Country Size, Per-Capita Income, and Comparative Advantage: Services Versus Manufacturing*

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Abstract

The paper develops a trade model with novel implications: that larger and richer countries are likely to have comparative advantage in manufacturing and that smaller and poorer countries are likely to have comparative advantage in services. Two forces drive these results: non-homothetic tastes that cause demand to shift toward services as income increases, and services having a higher degree of product differentiation than manufacturing. Empirical analysis using data from 2005 through 2016 finds support for the theoretical predictions: country size and per-capita income have positive relationships with manufacturing comparative advantage indices and negative relationships with services comparative advantage indices.

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1 *Introduction*

The world economy has experienced phenomenal growth of the services sector in the post-WWII era. In major economies, the share of services in GDP stands well above 50%. At the same time, the volume of international trade in services has also grown rapidly – thanks to the IT revolution that has considerably reduced the transactions costs of providing cross-border services. According to the WTO, the global value of service exports became 25% of world trade in commodities and services in the year 2014 (World Trade Organization ed. (2014)). A World Bank study (Newfarmer et al. (2002)) finds that, in the period 1985 to 1999, the compounded annual growth rate of world services exports (on a balance-of-payments basis) was about 9% as compared to 8.2% for world merchandise exports. We see this trend in more recent decades, too. According to World Trade Organization (2015), in the period 1995 to 2014, world commercial services exports grew annually by an average of 8%, outpacing world merchandise exports, whose average annual growth rate was recorded at 7%. Newfarmer et al. (2002) and UNCTAD (2014) also suggest that during the period 1986-2013, trade in services (in terms of value of exports as well as value of imports) has grown faster in developing countries as compared to developed nations.[1]

International trade in services began to attract the attention of many researchers in the early to mid eighties when an international agreement on trade in services was placed on the global trade liberalization agenda. Bhagwati (1984) elaborated the merits of splintering – later termed 'international outsourcing' – of services; Hindley and Smith (1984) discussed the determinants of comparative advantage in services; and Sampson and Snape (1985) classified the different modes of services trade which are incorporated in the General Agreement on Trade in Services (GATS). Since then, a burgeoning literature on trade in services has evolved, which has overlapped with that of international outsourcing and offshoring of tasks.

While Figure 1 shows an overall increasing trend of the world *merchandise* trade to GDP ratio, it has stalled *after* the recovery from the Great Recession period. This "loss of dynamism" is seen by some scholars as a lasting change in the structure of the global economy and has been attributed to an end of an integration process and productivity gains following the removal of merchandise trade barriers under the WTO system; see *The Economist* (December 13, 2014), Constantinescu et al. (2015), and Hoekman (2015).

[1]According to Newfarmer et al. (2002), over the period 1986-1998, the value of services exports grew at an average annual rate of about 8% for developed and 11% for developing countries. UNCTAD (2014) notes that the service exports growth rate has tapered off in recent years, 2008-2013: 2% annually for developed and about 5% annually for developing countries.

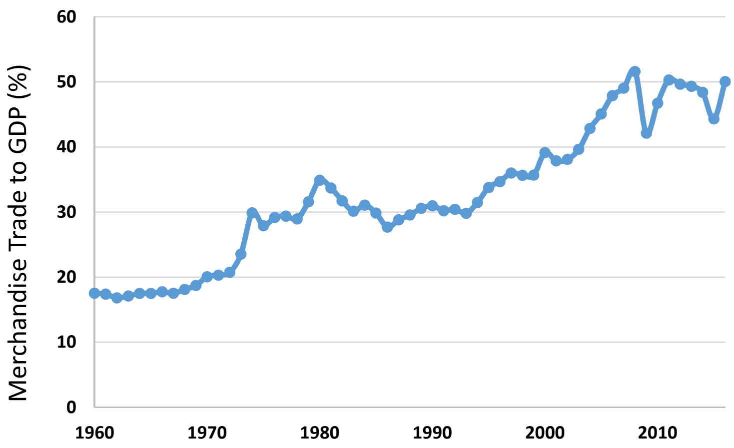
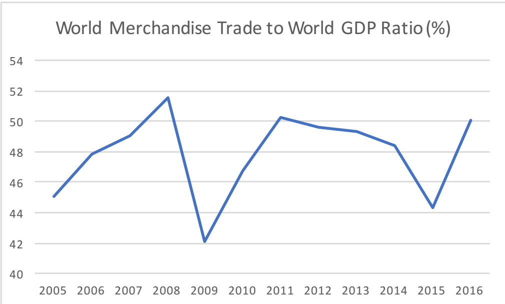
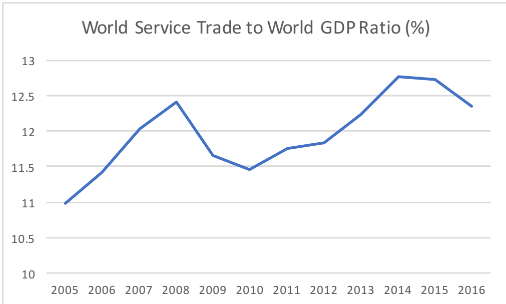


Figure 1: Historical Trend of World Merchandise Trade to World GDP Ratio in %, 1960-2014; Source: World Bank Database



(a)



(b)

Figure 2: World Trade (Sum of Exports and Imports) to World GDP Ratio; *Source:* World Bank Online Database, accessed on August 15, 2017

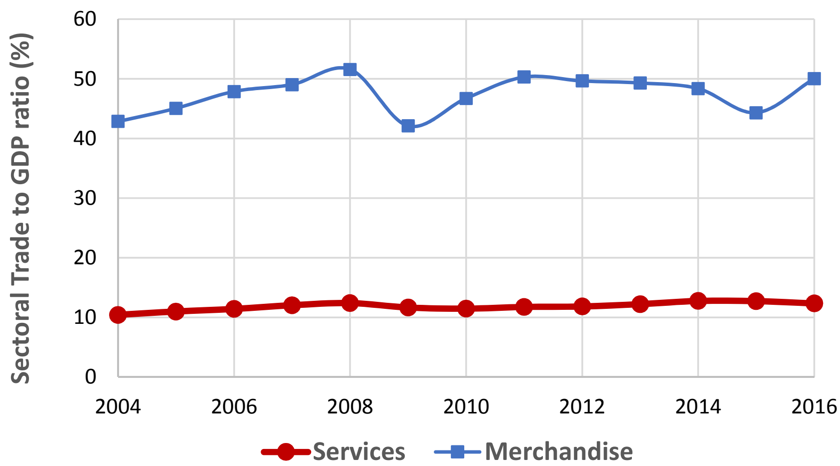


Figure 3: World Trade (Sum of Exports and Imports) to World GDP Ratio; *Source:* World Bank Online Database, accessed on September 17, 2017

In contrast, the ratio of world trade in services to world GDP has continued its trend after the Great Recession period. Figure 2 exhibits this over the period 2005-2016 vis-a-vis that of the merchandise trade to global GDP ratio, while Figure 3 that plots the two time series in the same graph illustrates the relative magnitudes of trade in manufacturing and trade in services.[2]

In the backdrop of the growing importance of trade in services we need to understand systematic differences in trade patterns across manufacturing and services – because, if there are such differences, using theoretical and empirical models that are tailored for trade in manufacturing to analyze trade in services will be misleading. While both trade in manufactures and trade in services would be undeniably governed by comparative advantage, do differences across countries imply differential patterns of trade for manufacturing and services? This paper finds an affirmative answer. It explores, more specifically, how differences in economy size and per-capita income bear differentially upon comparative advantage in manufacturing and services. We formulate a hypothesis that *both larger and richer nations tend to have comparative advantage in manufacturing, while smaller and poorer nations have comparative advantage in services.* We explore two mechanisms that jointly lead to this hypothesis: demand bias resulting from non-homothetic tastes and differences in national product differentiation in manufacturing and services.

Concerning the former, a voluminous literature views services as a product for which the income elasticity of demand is higher than that for manufacturing or agricultural goods.[3] Such *demand bias* toward services implies that larger per-capita income economies would tend to demand services disproportionately more than manufacturing and hence would tend to be net importers of services — leading to the hypothesis just posited.

The second rationale behind our hypothesis is more subtle and rests on a crucial assumption that the Armington elasticity for manufacturing exceeds that for services.[4]

[2]Service trade reported in Figures 2 and 3 is measured by BPM6, which classifies twelve main service components. However, it includes service trade among residents and non-residents of a country only. A foreign person or business is counted as a resident of the host country if the duration of stay has exceeded one year. BPM6 thus does not include a substantial portion of service trade through foreign affiliates *a la* Mode 3, commercial presence, and partially includes Mode 4. See World Trade Organization (2010, page 18) and World Bank (2011, Page 87). Inclusion of these service transactions would indicate a much higher share of services in total international trade.

[3]The idea owes its origin to Kuznets (1957) and Fuchs (1968). More recent examples include, among others, Kongsamut et al. (2001), Matsuyama (2009), Boppart (2014), and Comin et al. (2017).

[4]Bilgic et al. (2002) review different regional and national studies that estimate Armington elasticities for the US for commodities and services. Elasticities for traded commodities range from 1.5 to 3.5, while those for services vary from 0.2 to 2.0. Irrespective of the methodology used, services products generally have lower Armington elasticities than manufacturing products. De Melo and Tarr (1992) report Armington elasticities of 1.5 and 0.4, respectively, for commodities and services. Donnelly et al. (2004) presents a set of Armington elasticities for selected industries in the US for the USITC and

That is, in the terminology of Head and Ries (2001) and others, "national product differentiation" is greater for services than manufacturing. Equivalently put, services are more country-specific than manufacturing.

Examples of country-specific services in the international market include, for example, Bollywood movies, Hollywood movies, European cinema, and Australian films, which are perceived as country-specific varieties in the category of cultural and recreational services. In the tourism sector, different countries offer their own unique tourist attractions. Further, for different tourist destinations, one needs to avail route-specific, and at times country-specific, transportation. For example, Quantas shall fly an Indian to Australia and Turkish Airlines will fly her or him to Turkey and not to many other destinations. Driven by concentration of educated youth, ease of transportation, and supporting infrastructure, in IT different hubs have sprung in different countries. Silicon Valley in the USA is the hotspot of major hardware and software technologies; Bangalore in India is the center for back-end IT related services; Vancouver in Canada specializes in web and web-related software development; Tel Aviv in Israel is the nursery of tech startups driving creation of new apps; and so on. Similarly, there are financial hubs around the world, specialized in different types of services. The U.K. is well-known for its services in investment management, Singapore, for government and regulatory financial services, Hong Kong, for banking, to name a few; their position is helped by their unique connectedness to other surrounding countries and business friendly environments.[5]

The more nationally differentiated, and thus the more nation-specific, a product is, the more world demand dictates its production.[6] This leads to smaller nations having comparative advantage in more differentiated products, because, assuming that demand is symmetric across differentiated products, meeting world demand requires a bigger fraction of small nations' resources than of large nations'. Thus, small nations' production will be skewed more towards differentiated products than will large nations' production, giving small nations comparative advantage in differentiated products. Since services are more differentiated than manufacturing goods, small nations have a comparative advantage in services, relative to manufacturing.

GTAP CGE models. For the former, elasticities average out to be 3.02 and 2.35 for manufacturing and services products, and, for GTAP, these are 2.89 and 2.35, respectively.

[5]Country-specificity or uniqueness of service provision may depend on relative factor abundance, history, culture, etc. which are not addressed in our model.

[6]To see this, consider two extremes: homogeneous products and unique ones with no substitutes at all. With free trade, production costs, not world demand, determine how much of a homogeneous product each nation produces. A nation producing a unique product, though, will produce exactly the amount that the world demands in equilibrium. In this case, world demand completely determines the output level of that unique product. More generally, the more differentiated the product, the more that world demand determines production.

Thus, comparative advantage arises from two sources:

[a] non-homothetic tastes imply that *demand bias* towards services create a negative relationship between **per-capita income** and comparative advantage in services, whereas,

[b] services being more nationally differentiated than manufacturing leads to a *supply bias* in which smaller nations shift their production towards services, implying a negative relationship between **economy size** and comparative advantage in services.

Section 2 provides a brief discussion of the existing literature on the link between country or region sizes and the pattern of trade and how our work distinguishes itself from this literature and explores new frontiers.

In section 3, we develop a multi-country, three-good model of trade in manufacturing and services (besides a numeraire good), in which they differ from each other in terms of the two characteristics discussed above: services have a higher income elasticity of demand and are more differentiated nationally. These differences are shown to imply our hypothesis on the relationship between per-capita income and national economy size on one hand and the two alternative indices of comparative advantage on the other. Proofs of all propositions are provided in the Appendix. Section 4 presents an empirical analysis of the theoretical predictions with robustness checks in Section 5. Section 6 concludes the paper.

2 Relation to the Existing Literature

The 'modern' literature on how the size of trading countries relates to the pattern of trade began in the late seventies when newer trade models started to feature scale economies, product differentiation, and intraindustry trade. See Krugman (1979, 1980), Dixit and Norman (1980), Helpman (1981) and Helpman and Krugman (1985), among many others. In this literature, the pattern of trade typically referred to the share of intraindustry trade in total trade: how this share may be affected by differences in relative factor endowment differences as well as absolute size of the economies. But this research did not explore how economic size or per capita income differences affect comparative advantage, i.e., the international competitiveness of a trading nation.

Krugman (1980) does argue that, in a two-region world with two sectors, one differentiated and one homogeneous, and transport costs, larger regions will be the net exporters of differentiated products. It follows from the home market effect: larger countries sustain a more than proportionate number of firms in the differentiated-good sector with scale economies and thus are the net exporters of the same good. Helpman (1981) and Helpman and Krugman (1985) discuss how per capita income differences affect the share of intra-industry trade but do not analyze how per capita income can drive comparative advantage.

While this literature aims to link patterns of trade within manufacturing and between manufacturing and a homogeneous sector, we break new ground by both allowing for two broad and distinct differentiated products sectors, namely manufacturing and services, and using non-homothetic tastes. This framework allows us to show, for the first time, that both larger and richer regions have comparative advantage in the sector that is less differentiated, namely, manufacturing, and it is the small and poorer nations that would tend to have competitiveness in services — which is more differentiated.

More recently, gravity based comparative advantage models, as in Hanson et al. (2015) and French (2017), attempt to *infer* cross-country differences from bilateral trade flows, whereas we seek to explain a country's overall trade flows, in particular comparative advantage in manufacturing versus services, based on observable country characteristics like size and per-capita income.

As shown by Fieler (2011), Markusen (2013), and Xie (2015), non-homothetic tastes imply that size and per-capita income have distinct effects on bilateral volumes of trade. In sharp contrast, we show in this paper that the size effect cancels out: non-homothetic tastes imply a link between per-capita income and comparative advantage, not between size and comparative advantage. It is the difference in the degree of national product differentiation between services and manufacturing that leads to a relationship between size and comparative advantage.

3 A Multi-Country Trade Model

In the introduction, we intuitively discussed how differences in the pattern of comparative advantage stem from tastes and technology differences between manufacturing and services. In the general equilibrium of the world economy, per-capita income and size differences across countries imply differences in the marginal costs of production and in price indices across countries. Both of these types of differences affect the volume and values of exports and imports of both manufacturing and services. Therefore, the general-equilibrium link between per-capita income and economy size differences on one hand and the difference in the pattern of comparative advantage in services and manufacturing on the other is far from obvious.

In what follows, we formulate a multi-country, costless trade model with three goods: namely, services, manufacturing, and a numeraire good. The world economy consists of N trading countries, indexed by i, k, or r. The two sectors in each country, manufacturing m and consumer services s, each produce differentiated products.

There is one composite factor of production, labor, inelastically supplied in each country. Each household in any country possesses a unit of labor. Let L_r be the total endowment of labor (equal to the total number of households) in country r and $0 < L_1 \leq L_2 < \cdots \leq L_N$. Let good 0 be the numeraire good, which is not produced. Country r is endowed with some amount of good 0, say $\bar{Q}_{0r} > 0$, divided into equal endowments by all households. The existence of a numeraire good serves two purposes. It allows for a country to be the net exporter or exporter of both manufacturing and services, and more importantly, allows real wages to vary even if manufacturing and services prices are fixed.

We use the following notations:

c_{mr} $[c_{sr}]$:	household consumption in country r of the manufacturing [services] composite consisting of varieties produced in all trading countries,
P_{mr} $[P_{sr}]$:	price in country r of the manufacturing [services] composite consisting of varieties produced in all trading countries,
c_{mir} $[c_{sir}]$:	household consumption in country r of the manufacturing [services] composite consisting of varieties produced in country i only,
P_{mir} $[P_{sir}]$:	price in country r of the manufacturing [services] composite consisting of varieties produced in country i only,
$c_{mir}(u)$ $[c_{sir}(u)]$:	household consumption in country r of a manufacturing [services] variety produced in country i,
$p_{mir}(u)$ $[p_{sir}(u)]$:	price in country r of a manufacturing [services] variety produced in country i,
Ω_{mr} $[\Omega_{sr}]$:	mass of manufacturing [services] varieties produced in country r,
y_r:	household or per capita income in country r, which includes the value of the endowment of the numeraire good.

