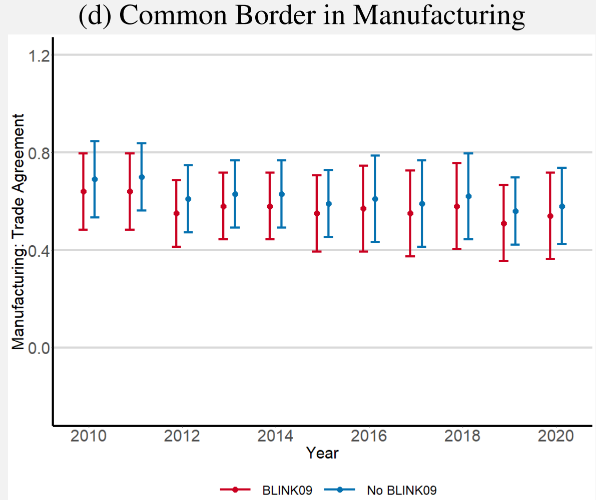
(c) Common Border in Services



(d) Common Border in Manufacturing



(c) Trade Agreement in Services



(d) Trade Agreement in Manufacturing

Distance, Common Border, Common Language and Colony, and Substitution Effects: The coefficients of these standard trade-cost variables bear their expected signs. However, it is surprising that when BLINK09 is present as a regressor (Table 8), the coefficients of common language and colonial relation generally become statistically insignificant (less so for colonial relation). 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 7 and 8, 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 partially substitutes physical proximity. There are two implications of this finding. First, it does *not* mean that physical proximity is less important than virtual proximity. In fact, 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 earlier than 2010. 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.

Free Trade Agreement: Tables 5 to 8 show a positive and statistically significant elasticity of trade flows in services and manufacturing to the existence of a bilateral trade agreement. Thus, bilateral trade agreements are an important determinant of both categories of trade. Furthermore, we notice that the coefficient is greater in magnitude for manufacturing, suggesting that manufacturing trade is more sensitive to the existence of bilateral trade agreements than is trade in services.

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. With this in mind, we consider GDPs measured by PPP. Corresponding estimates are displayed in Table 10. Notice that the results are similar to those in our baseline model, supporting the hypotheses from the theoretical section.

We also consider alternative measures of income inequality, namely, the income share held by the top 10 and 1 percentiles of the income distribution. Panels (b) and (c) of Table 11 report the estimates of the coefficients on importer-country-specific regressors. (The first-stage and second-stage estimates for the exporting-country-specific regressors remain unchanged.) For comparison,

Table 10: Two-stages PPML using GDP PPP, with BLINK09 GDP PPP and GDP PPP per-capita instrumented

