Putting Per-Capita Income back into Trade Theory

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Abstract

A major role for per-capita income in international trade, as opposed to simply country size, was persuasively advanced by many early economists including Linder (1961), Kuznets (1966), and Chenery and Syrquin (1975) . Yet this crucial element of their story was abandon by most later trade economists in favor of the analytically-tractable but counter-empirical assumption that all countries share identical and homothetic preferences. This paper collects and unifies a number of disjoint points in the existing literature and builds further on them using simple and tractable alternative preferences. Adding non-homothetic preferences to a traditional models helps explain such diverse phenomenon as a growing skill premium, the mystery of the missing trade, home bias in consumption, and the role of intra-country income distribution, from the demand side of general equilibrium. With imperfect competition, we can explain higher markups and higher price levels in higher per-capita income countries, and the puzzle that gravity equations show a positive dependence of trade on per-capita-incomes, aggregate income held constant. The effects of growth are quite different depending on whether it is growth in productivity or through neutral factor-endowment growth, and suggestions are made for calibration, estimation, and gravity equations. The final section reports recent empirical results that good support to the crucial assumption that produces many of the results just listed: skilled-labor and capital-intensive goods are systematically goods with high income elasticities of demand in consumption.

N.B., issues of product quality and the intra-country distribution of income, while of great importance and interest, have proved to be beyond the scope of one paper. A number of important papers are reference as an acknowledgment of valuable related work, but they are not analyzed or discussed.

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Thanks to participants in many seminars, conferences and workshops. Special thanks to Adrian Wood, for gently reminding me that per-capita income was once an important part of international economics. Comments, suggestions and added citations welcome.

1. Introduction

All international trade economists understand that many things can cause trade. However, our models and empirical analyses typically and appropriately tend to focus on one cause of trade at a time in order to understand how a particular basis for trade contributes to explaining trade patterns, determines gains from trade, and impacts on income distribution. That having been said, it seems that most trade theory focuses on production-side determinants of trade. It is typically assumed that consumers have identical and homothetic preferences within and across countries. Aggregate demand depends only on commodity prices and aggregate income, and it is independent of the distribution of income. I also believe that it is appropriate to suggest that no one thinks that this is a good empirical assumption and that it is made for analytical convenience and tractability.[1]

If we control for differences in prices across countries, the observation of different budget shares can indicate either that preferences differ and/or that they are non-homothetic. Two pure cases can be distinguished: one in which countries have homothetic but non-identical preferences and one in which countries have identical but non-homothetic preferences. I feel much more comfortable with the second alternative. Then demand differences are not only systematic but the hypothesis is testable and falsifiable.

The purpose of this paper is collect, synthesize, and build on fragmented results from existing research in order to offer a generic model of identical but non-homothetic preferences and present a unified and testable set of results. In section two, the preferences are presented and analyzed and then placed on top of a standard two-good, two-factor, two-country Heckscher-Ohlin model. The resulting model offers alternative explanations for such diverse phenomenon as growing skill premiums, the mystery of the missing trade, home bias in consumption, and a role for intra-country income distribution solely from the demand side of general equilibrium. In section 3, I add scale economies and imperfect competition and show that the model can offer alternative explanations for higher price levels and higher markups in high-productivity economies, and a higher trade volume between identical high per-capita income countries, aggregate income held constant. In both competitive and imperfect-competition cases the effects of growth are quite different depending on whether it is growth in productivity or in neutral factor accumulation.

A number of the ideas here are found in earlier papers focusing on specific issues. Several papers, obviously beginning with Linder, focused on monopolistic competition and the impact of non-homothetic preferences on intra versus inter-industry trade. Papers by Markusen (1986), Bergstrand (1990), and Francois and Kaplan (1996) draw out implications for intra-industry and total trade volumes. Matsuyama (2000) uses a competitive Ricardian model in

[1]A more egregious assumption is made in much of the strategic trade-policy literature: quasi-linear preferences in which the income elasticity of demand for increasing-returns good(s) is zero. Yet the industries offered as examples, such as aircraft and electronics are surely goods with income elasticities greater than one! The present author has of course been guilty himself of this atrocity.

which the South's comparative-advantage goods are low-income-elasticity-of-demand goods to derive results similar to some here. Fieler (2010) uses a Ricardian approach ala Eaton and Kortum (2002), which yields outcomes related to those from monopolistic competition. There is a dispersion of technologies across goods and a variability of labor efficiency across countries. High income elasticity goods have a higher dispersion and are produced in high-income countries. This higher dispersion leads to more trade among the high-income countries relative to low-income countries. Recent working papers by Bernasconi (2009) and Martinez-Larzoso (2010) give strong empirical support to the positive relationship of bilateral trade to per-capita income, direct support for Linder.

Markusen (1986) is a three-region model with "east-west" trade among identical high-income (north) countries and "north-south" trade between the high and low per-capita-income countries. High income-elasticity goods are both capital-intensive and differentiated, while the homogeneous low-income elasticity good is labor intensive. The volume of east-west (north-north) trade is then higher than north-south trade relative to identical and homothetic preferences. Fieler (2010) makes substantial theoretical progress on this sort of multi-country prediction in her Ricardian model and deals with south-south trade as well..

Income-elasticity estimates for broad categories of consumption goods from Markusen and Hunter (1989) suggest income elasticities from about 0.45 (food) to 1.90 (medical care). Alternatively, non-homotheticity means that the shares of a country's national expenditure for goods vary systematically with levels of per-capita income. Shares from Hunter (1991) and Cassing and Nishioka (2010) suggest that preferences are not just differing randomly across countries but observed shares are related to per-capita income.