Let uppercase 'C' denote aggregate consumption at the country level, e.g., C_{mir} is the total consumption in country r of the manufacturing composite consisting of varieties produced in country i only.

3.1 Tastes

All households in all countries have the same tastes. (As stated earlier, all households share the same endowment of labor and the numeraire good, too.) We model demand bias towards services through two alternative specifications of nonhomothetic tastes.

3.1.1 Non-Sector Specific Nonhomothetic Tastes: Gorman Tastes

First, we use the traditional Gorman tastes structure where an additive parameter represents non-essentiality of the consumption of services (see Kongsamut et al. (2001), Bhattacharya and Das (2008), Matsuyama (2009), and Markusen (2013)) among others).[7] Let the household utility function be

$$u_r = \beta_0 \ln c_{0r} + \beta_m \ln c_{mr} + \beta_s \ln(c_{sr} + \delta), \ \delta > 0; \beta_0, \beta_m, \beta_s \in (0,1); \beta_0 + \beta_m + \beta_s = 1, \tag{1}$$

$$\text{where } c_{jr} = \left(\sum_{i=1}^{N} c_{jir}^{\frac{\epsilon_j - 1}{\epsilon_j}} \right)^{\frac{\epsilon_j}{\epsilon_j - 1}}, \ j = m, s; \quad c_{jir} = \left(\int_{u \in \Omega_{ji}} c_{jir}(u)^{\frac{\sigma-1}{\sigma}} du \right)^{\frac{\sigma}{\sigma-1}}, \ j = m, s. \tag{2}$$

The presence of the additive parameter δ implies that the income elasticity of demand exceeds one for services, while these elasticities for manufactures and the numeraire good are less than unity. Note that these income elasticities change as income changes.

Within the manufacturing or the services baskets, the tastes are of the Dixit-Stiglitz type. The utility function (1) is an improvisation upon that used by Ardelean and Lugovskyy (2010).

Assumption 1. (a) $\sigma, \epsilon_m, \epsilon_s > 1$; (b) $\epsilon_m > \epsilon_s$; (c) $\sigma > \epsilon_m$.

Remarks.

[a] Expression (1) defines a three-tier utility function. Each tier serves a purpose. The outermost tier specifies tastes across the numeraire good, the manufacturing bundle, and the services bundle, and this is where nonhomotheticity figures in. The intermediate tier specifies the manufacturing and the services bundles as composites of bundles produced across countries. This brings into play nationally differentiated products and hence differences in the degree of national product differentiation between manufacturing and services. Distinct varieties within a country constitute the innermost tier. The constant-elasticity specification implies a constant mark up of price over marginal cost of production. We do not focus on variable mark-up and its implications.

[b] Apart from nonhomotheticity, Assumption 1(b) is a key assumption, stating that services are more nationally differentiated than manufacturing.

[c] Assumption 1(c) reflects that substitutability among within-country varieties is greater than among across-country varieties — for both manufacturing and services. This

[7] Markusen (2013) does not refer to the service sector directly, but its earlier NBER working paper version did.

is assumed by Ardelean and Lugovskyy (2010), and Ardelean (2009) provides supporting empirical evidence.

The utility function (1) leads to the following household demand functions at various levels of disaggregation of goods.

$$
\begin{aligned}
&c_{0r} = \beta_0(y_r + \delta P_{sr}); \quad c_{mr} = \frac{\beta_m(y_r + \delta P_{sr})}{P_{mr}}; \quad c_{sr} = \frac{\beta_s[y_r - \delta(1/\beta_s - 1)P_{sr}]}{P_{sr}} \\
&c_{jir} = \left(\frac{P_{jir}}{P_{jr}}\right)^{-\epsilon_j} c_{jr},\ j = m, s; \quad c_{jir}(u) = \left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma} c_{jir},\ j = m, s \\
&\quad \text{where } P_{jr}^{1-\epsilon_j} \equiv \sum_{i=1}^{N} P_{jir}^{1-\epsilon_j},\ j = m, s; \quad P_{jir}^{1-\sigma} \equiv \int_{u \in \Omega_{ji}} p_{jir}(u)^{1-\sigma} du,\ j = m, s.
\end{aligned} \tag{3}
$$

At the aggregate level

$$
C_{0r} = \beta_0 L_r(y_r + \delta P_{sr}); \quad C_{mr} = \frac{\beta_m L_r(y_r + \delta P_{sr})}{P_{mr}}; \quad C_{sr} = \frac{\beta_s L_r[y_r - \delta(1/\beta_s - 1)P_{sr}]}{P_{sr}}. \tag{4}
$$

Notice that nonhomothecity implies that proportional changes in size and per capita income have different effects on aggregate demand for each good. Hence neither aggregate demand nor total expenditure on a commodity depends solely on total income. The division of total income into per-capita income and market size matters. More particularly, the demand bias towards services (reflected by the positive sign of δ) implies that an increase in per capita income (y_r) has a less than proportionate effect on the aggregate expenditure on manufacturing and the numeraire good and a more than proportionate impact on aggregate expenditure on services. In contrast, an increase in the size of the economy (L_r) has a proportional effect on the aggregate demand for, and the aggregate expenditure on, any good. Thus, with this taste structure, total economic size will not affect comparative advantage, but per capita income will.

3.1.2 Sector-Specific Nonhomothetic Tastes: Non-Gorman Tastes

As an alternative to Gorman tastes, we incorporate the recent approach to modeling non-homothetic tastes — *a la* Fieler (2011), Comin et al. (2017), and Matsuyama (2015) — that allows for sector-specific income elasticity parameters, such that sectors can be uniquely ranked in terms of their income elasticity of demand. Our specifications mirror Comin et al. (2017) and Matsuyama (2015). In order to contrast with the earlier approach, we call them 'non-Gorman tastes.'[8]

[8] Comin et al. (2017) use the term 'nonhomothetic CES.'

[a] Nonhomotheticity is confined to manufacturing and services. These goods are combined into a composite that provides a sub-utility, say c_r. Let P_r denote its price. Expenditure on this composite is $e_r \equiv P_r c_r$.

[b] Tastes over c_r and good 0 are Cobb-Douglas or equivalently log-linear: $v = \beta_0 \ln c_{0r} + \beta \ln c_r$, where $\beta_0 > 0$, $\beta > 0$ and $\beta_0 + \beta = 1$. This is the overall utility function, and, it yields $c_{0r} = \beta_0 y_r$ and $c_r = \beta y_r / P_r$.

[c] Tastes over different varieties within manufacturing or services are the same as in (2), i.e., Dixit-Stiglitz.

The critical, distinguishing feature is part [a]. The innovation is that c_r is implicitly defined by:

$$\sum_{j\in(m,s)} c_r^{\frac{\tau_j-\eta}{\eta}} c_{jr}^{\frac{\eta-1}{\eta}} = 1, \tag{5}$$

where recall that c_{jr}, $j = m, s$, are manufacturing and services composites.

We impose the following restrictions on the parameters:

$$0 < \tau_m < \tau_s < 1 + \tau_m, \tag{R1}$$

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

Remarks.

[a] Like (1), the expression (5) also defines a three-tier utility function.

[b] If $\tau_m = \tau_s = 1$, (5) returns the standard Dixit-Stiglitz function over manufacturing and services.

[c] While $\tau_m \neq \tau_s$ is a necessary condition for non-homotheticity, (R1) states that the difference between them cannot be very large. It ensures normality of both goods.[9]

[d] However, the magnitudes of τ_m and τ_s can be large or small: they may exceed or fall short of unity.

[e] Whereas (R2) implies that $\eta > 1$, (R1) and (R2) together imply that $\eta > \tau_s > \tau_m > 0$.[10]

[9] 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.

[10] If $\tau_s \leq 1$, it is obvious that $\eta > \tau_s > \tau_m > 0$. Suppose $\tau_s > 1$. Then (R2)

$$\eta - \tau_s = \frac{(\tau_s - 1)(\tau_s - \tau_m)}{1 + \tau_m - \tau_s} > 0$$
$$\Rightarrow \eta > \tau_s > \tau_m > 0.$$

The household problem of choice over c_{mr} and c_{sr} is to

maximize c_r, subject to

(i) "utility constraint" (5) and (ii) the budget constraint:

$$P_{mr}c_{mr} + P_{sr}c_{sr} = e_r. \tag{6}$$

Letting γ and μ_r denote the respective Lagrange multipliers, the first order conditions with respect to c_r, c_{mr}, and c_{sr} are:

$$1 + \gamma \sum_{j\in(m,s)} \frac{\tau_j - \eta}{\eta} c_r^{\frac{\tau_j - 2\eta}{\eta}} c_{jr}^{\frac{\eta-1}{\eta}} = 0, \tag{7}$$

$$\gamma \frac{\eta - 1}{\eta} c_r^{\frac{\tau_m - \eta}{\eta}} c_{mr}^{-\frac{1}{\eta}} = \mu_r P_{mr}, \tag{8}$$

$$\gamma \frac{\eta - 1}{\eta} c_r^{\frac{\tau_s - \eta}{\eta}} c_{sr}^{-\frac{1}{\eta}} = \mu_r P_{sr}. \tag{9}$$

Dividing (8) by (9),

$$\frac{c_{mr}}{c_{sr}} = c_r^{-(\tau_s - \tau_m)} \left(\frac{P_{mr}}{P_{sr}}\right)^{-\eta}. \tag{10}$$

Remarks.

[a] The consumption ratio, c_{mr}/c_{sr}, depends on overall sub-utility. Hence, tastes over manufacturing and services are non-homothetic. Given $\tau_s > \tau_m$, the higher the sub-utility, the higher is the services to manufacturing consumption ratio, capturing higher income elasticity of demand for services than for manufacturing and thus a demand bias towards services. Using the household expenditure data of U.S. and India, Comin et al. (2017) do find the estimate $\tau_s - \tau_m$ to be positive.

[b] Unlike Gorman tastes, the parameter η measures the *constant* elasticity of substitution between manufacturing and services.

[c] Multiply (8) and (9) respectively by c_{mr} and c_{sr}, add, and use the utility constraint to obtain

$$e_r = \frac{\gamma(\eta - 1)}{\mu_r \eta}. \tag{11}$$

Substituting this back into (8) and (9), eliminating μ_r, and defining the price of the manufacturing-services bundle as $P_r \equiv e_r/c_r$ give the respective demand functions and expenditure shares:

$$c_{jr} = \left(\frac{P_{jr}}{e_r}\right)^{-\eta} c_r^{\tau_j - \eta} = \left(\frac{P_{jr}}{P_r}\right)^{-\eta} c_r^{\tau_j},$$
$$s_j \equiv \frac{P_{jr} c_{jr}}{e_r} = \left(\frac{P_{jr}}{e_r}\right)^{1-\eta} c_r^{\tau_j - \eta} = \left(\frac{P_{jr}}{P_r}\right)^{1-\eta} c_r^{\tau_j - 1}. \tag{12}$$

[d] Expenditure shares add up to unity, i.e.,

$$\sum_{j \in (m,s)} P_{jr}^{1-\eta} c_r^{\tau_j - \eta} = e_r^{1-\eta}, \tag{13}$$

which implicitly solves c_r. Intuitively, the higher the expenditure on the manufacturing-services composite, the greater is the sub-utility.

[e] Substituting $P_r = e_r / c_r$ into (13),

$$P_r^{1-\eta} = \sum_{j \in (m,s)} P_{jr}^{1-\eta} c_r^{\tau_j - 1}. \tag{14}$$

[f] As proved in Appendix A, both manufacturing and service bundles are normal goods, i.e., given P_{jr}, $dc_{jr}/dc_r > 0$.

Unlike under Gorman tastes, an increase in per capita income (y_r) has a proportionate effect on the aggregate expenditure on the numeraire good. But income effects on manufacturing and services differ: a given increase in per-capita income exerts a less than proportionate effect on the manufactures aggregate expenditure and a more than proportionate impact on services aggregate expenditure. In addition, an increase in size (L_r) has a proportional effect on the aggregate expenditure on any good.[11]

This completes the description of tastes.

[11] Given $c_{0r} = \beta_0 y_r$, individual expenditure on the numeraire good is proportional to y_r. From Appendix A, $\hat{c}_{jr} = \Lambda_j \hat{c}_r$. Substituting the relation between $\hat{c}_r$ and $\hat{e}_r$, noting that $\hat{e}_r = \hat{y}_r$, and using the expressions of Λ_m and Λ_s,

$$\hat{c}_{mr} = \frac{\eta[1 - \lambda_s(\tau_s - \tau_m)] - \tau_m}{\sum_j \lambda_j(\eta - \tau_j)} \cdot \hat{y}_r; \quad \hat{c}_{sr} = \frac{\eta - \tau_s + \eta\lambda_m(\tau_s - \tau_m)}{\sum_j \lambda_j(\eta - \tau_j)} \cdot \hat{y}_r.$$

In view of (R1) and (R2), it is easy to show that $\hat{c}_{mr}/\hat{y}_r < 1 < \hat{c}_{sr}/\hat{y}_r$. Hence, at given prices, $\hat{P}_{mr} c_{mr}/\hat{y}_r < 1 < \hat{P}_{sr} c_{sr}/\hat{y}_r$. This proves the first part. The second part follows from aggregating the demand functions over identical households.

3.2 The Supply Side

The two production sectors, manufacturing and services, have increasing returns to scale. Let the technology in producing a variety in either sector be given by the labor requirement function, $l_j = \alpha + q_j$, $\alpha > 0$, where units of manufacturing and services are normalized such that the variable labor coefficient is unity in both sectors. The market structure in these two sectors is monopolistic competition. An individual firm in either production sector faces constant price elasticity of demand for its variety (under either kind of tastes structure). Hence the price markup over marginal cost is constant:

$$p_{jir}(u) = \frac{\sigma w_i}{\sigma - 1}, \tag{15}$$

where the marginal cost of production in country i is equal to the wage rate in country i, w_i. It leads to

$$P_{jir} = \frac{\sigma w_i}{\sigma - 1} \cdot \Omega_{ji}^{-\frac{1}{\sigma-1}}; \quad \frac{p_{jir}(u)}{P_{jir}} = \Omega_{ji}^{\frac{1}{\sigma-1}};$$

$$P_{jr} = \frac{\sigma}{\sigma - 1}\left(\sum_{i=1}^{N} w_i^{1-\epsilon_j}\Omega_{ji}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{1}{1-\epsilon_j}} \equiv P_j; \quad \frac{P_{jir}}{P_{jr}} = \frac{w_i \Omega_{ji}^{\frac{1}{1-\sigma}}}{\left(\sum_{i=1}^{N} w_i^{1-\epsilon_j}\Omega_{ji}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{1}{1-\epsilon_j}}}. \tag{16}$$

We characterize free trade equilibrium where all trading countries produce both services and manufacturing. Zero-profit conditions in manufacturing and service sectors together with the constant markup equation imply that firm-level equilibrium output and employment levels in each country are constant and equal to: $q_j = \alpha(\sigma - 1)$ and $l_j = \alpha\sigma$. That is, firm output and employment in a given sector are the same across countries. The full-employment condition in country i is

$$\alpha\sigma\left(\Omega_{mi} + \Omega_{si}\right) = L_i. \tag{17}$$

3.3 Free Trade Equilibrium

We now are in a position to characterize free trade equilibrium.

3.3.1 Gorman Tastes

The world market clearing condition for the numeraire good is given by

$$\sum_{r=1}^{N} \bar{Q}_{0r} = \beta_0 \sum_{r=1}^{N}\left(w_r L_r + \bar{Q}_{0r} + \delta P_s\right).^{12} \tag{18}$$

The equilibrium supply of a service variety produced in any country equals $q_s = \alpha(\sigma - 1)$. The world demand for a service variety produced in country i has the expression, $\sum_{r=1}^{N} c_{sir}(u)$, which expands to[13]

$$\frac{\beta_s(\sigma-1)w_i^{-\epsilon_s}\Omega_{si}^{-\frac{\sigma-\epsilon_s}{\sigma-1}}}{\sigma\sum_{r=1}^{N} w_r^{1-\epsilon_s}\Omega_{sr}^{\frac{1-\epsilon_s}{1-\sigma}}}\sum_{r=1}^{N} L_r\left[y_r-\delta\left(\frac{1}{\beta_s}-1\right)P_s\right]. \tag{19}$$

Thus, the world market clearing condition for a services variety is:

$$\alpha\sigma = \frac{\beta_s w_i^{-\epsilon_s}\Omega_{si}^{-\frac{\sigma-\epsilon_s}{\sigma-1}}}{\sum_{r=1}^{N} w_r^{1-\epsilon_s}\Omega_{sr}^{\frac{1-\epsilon_s}{1-\sigma}}}\sum_{r=1}^{N} L_r\left[y_r-\delta\left(\frac{1}{\beta_s}-1\right)P_s\right]. \tag{20}$$

Similarly, the world market clearing of a manufacturing variety produced in country i is expressed as

$$\alpha\sigma = \frac{\beta_m w_i^{-\epsilon_m}\Omega_{mi}^{-\frac{\sigma-\epsilon_m}{\sigma-1}}}{\sum_{r=1}^{N} w_r^{1-\epsilon_m}\Omega_{mr}^{\frac{1-\epsilon_m}{1-\sigma}}}\sum_{r=1}^{N} L_r(y_r+\delta P_s). \tag{21}$$

The services composite price expression (the first equation in 16), the N full employment equations (17), together with the $2N$ equations in (20) and (21), constitute $3N+1$ equations that determine the price of the services composite, and, for each nation, the wage rate, the mass of manufacturing varieties, and the mass of service varieties — thus solving the free trade equilibrium.