	Services											Manufacturing										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020	(12) 2010	(13) 2011	(14) 2012	(15) 2013	(16) 2014	(17) 2015	(18) 2016	(19) 2017	(20) 2018	(21) 2019	(22) 2020
First Stage Regressions																						
Distance (log)	–0.50***	–0.45***	–0.48***	–0.49***	–0.50***	–0.47***	–0.41***	–0.41***	–0.40***	–0.43***	–0.38***	–0.50***	–0.50***	–0.54***	–0.55***	–0.54***	–0.54***	–0.51***	–0.51***	–0.50***	–0.51***	–0.51***
	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(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)	(0.03)	(0.03)
Common border	0.15	0.18	0.19	0.13	0.05	0.03	0.12	0.11	0.09	0.09	0.08	0.35***	0.34***	0.33***	0.36***	0.37***	0.38***	0.46***	0.43***	0.40***	0.44***	0.44***
	(0.14)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Common language	0.12	0.22*	0.16	0.24*	0.26*	0.24*	0.26*	0.24*	0.27*	0.25*	0.34**	–0.08	–0.09	–0.11	–0.10	–0.11	–0.11	–0.10	–0.09	–0.11	–0.07	–0.06
	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.11)	(0.11)	(0.13)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Colony	0.45***	0.39***	0.40***	0.35**	0.29*	0.27*	0.26*	0.24*	0.28*	0.19	0.15	0.20	0.21*	0.22*	0.20	0.18	0.17	0.16	0.17	0.18	0.18	0.18
	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.13)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)
Trade Agreement	0.35*	0.37**	0.35**	0.31**	0.36**	0.32**	0.41***	0.37***	0.43***	0.24*	0.29**	0.64***	0.64***	0.55***	0.58***	0.58***	0.55***	0.57***	0.55***	0.58***	0.51***	0.54***
	(0.14)	(0.13)	(0.12)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.11)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)
BLINK09 (log)	0.17***	0.17***	0.18***	0.17***	0.17***	0.22***	0.18***	0.21***	0.20***	0.21***	0.16***	0.20***	0.22***	0.24***	0.22***	0.21***	0.21***	0.18***	0.19***	0.22***	0.21***	0.20***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.05)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
N	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	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.84	0.86	0.85	0.85	0.86	0.87	0.87	0.87	0.88	0.87	0.87	0.92	0.92	0.93	0.93	0.93	0.94	0.93	0.92	0.92	0.92	0.92
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions																						
Dependent variable: Exporter Fixed Effects, $\widehat{\exp}(X_{ji})$																						
Exporter GDP (log)	0.67***	0.68***	0.66***	0.66***	0.68***	0.64***	0.70***	0.67***	0.66***	0.63***	0.71***	0.78***	0.78***	0.75***	0.78***	0.80***	0.81***	0.80***	0.79***	0.77***	0.77***	0.80***
	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.10)	(0.07)	(0.08)	(0.08)	(0.08)	(0.09)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)	(0.12)
Internet Exporter (log)	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***	0.03***	0.03***	0.03***	0.03***	0.05***	0.01*	0.01*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.00)	(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)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	67	67	67	67	67	67	67	67	66	65	64	67	67	67	67	67	67	67	67	66	65	64
Dependent variable: Importer Fixed Effects, $\widehat{\exp}(M_{jr})$																						
Importer Population (log)	0.58***	0.60***	0.58***	0.58***	0.61***	0.56***	0.63***	0.59***	0.60***	0.57***	0.62***	0.62***	0.59***	0.54***	0.58***	0.62***	0.62***	0.66***	0.67***	0.65***	0.65***	0.70***
	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Importer GDP percap (log)	1.29***	1.22***	1.31***	1.32***	1.32***	1.27***	1.36***	1.47***	1.69***	1.60***	1.76***	0.88***	0.84***	0.83***	0.93***	0.95***	1.02***	1.00***	0.85**	0.74	0.81**	0.84**
	(0.21)	(0.19)	(0.23)	(0.22)	(0.20)	(0.22)	(0.22)	(0.23)	(0.26)	(0.23)	(0.20)	(0.20)	(0.23)	(0.31)	(0.36)	(0.33)	(0.35)	(0.38)	(0.41)	(0.46)	(0.37)	(0.36)
Internet Importer	0.01**	0.02***	0.01*	0.01	0.01	0.01	0.01	0.00	-0.01	-0.00	-0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Importer Gini	0.03***	0.03***	0.03***	0.03***	0.03**	0.02**	0.02*	0.02**	0.01	0.02**	0.02**	0.03**	0.03**	0.03***	0.03**	0.03**	0.03**	0.02**	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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	62	62	62	62	62	63	63	63	63	62	61	62	62	62	62	62	63	63	63	63	62	61

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

Table 11: Second-Stage Estimates: Alternative Measures of Income Inequality, with BLINK09, GDP and per-capita GDP instrumented