Hunter (1991) shows that the influence of non-homotheticity is in the direction of reducing the volume of trade. A counter-factual analysis neutralizes the estimated non-homotheticity and finds that the effect of imposing homotheticity is to raise trade flows by 29 percent. Cassing and Nishioka (2010) use a neutralization exercise similar to Hunter's and find that developing countries consume relatively more labor-intensive goods than under preference homogeneity. Second, they find that preference biases between rich and poor countries explain a larger proportion of missing factor trade than do differences in technology, though preference differences are not distinguished from non-homotheticity. Fieler's (2010) emprical results are strong and convincing. Her model correctly predicts both the large volume of trade among high-income countries and the low volume of trade among poor countries, whereas previous gravity-type work has done a poor job on the latter.

Bernasconi (2010) has an interesting alternative story, which is that high-per-capita-income consumers/countries consume a broader range of goods, and this in turn increases the volume of north-north trade. Martinez-Zarzoso and Vollmer (2010) show a strong and positive relationship between trade volumes and per-capita income, and trade volumes and income inequality, with the latter relationship stronger for more sophisticated goods, both consistent with the model adopted below.

Some of these results contrast with Bowen, Leamer and Sveikauskas (1987) and Trefler (1995) who do introduce non-homothetic preferences into their analyses and get weak value added from doing so. Neither paper addresses non-homotheticity as a cause of missing trade or home bias (Trefler does find it helps solve the “endowment paradox”). Reimer and Hertel (2010) find that non-homothetic preferences play only a small role in missing trade over broad categories of goods. Rather, they find that, as income grows, it is directed toward the relatively capital-intensive version of a given good.

Results in the section introducing imperfect competition are similar to those found in Wong (2003), Coibion, Einav and Hallak (2007), Hummels and Lugovskyy (2009) and Simonovska,(2009) which is that markups and hence the price level will be higher in the high per-capita-income country. Simonovska gets strong empirical support for this relationship. I should also note that Simonovska carefully considers identical products, which eliminates quality issues which could be an alternative explanation for systematic price differences by per-capita income. Essentially the same result was found by Wong for pricing of identical pharmaceutical products.

An area where per-capita income does play an important role is in the analysis of product quality. If a consumer is going to buy only one unit of a good or zero, then the quality demanded is likely to depend on per-capita income. This makes the average level of per-capita income important for trade but also the intra-country distribution of income matters for inter-country trade. I am the first to acknowledge that these issues are of great interest and importance. But it became clear to me that dealing with them is far beyond the scope of one paper for a number of reasons, including that they require a quite different analytical and empirical approach. *Thus I will not deal with issues of product quality and/or the intra-country distribution of income*, but include many references in a separate section at the end of the paper. A good place to start on this literature is a recent paper by Hallak (2010) which also notes the contributions of many earlier papers.

The final section of the paper presents empirical evidence on the crucial assumption linking high ratios of skilled labor and capital to unskilled labor in production to high income elasticities of demand that leads to many of the theoretical results in the paper. These are findings from a project currently underway (Caron, Fally and Markusen 2011), and they give good support (economic and statistical significance) to this link.

2. A Generic Model

The preferences we will use are variation on a standard Stone-Geary utility function, to be introduced shortly. The production side of the model is deliberately Heckscher-Ohlin to permit an easy comparison with traditional results. There are two good (X and Y), two factors of production (K and L) and two countries home and foreign (h and f).

Throughout the paper, the following assumptions are made.

(1) good *X* is relatively capital intensive, and *Y* is relatively labor intensive
(2) good *X* has an income elasticity of demand greater than one
(3) good *X* is the increasing-returns good if there is one (section 3)
(4) the labor supply is identical to the number of households, implying that the capital-abundant country must be the high-per-capita-income country
(5) country h is relatively capital abundant when relative endowments differ
(6) country h has higher productivity when productivities differ across countries

Most of these assumptions are without loss of generality, but the *intersection* of (1) - (4) matters; in particular, that the capital-intensive good has the high income elasticity of demand. Empirical support for this assumption is found in Bergstrand (1990) and indirectly in Hunter (1991) Cassing and Nishioka (2009) and Caron, Fally and Markusen (2011). Matsuyama (2000) uses an equivalent assumption in his Ricardian model: the South's comparative advantage goods are low-income-elasticity goods. Fieler's (2010) theory is also Ricardian, and the theory and empirical evidence deliver a related result: the south has a comparative advantage in low-income elasticity standardized goods while the north has an advantage in high-income- elasticity goods whose production technologies are more variable across countries.

Table 1 presents some statistics and estimates from Caron, Fally, and Markusen (2011) to hopefully convince us that this set of assumptions is empirically plausible. Assumption (4) implies that capital-abundant countries are high-per-capita-income countries as noted. Panel A of Table 1 correlates country per-capita incomes on different definitions of factor-endowment ratios (data from the GTAP data set: 112 countries, 5 factors). We see that there is a strong positive relationship between per-capita income and capital intensity if (and essentially only if) skilled labor (human capital) is included with physical capital in the definition of "capital". The ratio of capital to all labor has a negative correlation with per-capita income. Henceforth, let's think of "capital" in the theoretical models as including both physical and human capital, in which case (4) is plausible: per-capita income increases with the share of skilled workers in *L*.

Panel B of Table 1 presents some simple regressions from Caron, Fally and Markusen (2011). These are the second step of a two-step procedure: the first is to use the Deaton and Muellbauer (1980) AIDS demand system, discussed in section 5 below, to estimate income-elasticities of demand (not shown) across the 57 sectors. These are then regressed on the average world factor intensities of the sectors using the same definitions as Panel A. The results give good support to the combined assumption (1)-(2) above, provided again that "capital" is defined as physical plus human capital. Hopefully, the results of Table 1 thus convince us that the model outlined above is empirically plausible.