3.3.2 Non-Gorman Tastes

The market clearing for a manufacturing or service variety produced in country i is expressed as

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

[12]It yields the following expression for the world GDP:

$$\sum_{r=1}^{N} y_r L_r = \frac{\sum_{r=1}^{N}(w_r L_r+\beta_0\delta P_s)}{1-\beta_0}.$$

[13]This as well as the expression of world demand for a manufacturing variety are derived in Appendix B.

$$= \frac{w_i^{-\epsilon_j}\Omega_{ji}^{-\frac{\sigma-\epsilon_j}{\sigma-1}}}{\left(\sum_{r=1}^{N} w_r^{1-\epsilon_j}\Omega_{jr}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{\epsilon_j}{\epsilon_j-1}}} \cdot \sum_{r=1}^{N} L_r c_{jr}, \quad j = m, s, \tag{22}$$

where the supply of a product variety equals $\alpha(\sigma-1)$ and the expression of demand for it is based on (3) and (16).

The $2N$ demand functions for manufacturing and services consumption bundles in (12), N expenditure shares adding up equations in (13), 2 equations for the relative prices of manufacturing and services composites in (16), N full employment conditions in (17), $2N$ manufacturing and services' varieties market clearing conditions in (22), together with another N equations, $e_r = \beta y_r$, constitute $7N+2$ equations which determine w_r, Ω_{mr}, Ω_{sr}, P_m, P_s, c_{mr}, c_{sr}, c_r and e_r.

3.3.3 An Initial Result

We begin with the following initial result, which Appendix C proves.

Proposition 1: *Whether tastes are Gorman or non-Gorman, as long as all countries produce both services and manufacturing in free trade, and given that* $0 < L_1 \leq L_2 \leq \cdots \leq L_N$,

$$\begin{aligned} w_1 \geq w_2 \cdots \geq w_N \\ w_1 L_1 \leq w_2 L_2 \cdots \leq w_N L_N, \end{aligned} \tag{23}$$

where equalities and strict inequalities hold correspondingly.

3.4 Notions of Comparative Advantage

Our purpose is to relate comparative advantage in manufacturing and services to country size and per-capita income.

In a multi-country, multi-good context, the most commonly used and the most famous notion of comparative advantage is that of revealed comparative advantage (RCA) due to Balassa (1963). The revealed comparative advantage index (RCI) measures a country's export capacity of a product (or a group of products). For product j and country i, it is defined as the ratio of the share of country i's world exports of good j in its total gross exports of *all* goods to the share of world gross exports of good j in total world exports of *all* goods. However, it doesn't directly compare the export capacity of one good or group of goods vis-a-vis another. Instead of focusing on the exports of one good relative to the entire basket of exports at the country and global level, we propose a refinement of RCA that focuses on the exports of two goods and call it *pair-wise revealed comparative advantage.*

In general, let the two goods be s and m, and let X_{ji} denote the value of country i's gross exports of good j, $j = s, m$. Define $X_i = \sum_j X_{ji}$ and $X_R = \sum_i X_i = \sum_i \sum_j X_{ji}$, respectively the total exports of the two goods combined at a country and the global level.

Definition. *Country i has* **pairwise revealed comparative advantage (PRCA) in good s (m) vis-a-vis good m (s)** *if and only if*

$$\Psi_{si} \equiv \frac{X_{si}/X_i}{X_{sR}/X_R} > 1 \quad \left(\Psi_{mi} \equiv \frac{X_{mi}/X_i}{X_{mR}/X_R} > 1, \right) \tag{24}$$

where Ψ_{si} and Ψ_{mi}'s are the respective **pairwise revealed comparative indices (PRCI)**. In Balassa's revealed comparative advantage measure, X_i and X_R in (24) would refer to the total exports of all goods, instead of the total exports of just two goods. We can equivalently express

$$\Psi_{si} = \frac{1 + X_{mR}/X_{sR}}{1 + X_{mi}/X_{si}}; \quad \Psi_{mi} = \frac{1 + X_{sR}/X_{mR}}{1 + X_{si}/X_{mi}}, \tag{25}$$

which imply that $\Psi_{si} \gtreqless 1 \Leftrightarrow \Psi_{mi} \lesseqgtr 1$. Denoting services and manufacturing by s and m respectively, if a country i has PRCA in services vis-a-vis manufacturing, it has pairwise revealed comparative **dis**advantage in manufacturing vis-a-vis services.

Besides PRCA, we propose another notion of comparative advantage that is new and uses information on a country's exports *as well as imports* of a particular good or group of goods — which Balassa's RCA does not. We call it the relative export advantage, which compares two ratios: the ratio of a country's exports of one product group (s or m) to the country's trade (sum of exports and imports) of the same product group and the same for the other product group (m or s). Denoting the value of country i's imports of good j by I_{ji}, $j = s, m$, we define the following:

Definition. *Country i has* **relative exports advantage (RXA) in s vis-a-vis good m** *if and only if*

$$\Phi_{si} \equiv \frac{X_{si}/(X_{si} + I_{si})}{X_{mi}/(X_{mi} + I_{mi})} = \frac{1 + I_{mi}/X_{mi}}{1 + I_{si}/X_{si}} > 1 \Leftrightarrow \Phi_{mi} \equiv \frac{X_{mi}/(X_{mi} + I_{mi})}{X_{si}/(X_{si} + I_{si})} < 1, \tag{26}$$

where Φ_{si} and Φ_{mi} are the respective **relative exports indices or RXI**.

Similar to pairwise revealed comparative advantage, if a country has RXA in one good vis-a-vis another, it has relative exports **dis**advantage in the second good vis-a-vis the first. An advantage of this notion of comparative advantage is that it is not directly affected by exports or imports of other countries.

It turns out that we have the following proposition, proven in Appendix D:

Proposition 2: *In a two-country world, PRCA and RXA are equivalent.*

3.5 Expressions for Export Ratios

Notice from (25) that the PRCI depends on the ratio of services to manufacturing exports. We now present the expressions for this ratio so that we can analytically compare this, as well as indices of comparative advantage, across countries varying in size and per-capita income.

Under Gorman tastes, we use demand functions (3) and relative price expressions (16) and obtain

$$\begin{aligned}\frac{X_{si}}{X_{mi}} &= \frac{\sum\limits_{r\neq i} P_{sir} L_r c_{sir}}{\sum\limits_{r\neq i} P_{mir} L_r c_{mir}} = \chi_1 \cdot w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} \frac{\sum\limits_{r\neq i} L_r(y_r - \delta(1/\beta_s - 1)P_s)}{\sum\limits_{r\neq i} L_r(y_r + \delta P_s)} \\ &= \chi_1 \cdot w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} \frac{Y_R - L_i y_i - (L_R - L_i)\,\delta(1/\beta_s - 1)P_s}{Y_R - L_i y_i + (L_R - L_i)\,\delta P_s}, \end{aligned} \tag{27}$$

where

$$\chi_1 \equiv \frac{\beta_s A_s^{\frac{1-\epsilon_s}{1-\sigma}}}{\beta_m A_m^{\frac{1-\epsilon_m}{1-\sigma}}} \left(\frac{\sigma}{\sigma-1}\right)^{\epsilon_m-\epsilon_s} \frac{P_m^{1-\epsilon_m}}{P_s^{1-\epsilon_s}}$$

is invariant across countries. Also, at the world level, we have

$$\begin{aligned}\frac{X_{sR}}{X_{mR}} = \frac{\sum_i X_{si}}{\sum_i X_{mi}} &= \frac{\sum_i \left[\chi_1 \cdot w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} X_{mi} \frac{\sum\limits_{r\neq i} L_r(y_r - \delta(1/\beta_s-1)P_s)}{\sum\limits_{r\neq i} L_r(y_r+\delta P_s)}\right]}{\sum_i X_{mi}} \\ &= \frac{\chi_1 \sum_i \left[w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} X_{mi} \frac{Y_R - L_i y_i - (L_R-L_i)\delta(1/\beta_s-1)P_s}{Y_R - Y_i + (L_R - L_i)\delta P_s}\right]}{\sum_i X_{mi}}. \end{aligned} \tag{28}$$

Likewise, by making use of the product variety demand expression (3) and relative price expressions (16), under non-Gorman tastes,

$$\frac{X_{si}}{X_{mi}} = \frac{\sum_{r\neq i} P_{sir} L_r c_{sir}}{\sum_{r\neq i} P_{mir} L_r c_{mir}} = \frac{\sum_{r\neq i} P_{sir}\left(\frac{P_{sir}}{P_s}\right)^{-\epsilon_s} L_r c_{sr}}{\sum_{r\neq i} P_{mir}\left(\frac{P_{mir}}{P_m}\right)^{-\epsilon_m} L_r c_{mr}}$$

$$= \left(\frac{\sigma}{\sigma-1}\right)^{\epsilon_m-\epsilon_s} \frac{P_s^{\epsilon_s}}{P_m^{\epsilon_m}} \frac{w_i^{\epsilon_m-\epsilon_s}\Omega_{si}^{\frac{1-\epsilon_s}{1-\sigma}}}{\Omega_{mi}^{\frac{1-\epsilon_m}{1-\sigma}}} \cdot \frac{\sum_{r\neq i} L_r c_{sr}}{\sum_{r\neq i} L_r c_{mr}}$$

$$= \chi_2 w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} \cdot \frac{\sum_{r\neq i} L_r c_{sr}}{\sum_{r\neq i} L_r c_{mr}}, \text{ making use of (A.7)}, \tag{29}$$

where χ_2 is invariant across countries and has the expression

$$\chi_2 \equiv \left(\frac{\sigma}{\sigma-1}\right)^{\epsilon_m-\epsilon_s} \frac{P_s^{\epsilon_s}}{P_m^{\epsilon_m}} \frac{\bar{A}_s^{\frac{1-\epsilon_s}{1-\sigma}}}{\bar{A}_m^{\frac{1-\epsilon_m}{1-\sigma}}}.$$

The relative service exports for the world economy have the expression:

$$\frac{X_{sR}}{X_{mR}} = \frac{\chi_2 \sum_r \left(w_r^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_s)(\sigma-\epsilon_m)}} X_{mr} \cdot \frac{\sum_{r\neq i} L_r c_{sr}}{\sum_{r\neq i} L_r c_{mr}} \right)}{\sum_r X_{mr}}. \tag{30}$$

3.6 Comparative-Advantage Propositions

With the help of the expressions (27)–(30), we derive the following propositions that establish our comparative-advantage hypotheses. Proposition 3 pertains to demand bias while suppressing the differences in national product differentiation. In turn, Proposition 4 states the implications of differences in national product differentiation while assuming no demand bias.

3.6.1 Demand Bias and Comparative Advantage

Proposition 3: *In the presence of demand bias toward services and no difference in national product differentiation between services and manufacturing,*
(a) if country sizes in terms of labor endowments differ while per-capita incomes are the same across countries,[14] *then relative exports, X_{si}/X_{mi}, and indices of comparative advantage, PRCI and RXI, are independent of the distribution $\{L_r\}$, irrespective of whether the nonhomothetic taste structure is Gorman or non-Gorman;*

Now suppose the reverse: labor endowments are the same across countries, while per-capita endowments of the numeraire good differ such that $y_1 < y_2 < \cdots < y_N$; then
(b) if tastes are Gorman, (i) relative exports of services, X_{si}/X_{mi}, and PRCI in services decrease with per-capita income; (ii) there exists a country N_0 (respectively N_0^*) between 2 and N such that all countries indexed smaller than N_0 (respectively N_0^*) have PRCA

[14] Given $L_1 \le L_2 \le \cdots \le L_N$, we have $w_1 \ge w_2 \ge \cdots \ge w_N$. Let $\bar{q}_{01} \ge \bar{q}_{02} \ge \cdots \ge \bar{q}_{0N}$ be such that per-capita income, equal to $y_r \equiv w_r + \bar{q}_{0r}$, is invariant across countries.

(respectively RXA) in services and the rest have PCRA (respectively RXA) in manufacturing.
(c) if tastes are non-Gorman, (i) beyond a threshold size, the relative exports of services decrease with per-capita income; (ii) PRCI in services decreases with per-capita income beyond a threshold, and the lowest per-capita income country has PRCA in services as long as demand bias towards service consumption is strong enough[15] *and; (iii) like PRCI in services, RXI in services decreases with per-capita income beyond a threshold, and the lowest per-capita income country has RXA in services vis-a-vis manufacturing. Further, there exists a country N_1 between 2 and N such that all countries indexed smaller than N_1 have RXA in services and the rest have RXA in manufacturing.*
(Proof in Appendix E)

Proposition 3 essentially says that, in the presence of demand bias towards services, higher (respectively lower) per-capita income countries tend to have comparative advantage in manufacturing (respectively services). The precise results are stronger with Gorman tastes than with non-Gorman tastes.

3.6.2 National Product Differentiation, Supply Bias, and Comparative Advantage

Proposition 4: *Given that there is no demand bias and services are more nationally differentiated than manufacturing, (a) Relative exports and PRCI depend on the country size distribution $\{L_r\}_1^N$ only; RXI, in contrast, depends on both the country size distribution and the per-capita income distribution across countries; (b) Relative service exports decline unambiguously with country size, and, (c) there exists a country N_2 (N_2^* respectively) between 2 and N such that all countries indexed smaller than N_2 (N_2^* respectively) have PRCA (RXA respectively) in services and the rest have the same in manufacturing. (Proof in Appendix F)*

Central to the understanding of Proposition 4 is that a higher degree of national product differentiation of services compared to manufacturing creates a supply bias. That is,

Proposition 5: *If there is no demand bias, and services are more nationally differentiated than manufacturing, in free trade equilibrium, the ratio of manufacturing to services output in country i is higher than the same ratio in country j if $L_i > L_j$. (Proof in Appendix G)*

Hence, larger (respectively smaller) countries tend to have comparative advantage in manufacturing (respectively services).

[15] A precise (sufficient) condition is derived in Appendix E.

In a nutshell, Propositions 3, 4, and 5 tell us that comparative advantage differences between services and manufacturing result from per-capita income differences with demand bias and from economy-size differences with supply bias.

Before leaving this theoretical section, we remark that our model does not incorporate manufacturing and services being used as intermediate inputs in production. Hence there is no trade in intermediates. To account for industrial use of, and trade in, these goods, we may specify manufacturing and services technologies where the same goods are used as intermediates (alongside labor) and, for tractability, the variable input bundle is Cobb-Douglas in terms of labor, manufacturing, and services. The full specification of trade equilibrium in this environment promises to be much more complicated algebraically than our model, but it is not difficult to anticipate the implications.

The market clearing condition for any variety of either good must reflect the two sources of demand: industrial demand and household demand. There is, though, no compelling argument for an industrial demand bias toward services as inputs. Hence, the link between per-capita income and comparative advantage will be weaker insofar as there is trade in intermediates, compared to a world where manufacturing and services are not used in production. On the other hand, the concept of services being more nationally differentiated than manufacturing is likely to be applicable in the context of both household and industrial demand for goods. Therefore, the link between country size and comparative advantage should remain intact.

4 Empirical Analysis

The present section examines the empirical validity of our hypotheses. Unlike gravity models that predict bilateral trade in value terms (we may loosely call it 'volume of trade'), comparative advantage of an individual country concerns its trade with the rest of the world. Further, instead of trade volume, comparative advantage focuses on export competitiveness in one broad group of products, such as, services, vis-à-vis another, such as, manufacturing. Accordingly, the determinants of comparative advantage of individual countries vis-à-vis the rest of the world would, in general, be different from those of the *volume* of *bilateral* trade.

Recent empirical work on the sources of comparative advantage has looked at the role of institutions, where comparative advantage is indicated by the level of exports rather than in terms of indices. Levchenko (2007) and Nunn (2007) use cross-country data to test whether a country's ability to enforce written contracts determines export volumes. In a China based study, Feenstra et al. (2013) use province-level data to investigate the role of contracts enforcement institutions in facilitating trade in various types of manufacturing goods, like those which are assembled in China to make final goods compared to goods produced from primary inputs. They also look into the effect of firm ownership status (domestic or foreign) on export volumes. Using bilateral data, Manova (2013) estimates the impact of financial market imperfections on the level of sectoral exports.

The general finding of this literature is that improvements in institutional quality, both over time and across a cross section of countries, increase export volumes in industries that rely more on institutions. In contrast, our paper focuses on the cross-country patterns of *comparative advantage of one set of goods vis-à-vis another.* More specifically, it uncovers two sources of the differential *cross-section* patterns of comparative advantage in trade in services vis-à-vis in manufacturing: one based on economy size and the other on per-capita income. Across trading countries, comparative advantages in services and manufacturing are respectively negatively and positively related to both economy size and per-capita income.