	Services											Manufacturing										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020	(12) 2010	(13) 2011	(14) 2012	(15) 2013	(16) 2014	(17) 2015	(18) 2016	(19) 2017	(20) 2018	(21) 2019	(22) 2020
Panel a: Importer Gini Coefficient																						
Importer Population (log)	0.57***	0.58***	0.55***	0.56***	0.58***	0.50***	0.57***	0.53***	0.53***	0.51***	0.55***	0.61***	0.58***	0.53***	0.57***	0.60***	0.58***	0.61***	0.63***	0.62***	0.62***	0.67***
	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.07)	(0.07)	(0.06)	(0.06)
Importer GDP percap (log)	0.97***	0.95***	1.02***	1.03***	0.99***	0.96***	1.00***	1.05***	1.14***	1.07***	1.11***	0.65***	0.63***	0.63**	0.73**	0.71***	0.77***	0.74**	0.59*	0.47	0.52**	0.50**
	(0.22)	(0.22)	(0.25)	(0.21)	(0.19)	(0.20)	(0.19)	(0.20)	(0.23)	(0.19)	(0.15)	(0.17)	(0.21)	(0.27)	(0.30)	(0.27)	(0.28)	(0.31)	(0.31)	(0.32)	(0.25)	(0.23)
Internet Importer	0.00	0.01	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	0.01	0.02	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)	(0.02)	(0.01)	(0.01)
Importer Gini	0.03**	0.03**	0.03**	0.03**	0.03*	0.02*	0.02*	0.02*	0.02	0.02*	0.02***	0.02*	0.02*	0.03**	0.03**	0.02*	0.02**	0.02*	0.02	0.02	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(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	62	62	62	62	62	63	63	63	63	62	61	62	62	62	62	62	63	63	63	63	62	61
Panel b: Importer Top 10^{th} percentile of income share																						
Importer Population (log)	0.59***	0.60***	0.57***	0.57***	0.59***	0.51***	0.58***	0.54***	0.54***	0.51***	0.55***	0.62***	0.59***	0.54***	0.58***	0.61***	0.59***	0.63***	0.64***	0.64***	0.64***	0.68***
	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)
Importer GDP percap (log)	0.97***	0.96***	1.03***	1.04***	1.00***	0.97***	1.01***	1.07***	1.15***	1.09***	1.14***	0.64***	0.62***	0.62**	0.73**	0.71**	0.77***	0.73**	0.58*	0.46	0.51*	0.49**
	(0.22)	(0.22)	(0.26)	(0.22)	(0.20)	(0.21)	(0.20)	(0.21)	(0.23)	(0.20)	(0.15)	(0.17)	(0.22)	(0.28)	(0.31)	(0.28)	(0.29)	(0.32)	(0.32)	(0.32)	(0.26)	(0.23)
Internet Importer	0.00	0.00	0.00	–0.00	–0.00	–0.00	–0.00	–0.01	–0.01	–0.01	–0.00	–0.00	–0.00	–0.00	–0.00	–0.00	–0.00	0.00	0.01	0.02	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)	(0.02)	(0.01)	(0.01)
Top 10^{th} percentile of income share	0.03*	0.03**	0.04**	0.03**	0.03*	0.02	0.02	0.02	0.02	0.02*	0.04***	0.02	0.02	0.03**	0.03*	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(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)	(0.02)	(0.02)	(0.02)
N	62	62	62	62	62	63	63	63	63	62	61	62	62	62	62	62	63	63	63	63	62	61
Panel c: Importer Top 1^{st} percentile of income share																						
Importer Population (log)	0.60***	0.61***	0.58***	0.58***	0.60***	0.52***	0.59***	0.55***	0.55***	0.52***	0.57***	0.62***	0.60***	0.55***	0.59***	0.61***	0.60***	0.64***	0.65***	0.64***	0.64***	0.69***
	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)
Importer GDP percap (log)	0.93***	0.93***	1.01***	1.03***	0.98***	0.95***	1.00***	1.04***	1.13***	1.07***	1.12***	0.62***	0.60***	0.60**	0.71**	0.70**	0.75***	0.70**	0.55*	0.44	0.49**	0.47**
	(0.21)	(0.22)	(0.26)	(0.22)	(0.20)	(0.21)	(0.20)	(0.21)	(0.23)	(0.19)	(0.15)	(0.17)	(0.21)	(0.28)	(0.31)	(0.28)	(0.29)	(0.31)	(0.31)	(0.30)	(0.25)	(0.22)
Internet Importer	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	–0.01	–0.00	–0.00	0.00	0.01	0.02	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)	(0.02)	(0.01)	(0.01)
Top 1^{st} percentile of income share	0.04	0.05*	0.08**	0.07*	0.05	0.04	0.04	0.04	0.05	0.05*	0.09***	0.02	0.03	0.06*	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.02
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
N	62	62	62	62	62	63	63	63	63	62	61	62	62	62	62	62	63	63	63	63	62	61