Since we will focus on a limited number of experiments, some short-hand terminology is used throughout. *Productivity advantage* or growth, or higher productivity refers to an equal proportional Hicks-neutral productivity advantage or growth in *both* sectors in one country (always country h). *Factor accumulation* refers to a equal proportional ('neutral') growth in the endowments of *both* factors of one or both countries: factor accumulation increases the number of households in the same proportion to total income.

TABLE 1: Factor intensities, factor endowments, and per-capita income

GTAP data: 57 sectors, 5 factors, 112 countries (Caron, Fally, and Markusen (2011))

Panel A: Factor *endowments* correlated with per-capita income

Factor-endowment ratio definitions	Country *endowment ratio* correlations with country per-capita income
K4 - (capital+skilled) / (unskilled+resources+land)	0.368
K3 - (capital+skilled) /unskilled	0.123
K2 - (capital+resources+land)/(skilled+unskilled)	-0.278
K1 - capital/(skilled lab + unskilled lab)	-0.212

Panel B: Relationship between factor *intensities* and income elasticities

DEPENDENT VARIABLE: log of income elasticity of demand for good i
(from AIDS estimation - Caron, Fally, Markusen)

VARIABLES: log factor *intensity ratio* in good i (world average)

K4	0.464***			
	(0.103)			
K3		0.382***		
		(0.111)		
K2			-0.167	
			(-0.104)	
K1				0.0907
				(0.083)
Constant	0.630***	0.560***	0.755***	0.752***
	(0.045)	(0.074)	(0.051)	(0.048)
Observations	57	57	57	57
R-squared	0.494	0.267	0.054	0.014

N.B.: factor intensities are indirect, including intermediate use:
income elasticity evaluated at mean world PCI

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

Lower-case letters denote per-household quantities. In addition to x and y, there is a parameter $z > 0$ at the household level. Preferences or utility (u) are given as follows.

$$u = (x + z)^{\beta} y^{1-\beta} \tag{1}$$

We could interpret z as an endowment good and assume that *households cannot buy or sell* z. x could be televisions and z could be watching a sunset (non-rivaled and non-excludable: sitting on a dock on the bay as Otis Redding might say). The assumption that x and z are additive has little to with the results of this paper, but has the advantages that (a) there is a simple analytical solution for demand and (b) aggregate demand does not depend on the distribution of income (with a qualification noted below).[2]

It is more common to see Stone-Geary written with $(y - z)$ instead of $(x + z)$, with $z > 0$ then referred to as a “minimum consumption requirement”. But this leads to a problem if income is insufficient to purchase the minimum consumption requirement and no household will ever be observed to purchase only good Y. In addition, our formulation in (1) will mean that the price elasticity of demand for X will be falling in per-capita income, a property exploited in Wong and in Simonovska.

Let m^i denote the income of household i and let p_x and p_y denote the prices of X and Y. The households budget constraint is given by:

$$m^i = p_x x + p_y y \tag{2}$$

Maximization of (1) subject to (2) gives the following Marshallian demand functions.

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$$x^i = \max\left[0,\ (\beta - 1)z + \frac{\beta m^i}{p_x}\right] \qquad y^i = \min\left[\frac{m^i}{p_y},\ \frac{(1-\beta)(m^i + p_x z)}{p_y}\right] \tag{3}$$

$$x^i > 0 \quad \textit{iff} \quad m^i > \frac{(1-\beta)}{\beta} p_x z \equiv m^0 \tag{4}$$

At low levels of income, the household buys only good Y, and above the threshold income indicated in (4) by m^0, begins to buy X. This is an interesting and surely realistic point, and it makes aggregate demand depend on the distribution of income. I will assume for much of the paper that (4) holds with strict inequality for all households.

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[2] Virtually all the results go through with the CES-Cobb-Douglas version $u = (x^{\alpha} + z^{\alpha})^{\beta/\alpha} y^{1-\beta}$ except perfect aggregation: aggregate demand always depends on the distribution of income. This function is hard to work with analytically (though easy for the computer).

Properties of the preferences are illustrated in Figure 1, left panel. The Engels curve (prices constant) is given by $0y_0A$: up to income m_0, given by (4) with equality, the household consumes only good *Y* and then has a constant marginal propensity to consumer *X* and *Y* as income rises. The share of *X* in consumption as household income rises is shown in the right-hand panel (calibration is $\beta = 0.667$) of Figure 1.

Let *L* denote *both* the country's labor supply *and* household measure so that $Z = zL$ denotes the economy-wide "endowment" of *Z*: *z* is a *parameter*, while *Z* is strictly proportional to the number of households. If (4) holds for all households, aggregate demand for *X* is independent of the distribution of income and given by[3]

$$X = \sum_{i=1}^{L} x^i = (\beta - 1)Z + \frac{\beta M}{p_x} \qquad Z = zL \qquad M = \sum_{i=1}^{L} m^i \tag{5}$$

Now consider the income elasticity of demand for *X* and assume that income grows through a productivity increase, holding the number of households *L* and therefore *Z* constant.

$$\left[\frac{M}{X}\frac{dX}{dM}\right]_{dZ=0} = \frac{\beta M}{\beta M + (\beta - 1)p_x Z} = \frac{m}{m - m^0} > 1 \tag{6}$$

(growth through productivity improvement)

If growth instead occurs through neutral factor accumulation, *Z* is strictly proportional to *M*, then

$$\left[\frac{M}{X}\frac{dX}{dM}\right]_{dZ/Z = dM/M} = 1 \qquad \text{(growth through neutral factor accumulation)} \tag{7}$$

Using $dX/dp_x = -\beta M/p_x^2$, the Marshallian price elasticity, defined as positive, is

$$\epsilon \equiv -\left[\frac{p_x}{X}\frac{dX}{dp}\right] = \frac{\beta M}{\beta M + (\beta - 1)p_x Z} = \frac{m}{m - m^0} > 1 \tag{8}$$

Thus the per-capita income and the price elasticities of demand for *X* are (locally) the same, and illustrated in the right-hand panel of Figure 1.