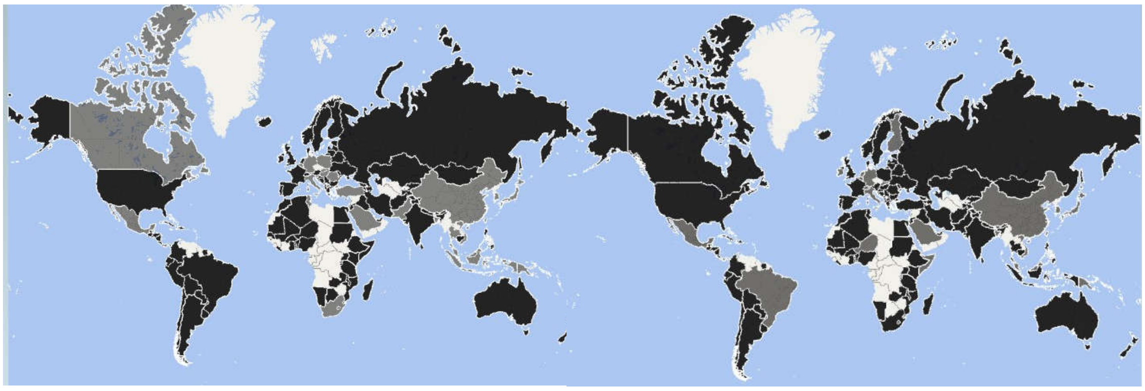
Cross-country *multilateral* data on gross exports and imports in manufacturing, services, and other products are available, *inter alia*, from World Development Indicators - World Bank and UNCTADstat. We use trade data from UNCTADstat since it clearly specifies the basis of measuring trade in services in particular. We choose the sample period 2005-2016 because service trade data based on BPM6 is available only as far back as 2005, whereas for earlier years the services trade data followed BPM5 and earlier categorizations. It is a known fact that services trade data are relatively incomplete and imprecise compared to goods trade data. For example, service trade data based on balance of payments methods do not incorporate a major share of trade through Mode 3, commercial presence. Nonetheless, balance of payments based service data is widely used, e.g. Francois et al. (2009), Head et al. (2009), Loungani et al. (2017), and World Trade Organization (2017).

Country or market size is measured by population and size of the labor force. We measure per capita income by per capita real GDP in 2010 US dollars as well as in PPP adjusted 2011 international dollars. Data on population, labor force, and per-capita income are obtained from World Development Indicators - World Bank.

Appendix H gives details of data sources.

4.1 Preliminary Empirics

As a prelude to our empirical analysis, Figure 4 exhibits the global patterns of PRCA and RXA for the year 2016. The grey colored countries have comparative advantage in manufacturing, and the black colored countries, in services. For those in white,



(a) Pairwise Revealed Comparative Advantage (b) Relative Export Advantage

Figure 4: Cross Country Patterns of PRCA and RXA in 2016
Grey is manufacturing comparative advantage, black is services comparative advantage, and white denotes data unavailability.

services and/or manufacturing trade data is not available. Note that a country with PRCA in manufacturing (or services) may not have RXA in manufacturing (or services), e.g, Canada. Irrespective of the measure, a large majority of countries have comparative advantage in services. This is consistent with our model as the distribution of size and per-capita income is skewed to the right, and smaller and poorer countries tend to have comparative advantage in services. Manufacturing hubs like China, Germany, and Bangladesh do have comparative advantage in manufacturing in terms of either measure. Countries with services comparative advantage are more diverse, including less developed regions in Africa and South America as well as less populated regions in Asia.[16]

Table 1 displays the summary statistics of the comparative-advantage indices, which are non-negative and have no upper bound. Notice that variations in export advantage indices are greater than those of pair-wise revealed comparative advantage indices. Since PRCI refers to the composition of a country's export basket relative to world average while RXI is based on a country's gross exports and imports of different groups of goods without reference to the world average, the latter exhibits greater variance. Nonetheless, the respective PRCI and RXI indices (in logs) are strongly correlated.

[16]In the 2016 data, rich countries like Luxembourg, Norway, Qatar, Sweden, Denmark, Australia, and the US exhibit comparative advantage in services. This suggests that the spread of comparative advantage in services is 'wide', especially within high income countries. We shall see this in our scatter plots in Figure 5. Perhaps this wide variance in comparative advantage for services results from technological differences not captured by our model. However, on an average, the correlation between services comparative advantage and per capita income is negative.

Table 1: Summary Statistics of Comparative Advantage Indices, 2005-2016

VARIABLES	(1) # of observations	(2) mean	(3) s.d.	(4) min	(5) max
PRCI of services (ψ_{si})	2,242	2.023	0.971	0.174	3.864
PRCI of manufactures (ψ_{mi})	2,242	0.601	0.378	0.002	1.352
RXI of services (ϕ_{si})	2,241	5.188	11.881	0.096	236.537
RXI of manufactures (ϕ_{mi})	2,241	0.629	0.652	0.004	10.433

Corr[log PCRI of services, log RXI of services] = 0.7909
Corr[log PCRI of manufactures, log RXI of manufactures] = 0.9011

Table 2: Top Ten Countries with Comparative Advantage in Services and Manufacturing, 2016

PCRA in services	RXA in services	PCRA in manufactures	RXA in manufactures
Maldives	Maldives	Lesotho	China
Bermuda	Iraq	Mexico	Lesotho
Aruba	Sudan	Viet Nam	Bangladesh
Timor-Leste	Bermuda	China	Ireland
Iraq	Afghanistan	Bangladesh	Swaziland
Tuvalu	Cuba	Slovakia	Taiwan
Sudan	Montenegro	Taiwan	S. Korea
Seychelles	Tonga	Swaziland	Saudi Arabia
Tonga	Timor-Leste	S. Korea	Papua New Guinea
Jamaica	Aruba	Germany	Germany

The top ten countries in terms of comparative-advantage indices for services and manufacturing are listed in Table 2. Whether we rank countries on the basis of PRCA or RXA, several countries overlap in the list of the top ranked countries with comparative advantage in services or manufacturing. By definition, comparative advantage in services (respectively manufacturing) could be attributed to high services (respectively manufacturing) exports or high manufactures (respectively services) imports.

Top services-comparative-advantage countries include relatively small and poorer countries like Maldives, Timor-Leste, and Aruba that are well-known for their tourism exports as well as Afghanistan, Sudan, and Iraq that are heavy importers of military equipment. Top countries with manufacturing comparative advantage are not surprising — Bangladesh, the largest textile exporting country; Lesotho, the largest exporter of garments to the US from sub-Saharan Africa; the Republic of Korea and Taiwan, the largest exporters of electronic equipment; Germany, the largest automobile parts exporter; and China, the largest machine equipment exporter, to list a few. The list of top

Table 3: Simple Correlations

(a) Correlations, 2005-2016

	PRCI of services (ψ_{si})	PRCI of manufactures (ψ_{mi})	RXI of services (ϕ_{si})
Population	-0.4822	0.5814	-0.4377
Labor force	-0.4338	0.4901	-0.3358
Per Capita Real GDP (2010 USD)	-0.2296	0.1959	-0.3084
Per Capita Real GDP (2011 PPP International Dollars)	-0.2752	0.2518	-0.3415

(b) Correlations, 2005

	PRCI of services (ψ_{si})	PRCI of manufactures (ψ_{mi})	RXI of services (ϕ_{si})
Population	-0.4744	0.5400	-0.4011
Labor force	-0.4384	0.4767	-0.3359
Per Capita Real GDP (2010 USD)	-0.2678	0.2726	-0.3216
Per Capita Real GDP (2011 PPP International Dollars)	-0.3107	0.3400	-0.3675

(c) Correlations, 2016

	PRCI of services (ψ_{si})	PRCI of manufactures (ψ_{mi})	RXI of services (ϕ_{si})
Population	-0.4977	0.6099	-0.4481
Labor force	-0.4570	0.5151	-0.3458
Per Capita Real GDP (2010 USD)	-0.1531	0.1269	-0.2992
Per Capita Real GDP (2011 PPP International Dollars)	-0.1872	0.1585	-0.3132

ranked countries with manufacturing comparative advantage also contains countries with high GDP per capita (PPP adjusted) like Ireland, Germany, and Saudi Arabia, as well as highly populous countries like China, Bangladesh, and Mexico.

Table 3 presents simple correlations between (logs of) comparative-advantage indices on one hand, and, log of size and per-capita income measures on the other over the entire sample period as well as for 2005 and 2016. Indeed we find the same pattern not just for these two years but for each year in our sample period.

Corresponding scatter plots for the year 2016 are exhibited in Figure 5. We plot correlation between the three measures of comparative advantage (logs of PRCI and RXI in services, and the log of PRCI in manufacturing) on one hand, and two measu-

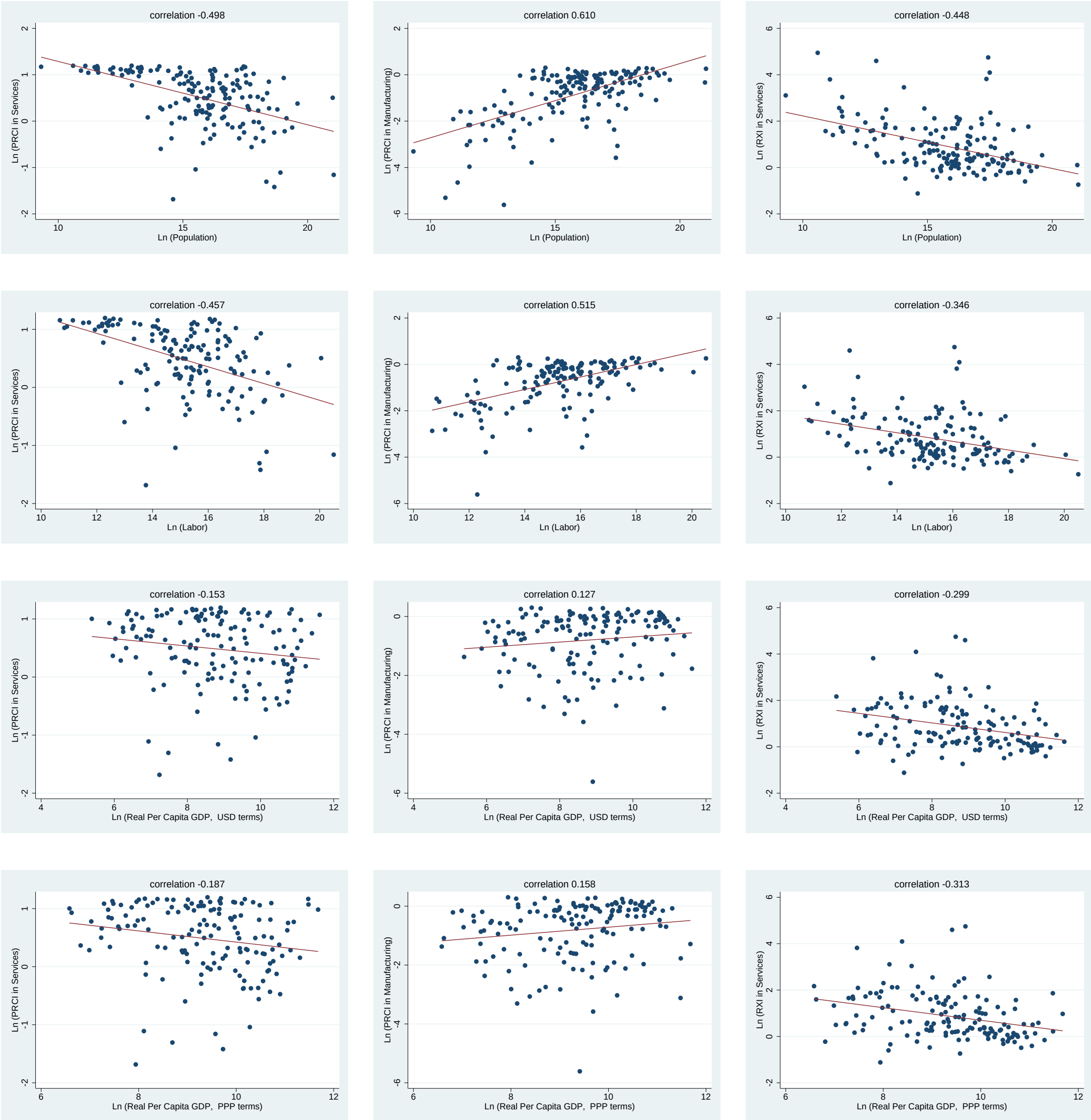


Figure 5: Correlation plots between measures of comparative advantage and measures of size and per capita income for 2016

res of size (population and labor force both in logs) and two measures of per-capita income (per-capita real GDP in 2010 US dollars and that in PPP adjusted 2011 international dollars, both in logs also) on the other.[17]

Table 3, as well as the scatter plots, corroborate our theoretical model: services (or manufacturing) comparative advantage is negatively (or positively) correlated with both country size and per capita income measures. Econometric analysis is our next step.

[17]We omit the correlation plots in Figure 5, as well as the correlation results in Table 3, with respect to RXI in manufacturing, since its log is the negative of the log of RXI in services.

4.2 Econometric Estimations

The theoretical model predicts how comparative advantage indices vary across countries in a cross-sectional equilibrium. They are not based on relationships specific for any particular trading country over time. For estimation we assume the following log-linear parametric equation:

$$\ln \chi_k^j = \beta_0^j + \beta_1^j \ln L_k + \beta_2^j \ln y_k + \boldsymbol{X}_k' \boldsymbol{\gamma}^j + u_k^j, \tag{31}$$

which cross-sectionally relates comparative advantage to size and per-capita income, and, where k denotes countries, $\chi_k^j, j = s, m$ is the respective comparative-advantage index, L_k is the measure of size, and y_k denotes per-capita income. The vector $\boldsymbol{X}$ captures other potential determinants of comparative advantage. Our testable hypotheses are $\beta_1^s < 0 < \beta_1^m$ and $\beta_2^s < 0 < \beta_2^m$. The slope coefficients reflect the respective marginal effects *across countries*, not time. Hence, although we have a panel of observations across countries and time, it is pertinent to estimate (31) at a given point of time.

4.3 Year-by-Year Regressions

4.3.1 Inclusion of Size and Per-Capita Income Variables Only

We begin with size and per-capita income as the only predictors of comparative advantage. While Panel (a) of Table 4 presents the OLS estimations of (31) for 2010, which is the mid year in our sample period, the regression coefficients are shown pictorially for all years in our sample in Figure 6. We plot the yearly beta coefficients, along with their 95% percent confidence interval, of the two independent variables log (population) and log (per capita real GDP). The coefficients of both size and per-capita income are significant at one percent, and their signs are consistent with the theoretical prediction.

4.3.2 Relative Factor Endowment Differences and Instrumenting Per-Capita Income

While the results are supportive, it is natural to think that relative factor abundance differences play a role in comparative advantage between manufacturing and services. Redding and Vera-Martin (2006) argue that factor endowments explain the pattern of production across broad sectors like agriculture, manufacturing, and services better than across disaggregated manufacturing industries.

Table 4: Regressions with Robust Standard Errors, Year 2010

(a) OLS

VARIABLES	PRCI Services	PRCI Manufactures	RXI Services
Ln (Population)	-0.147***	0.290***	-0.215***
	(0.0172)	(0.0307)	(0.0297)
Ln (Per Capita Real GDP)	-0.111***	0.164***	-0.228***
	(0.0243)	(0.0405)	(0.0441)
Constant	3.760***	-6.730***	6.136***
	(0.356)	(0.570)	(0.597)
Observations	177	177	177
R-squared	0.306	0.391	0.281

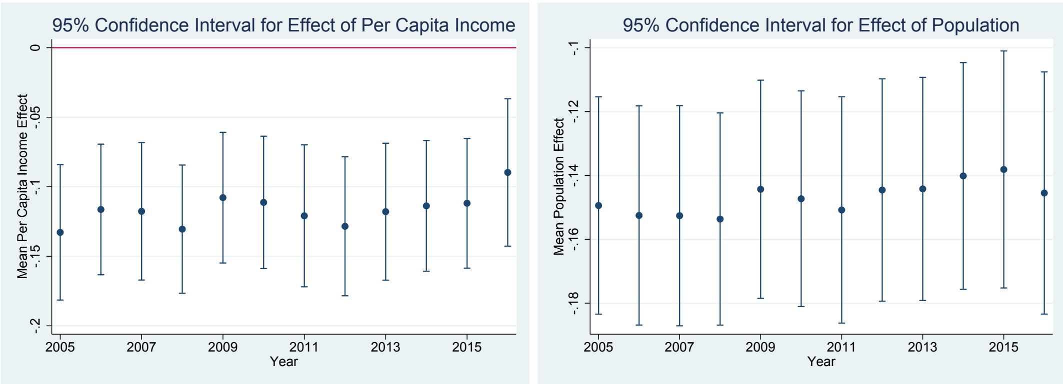
(b) IV

VARIABLES	PRCI Services	PRCI Manufactures	RXI Services
Ln (Population)	-0.135***	0.148***	-0.129***
	(0.036)	(0.034)	(0.040)
Ln (Per Capita Real GDP)	-0.094*	0.083	-0.216***
	(0.051)	(0.059)	(0.084)
Ln (Human Capital Index)	-0.072	0.222	0.156
	(0.284)	(0.314)	(0.449)
Constant	3.466***	-3.785***	4.418***
	(0.669)	(0.686)	(0.941)
Observations	116	116	116
F statistic of First Stage	134.281	134.281	134.281
LM test statistic for underidentification	34.077	34.077	34.077
Hansen J Statistics for overidentification	2.199	1.693	0.959

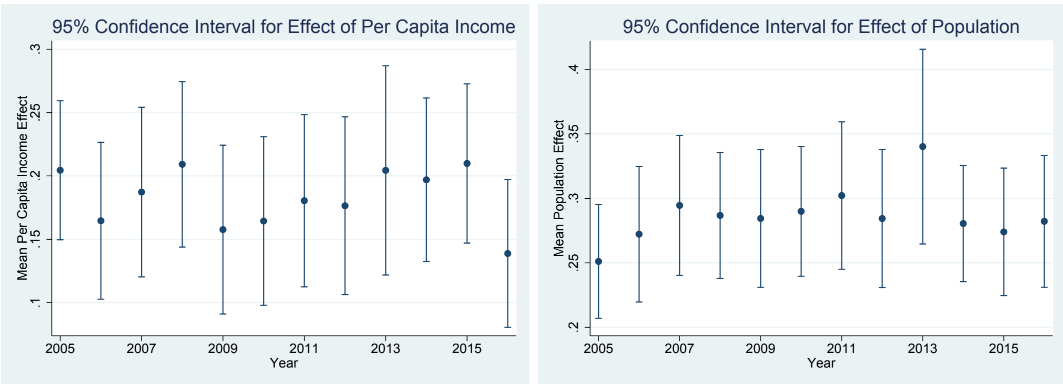
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Instruments are latitude, two-period lags of the gross savings rates and per capita real capital stock.