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

the top panel reproduces the estimates using GINI, reported earlier in Table 8. Overall, the results are similar across the different measures for within-country income inequality. More income inequality is associated with more bilateral trade in both manufacturing and services, but weakly so.[30]

5.2 Panel Estimation

Table 12: PPML Panel Estimates (2010-2020)

	Services					Manufacturing				
	Pooled (1)	FE (2)	RE (3)	FE (4)	RE (5)	Pooled (6)	FE (7)	RE (8)	FE (9)	RE (10)
Distance (log)	–0.50***	–0.45***	–0.47***	–	–0.66***	–0.44***	–0.54***	–0.50***	–	–0.74***
	(0.05)	(0.04)	(0.01)		(0.03)	(0.08)	(0.03)	(0.01)		(0.03)
Common border	–0.07	0.14	0.11***	–	–0.02	0.77***	0.44***	0.35***	–	0.21*
	(0.15)	(0.10)	(0.03)		(0.13)	(0.20)	(0.09)	(0.02)		(0.12)
Common language	0.68***	0.23*	0.29***	–	0.75***	0.20	–0.05	–0.13***	–	0.47***
	(0.13)	(0.11)	(0.03)		(0.09)	(0.20)	(0.09)	(0.03)		(0.09)
Colony	0.25*	0.29*	0.29***	–	0.40***	–0.25	0.21*	0.17***	–	0.02
	(0.12)	(0.11)	(0.02)		(0.12)	(0.16)	(0.10)	(0.02)		(0.12)
Trade Agreement	0.16	0.37***	0.35***	–	0.03	0.45***	0.60***	0.55***	–	–0.07***
	(0.10)	(0.09)	(0.02)		(0.04)	(0.12)	(0.07)	(0.01)		(0.02)
Bilateral hyperlinks (2009)	0.19***	0.33***	0.14***	–	0.29***	0.19***	0.26***	0.28***	–	0.42***
	(0.05)	(0.04)	(0.04)		(0.02)	(0.05)	(0.04)	(0.04)		(0.02)
Exporter GDP (log)	0.58***	–	0.63***	0.43***	0.47***	0.66***	–	0.60***	0.36***	0.42***
	(0.06)		(0.05)	(0.11)	(0.03)	(0.08)		(0.05)	(0.07)	(0.02)
Internet Exporter	0.01***	–	0.01***	0.00*	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)
Importer Population (log)	0.51***	–	0.63***	1.40***	0.45***	0.59***	–	0.49***	–0.32	0.31***
	(0.06)		(0.05)	(0.41)	(0.03)	(0.08)		(0.05)	(0.21)	(0.02)
Importer GDP percap (log)	0.92***	–	1.07***	0.61***	0.77***	0.59***	–	0.50***	0.49***	0.43***
	(0.10)		(0.09)	(0.09)	(0.04)	(0.14)		(0.08)	(0.06)	(0.02)
Internet Importer	–0.00	–	0.00	0.00	0.00	–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 Gini	0.02**	–	0.01*	–0.01	0.01***	0.04**	–	0.01	0.00	0.02***
	(0.01)		(0.01)	(0.01)	(0.01)	(0.01)		(0.01)	(0.00)	(0.00)
N	38,497	38,497	31,633	33,814	31,633	38,497	38,497	31,633	38,453	31,633
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, panel estimation might still be of interest, considering that a significant part of the existing literature has adopted this 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 empirical methodology available incorporating PPML together with fixed effects *and* instrumental variables to address endogeneity.