[3]The general n-good name for this type of demand function is "linear expenditure system" and is also used in Bowen, Leamer, and Sveikauskas, (1987) who refer to the Zs as "autonomous" expenditure. See Deaton and Muellbauer (1980) for the classic general analysis.

The properties of aggregate demand for the economy holding prices constant are shown in Figure 2. Let Z_0 denotes the initial value of *Z*. Hold *Z* constant but allowing aggregate income to vary either through productivity or through capital accumulation, holding *L* constant. This leads to an Engels income-consumption curve that starts at the origin and moves up the *Y* axis (consuming only *Y*) to point Y_0 after which higher income will result in positive *X* demand. At incomes above that which allows point Y_0 to be reached, the Engels curve is linear through A at income level M_0 and reaching B at income level M_1.

Consider point A and income level M_0 in Figure 2. Now suppose instead we let the economy grow through proportional factor accumulation, adding households in strict proportion to the increase in income, so *Z* and *M* grow to Z_1 and M_1 respectively. Now the Engels curve beyond A will be given by a ray through the origin and points A and C and aggregate demand is homothetic with respect to aggregate income. Figure 2 gives the first important result of the paper: a growing economy will look very different depending on whether growth is through productivity or capital accumulation on the one hand, or neutral factor accumulation on the other (aggregate income and households grow in strict proportion).

From this point on, I will present some results in terms of simulations. All of the results are intuitive, some are found formally in earlier papers and I am quite sure that all of the qualitative properties of all results have no dependence on the specific parameters or other assumptions used in these specific examples. The initial "calibration" point is the one used in the right-hand panel of Figure 1: at productivity one, the income and price elasticity are 1.333 and the share of *X* in consumption is 0.5; the value of $\beta = 2/3$ is used in this example and throughout the paper. As productivity grows without bound the income and price elasticities approaches one and the *X* consumption share approaches its marginal value of 2/3 in Figure 1.

With the neutral and equal productivity growth in both sectors, the production frontier of the economy is growing radially, but demand is shifting toward good *X*. This generates a movement around the frontier toward *X*, so the relative price of *X* rises as shown in Figure 3. But this generates the usual Stolper-Samuelson effect on relative factor prices, so the rental (*r*) - wage (*w*) ratio *r/w* is rising as shown in Figure 3. Suppose we interpret capital as skilled labor or human capital and *L* as unskilled labor. A neutral productivity growth generates an increase in the wage gap between skilled and unskilled labor. Thus we can get a wage gap (skill premium) phenomenon driven by the demand side of the general-equilibrium model without appealing to trade or to skill-biased technical change.[4]

Now consider differences in relative endowments, beginning with the two countries identical, under the assumption of costless trade. Move capital from f to h and labor from h to f, implying the *Z* rises in f and falls in h by an equal and opposite amount. Their Engels curves will move apart in Figure 2 but they remain parallel. Figure 4 shows the effect of widening the

[4]An extension possibly relates to the Prebisch (1950) -Singer (1950) hypothesis. If the countries differ in relative endowments (standard Heckscher-Ohlin), then neutral productivity growth in both countries will lead to a terms-of-trade deterioration for the labor-abundant country: the "south".

endowment differences. It graphs the share of world consumption and production in each country. The consumption shares in this exercise would be constant at 0.5 under homothetic demand. But under our assumption that the capital intensive good is the high-income-elasticity good, the consumption shares are positively correlated with their respective good's production share.

Figure 4 gives a demand-side explanation for two phenomenon that have previously been identified and attributed to production-side causes. The positive correlation between production and consumption shares has been one (of several) definition of "home bias". Secondly, the volume of trade is less under our assumptions than is predicted under a standard Heckscher-Ohlin model and thus offers a demand-side explanation for the empirical puzzle of "missing trade" in Trefler's (1995) terminology. The amount of missing trade is identified in Figure 4 and note that it continues to grow in importance once countries are specialized: production specialization cannot continue to increase but consumption specialization can. As noted earlier, non-homotheticity as a cause of missing trade was noted theoretically by Markusen (1986) is empirically verified in Hunter (1991) and in Cassing and Nishioka (2010). Closely related points in the Ricardian context are found in Matsuyama's (2000) theory and in Fieler's (2010) theoretical and empirical paper.[5]

As a final exercise with the competitive case, consider the role of intra-country income distribution which has been noted before.[6] If each consumer in a country has enough income as given in (4) to want positive amounts of X, then the linear property of the Engels curve means that redistribution of income within the country (subject to (4) continuing to hold for all households) does not affect aggregate demand. But if redistribution puts some households on the vertical section of the curve in Figure 1or 2 where they only buy Y (points below Y^0), then it does matter.

Let there be two sets of households, denoted with superscript p (poor) and r (rich). There are L^p poor households and L^r rich households, $L = L^p + L^r$ with per-capital incomes m^p and m^r respectively. m^a will denote the average income. Assume that a household with average income would purchase positive amounts of X but poor households do not. With reference back to the minimum income condition in (4), we assume that

$$m^a = \frac{m^p L^p + m^r L^r}{L} \qquad m^p < \frac{(1-\beta)}{\beta} p_x z = m^0 < m^a \tag{9}$$

[5]Markusen (1986) and Fieler (2010) explicitly explain large "north-north" versus small "north-south" (and south-south in Fieler) trade volumes. An entirely different explanation is advance in Markusen and Wigle (1990): north-south and south-south trade is small because the south is poor and because the pattern of wold protection discriminates heavily against north-south and south-south trade.

[6]The role of the intra-country distribution of income for inter-country trade is an important focus of the literature on product quality. Please see the long list of references at the end of the paper in the product-quality grouping.