Acemoğlu and Guerrieri (2008) present data on capital intensities across sectors in the U.S., indicating that the services sector has roughly the same capital intensity as manufacturing. Over 1987-2005, the average capital share for selected manufacturing industries was about 37%, while that in selected services industries was about 37.3%. According to the EUKLEMS database, in the period 1970-2007, the US and the UK have a slightly higher capital intensity in services as compared to manufacturing. This stems from higher use of IT capital in the services sector. If the service sector is more capital-intensive than manufacturing, a relatively capital-abundant country, *ceteris paribus*, would tend to command comparative advantage in services.

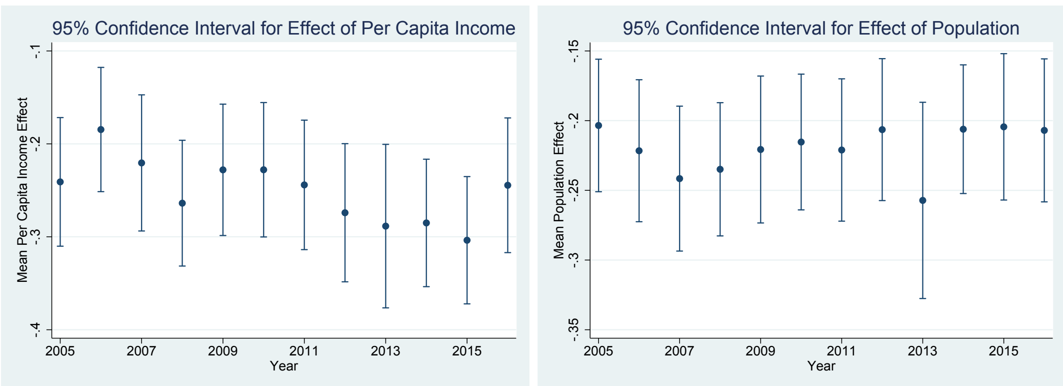
Figure 6: OLS Regressions. Beta Coefficients with 95% Confidence Interval.



(a) Dependent Variable: PRCI in Services



(b) Dependent Variable: PRCI in Manufactures



(c) Dependent Variable: RXI in Services

One can think of relative skill abundance playing a role. In their empirical study of the pattern of production across fourteen industries in Europe, Redding and Vera-Martin (2006) find supporting evidence of the service sector being more skill intensive than manufacturing. Bussolo et al. (2012) conclude that services are more skill intensive than other sectors of an economy. If so, a relatively human capital abundant country would, *ceteris paribus*, possess comparative advantage in services.

While capital abundance may affect relative comparative advantage, per-capita real capital stock is strongly correlated with per-capita real income, leading to a multicollinearity issue. In our sample period, the correlation coefficient between these two variables (both in logs) is 96%. Hence, not only is there a relatively weak theoretical presumption of relative factor endowment differences affecting comparative advantage between manufacturing and services (since intensity differences are rather small), it is difficult to empirically separate out the effect of factor endowments, if any, on comparative advantage between manufacturing and services.

Correcting for human capital, though, shows more promise. Our dataset includes a human capital index across countries and years, which we use as a measure of relative skill abundance. The theoretical basis for it potentially explaining comparative advantage between manufacturing and services is somewhat stronger than that of the relative capital endowment measure, and, moreover, the coefficient of correlation between (log of) the human capital index and (log of) per capita real income is 79%, far less than that between (log of) per-capita real capital and (log of) per capita real income. In what follows we include the log of the human capital index as an additional regressor.

The inclusion of per-capita income as a regressor raises the question of endogeneity. A large sectoral technology shock to a country can influence comparative advantage as well as income. In the general equilibrium of the world economy, both the comparative advantage indices as well as per-capita income of individual countries are endogenous. Hence per-capita income and the error term may be correlated, implying inconsistency of OLS estimates and a need for instrumenting per-capita income.

Different studies have used different instruments. Noguer and Siscart (2005), among others, find latitudes of countries to be a significant predictor of per-capita income. Indeed, over the period 2005-2016, the correlation between log-per-capita income and latitude is 61%. Acemoglu et al. (2008) use past savings rate as an instrument for per capita income. In our sample period 2005-2016, the correlation between log of per-capita income and one-year lag of gross savings rate is 14%, and about the same when we consider a two-year lag in savings rate. In our context, there is no compelling reason as to why latitude or lag of savings rate may directly affect comparative advantage of services over manufacturing or vice versa. Furthermore, if we think that the relative physical capital abundance differences do not have a significant impact on comparative advantage in services vis-à-vis manufacturing on its own, per-capita real capital stock can be a good instrument for per-capita income (see Frankel (1997)).[18]

We instrument per-capita income on latitude, one and two-period lags of the gross savings rate, and physical per-capita capital stock.[19,20] While the lagged gross savings rates may be weakly correlated with log of per-capita income as compared to latitude or per capita capital stock, the three variables together constitute a strong set of instruments for per capita income. Panel (b) in Table 4 reports the results for 2010, whereas Figure 7 plots the coefficients for all years.

It is noteworthy that the coefficients of human capital are insignificant. But the marginal effects of size remain strong while controlling for human capital and endogeneity of per-capita income. Those of per-capita income are a bit weaker however: its effect on PRCI in manufactures is positive, but it is not statistically significant.

4.4 Panel Regressions

Since we have panel data, it seems natural to extend (31) to the panel regression framework:

$$\ln \chi_{kt}^{j} = \beta_0^{j} + \beta_1^{j} \ln L_{kt} + \beta_2^{j} \ln y_{kt} + \boldsymbol{X}_{kt}' \boldsymbol{\gamma}^{j} + \alpha_i^{j} + \delta_t^{j} + u_{kt}^{j}, \tag{32}$$

where the specification may include country (α_i^j) and time dummies (δ_t^j).

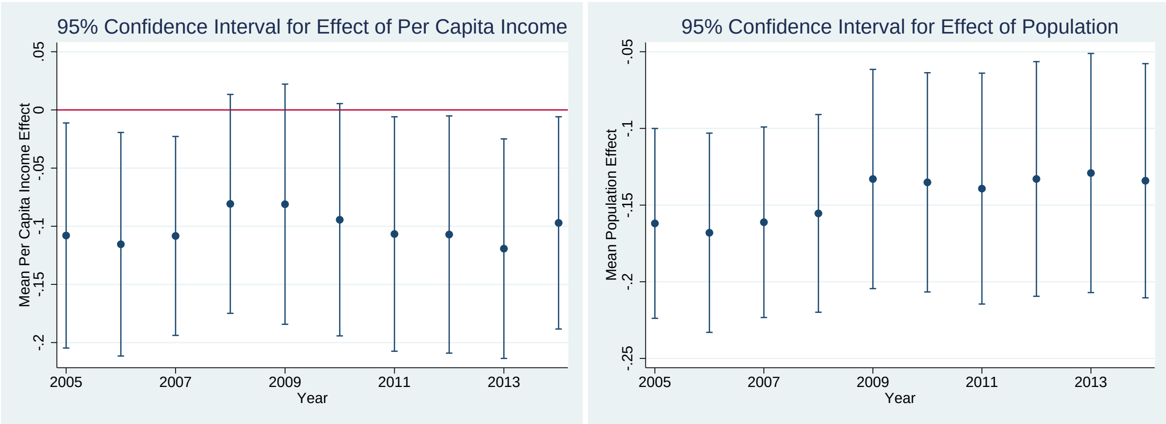
We have a problem, though: unlike the prediction of individual outcomes based on individual characteristics by using panel data, the coefficients of a cross-sectional equilibrium relationship such as (31) are *not* amenable to interpretation when there are 'within-country' variations over time. To make this point clearer, consider the first example of the potential use of panel data given in Allison (2009): the effect of marriage on recidivism among chronic offenders. This cause-effect relationship has both cross-sectional and intertemporal interpretations: how recidivism varies across two offenders, one married and the other unmarried, at given point of time, all else

[18]Brückner et al. (2012) and Brückner et al. (2015) instrument a country's per-capita GDP on the oil price shock it faces, whereas Brueckner and Lederman (2015) use rainfall as an instrument of per-capita GDP of sub-Saharan-Africa countries.

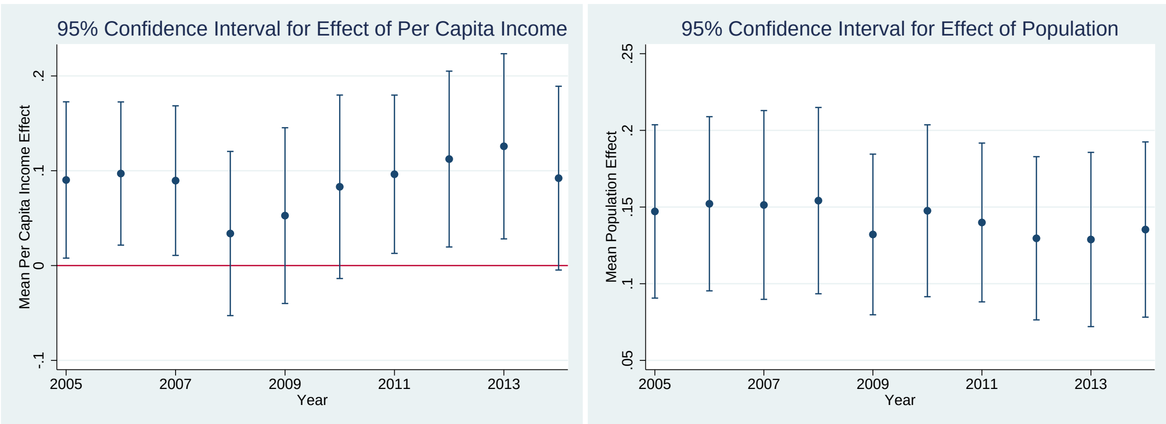
[19]Gross savings rate is the ratio of gross national income less total consumption plus net transfers to GDP.

[20]2014 is the most recent year for which the human-capital indices are available.

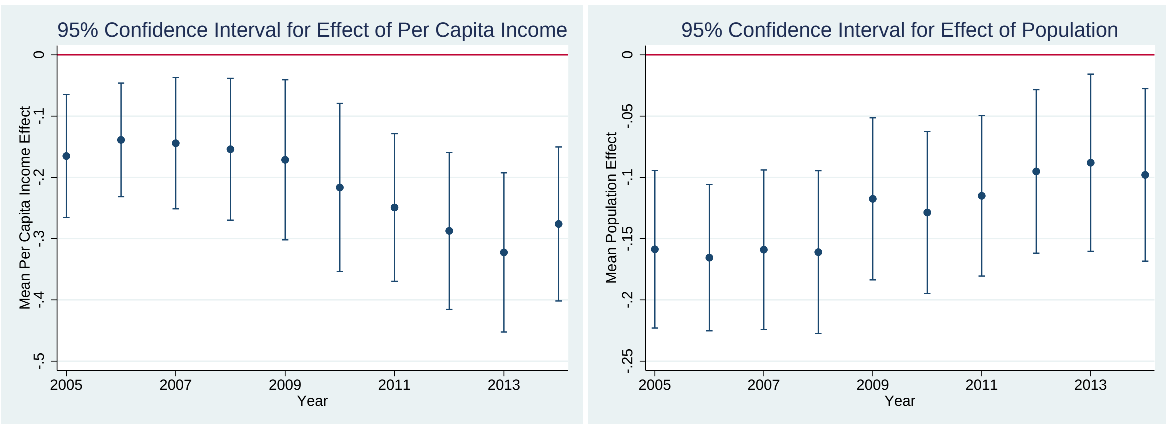
Figure 7: IV Regressions with Per-Capita Income Instrumented on Latitude, Per-Capita Capital Stock and Lags of Gross Savings Rate. Beta Coefficients with 95% Confidence Interval.



(a) Dependent Variable: PRCI in Services



(b) Dependent Variable: PRCI in Manufactures



(c) Dependent Variable: RXI in Services

the same, and how recidivism varies across time for the same individual, all else the same. But, unlike this example — typical of across-individual and across-time variations that panel data regression can capture — there is no across-time interpretation of how size or per-capita income of a country may affect its export competitiveness.

In order to obtain an across-time interpretation of the coefficients β_1^j, β_2^j and $\boldsymbol{\gamma}^j$ and thus avail the merits of panel regression, we may use *relative* magnitudes of size and per-capita income of countries since comparative advantage is fundamentally a relative concept. Instead of L_{kt} and y_{kt} as in (32), we may postulate

$$\ln \chi_{kt}^j = \beta_0^j + \beta_1^j L_{kt}^r + \beta_2^j y_{kt}^r + \boldsymbol{X}_{kt}' \boldsymbol{\gamma}^j + \alpha_i^j + \delta_t^j + u_{kt}^j, \tag{33}$$

where L_{kt}^r and y_{kt}^r denote size and per-capita income of country k at time t, *relative to other countries.* For any given year, we use the corresponding percentile as a country's measures of relative size and relative per-capita income.

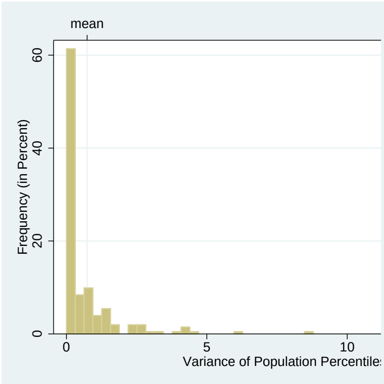
One of the obvious advantages of panel regression is that it captures both within-variation (over time) and between-variation (across units) of the regressors. Table 5 reports these variations in percentage of total variation for all three regressors we include. It is striking that, compared to between-variations, within-variations of each variable are rather minuscule. (The within-variations of the dependent variables, i.e., logs of PRCI-Services, PRCI-Manufactures, and RXI-Services, are somewhat higher (6%, 7% and 10% respectively), yet small.) This characteristic is borne out more sharply in Figure 8, which depicts the distribution of country-wise within-variation, over time, of population in percentile, real per-capita GDP in percentile, and human capital index in percentile across the countries in the sample. The extreme skewness to the right illustrates how small within-variations are.

Table 5: Variance Decomposition of Regressors

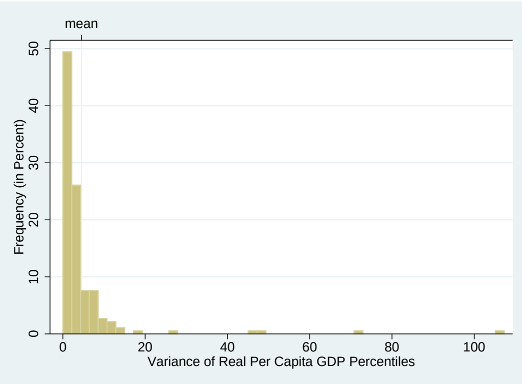
Variable	Within-Variance (in %)	Between-Variance (in %)
Population in Percentile	0.25	99.75
Real Per-Capita GDP in Percentile	1.15	98.85
Human Capital Index in Percentile	0.39	99.61

The implication is that fixed-effects estimation — which uses only within-variation in order to minimize omitted variable bias in the presence of unobserved heterogeneity — is *not* suitable for our purpose. For example, comparing national health systems, Gravelle et al. (2003) discuss the problem with fixed-effect estimation when within-variations are small: estimates lack precision and conventional tests to dis-

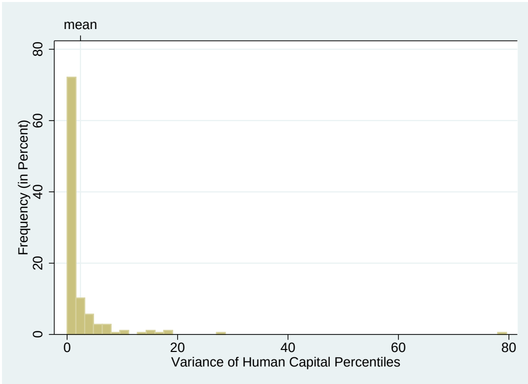
Figure 8: Distribution of Country-wise Within-Variation of Variables



(a) Population



(b) Per Capita Income



(c) Human Capital Index

criminate between alternative models can be misleading.[21] In our model, ignoring the between-variations effectively amounts to glossing over the cross-sectional variation, which is the foundation underneath the effects of size and per-capita income on comparative advantage.