At the cost of endogeneity bias, Table 12 presents the results from pooled, random effects, along with various combinations of fixed-effects specifications but without instrumenting BLINK09, GDP

[30] The estimates of the coefficients on other variables are comparable to our baseline model.

or per capita GDP.[31] The panel covers the period 2010-2020.

Notice that the predicted patterns on the impact of exporter GDP and importer per capita GDP are generally borne out from the pooled specification. Exporter-year and importer-year fixed effects do not yield estimates of country-specific variables due to perfect multicollinearity. The theoretical predictions about the importer's GDP per capita and physical distance are supported by the panel results. However, the fixed effects or random effects estimates do not support the theoretical predictions about the exporter's GDP. As argued earlier, this is because the between-variations are unaccounted.[32]

5.3 Institutional Quality

What is the role of soft infrastructure like institutions in determning trade flows in services and manufacturing? Nawaz and Mangla (2021) show that institutional quality is an important determninant of economic growth, and it complements regional integration in improving the spillover effects of infrastructure to economic growth. Portugal-Perez and Wilson (2012) include two types of soft infrastructure, business environment and border and transport efficiency in their investigation of the impact of hard and soft infrastructure the export performance of developing countries. As mentioned in Section 3.1, we include IQI (an index of institutional quality), which is similar to Nawaz and Mangla (2021) and the business-environmet indicator of Portugal-Perez and Wilson (2012).[33]

Expectedly and yet interestingly, soft infrastructure plays a positive role in trade in services. Table 13 shows that the exporter-country IQI exerts a positive and statistically significant impact on trade in services, while its effect on trade in manufacturing is insignificant. Moreover, the importer-country IQI is insignificant in explaining trade in either category. The coefficients of the other explanatory variables are not significantly affected by the inclusion of the IQI. In sum, the institutional quality has a nuanced effect on trade in services.

6 Concluding Remarks

This paper aims to understand why and how aggregate bilateral trade in manufacturing and services may respond differently to various determinants of trade. Furthermore, it introduces virtual proximity as an 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 products: 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 estimated separately, they help us to understand and interpret the differences in the magnitudes of the marginal effect of an explanatory variable between two product groups in light of our theoretical predictions. Compared

[31] 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.

[32] 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.

[33] We do not incorporate an indicator of border and transport efficiency because some components of this is already captured by some of the indicator variables included in the IQI. For instance, the number of days and the number of documents to export and import are partly dependent on the institutions of the country such as its government effectiveness, and regulatory quality, which are included in IQI. Moreover, border and transport efficiency relates very much to trade costs, which are represented by other indicators.