When there are just these two household types, only the rich ones will purchase *X*. Suppose on the other hand, that all household types have the average per capita income. Aggregate demand X^r and X^a in these two scenarios are given as follows.

$$X^r = (\beta - 1)zL^r + \frac{\beta m^r L^r}{p_x} \qquad X^a = (\beta - 1)zL + \frac{\beta m^a L}{p_x} \tag{10}$$

Subtract the second equation of (10) from the first, and substitute for m^a from the first equation of (9). The difference in aggregate demand is

$$X^r - X^a = (1 - \beta)zL^p - \frac{\beta m^p L^p}{p_x} > 0 \qquad \frac{X^r - X^a}{L} = \beta\left[\frac{m^0 - m^p}{p_x}\right]\frac{L^p}{L} > 0 \tag{11}$$

where the inequalities hold by assumption (the income of poor households is too low to purchase *X*). Perfect aggregation does not hold with a wide distribution of household income and, for two countries with the same average income, aggregate demand for the luxury will be higher in the country with the more unequal distribution (those Mercedes in Africa).[7]

3. Imperfect competition, prices and markups

In this section, we add scale economies, imperfect competition, and free entry and exit of firms in the *X* industry in a standard model of Cournot competition, continuing with the assumption that *X* is a homogeneous good. *Y* is produced with constant returns under perfect competition. We assume segmented markets simply because the results are more interesting and in line with Simonovska for example, so the model is similar to Venables (1985) or Markusen and Venables (1988), the latter contrasting segmented and integrated markets cases.

To keep matter manageable, we will concentrate on the case of per-capita income differences arising from productivity difference, but the qualitative results are identical to the case where countries differ in endowment ratios. Suppose that there is just a single factor of production, *L*, and distinguish between the household count and the "effective" or productivity-adjusted supply of labor in each of the two countries. One unit of *Y* uses one unit of effective labor supply and *X* uses *c* units of effective labor for marginal costs and *F* units for fixed costs. The two countries could have identical aggregate incomes but different per-capita incomes: one country can have higher productivity but proportionately lower household count.

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[7]With the CES-CD version described in footnote 2, the Engels curve and the ratio *Y/X* is a smooth concave curve rather than the kinked version in Figure 1. Perfect aggregation never holds in the CES-CD case, and the aggregate demand for *X* will always be higher with a wider income distribution. Again, please see the papers on product quality reference below for much more complete analyses.

Good Y is used as numeraire. Revenue (R) for a Cournot firm in country i and selling in country j is given by the price in j times quantity of the firm's sales. Price is a function of all firms' sales.

$$R_{ij} = p_j(X_j)X_{ij}. \qquad X_j \text{ is total sales in market j: } X_j = \sum_i X_{ij}$$

Assume zero trade costs and segmented markets, with c and F having the same value across countries. Then any firm that operates will sell in both markets and will sell the same in each market as any other firm regardless of that particular firm's home country: $X_{ii} = X_{ji},\ X_{jj} = X_{ij}$. n will then denote the total number of firms from both countries active in equilibrium, where n is determined by the usual free-entry zero-profit conditions. This zero–profit condition for a firm from i is as follows, with a corresponding condition for a firm from j.

$$p_i X_{ii} + p_j X_{ij} - c(X_{ii} + X_{ij}) - F = 0 \qquad \text{zero profits} \qquad (12)$$

The result that gives the Cournot markup of a firm is fairly well known and I will not re-derive it here: the markup in j (defined on price p_j) is given by the firm's market share divided by the price elasticity of demand. With zero trade costs and equal marginal costs, each firm in selling in a market has the same market share as any other firm regardless of home country. So the market share is always just *1/n* and the markup is $1/(n\epsilon_j)$.

$$mr_{jj} = mr_{ij} = p_j\left[1 - \frac{1}{n\epsilon_j}\right] = c \quad \text{or} \quad p_j = \left[\frac{n\epsilon_j}{n\epsilon_j - 1}\right]c \qquad \text{Cournot pricing} \qquad (13)$$

Market clearing in country j is given from earlier results, similarly for i.

$$p_j n X_{ij} + p_j n X_{jj} = \beta(M_j - M_j^0) \qquad M_j^0 \equiv \frac{(1-\beta)}{\beta} p_x z L_j \qquad \text{market clears} \qquad (14)$$

The elasticity of demand ϵ is given from (8) above. Also use (13) to replace p in m^0.

$$\epsilon_j = \frac{m_j}{m_j - m_j^0} \qquad m_j^0 = p_j \frac{1-\beta}{\beta} z = \frac{n\epsilon_j}{n\epsilon_j - 1}\frac{1-\beta}{\beta} zc \qquad (15)$$

Using the second equation of (15), the first becomes

$$\epsilon_j = \frac{m_j}{m_j - \dfrac{n\epsilon_j}{n\epsilon_j - 1}\dfrac{1-\beta}{\beta} zc} \qquad (16)$$

which in turn reduces to

$$\left[\frac{n\epsilon_j - 1}{n\epsilon_j}\right]\left[\frac{\epsilon_j - 1}{\epsilon_j}\right] = \frac{1-\beta}{\beta}\frac{zc}{m_j} \qquad \epsilon_j \text{ is decreasing in } m_j,\ n \text{ constant} \tag{17}$$

Recall that the number of firms n is common between i and j. We then get a "cross-section" result from (17): comparing two countries, the higher per-capita income country will have a lower price elasticity, higher markup and higher price level.