We, nonetheless, present results from fixed-effects estimations, but inferences from random-effects estimations are more pertinent. In the absence of significant within variations, as a robustness check, we also present the results from pooled OLS regressions in section 5.

Table 6 presents panel regression results without use of instruments, whereas results when per-capita income is instrumented on latitude, lags of gross savings rate, and per-capita real capital stock are reported in Table 7.

Under fixed-effects estimation (columns (1), (2) and (3) in both tables), the coefficients of size are insignificant whether or not per-capita income is instrumented; those of per-capita income are significant but bear opposite sign relative to theory when per-capita income is not instrumented and are insignificant when per-capita

[21]Also, see (Deaton, 1997, pp. 107-108).

Table 6: Panel Regressions: No Instruments Used

	Fixed Effects			Random Effects		
VARIABLES	(1) PRCI Services	(2) PRCI Manufact.	(3) RXI Services	(4) PRCI Services	(5) PRCI Manufact.	(6) RXI Services
Population in Percentile	-0.00784	-0.00459	0.00667	-0.00880***	0.0128***	-0.00744***
	(0.00997)	(0.0143)	(0.0176)	(0.00193)	(0.00249)	(0.00267)
Per Capita Real GDP in Percentile	0.00657	-0.0278**	0.0367***	0.00223	-0.0107**	0.0150**
	(0.00474)	(0.0118)	(0.0116)	(0.00370)	(0.00541)	(0.00689)
Human Capital Index in Percentile	-0.000305	-0.00799	-0.0101	-0.00278	0.00875***	-0.0108***
	(0.00531)	(0.00954)	(0.00889)	(0.00213)	(0.00288)	(0.00293)
Per Capita Real Physical Capital in Percentile	0.000992	-0.00523	-0.00201	-0.00480	0.00932*	-0.0162**
	(0.00755)	(0.0119)	(0.0149)	(0.00483)	(0.00551)	(0.00757)
Constant	0.566	1.641	-0.882	1.263***	-1.794***	1.767***
	(0.644)	(1.667)	(1.362)	(0.145)	(0.230)	(0.227)
Observations	1,622	1,622	1,622	1,622	1,622	1,622
R-squared	0.009	0.030	0.031			
Number of Nations	168	168	168	168	168	168

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

income is instrumented. These poor results underscore the implications of the small within-variations of the regressors.

However, random-effects estimations yield more consistent results and significant coefficients. (a) The coefficients of size are highly significant and conform to the theoretical predictions under random-effects estimation and whether or not per-capita income is instrumented. (b) As one would expect, the coefficients of per-capita income are sensitive to whether it is instrumented and they are significant and consistent with theory under random-effects estimation when per-capita income is instrumented.

It follows from Table 7 column (5) that a unit increase in the per capita real GDP percentile rank would lead to 0.241 percentile rank increase in PRCI of manufacturing. In other words, to jump one percentile rank up in PRCI in manufacturing, a country would have to climb up four percentile ranks in real per-capita GDP ranking (or three percentile ranks in population ranking). Building comparative advantage in manufacturing requires significant improvements in terms of per capita GDP as well as population size. For a one percentile rank improvement in PRCI in manufactures, a country not only has to increase its size or income, it has to outrank an additional

Table 7: Panel Regressions: Per-Capita Income Instrumented on Per-Capita Real Capital Stock, Latitude and Lags of Gross Savings Rate

	Fixed Effects			Random Effects		
VARIABLES	(1) PRCI Services	(2) PRCI Manufactures	(3) RXI Services	(4) PRCI Services	(5) PRCI Manufactures	(6) RXI Services
Population in Percentile	-0.838	0.843	-0.672	-0.387***	0.388***	-0.266***
	(0.618)	(0.629)	(0.726)	(0.097)	(0.097)	(0.092)
Per Capita Real GDP in Percentile	-0.136	0.166	-0.158	-0.236**	0.241**	-0.281***
	(0.731)	(0.735)	(0.925)	(0.112)	(0.113)	(0.109)
Human Capital Index in Percentile	-0.176	0.175	-0.633*	-0.109	0.106	-0.187*
	(0.276)	(0.277)	(0.377)	(0.109)	(0.110)	(0.100)
Constant	110.240*	-11.441	128.560	84.440***	15.904**	84.771***
	(64.017)	(64.670)	(83.115)	(7.366)	(7.372)	(7.706)
Observations	1,245	1,245	1,245	1,245	1,245	1,245
Number of Nations	139	139	139	139	139	139

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

3-4% of the countries in the world. The magnitude of effects are similar for services comparative advantage: a decline in four percentile ranks in per-capita income (or three in population) would lead to one percentile rank improvement in PRCI in services.

There are at least three reasons why we may expect the effect of size on comparative advantage to be more robust than that of per-capita income. First, theoretical propositions in section 3 suggest that the link between size and comparative advantage is more robust than that between per-capita income and comparative advantage — in that the latter link is more assumption-dependent than that between size and comparative advantage. Second, while it is reasonable to suppose that consumption services have a demand bias, there is no such compelling reason to believe that there may be demand bias toward services as productive inputs. Therefore, the cross-section relation between per-capita income and comparative advantage in trade in *total* services is likely to be relatively weak. On the other hand, it seems reasonable to suppose that the assumption of services being more differentiated nationally than manufacturing would be true for producer services as well. Thus the cross-section relation between size and comparative advantage is expected to remain intact when services are used in consumption as well as production. Third, the use of instruments to reduce the endogeneity problem associated with per capita income as a regressor reduces the efficiency of estimation.

Apart from size and per-capita income that our model highlights, the effects of relative skill differences on comparative advantage between manufacturing and services remain generally insignificant. This is consistent with year-by-year regression results

5 *Robustness*

Alongside reporting and discussing the results from panel regression based on (33), we show the IV cross section estimates for year 2010 when size and per-capita income for different countries are measured in respective percentiles. The results are indeed similar, as shown in Table 8, the analog of Panel (b) Table 4. The regression estimates are similar for all years in the sample. This reinforces our claim that transforming our variables to percentile ranks does not affect the sign or statistical significance of the central findings.

We also present results for pooled OLS regression with clustered standard errors in Table 9. In these regressions, we find a negative (or positive) effect of size and per-capita income on services (or manufacturing) comparative advantage, whether we instrument for relative per-capita income or not. The estimates are in line with the findings of yearwise regressions in Table 4, as well as random-effects regression in Tables 6 and 7. On pooling all countries in the world for all time periods, we still find that larger countries have comparative advantage in manufacturing relative to services.

Table 8: IV Regressions with Human Capital, and Per-Capita Income Instrumented on Per-Capita Capital Stock, Latitude and Lags of Gross Savings Rate: All Regressors including Instrument in Percentile. Year 2010

VARIABLES	PRCI-Services	PRCI-Manufactures	RXI-Services
Population in Percentile	-0.373***	0.372***	-0.306***
	(0.091)	(0.091)	(0.093)
Per Capita Real GDP in Percentile	-0.271***	0.271***	-0.360***
	(0.092)	(0.091)	(0.105)
Human Capital Index in Percentile	0.001	-0.001	-0.001
	(0.104)	(0.104)	(0.103)
Constant	78.271***	22.367***	80.780***
	(7.897)	(7.883)	(8.794)
Observations	127	127	127
F statistic for First Stage	297.990	297.990	297.990
LM test statistic for underidentification	47.046	47.046	47.046
Hansen J Statistics for overidentification	2.616	2.558	1.045

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Pooled OLS Regressions

	No Instruments			With Instruments		
VARIABLES	(1) PRCI Services	(2) PRCI Manufactures	(3) RXI Services	(4) PRCI Services	(5) PRCI Manufactures	(6) RXI Services
Population in Percentile	-0.457***	0.458***	-0.341***	-0.386***	0.387***	-0.315***
	(0.071)	(0.071)	(0.071)	(0.080)	(0.080)	(0.079)
Per Capita Real GDP in Percentile	-0.209***	0.209***	-0.266***	-0.293***	0.293***	-0.378***
	(0.074)	(0.074)	(0.080)	(0.081)	(0.080)	(0.081)
Human Capital Index in Percentile	-0.146*	0.146*	-0.167**	-0.012	0.012	-0.010
	(0.077)	(0.077)	(0.070)	(0.092)	(0.092)	(0.078)
Constant	90.570***	9.839*	88.317***	81.140***	19.273***	82.442***
	(5.295)	(5.296)	(5.752)	(6.450)	(6.451)	(6.757)
Observations	1,622	1,622	1,622	1,245	1,245	1,245
R-squared	0.318	0.319	0.280	0.213	0.214	0.209
Number of Nations	168	168	168	139	139	139
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes

In columns (4) - (6) per capita income is instrumented on per capita capital stock, latitude and lags of gross savings rate, where all regressors including instrument in are in percentile. Country clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6 *Summary and Concluding Remarks*

In the light of the increasing importance of services in international trade, the paper has asked if there is any difference between the patterns of trade in manufacturing and services. In a multi-country world, we have defined comparative advantage in manufacturing vis-à-vis services in two ways: one is an adaptation of Balassa's revealed comparative advantage to a comparison of two groups of goods — manufacturing or services — what we call "pairwise revealed comparative advantage", and the other is based on the share of exports of one group of goods in its total trade (e.g. manufacturing) relative to the same share of another reference groups of goods (e.g. services), what we call "relative exports advantage". Both attempt to measure the export competitiveness of one group of goods relative to another.

Our three-good, multi-country theoretical model of world trade finds an interesting contrast in the patterns of comparative advantage between manufacturing and services based on country size and per-capita income. The model predicts that comparative advantage in services (manufacturing) will be negatively (positively) related to country size and per-capita income. The link between comparative advantage and per-capita income stems from demand bias toward services, whereas the link between comparative advantage and economic size follows from service goods being more nationally differentiated than manufactures.

These hypotheses — with respect to size and per-capita income — are borne out in the year-by-year cross-section regressions of comparative-advantage indices upon measures of size and per-capita income for each year from 2005 to 2016, whereas in panel regressions the effects of size on comparative advantage as predicted by the theory remain significant, but the effects of per-capita income are weaker.

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Appendices

A Proof that Both Manufacturing and Services are Normal Goods under Gorman Tastes

Eqs. (12) and (13) imply,

$$\begin{aligned}\hat{c}_{jr} &= \eta\hat{e}_r - (\eta - \tau_j)\hat{c}_r \\ \hat{e}_r &= \frac{\sum_j \lambda_j(\eta - \tau_j)}{\eta - 1}\cdot\hat{c}_r, \quad \text{where } \lambda_j \equiv \frac{P_{jr}^{1-\eta}c_r^{\tau_j-\eta}}{e_r^{1-\eta}} \in (0,1).\end{aligned}$$

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

$$\begin{aligned}\Lambda_j &\equiv \frac{\eta}{\eta-1}\sum_j \lambda_j(\eta-\tau_j) - (\eta - \tau_j) \\ &= \frac{\eta\left(1 + \tau_j - \sum_j \lambda_j\tau_j\right) - \tau_j}{\eta - 1}\end{aligned}$$

implying

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

$$\begin{aligned}\Lambda_m &= \frac{\eta[1 - \lambda_s(\tau_s - \tau_m)] - \tau_m}{\eta - 1} \\ &> \frac{\eta(1 - \tau_s + \tau_m) - \tau_m}{\eta - 1} \\ &> 0 \text{ in view of (R2).}^{22}\end{aligned} \tag{A.2}$$

[22] It is easy to see that both goods are normal if $\eta > 1 \geq \tau_s > \tau_m > 0$. Then, from (14), $\partial P_r/\partial c_r > 0$. Eq. (12) in turn implies $dc_{jr}/dc_r = \partial c_{jr}/\partial c_r + \partial c_{jr}/\partial P_r \cdot \partial P_r/\partial c_r > 0$.

B World Demand Expressions for a Services and a Manufacturing Variety produced in Country i under Gorman Taste: Basis of Eqs. (20) and (21)

The world demand for a manufacturing or service variety produced in country i has the expression

$$\sum_{r=1}^{N}\left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma} L_r c_{jir} = \sum_{r=1}^{N}\left(\frac{p_{jir}(u)}{P_{jir}}\right)^{-\sigma}\left(\frac{P_{jir}}{P_{jr}}\right)^{-\epsilon_j} L_r c_{jr}, \quad j=m,s. \tag{A.3}$$

The last expression for services varieties expands to

$$\begin{aligned}
&\sum_{r=1}^{N}\left(\frac{p_{sir}(u)}{P_{sir}}\right)^{-\sigma}\left(\frac{P_{sir}^{-\epsilon_s}}{P_{sr}^{1-\epsilon_s}}\right)\beta_s L_r(y_r-\delta(1/\beta_s-1)P_s) \qquad \text{using (3)}\\
&=\beta_s\Omega_{si}^{-\frac{\sigma}{\sigma-1}} w_i^{-\epsilon_s}\Omega_{si}^{\frac{\epsilon_s}{\sigma-1}}\left(\frac{\sigma}{\sigma-1}\right)^{-\epsilon_s}\frac{\sum_{r=1}^{N} L_r(y_r-\delta(1/\beta_s-1)P_s)}{P_s^{1-\epsilon_s}}\\
&=\frac{\beta_s(\sigma-1)w_i^{-\epsilon_s}\Omega_{si}^{-\frac{\sigma-\epsilon_s}{\sigma-1}}}{\sigma\sum_{r=1}^{N} w_r^{1-\epsilon_s}\Omega_{sr}^{\frac{1-\epsilon_s}{1-\sigma}}}\sum_{r=1}^{N} L_r(y_r-\delta(1/\beta_s-1)P_s).
\end{aligned} \tag{A.4}$$

This is same as (19) in the text.

Likewise the world demand for a manufacturing variety has the expression:

$$\sum_{r=1}^{N}\left(\frac{p_{mir}(u)}{P_{mir}}\right)^{-\sigma} L_r c_{mir} = \frac{\beta_m(\sigma-1)w_i^{-\epsilon_m}\Omega_{mi}^{-\frac{\sigma-\epsilon_m}{\sigma-1}}}{\sigma\sum_{r=1}^{N} w_r^{1-\epsilon_m}\Omega_{mr}^{\frac{1-\epsilon_m}{1-\sigma}}}\sum_{r=1}^{N} L_r(y_r+\delta P_s). \tag{A.5}$$

C Proposition 1

Proof. For Gorman tastes eqs. (20) and (21) yield

$$\Omega_{ji} = A_j w_i^{-\frac{\epsilon_j(\sigma-1)}{\sigma-\epsilon_j}}, \tag{A.6}$$

where $A_j > 0$ is invariant across countries.[23] For non-Gorman tastes, eq. (22) implies

$$\Omega_{ji} = \bar{A}_j w_i^{-\frac{\epsilon_j(\sigma-1)}{\sigma-\epsilon_j}}, \tag{A.7}$$

[23]
$$A_m \equiv \left[\frac{\beta_m\sum_{r=1}^{N} L_r(y_r+\delta P_s)}{\alpha\sigma\sum_{r=1}^{N} w_r^{1-\epsilon_m}\Omega_{mr}^{\frac{1-\epsilon_m}{1-\sigma}}}\right]^{\frac{\sigma-1}{\sigma-\epsilon_m}}; \quad A_s \equiv \left[\frac{\beta_s\sum_{r=1}^{N} L_r[y_r-\delta(1/\beta_s-1)P_s]}{\alpha\sigma\sum_{r=1}^{N} w_r^{1-\epsilon_s}\Omega_{sr}^{\frac{1-\epsilon_s}{1-\sigma}}}\right]^{\frac{\sigma-1}{\sigma-\epsilon_s}}.$$

where $\bar{A}_j$ is invariant across countries.[24]

As $\sigma > \epsilon_j$, Ω_{ji} is negatively related to w_i for both taste structures. Substituting the above expressions into the full employment equation yields a negative relationship between L_i and w_i, proving the first inequality. Using the same expressions above and multiplying w_i with the full employment equations imply a negative relationship between $w_i L_i$ and w_i. As w_i is negatively related to both L_i and $w_i L_i$, it follows that L_i and $w_i L_i$ are positively related. This proves the second inequality. ∎

D Proposition 2

Proof. Suppose there are two countries only, 1 and 2. Then

$$X_{jk} = I_{j\sim k}, \quad X_{j1} + X_{j2} = X_{jR}, \quad j \in \{m, s\}, \ k \in \{1, 2\}$$

We show $\Phi_{ji} \gtreqless 1 \Rightarrow \Psi_{ji} \gtreqless 1$. Let $\Phi_{s1} > 1$. We have

$$\begin{aligned}
&\frac{1 + I_{m1}/X_{m1}}{1 + I_{s1}/X_{s1}} > 1 \\
\Rightarrow\ & \frac{X_{s1}/X_{m1}}{I_{s1}/I_{m1}} > 1 \\
\Rightarrow\ & \frac{X_{s1}/X_{m1}}{X_{s2}/X_{m2}} > 1 \\
\Rightarrow\ & \frac{X_{m2}}{X_{s2}} > \frac{X_{m1}}{X_{s1}} \\
\Rightarrow\ & \frac{X_{mR}}{X_{sR}} \equiv \frac{X_{m1} + X_{m2}}{X_{s1} + X_{s2}} > \frac{X_{m1}}{X_{s1}} \\
\Rightarrow\ & \Psi_{s1} > 1.
\end{aligned}$$

Similarly if $\Phi_{si} \leq 1$ then $\Psi_{si} \leq 1$. Further as $\Phi_{si} = 1/\Phi_{mi}$, the statement holds in terms of manufacturing comparative advantages as well. ∎

E Proposition 3

We suppress differences in national product differentiation, so that $\epsilon_m = \epsilon_s = \epsilon$.