Table 13: PPML estimates with the Inclusion of Institutional Quality Index

	Services											Manufacturing										
	(1) 2010	(2) 2011	(3) 2012	(4) 2013	(5) 2014	(6) 2015	(7) 2016	(8) 2017	(9) 2018	(10) 2019	(11) 2020	(12) 2010	(13) 2011	(14) 2012	(15) 2013	(16) 2014	(17) 2015	(18) 2016	(19) 2017	(20) 2018	(21) 2019	(22) 2020
First Stage Regressions																						
Distance (log)	–0.50***	–0.45***	–0.48***	–0.49***	–0.50***	–0.47***	–0.41***	–0.41***	–0.40***	–0.43***	–0.38***	–0.50***	–0.50***	–0.54***	–0.55***	–0.54***	–0.54***	–0.51***	–0.51***	–0.50***	–0.51***	–0.51***
	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(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)	(0.03)	(0.03)
Common border	0.15	0.18	0.19	0.13	0.05	0.03	0.12	0.11	0.09	0.09	0.08	0.35***	0.34***	0.33***	0.36***	0.37***	0.38***	0.46***	0.43***	0.40***	0.44***	0.44***
	(0.14)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.12)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Common language	0.12	0.22*	0.16	0.24*	0.26*	0.24*	0.26*	0.24*	0.27*	0.25*	0.34**	–0.08	–0.09	–0.11	–0.10	–0.11	–0.11	–0.10	–0.09	–0.11	–0.07	–0.06
	(0.12)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.11)	(0.11)	(0.13)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.11)
Colony	0.45***	0.39***	0.40***	0.35**	0.29*	0.27*	0.26*	0.24*	0.28*	0.19	0.15	0.20	0.21*	0.22*	0.20	0.18	0.17	0.16	0.17	0.18	0.18	0.18
	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)	(0.13)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.12)
Trade Agreement	0.35*	0.37**	0.35**	0.31**	0.36**	0.32**	0.41***	0.37***	0.43***	0.24*	0.29**	0.64***	0.64***	0.55***	0.58***	0.58***	0.55***	0.57***	0.55***	0.58***	0.51***	0.54***
	(0.14)	(0.13)	(0.12)	(0.12)	(0.11)	(0.11)	(0.10)	(0.10)	(0.09)	(0.09)	(0.11)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)
BLINK09 (log)	0.17***	0.17***	0.18***	0.17***	0.17***	0.22***	0.18***	0.21***	0.20***	0.21***	0.16***	0.20***	0.22***	0.24***	0.22***	0.21***	0.21***	0.18***	0.19***	0.22***	0.21***	0.20***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.05)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
N	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	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037	3,037
R-sq	0.84	0.86	0.85	0.85	0.86	0.87	0.87	0.87	0.88	0.87	0.87	0.92	0.92	0.93	0.93	0.93	0.94	0.93	0.92	0.92	0.92	0.92
Exporter and Importer FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Second Stage Regressions																						
Dependent variable: Exporter Fixed Effects, $\widehat{\exp(X_{ji})}$																						
Exporter GDP (log)	0.64***	0.63***	0.61***	0.61***	0.62***	0.57***	0.65***	0.60***	0.59***	0.57***	0.64***	0.74***	0.74***	0.72***	0.74***	0.75***	0.74***	0.74***	0.72***	0.70***	0.70***	0.72***
	(0.09)	(0.07)	(0.08)	(0.07)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.07)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)
Internet Exporter (log)	–0.01	–0.01	–0.01	–0.01*	–0.01	–0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	–0.00	–0.00	–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)	(0.00)	(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)
Institutional Quality (log)	2.19***	2.38***	2.37***	2.55***	2.30***	2.18***	1.89***	1.96***	2.00***	2.05***	2.43***	–1.00	–0.34	–0.07	–0.09	–0.05	–0.28	–0.11	0.12	–0.10	–0.28	–0.37
	(0.79)	(0.77)	(0.74)	(0.67)	(0.56)	(0.53)	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)	(1.42)	(1.32)	(1.24)	(1.16)	(1.11)	(1.00)	(0.89)	(0.83)	(0.80)	(0.75)	(0.75)
N	67	67	67	67	67	67	67	67	66	65	64	67	67	67	67	67	67	67	67	66	65	64
Dependent variable: Importer Fixed Effects, $\widehat{\exp(M_{jr})}$																						
Importer Population (log)	0.57***	0.58***	0.56***	0.56***	0.59***	0.50***	0.57***	0.53***	0.53***	0.50***	0.54***	0.60***	0.58***	0.53***	0.57***	0.60***	0.57***	0.60***	0.62***	0.62***	0.61***	0.65***
	(0.08)	(0.07)	(0.07)	(0.06)	(0.06)	(0.07)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.08)	(0.08)
Importer GDP percap (log)	0.96***	0.93***	0.98***	1.00***	0.91***	1.01***	1.02***	1.07***	1.24***	1.16***	1.14***	0.67***	0.66***	0.66**	0.76**	0.72**	0.90**	0.86*	0.66	0.51	0.63	0.61
	(0.25)	(0.23)	(0.28)	(0.27)	(0.24)	(0.30)	(0.25)	(0.29)	(0.38)	(0.30)	(0.26)	(0.17)	(0.20)	(0.27)	(0.32)	(0.30)	(0.42)	(0.44)	(0.46)	(0.51)	(0.43)	(0.42)
Internet Importer	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	0.01	0.01	0.02	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)	(0.02)	(0.01)	(0.01)
Importer Gini	0.03**	0.03**	0.03**	0.03**	0.02*	0.02*	0.02*	0.02*	0.02	0.02*	0.02***	0.02**	0.02**	0.03**	0.03**	0.02*	0.03**	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)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Institutional Quality (log)	0.16	0.21	0.29	0.13	0.51	–0.28	–0.19	–0.11	–0.60	–0.56	–0.21	–0.31	–0.28	–0.22	–0.22	–0.01	–0.76	–0.85	–0.43	–0.17	–0.62	–0.59
	(0.85)	(0.57)	(0.57)	(0.56)	(0.58)	(0.82)	(0.69)	(0.73)	(1.01)	(0.85)	(0.82)	(0.39)	(0.46)	(0.51)	(0.55)	(0.52)	(1.07)	(1.07)	(1.03)	(1.20)	(1.19)	(1.25)
N	62	62	62	62	62	63	63	63	63	62	61	62	62	62	62	62	63	63	63	63	62	61