Add the zero-profit conditions for the representative firms in i and j in (12) together. There are four Cournot pricing equations (13) for the two market supplies for the representative firm from each country. Multiply both sides of the four pricing equations (13) by the relevant outputs and set to zero (move c terms to the left-hand side). Add these four together and subtract them from (12). This will yield the condition that markups revenues equal fixed costs:

$$\frac{p_j(X_{jj}+X_{ij})}{n\epsilon_j} + \frac{p_i(X_{ii}+X_{ji})}{n\epsilon_i} = 2F \qquad \text{(markups revenues equal fixed costs)} \tag{18}$$

Use the market-clearing equations in (14) to substitute for the revenue terms in (18).

$$\frac{\beta(M_j - M_j^0)}{n^2\epsilon_j} + \frac{\beta(M_i - M_i^0)}{n^2\epsilon_i} = 2F \tag{19}$$

and replace ϵ_i and ϵ_j with (15) $(m_i/(m_i - m_i^0) = M_i/(M_i - M_i^0))$. (19) becomes

$$\frac{\beta(M_j - M_j^0)^2}{n^2 M_j} + \frac{\beta(M_i - M_i^0)^2}{n^2 M_i} = 2F \tag{20}$$

Solving for n, we have

$$n = \left[\left(\frac{(M_j - M_j^0)^2}{M_j} + \frac{(M_i - M_i^0)^2}{M_i}\right)\left(\frac{\beta}{2F}\right)\right]^{\frac{1}{2}} \quad \text{and} \tag{21}$$

$$n\epsilon_j = \left[\left(\frac{(M_j - M_j^0)^2}{M_j} + \frac{(M_i - M_i^0)^2}{M_i}\right)\left(\frac{\beta}{2F}\right)\right]^{\frac{1}{2}}\left[\frac{M_j}{M_j - M_j^0}\right] \tag{22}$$

Consider two identical countries with equal aggregate incomes $M = M_i = M_j$

$$n\epsilon = \left[\left(2\frac{(M-M^0)^2}{M}\right)\left(\frac{\beta}{2F}\right)\right]^{\frac{1}{2}}\left[\frac{M}{M-M^0}\right] = \left(\frac{\beta}{F}\right)^{\frac{1}{2}}\left[\frac{M-M^0}{M^{1/2}}\right]\left[\frac{M}{M-M^0}\right] = \left(\frac{\beta M}{F}\right)^{\frac{1}{2}} \tag{24}$$

which (when inverted) gives a simple formula for the common markup.

$$\frac{1}{n\epsilon} = \left[\frac{F}{\beta M}\right]^{\frac{1}{2}} = \text{common markup for identical countries} \tag{25}$$

The markup falls with a growth in *aggregate* income due to the pro-competitive effects of entry (Venables 1985, Markusen and Venables 1988). But the interesting thing about (25) is that non-homotheticity washes out. Holding aggregate income constant, increase *per-capita* income (increase productivity offset by fewer households). This lowers the price elasticity of demand but this is exactly offset in this special case by more entry. Recognizing that this last result is derived for identical economies only, we can thus suggest that non-homotheticity does not have a "time-series" effect on markups as per-capita income grows over time, but does show up in the "cross-section" comparison between countries with different per-capita incomes.

Results for this section are illustrated in Figure 5. The "cross-section" result is shown in the left-hand panel. The two-countries are identical at a value of 0.5 on the horizontal axis. Then productivity increases in h and falls in f holding aggregate incomes constant and equal (household numbers move inversely with productivity). With the price of *Y* equalized between countries, this means that the price index is greater in country h as shown in Figure 5. The results on prices and markups is consistent with those in Wong (2003), Hummels and Lugovskyy (2009), and Simonovska (2009). Qualitatively, the same result occurs if we maintain equal productivities equal but transfer *K* from f to h and *L* from h to f.

A volume-of-trade result is shown in the right-hand panel of Figure 5 where the two countries are identical. Productivity is rising along the horizontal axis and absolute endowment lowered to maintain identical and constant aggregate incomes. The higher per-capita income moving to the right leads to a shift in consumption to *X* and to an increase in intra-industry trade, inter-industry trade being zero. Thus trade volume increases relative to aggregate income. The same result will of course hold under monopolistic competition (Markusen 1986, Bergstrand 1989). A consequence is that gravity equations should show trade rising with per-capita income, aggregate income held constant, a topic discussed in the next section.

4. Calibration, estimation and gravity

I want to conclude by offering some thought on the implications of the analysis for calibrated modeling (applied general-equilibrium analysis) and econometric estimation. A common procedure in AGE modeling is to assume a homothetic functional form such as Cobb-

Douglas for example, and then used observed expenditure shares in the data to calibrate the share parameters of the Cobb Douglas.

Refer back to Figure 2 and think of expenditure shares at point A as being 0.5. The common AGE calibration method then assumes that any expansions of the economy will be on the Engels curve through A and C. However, the marginal expenditure share per household used in these experiments is 0.667 ($\beta = 2/3$). Thus if some counterfactual leads to an increase in per-capita income, the actual Engels curve is that through A and B in Figure 2. Furthermore, if two countries are observed to have different initial budget shares, such as one country at A and one at B in Figure 2, then they will be calibrated as having different but homothetic preferences when in fact they might have identical but non-homothetic preferences.[8]

There is a rather simple procedure that GE modelers can use to recalibrate their models to identical but non-homothetic preferences of the type used here. First, their data can be used as a cross-section data set to estimate the type of Stone-Geary utility function used here: the Stone-Geary yields the familiar linear expenditure system, which is the approach used in Bowen, Leamer and Sveikauskas (1987) and Hunter and Markusen (1989). This could, for example, generate a common value of β in our two-good case, or more generally a set of βs across consumption goods. Then in each country the *z* or *Z*s could be calibrated by using the observed consumption shares in the data with the estimated βs. In our two-good case, a rearrangement of (5) gives us

$$\sigma_x = \frac{p_x X}{M} = \beta + \frac{(\beta - 1) p_x Z}{M} = \beta + (\beta - 1) s_z \tag{17}$$

where σ_x is the *observed* share of *X* in expenditure and s_z is the *calibrated* share of (unobserved) *Z* in income using an econometric estimate of β common across countries. In counterfactual experiments not involving a change in the number of households *Z* is held constant while it is allowed to vary with the number of households when that occurs. This procedure then distinguishes between movements along Engels curves AC and AB in Figure 1. Failing to do so as in standard models will lead to a mis-prediction about the effects of world productivity growth or capital deepening.