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$$\bar{A}_j \equiv \left[\frac{\alpha(\sigma - 1)\left(\sum_r w_r^{1-\epsilon_j} \Omega_{jr}^{\frac{1-\epsilon_j}{1-\sigma}}\right)^{\frac{\epsilon_j}{\epsilon_j - 1}}}{\sum_r L_r c_{jr}} \right]^{-\frac{\sigma-1}{\sigma-\epsilon_j}}.$$

Expressions under Gorman Tastes

Under Gorman tastes, the expressions of country-wise exports ratios and the ratio of worldwide exports of goods s and m given in (27)-(28) reduce to

$$\frac{X_{si}}{X_{mi}} = \chi_1 \cdot \frac{Y_R - L_i y_i - (L_R - L_i)\,\delta(1/\beta_s - 1)P_s}{Y_R - L_i y_i + (L_R - L_i)\,\delta P_s} \tag{A.8}$$

$$\frac{X_{sR}}{X_{mR}} = \frac{\chi_1 \sum_i \left[X_{mi} \frac{Y_R - L_i y_i - (L_R - L_i)\delta(1/\beta_s - 1)P_s}{Y_R - Y_i + (L_R - L_i)\delta P_s}\right]}{\sum_i X_{mi}}, \tag{A.9}$$

Hence, PRCI and RXI are respectively equal to

$$\Psi_{si} = \frac{1 + \sum_i X_{mi} \Big/ \sum_i \left[\chi_1 X_{mi} \frac{Y_R - L_i y_i - (L_R - L_i)\delta(1/\beta_s - 1)P_s}{Y_R - Y_i + (L_R - L_i)\delta P_s}\right]}{1 + \frac{Y_R - L_i y_i + (L_R - L_i)\delta P_s}{\chi_1 [Y_R - L_i y_i - (L_R - L_i)\delta(1/\beta_s - 1)P_s]}} \tag{A.10}$$

$$\begin{aligned}\Phi_{si} &= \frac{1 + I_{mi}/X_{mi}}{1 + I_{si}/X_{si}} \\ &= \left[1 + \frac{\sum_{r \neq i} w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}} \cdot L_i(y_i + \delta P_s)}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}} \cdot \sum_{r \neq i} L_r(y_r + \delta P_s)}\right] \Bigg/ \left[1 + \frac{\sum_{r \neq i} w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}} \cdot L_i(y_i - \delta(1/\beta_s - 1)P_s)}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}} \cdot \sum_{r \neq i} L_r(y_r - \delta(1/\beta_s - 1)P_s)}\right].\end{aligned} \tag{A.11}$$

Expressions under non-Gorman Tastes

Similarly, under non-Gorman tastes, (29)-(30) reduce to

$$\frac{X_{si}}{X_{mi}} = \chi_2 \cdot \frac{\sum_{r \neq i} L_r c_{sr}}{\sum_{r \neq i} L_r c_{mr}} = \chi_2 \frac{C_{sR} - L_i c_{si}}{C_{mR} - L_i c_{mi}} \tag{A.12}$$

$$\frac{X_{sR}}{X_{mR}} = \frac{\chi_2 \sum_r \left(X_{mr} \cdot \frac{\sum_{r \neq i} L_r c_{sr}}{\sum_{r \neq i} L_r c_{mr}}\right)}{\sum_r X_{mr}},$$

implying PRCI and RXI indices, equal to

$$\Psi_{si} = \frac{1 + X_{mR}/X_{sR}}{1 + X_{mi}/X_{si}} = \frac{1 + \sum_k X_{mk} \Big/ \left[\chi_2 \sum_k \left(\frac{C_{sR} - L_k c_{sk}}{C_{mR} - L_k c_{mk}} X_{mk}\right)\right]}{1 + \frac{C_{mR} - L_i c_{mi}}{\chi_2 (C_{sR} - L_i c_{si})}} \tag{A.13}$$

$$\Phi_{si}=\frac{1+I_{mi}/X_{mi}}{1+I_{si}/X_{si}}=\left[1+\frac{\sum_{r\neq i}w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot L_i c_{mi}}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot\sum_{r\neq i}L_r c_{mr}}\right]\Bigg/\left[1+\frac{\sum_{r\neq i}w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot L_i c_{si}}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot\sum_{r\neq i}L_r c_{sr}}\right]. \tag{A.14}$$

Part a

If $y_i=\bar{y}\ \forall\ i$, then $Y_R=L_R\bar{y}$, $c_{mi}=\bar{c}_m$ and $c_{si}=\bar{c}_s$, $C_{mR}=L_R\bar{c}_m$ and $C_{sR}=L_R\bar{c}_s$. Using these expression, it can be easily checked that, under both types of tastes, X_{si}/X_{mi} for all i and X_{sR}/X_{mR} are independent of $\{L_r\}_1^N$, and, both indices of comparative advantage reduce to unity for any country i. $\square$

Part b(i)

Without loss of generality, let $L_i=1$. Thus $w_i=\bar{w}$, $Y_R=\sum_r y_r$ and $L_R=N$. In (A.8), we see that relative exports of services decrease with y_i. It is evident from (A.10) that PCRI in services decreases with y_i as well. $\square$

Part b(ii)

As X_{si}/X_{mi} ratio decreases with y_i, for any $i<N$

$$\begin{aligned}
&\frac{Y_R-y_i-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_i+\delta(N-1)P_s}>\frac{Y_R-y_N-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_N+\delta(N-1)P_s}\\
\Rightarrow\ &X_{mi}\frac{Y_R-y_i-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_i+\delta(N-1)P_s}>X_{mi}\frac{Y_R-y_N-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_N+\delta(N-1)P_s}\\
\Rightarrow\ &\sum_i X_{mi}\frac{Y_R-y_i-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_i+\delta(N-1)P_s}>\frac{Y_R-y_N-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_N+\delta(N-1)P_s}\sum_i X_{mi}\\
\Rightarrow\ &\frac{\sum_i X_{mi}\frac{Y_R-y_i-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_i+\delta(N-1)P_s}}{\sum_i X_{mi}}>\frac{Y_R-y_N-\delta(N-1)(1/\beta_s-1)P_s}{Y_R-y_N+\delta(N-1)P_s}\\
\Rightarrow\ &\frac{X_{sR}}{X_{mR}}>\frac{X_{sN}}{X_{mN}}\\
\Rightarrow\ &\Psi_{sN}<1.
\end{aligned}$$

It can be similarly established that $\Psi_{s1}>1$. Thus, $\Psi_{s1}>1>\Psi_{sN}$. It is obvious from (A.11)

$$\begin{aligned}
&\Phi_{si}\gtrless 1\\
\Leftrightarrow\ &\frac{\sum_{r\neq i}w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot L_i(y_i+\delta P_s)}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot\sum_{r\neq i}L_r(y_r+\delta P_s)}\gtrless\frac{\sum_{r\neq i}w_r^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot L_i(y_i-\delta(1/\beta_s-1)P_s)}{w_i^{\frac{\sigma(1-\epsilon)}{\sigma-\epsilon}}\cdot\sum_{r\neq i}L_r(y_r-\delta(1/\beta_s-1)P_s)}\\
\Leftrightarrow\ &\frac{(Y_R-Ny_i)\,\delta P_s/\beta_s}{[Y_R-y_i-(N-1)\delta(1/\beta_s-1)P_s][Y_R-y_i+(N-1)\,\delta P_s]}\gtrless 0\quad\text{for } L_i=1.
\end{aligned}$$

$Y_R - Ny_i \gtrless 0$ for $i = 1, N$ respectively, implying $\Phi_{s1} > 1 > \Phi_{sN}$. Further, $\forall\ i$ such that $y_i \lesseqgtr Y_R/N$, $\Phi_{si} \gtrless 1$. As PRCI in services decreases monotonically with size, part b(ii) of Proposition 3 follows.[25] $\square$

Part c(i)

Under non-Gorman tastes, we've $y_1 < y_2 < \dots y_N \Rightarrow c_1 < c_2 < \dots c_N$, where c_r is the sub-utility of a household of country i from consuming goods m and s. Demand bias towards services implies

$$\frac{c_{s1}}{c_{m1}} < \frac{c_{s2}}{c_{m2}} < \cdots < \frac{c_{sN}}{c_{mN}}. \tag{A.15}$$

Consider (A.12). As c_{si}, c_{mi} and c_{si}/c_{mi} increase with size, over the cross-section of countries,

$$\begin{aligned}
\frac{(C_{mR} - c_{mi})^2}{\chi_2} \frac{d\,(X_{si}/X_{mi})}{dc_{mi}} &= -(C_{mR} - c_{mi}) \frac{dc_{si}}{dc_{mi}} + (C_{sR} - c_{si}) \\
&< -(C_{mR} - c_{mi}) \frac{c_{si}}{c_{mi}} + (C_{sR} - c_{si}), \text{ since } \frac{dc_{si}}{dc_{mi}} > \frac{c_{si}}{c_{mi}} \\
&= C_{mR} \left(\frac{C_{sR}}{C_{mR}} - \frac{c_{si}}{c_{mi}} \right) \\
&< 0 \text{ if } \frac{c_{si}}{c_{mi}} > \frac{C_{sR}}{C_{mR}}.
\end{aligned}$$

Since c_{mi} increases monotonically with per-capita income, $d(X_{si}/X_{mi})/dc_{mi} < 0$. $\square$

Since PRCI of services is monotonic with respect to the X_{si}/X_{mi} ratio, it also falls with size beyond the same threshold.

Part c(ii)

We next prove $\Psi_{sN} < 1$, that is, the largest country has PRCA in manufacturing. Towards this we first prove a lemma.

Lemma 1: *For any country $k < N$,*

$$\frac{C_{mR} - c_{mk}}{C_{sR} - c_{sk}} < \frac{C_{mR} - c_{mN}}{C_{sR} - c_{sN}} \tag{A.16}$$

[25] With respect to relative exports advantage, the countries whose sizes are less (higher) than the average have RXA in services (manufacturing).

Proof. Let (A.16) be restated as

$$\underbrace{c_{sN}c_{mk}-c_{sk}c_{mN}}_{>0}+\underbrace{c_{sN}\sum_{r\neq k,N}c_{mr}-c_{mN}\sum_{r\neq k,N}c_{sr}}_{>0}+\underbrace{c_{mk}\sum_{r\neq k,N}c_{sr}-c_{sk}\sum_{r\neq k,N}c_{mr}}_{\gtrless 0}>0 \tag{A.17}$$

$$\text{or } (c_{sN}c_{mk}-c_{sk}c_{mN})\left(1+\frac{\sum_{r\neq k,N}c_{mr}}{c_{mk}}\right)-\frac{\left(c_{mk}\sum_{r\neq k,N}c_{sr}-c_{sk}\sum_{r\neq k,N}c_{mr}\right)(c_{mN}-c_{mk})}{c_{mk}}>0. \tag{A.18}$$

If $c_{mk}\sum_{r\neq k,N}c_{sr}-c_{sk}\sum_{r\neq k,N}c_{mr}\geq 0$, then (A.17) holds; if $c_{mk}\sum_{r\neq k,N}c_{sr}-c_{sk}\sum_{r\neq k,N}c_{mr}<0$, then (A.18) holds. Thus, (A.16) holds unambiguously. □

In view of Lemma 1, it follows from (A.13) that $\Psi_{sN}<1$. Together with our part c(i) which includes that Ψ_{si} decreases with size beyond a threshold, the implication is that countries whose size exceed a threshold have PRCA in manufacturing.

If, for any country $i>1$,

$$\frac{C_{mR}-c_{mi}}{C_{sR}-c_{si}}>\frac{C_{mR}-c_{m1}}{C_{sR}-c_{s1}}, \tag{A.19}$$

then $\Psi_{s1}>1$. However, unlike (A.16), (A.19) does not hold unambiguously. In the taste relation (10), if $\tau_s-\tau_m$ is large, i.e., demand bias for services is strong, then the elasticity of the consumption ratio c_{sr}/c_{mr} with respect to c_r is high, which implies that the elasticity of c_{sr} with respect to c_{mr}, say ζ_r, is large in magnitude.

We first demonstrate that

$$\zeta_r\equiv\frac{\hat{c}_{sr}}{\hat{c}_{mr}}>1+\frac{(\eta-1)(\tau_s-\tau_m)}{\eta-\tau_m}. \tag{A.20}$$

Using the expressions of Λ_s and Λ_m from (A.1) and (A.2)

$$\zeta_r=\frac{\eta-\tau_s+\eta\lambda_m(\tau_s-\tau_m)}{\eta[1-\lambda_s(\tau_s-\tau_m)]-\tau_m}$$

Noting that $\lambda_m+\lambda_s=1$, it can be derived that $\partial\zeta_r/\partial\lambda_m<0$. Hence

$$\zeta_r>\left.\frac{\eta-\tau_s+\eta\lambda_m(\tau_s-\tau_m)}{\eta[1-\lambda_s(\tau_s-\tau_m)]-\tau_m}\right|_{\lambda_m=1}=\frac{\eta-\tau_s+\eta(\tau_s-\tau_m)}{\eta-\tau_m}=1+\frac{(\eta-1)(\tau_s-\tau_m)}{\eta-\tau_m}.$$

■

Keeping this in view,

Lemma 2: *If the demand bias towards services is strong enough such that*

$$\begin{aligned}1+\frac{(\eta-1)(\tau_s-\tau_m)}{\eta-\tau_m} &> \frac{\frac{C_{sR}/C_{mR}}{c_{s1}/c_{m1}}\cdot\frac{C_{mR}}{c_{mN}}-1}{\frac{C_{mR}}{c_{mN}}-1}\\ \Leftrightarrow \frac{(\eta-1)(\tau_s-\tau_m)}{\eta-\tau_m} &> \frac{\frac{C_{mR}}{c_{mN}}\left(\frac{C_{sR}/C_{mR}}{c_{s1}/c_{m1}}-1\right)}{\frac{C_{mR}}{c_{mN}}-1},\end{aligned} \tag{A.21}$$

then (A.19) holds and $\Psi_{s1}>1$.[26]

Proof. Consider the ratio $\frac{C_{mR}-c_{mi}}{C_{sR}-c_{si}}$ for any $i\geq 1$.

$$\begin{aligned}\frac{d[(C_{mR}-c_{mi})/(C_{sR}-c_{si})]}{dc_{mi}} &= \frac{-(C_{sR}-c_{si})+(C_{mR}-c_{mi})dc_{si}/dc_{mi}}{(C_{sR}-c_{si})^2}\\ &= \frac{-(C_{sR}-c_{si})+(C_{mR}-c_{mi})(\zeta_i c_{si}/c_{mi})}{(C_{sR}-c_{si})^2}\\ &= \frac{c_{si}\left[\zeta_i(C_{mR}/c_{mi}-1)-(C_{sR}/c_{si}-1)\right]}{(C_{sR}-c_{si})^2}.\end{aligned} \tag{A.22}$$

Hence, as a sufficient condition, if (A.21) holds, then for any $i\geq 1$,

$$\begin{aligned}\zeta_i > \frac{\frac{C_{sR}/C_{mR}}{c_{s1}/c_{m1}}\cdot\frac{C_{mR}}{c_{mN}}-1}{\frac{C_{mR}}{c_{mN}}-1} &> \frac{\frac{C_{sR}/C_{mR}}{c_{s1}/c_{m1}}\cdot\frac{C_{mR}}{c_{mi}}-1}{\frac{C_{mR}}{c_{mi}}-1} \quad \text{as} \quad \frac{\frac{C_{sR}/C_{mR}}{c_{s1}/c_{m1}}\cdot\frac{C_{mR}}{c_{mi}}-1}{\frac{C_{mR}}{c_{mi}}-1} \text{ is increasing in } c_{mi}\\ &> \frac{\frac{C_{sR}/C_{mR}}{c_{si}/c_{mi}}\cdot\frac{C_{mR}}{c_{mi}}-1}{\frac{C_{mR}}{c_{mi}}-1} \quad \text{as} \quad \frac{c_{si}}{c_{mi}}>\frac{c_{s1}}{c_{m1}}\\ \zeta_i\left(\frac{C_{mR}}{c_{mi}}-1\right) &> \frac{C_{sR}}{c_{si}}-1\end{aligned}$$

and

$$\frac{d[(C_{mR}-c_{mi})/(C_{sR}-c_{si})]}{dc_{mi}}>0.$$

The last inequality implies (A.19) holds and $\Psi_{s1}>1$. This completes proof of Proposition 3 part c(ii).