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

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 depend 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 a crucial determinant of trade costs of both manufacturing and services, and it reduces the role of physical distance and language differences. It is also shown that soft infrastructure plays role in trade in services.

Some extensions that have the potential to provide 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, 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 subcategories 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 the one hand and growth or per capita income on the other will be promising.

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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),

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

Nonhomothetic 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

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

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

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

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

D Derivation of the Gravity Equation (23)

We have

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

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

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)	0.62***	
	(0.01)	
BLINK03 (log)		0.32***
		(0.01)
Distance (log)	–0.31***	–0.23***
	(0.02)	(0.02)
Common border	0.53***	0.24***
	(0.08)	(0.06)
Common language	0.60***	0.18***
	(0.05)	(0.05)
Colony	0.21**	0.03
	(0.07)	(0.06)
Trade Agreement	0.16***	–0.14***
	(0.04)	(0.04)
N	3,037	1,580
R-sq	0.95	0.96
F-statistic	434.4	388.8
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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dependent variable: GDP (log)											
Lagged Capital Stock (log)	0.95***	0.96***	0.97***	0.96***	0.96***	0.96***	0.96***	0.96***	0.95***	0.96***	0.97***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Internet Exporter	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)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	142	142	142	142	143	144	145	145	136	132	130
R-sq	0.95	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.95	0.95	0.95
F-statistic	1,237.03	1,306.22	1,324.47	1,319.17	1,286.91	1,195.95	1,157.67	1,214.55	1,251.62	1,227.52	1,092.65
Dependent variable: GDP percap (log)											
Lagged Capital Stock percap (log)	4.86***	4.49***	4.32***	4.14***	4.28***	3.88***	4.18***	4.60***	4.71***	4.94***	5.44***
	(0.89)	(0.80)	(0.74)	(0.69)	(0.65)	(0.59)	(0.60)	(0.57)	(0.55)	(0.55)	(0.53)
Importer Population (log)	-0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Internet Importer	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.04***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Importer Gini	0.01*	0.01**	0.01**	0.01**	0.02***	0.01**	0.01**	0.01**	0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	142	142	142	142	143	144	145	145	136	132	130
R-sq	0.87	0.89	0.89	0.90	0.91	0.91	0.90	0.90	0.91	0.91	0.90
F-statistic	220.39	265.25	279.38	311.15	328.72	343.72	316.48	318.8	322.21	303.12	277.23

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