There is a long history of fitting Heckscher-Ohlin theory (Leamer 1980, Maskus 1985, Bowen, Leamer and Sveikauskas 1987, Staiger (1988), Harrigan (1997), Davis and Weinstein 2001, Hakura 2001, Trefler 1995). A much simplified description of this literature is that it *starts* with the relationship $E = X - C$, where *E* is the net export vector, *X* is the production vector and *C* is the consumption vector. *E* is then converted into the "factor-content of trade". A simple procedure, for example, is to estimate a common technology matrix [*A*] where a_{ij} is good j's use of factor i. Then the *measured* factor content of trade for a country is [*A*]*E*. The

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[8]It is my understanding that the GTAP and GEMPAC models do allow the modeler to select non-homothetic preferences, but I am not familiar with their underlying structures.

predicted factor content of the production vector is just the country's endowment vector, *V*.

A considerable amount of effort has gone into trying to improve the fit through modifications of the basic model but I think that it is reasonable to say that almost all of that effort has gone the production side; e.g., allowing for technique differences, price differences, and differences in factor quality. In most all cases I am aware of, *C* is in fact not really fitted at all nor is it given by data: *C* is *assumed* to be given by sX^w, where *s* is the country's share of world income and X^w is the observed world production vector, equal to the world consumption vector. So the estimators *impose* the assumption of identical and homothetic preferences across countries and of course equal relative prices. The factor content of consumption is then $s[A]X^w = sV^w$. This gives the relationship $[A]E = (V - sV^w)$, where the left-hand side is the measured factor content of trade and the right-hand side is the predicted value. The typical result in the simplest formulations is that there is substantial "missing trade": measured value is much less than the predicted value.

The findings of Hunter (1991), Cassing - Nishioka (2010) and Fieler (2010) should encourage researchers to devote some effort to improving the estimation of the consumption vector. Let *C* continue to denote the consumption vector and assume identical but non-homothetic preferences across countries and assume that commodity prices are the same everywhere (this is not a new assumption here, it is used in virtually all of the literature referred to). Let β_i denote the marginal share of good i in consumption and $z_i^k = z_i L^k$ be the fixed "endowment" of good z_i. in country k: β_i and z_i are identical across countries. The hypothesized demand for good C_i in country k when condition (4) holds is given by[9]

$$C_i^k = -Z_i^k + \beta_i(M^k + \sum_j p_j Z_j^k)/p_i \tag{18}$$

These demand values can be converted into shares of consumption σ_i^k by multiplying through by the price of good i and dividing by income

$$\sigma_i^k = \frac{p_i C_i^k}{M^k} = \beta_i + \frac{\beta_i\left(\sum_j p_j Z_j^k\right) - p_i Z_i^k}{M^k} = \beta_i + \frac{\beta_i(\sum p_j z_j) - p_i z_i}{m^k} \tag{19}$$

where the last term follows by dividing numerator and denominator of the quotient in previous term by L^k. If we assume that prices are the same everywhere as is typical in this literature, then

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[9]Equation (18) here is virtually identical to equation (7) in Bowen, Leamer, and Sveikauskas (1987). But they turn to questions quite different from the points made in the present paper.

(19) reduces to [10]

$$\sigma_i^k = \beta_i + \frac{\alpha_i}{m^k} \qquad \sum_i \alpha_i / m^k = 0 \tag{20}$$

Since our demand system imposes identical preferences across countries, the σ_i^k's only differ from world average values by differences across countries in per-capita income, which is easily observed and calculated. These α and β parameters can be estimated across countries.

An appendix to the paper shows that, with a series of substitutions, the relationship between the measured and predicted factor-content of trade reduces to

$$[A]E = (V^k - s^k V^w) + s^k [A][I - \Sigma^k] X^w \tag{21}$$

where Σ is a diagonal matrix with its ith diagonal element equal to σ_i^k / σ_i^w and I is the identity matrix. σ_i^k is the *fitted* share of consumption of good i in country k, and σ_i^k is the *observed* share of good i in world consumption. The final term in (21) is zero under homothetic demand.

The equations in (21) give the intuition about how per-capita income differences due to different relative endowments combined with the assumption that labor intensity and low income elasticity are correlated tends to lower the predicted factor content of trade. Under these assumptions, there should be a systematic correlation such that export goods in which the country is relatively specialized in production $(X_i / s X_i^w) > 1$ are goods in which the country is relatively specialized in consumption $(\sigma_i^k / \sigma_i^w) > 1$ (or the ith diagonal element of $[I - \Sigma^k]$ is $(1 - \sigma_i^k / \sigma_i^w) < 0)$. Exports of good X_i are then smaller under our assumptions. Import goods for which $(X_i / s X_i^w) < 1$ are goods which have small shares in consumption, $(\sigma_i^k / \sigma_i^w) < 1$ (or the ith element of $[I - \Sigma^k]$ is $(1 - \sigma_i^k / \sigma_i^w) > 0)$. So net imports E_i are smaller (less negative) under our assumptions.

Our assumptions then tend to reduce the predicted factor content of trade for any vector of world outputs. The difference between actual and fitted values of trade would then be reduced, reducing missing trade, given that trade volumes are over-predicted in the standard

[10]Note the similarity here to Deaton and Muellbauer's (1980) "almost ideal demand system" (AIDS). Suppressing prices, this is $\sigma_i^k = \beta_i + \alpha_i \log(m^k)$ for *household* k where $\alpha > 0$ is an income-elastic good instead of $\alpha < 0$ in my formulation. This demand system could be used instead of the LES that I have discussed here: equation (21) is the same, though aggregation is a theoretically-awkward issue in both approaches. We use the AIDS formulation in the estimation in section 5.

analysis where $(\sigma_i^k/\sigma_i^w) = 1$ by assumption. However, I emphasize that such an outcome is by no means trivial or guaranteed. If differences in per-capita incomes reflect differences in productivity rather than differences in capital / labor endowments, then predicted trade could be even larger than under homothetic preferences.