Part c(iii)

Turning to relative exports advantage,

Lemma 3:

$$\Phi_{s1}>1>\Phi_{sN}. \tag{A.23}$$

[26] (A.21) is, obviously, an overly sufficient condition for Ψ_{s1} to exceed one.

Proof. Eq. (A.15) yields

$$\frac{c_{sr}}{c_{mr}} > \frac{c_{s1}}{c_{m1}} \text{ for } r = 2, \dots, N; \quad \frac{c_{sr}}{c_{mr}} < \frac{c_{sN}}{c_{mN}} \text{ for } r = 1, \dots, N-1.$$

Since each ratio being greater (less) than a given ratio implies that the ratio of sum of the numerators to the sum of the denominators is greater (less) than the given ratio,

$$\frac{\sum_{r=2}^{N} L_r c_{sr}}{\sum_{r=2}^{N} L_r c_{mr}} > \frac{L_1 c_{s1}}{L_1 c_{m1}}; \quad \frac{\sum_{r=1}^{N-1} L_r c_{sr}}{\sum_{r=1}^{N-1} L_r c_{mr}} < \frac{L_N c_{sN}}{L_N c_{mN}},$$

which implies, in view of the expression of RXI in (A.14), that $\Phi_{s1} > 1 > \Phi_{sN}$. □

Lemma 4: *Suppose* $\exists\ r < N$ (> 1) *such that* $\Phi_{sr} > 1$ (< 1). *Then for any country* $k < r$ $(> r)$, $\Phi_{sk} > 1$ (< 1).

Proof. Consider a country $r < N$ for which $\Phi_{sr} > 1$. Vis-a-vis another country $k < r$, $c_{sr}/c_{mr} > c_{sk}/c_{mk}$, and,

$$\begin{aligned}
&\Phi_{sr} > 1 \\
\Leftrightarrow\ & \frac{\sum_{i\neq r} c_{si}}{\sum_{i\neq r} c_{mi}} > \frac{c_{sr}}{c_{mr}} \\
\Rightarrow\ & c_{sr}c_{mk} - c_{mr}c_{sk} > 0 > c_{sr}\left(\sum_{i\neq r} c_{mi}\right) - c_{mr}\left(\sum_{i\neq r} c_{si}\right) \\
\Leftrightarrow\ & c_{mr}\left(\sum_{i\neq r} c_{si} - c_{sk} + c_{sr}\right) > c_{sr}\left(\sum_{i\neq r} c_{mi} - c_{mk} + c_{mr}\right) \\
\Leftrightarrow\ & c_{mr}\left(\sum_{i\neq k} c_{si}\right) > c_{sr}\left(\sum_{i\neq k} c_{mi}\right) \\
\Leftrightarrow\ & \frac{\sum_{i\neq k} c_{si}}{\sum_{i\neq k} c_{mi}} > \frac{c_{sr}}{c_{mr}} \\
\Rightarrow\ & \frac{\sum_{i\neq k} c_{si}}{\sum_{i\neq k} c_{mi}} > \frac{c_{sk}}{c_{mk}} \\
\Leftrightarrow\ & \Phi_{sk} > 1.
\end{aligned}$$

It can be similarly proved that if for any country $r < N$ such that $\Phi_{sr} < 1$, for any country $k > r$, $\Phi_{sk} < 1$ too. □

Lemma 5: *Suppose* $\exists\ r$ *such that* $c_{sr}/c_{mr} = c_{sR}/c_{mR}$. *Then for any country* $k < r$ $(> r)$, $\Phi_{sk} > 1$ (< 1).

It follows from (A.14),

$$
\begin{aligned}
&\Phi_{si} \gtrless 1 \\
\Leftrightarrow\ & \frac{N-1}{c_{mR}/c_{mi}-1} \gtrless \frac{N-1}{c_{sR}/c_{si}-1} \quad \text{for } \epsilon_m = \epsilon_s = \epsilon \\
\Leftrightarrow\ & \frac{c_{si}}{c_{mi}} \lessgtr \frac{c_{sR}}{c_{mR}}
\end{aligned}
$$

As c_{si}/c_{mi} is increasing in country size, smaller countries with $c_{si}/c_{mi} < c_{sR}/c_{mR}$ have RXA in services while larger countries do not. □

Lemmas 3, 4 and 5 prove c(iii) Proposition 3. ■

F Proposition 4

We suppress demand bias by assuming $\delta = 0$ in case of Gorman tastes and $\tau_m = \tau_s = 1$ under non-Gorman tastes. Under our specifications both demand systems do *not* however collapse into a common one. When $\delta = 0$ in (1), tastes are Cobb-Douglas, whereas if $\tau_m = \tau_s = 1$ in (5), the tastes are CES between manufacturing and services aggregates.

For Cobb-Douglas tastes ($\delta = 0$), from eqs. (27) - (28),

$$
\frac{X_{si}}{X_{mi}} = \chi_1 w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}}; \quad \frac{X_{sR}}{X_{mR}} = \chi_1 \frac{\sum_r w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}} X_{mr}}{\sum_r X_{mr}} \tag{A.24}
$$

In case of CES tastes, $C_{mr} = \left(\frac{P_{mr}}{P_{sr}}\right)^{-\eta} C_{sr}$, and, using this (29)-(30) yield

$$
\frac{X_{si}}{X_{mi}} = \chi_2 \left(\frac{P_{sr}}{P_{mr}}\right)^{-\eta} w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}}; \quad \frac{X_{sR}}{X_{mR}} = \chi_2 \left(\frac{P_{sr}}{P_{mr}}\right)^{-\eta} \frac{\sum_i w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}} X_{mi}}{\sum_i X_{mi}}. \tag{A.25}
$$

These expressions lead to the following expressions of PRCI and RXI in services:

$$
\Psi_{si} = \frac{1 + \sum_r X_{mr} \Big/ \sum_r \left[\chi w_r^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}} X_{mr}\right]}{1 + \left(\chi w_i^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}}\right)^{-1}} \tag{A.26}
$$

$$
\Phi_{si} = \frac{1 + I_{mi}/X_{mi}}{1 + I_{si}/X_{si}} = \left[1 + \frac{\sum_{r\neq i} w_r^{\frac{\sigma(1-\epsilon_m)}{\sigma-\epsilon_m}} \cdot L_i c_{mi}}{w_i^{\frac{\sigma(1-\epsilon_m)}{\sigma-\epsilon_m}} \cdot \sum_{r\neq i} L_r c_{mr}}\right] \Bigg/ \left[1 + \frac{\sum_{r\neq i} w_r^{\frac{\sigma(1-\epsilon_s)}{\sigma-\epsilon_s}} \cdot L_i c_{si}}{w_i^{\frac{\sigma(1-\epsilon_s)}{\sigma-\epsilon_s}} \cdot \sum_{r\neq i} L_r c_{sr}}\right], \tag{A.27}
$$

where $\chi \equiv \chi_1$ for Cobb-Douglas tastes, and $\chi \equiv \chi_2(P_{sr}/P_{mr})^{-\eta}$ for CES tastes. However, Φ_{si} has the same expression under both types of tastes.

Part (a)

In free trade, the equilibrium wage rates across countries are functions of country sizes, $\{L_r\}_1^N$, not influenced by per-capita income *per se* across countries. Hence X_{si}/X_{mi}, and Ψ_{si} are functions of $\{L_r\}_1^N$ only. However, Φ_{si} depends on consumption bundles, and hence, is a function of both $\{L_r\}_1^N$ and $\{y_r\}_1^N$. This proves part (a).

Interestingly, whether a country i has services comparative advantage or not depends only on L_i. Per capita income y_i does not determine whether $\Phi_{si} \gtrless 1$, but affect the magnitude of Φ_{si}.

Part (b)

By inspection, we see that relative exports of services decrease with size unambiguously. This proves part (b) of Proposition 4. □

Part (c)

Inspecting (A.26), if services are more nationally differentiated than manufacturing, PRCI in services decreases with country size. It is easy to show that PRCI in services for country 1 and country N exceed and fall short of unity respectively.[27] Hence, there must exist a country N_2 between 2 and N such that all countries smaller than N_2 have PRCA in services and the rest have the same in manufacturing. Proposition 4 part (c) with respect to PRCA is thus proved.

In reference to RXI expression in (A.27), define $\omega_{rk} = w_r/w_k$. The expression can be simplified for Gorman and non-Gorman tastes as:

$$\Phi_{si} = \begin{cases} \left[1 + \dfrac{\sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_m)}{\sigma-\epsilon_m}} \cdot L_i y_i}{\sum_{r\neq i} L_r y_r}\right] \Bigg/ \left[1 + \dfrac{\sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_s)}{\sigma-\epsilon_s}} \cdot L_i y_i}{\sum_{r\neq i} L_r y_r}\right] & \text{for } \delta = 0 \\ \left[1 + \dfrac{\sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_m)}{\sigma-\epsilon_m}} \cdot L_i y_i^{\tau} P_i^{\eta-\tau}}{\sum_{r\neq i} L_r y_r^{\tau} P_r^{\eta-\tau}}\right] \Bigg/ \left[1 + \dfrac{\sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_s)}{\sigma-\epsilon_s}} \cdot L_i y_i^{\tau} P_i^{\eta-\tau}}{\sum_{r\neq i} L_r y_r^{\tau} P_r^{\eta-\tau}}\right] & \text{for } \tau_s = \tau_m = \tau \end{cases}$$

It follows that

$$\Phi_{si} \gtrless 1 \Leftrightarrow \sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_m)}{\sigma-\epsilon_m}} \gtrless \sum_{r\neq i} \omega_{ri}^{\frac{\sigma(1-\epsilon_s)}{\sigma-\epsilon_s}}$$

Since country 1 is the smallest, and country N, the largest, $\omega_{r1} < 1$ for $r > 1$ and $\omega_{rN} > 1$ for $r < N$. Given $\epsilon_m > \epsilon_s$, we have $\omega_{r1}^{-\frac{\sigma(\epsilon_s-1)}{\sigma-\epsilon_s}} < \omega_{r1}^{-\frac{\sigma(\epsilon_m-1)}{\sigma-\epsilon_m}}$ for $r > 1$ and $\omega_{rN}^{-\frac{\sigma(\epsilon_s-1)}{\sigma-\epsilon_s}} > \omega_{rN}^{-\frac{\sigma(\epsilon_m-1)}{\sigma-\epsilon_m}}$ for $r < N$. This implies $\Phi_{s1} > 1 > \Phi_{sN}$.

[27] For country 1, $L_1 < L_r$ and $w_1 > w_r$ for all $r > 1$. Thus $\chi w_1^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}} X_{mr} > \chi w_r^{\frac{\sigma(\sigma-1)(\epsilon_m-\epsilon_s)}{(\sigma-\epsilon_m)(\sigma-\epsilon_s)}} X_{mr}, \forall r > 1 \Rightarrow \Psi_{s1} > 1$. It can be similarly proved that $\Psi_{sN} < 1$.

We next show that if $\exists\, r < N$ such that Φ_{sr} as defined in (A.27) is greater (less) than unity, then for any country $k < (>)\, r$, $\Phi_{sk} > (<)\, 1$. This is analogous to Lemma 4, would prove Proposition 4 (c) with respect to RXA and thus conclude the proof of Proposition 4.

Proof. Suppose for country $r < N$, $\Phi_{sr} > 1$. Consider any country $k < r$. We've $W_{mr}/W_{sr} > W_{mk}/W_{sk}$, and,

$$
\begin{aligned}
&\Phi_{sr} > 1 \\
\Leftrightarrow\ & \frac{\sum_{i\neq r} W_{mi}}{\sum_{i\neq r} W_{si}} > \frac{W_{mr}}{W_{sr}} \quad \text{where} \quad W_{si} \equiv w_i^{-\frac{\sigma(\epsilon_s-1)}{\sigma-\epsilon_s}}; \quad W_{mi} \equiv w_i^{-\frac{\sigma(\epsilon_m-1)}{\sigma-\epsilon_m}} \\
\Rightarrow\ & W_{sr}\left(\sum_{i\neq r} W_{mi}\right) - W_{mr}\left(\sum_{i\neq r} W_{si}\right) > 0 > W_{sr}W_{mk} - W_{mr}W_{sk} \\
\Leftrightarrow\ & W_{sr}\left(\sum_{i\neq r} W_{mi} - W_{mk} + W_{mr}\right) > W_{mr}\left(\sum_{i\neq r} W_{si} - W_{sk} + W_{sr}\right) \\
\Leftrightarrow\ & W_{sr}\left(\sum_{i\neq k} W_{mi}\right) > W_{mr}\left(\sum_{i\neq k} W_{si}\right) \\
\Leftrightarrow\ & \frac{\sum_{i\neq k} W_{mi}}{\sum_{i\neq k} W_{si}} > \frac{W_{mr}}{W_{sr}} \\
\Rightarrow\ & \frac{\sum_{i\neq k} W_{mi}}{\sum_{i\neq k} W_{si}} > \frac{W_{mk}}{W_{sk}} \\
\Leftrightarrow\ & \Phi_{sk} > 1.
\end{aligned}
$$

It can be shown likewise that if $\Phi_{sr} < 1$, then for any country $k > r$, $\Phi_{sk} < 1$. Hence there must exist a country N_2^* between 2 and N such that for all countries indexed less (respectively greater) than N_2^*, $\Phi_{sr} > 1$ (respectively < 1). ∎

G Proposition 5

Firm-level output being given in each production sector, industry output is proportional to the number of firms or varieties produced. We need to show

$$\frac{\Omega_{mi}/\Omega_{si}}{\Omega_{mj}/\Omega_{sj}} \gtreqless 1 \text{ as } L_i \gtreqless L_j. \tag{A.28}$$

From eqs. (20)-(21) or (22), in the absence of demand bias,

$$\frac{\Omega_{mi}}{\Omega_{mj}} = \left(\frac{w_i}{w_j}\right)^{-\frac{\epsilon_m(\sigma-1)}{\sigma-\epsilon_m}} \quad ; \quad \frac{\Omega_{si}}{\Omega_{sj}} = \left(\frac{w_i}{w_j}\right)^{-\frac{\epsilon_s(\sigma-1)}{\sigma-\epsilon_s}} . \tag{A.29}$$

Hence,

$$\frac{\Omega_{mi}/\Omega_{mj}}{\Omega_{si}/\Omega_{sj}} = \left(\frac{w_i}{w_j}\right)^{-(\sigma-1)\left(\frac{\epsilon_m}{\sigma-\epsilon_m}-\frac{\epsilon_s}{\sigma-\epsilon_s}\right)} \tag{A.30}$$

Given $\epsilon_m > \epsilon_s$, we have

$$\frac{\Omega_{mi}/\Omega_{si}}{\Omega_{mj}/\Omega_{sj}} \gtreqless 1 \text{ as } \frac{w_i}{w_j} \lesseqgtr 1.$$

If $L_i > L_j$, then $w_i < w_j$ and $\Omega_{mi}/\Omega_{si} > \Omega_{mj}/\Omega_{sj}$. ■

H Data Sources

Table 10: Data Sources

Variable Name	Source	Descriptions. Available Years
Manufactured Goods Imports	UNCTAD	In thousands of USD. 1995 - 2016
Manufactured Goods Exports	UNCTAD	In thousands of USD. 1995 - 2016
Services Imports	UNCTAD	In million USD. 2005 - 2016
Services Exports	UNCTAD	In million USD. 2005 - 2016
Real GDP	WDI, World Bank	In constant 2010 USD. 1960 - 2016
Real GDP in PPP	WDI, World Bank	In PPP 2011 International Dollars. 1960 - 2016
Per Capita Real GDP	WDI, World Bank	In constant 2010 USD. 1960 - 2016
Per Capita Real GDP in PPP	WDI, World Bank	In PPP 2011 International Dollars. 1960 - 2016
Population	WDI, World Bank	Number of residents in a country. 1960 - 2016
Latitude	Gallup et al. (2010)	Latitude of country centroid
Gross Savings Rate	WDI, World Bank	Gross savings as a share of GDP. Gross savings are calculated as gross national income less total consumption, plus net transfers. 1960 - 2016
Population	WDI, World Bank	Number of residents in a country. 1960 - 2016
Human Capital Index	Penn World Tables. 9.0	Based on years of schooling and returns to education. Min value 0, no max value. 1950 - 2014
Real Capital Stock	Penn World Tables. 9.0	In million 2011 USD. 1950 - 2014