A final point has to do with standard gravity equations. A common practice is to put in separate terms for both aggregate income (or population) and per-capita incomes, yet there is rarely if ever justification for this. With homothetic preferences, aggregate income should soak up all the explanatory power. Yet estimates of this type invariably show an important, positive and independent role for per-capita income.

There are a great many formulations of the gravity equation in the literature. Let me give a quick and simple example provided by Frankel et. al. (1998) (see similar strong results in Martinez-Zarzoso and Vollmer 2010). Let M_i denote aggregate income, P_i denote population for countries 1 and 2, and T_{12} the trade between countries i and j. The Frankel et. al. formulations is

$$\ln T_{12} = \alpha \ln(M_1 * M_2) + \beta \ln\left(\frac{M_1}{P_1} * \frac{M_2}{P_2}\right) + ... \tag{22}$$

In levels, this is equivalent to

$$T_{12} = (M_1 * M_2)^{\alpha}\left(\frac{M_1}{P_1} * \frac{M_2}{P_2}\right)^{\beta} = (M_1 * M_2)^{\alpha + \beta}(P_1 * P_2)^{-\beta} \tag{23}$$

If the world is characterized by homothetic preferences, then aggregate income is all that matters, so the hypothesis is $\beta = 0$. If preferences are non-homothetic, then we should find β to be non-zero, although in what direction is not obvious. If traded goods are income elastic (we should really include traded services here), then we should find $\beta > 0$.[11] Alternatively, if differentiated goods are high income-elasticity goods then higher per-capita income countries will have a higher volume of intra-industry trade as discussed in section 3 and Figure 5. Frankel et. al.'s results are that $\alpha = 0.72$ and $\beta = 0.23$ with both coefficients significant at the one-percent level. The result that $\beta > 0$ supports the view that per-capita income is important and suggest that traded goods or especially differentiated goods are income elastic.

Parenthetically, the common result from gravity models that trade is per-capita-income elastic seems in contradiction with Trefler (1995), whose analysis points in the direction of high

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[11]Giving one coefficient to the product of the two incomes is a somewhat unusual formulation. A more typical formulation is to give separate coefficients for both countries (e.g., $\ln T_{12} = \alpha_1 \ln M_1 + \alpha_2 \ln M_2$ .....) with homogeneity implying that the α's sum to one. Feenstra, Markusen and Rose (2001) use the relationship between α_1 and α_2 to discriminate between alternative theories of trade.

per-capita income countries trading less as a share of income (e.g., if income-elastic services are non-traded). Trefler (pp. 1038-1040) derives this in connection with his "endowment paradox", which is that poor countries seem abundant in most factors and rich countries are scarce in most factors.

5. Econometric Support

Research has now made progress in estimating and testing the crucial assumption that produces some of the theoretical results above: the positive relationship between skilled-labor and capital intensity of a good in production and the income elasticity of demand for that good in consumption (Caron, Fally and Markusen, 2010). We use the GTAP7 data set (111 regions, 57 sectors, 5 factors, 6216 observations) which gives us the relevant capital, skilled, and unskilled-labor used in value added and also use an input-output structure to add the indirect use of K and skilled/unskilled L from intermediate use.

One difficulty we encountered in this estimation has to do with a limitation of the Stone-Geary (linear expenditure system) approach with is illustrated in the right-hand panel of Figure 1. While the LES estimating equations are intuitive, globally regular (coming from a utility function), and easy to work with analytically, the problem is that there is a small range of incomes between which elasticities are either very large (positive or negative) or converge to one. Figure 1 illustrates this problem.

Because of this limitation, I'll briefly present some results using Deaton and Muellbauer's (1980) "almost ideal demand system" (AIDS) in the estimation. Suppressing prices, this is given in (24) for *household* k where $\alpha > 0$ is an income-elastic good instead of $\alpha < 0$ in the LES formulation in (20).

$$\sigma_i^k = \beta_i + \alpha_i \ln(m^k) \tag{24}$$

Theoretically, AIDS is not as elegant (hence the "almost"): it does not allow aggregation and is not globally regular. It can lead to predicted shares greater than one and less than zero at extremes of income. But incomes elasticities of demand are less sensitive income, and income elasticities less than one continue to fall as income increases rather than converging to one as in the LES formulation.

The *observed* consumption shares of the i goods in the k countries are regressed on country k's average per capital income to estimate α_i and β_i in equation (24). The estimated values of α_i and β_i (common across countries) are then used with the country-specific average per-capita-income level to give the predicted consumption share of good i in country k.

$$\sigma_i^k = \beta_i + \alpha_i \ln(m^k) \qquad \Rightarrow \qquad \text{estimates } \hat{\alpha}_i \quad \hat{\beta}_i \qquad \Rightarrow \qquad \text{fitted values } \hat{\sigma}_i^k \tag{24}$$

Again suppressing prices, the shares are simply ($\sigma_i^k = x_i/m^k$) (assumes prices are the same everywhere and normalize them to one). Multiply both sides of (24) by *m* to get an expression for *x* and then differentiate and form the income elasticity of demand. The estimated income elasticity of demand for good i in country k is then given by η:

$$\eta_i^k = 1 + \frac{\alpha_i}{\beta_i + \alpha_i \ln(m^k)} \tag{25}$$

The logs of these estimated income elasticities are then regressed on a constant and the logs of the indirect capital-labor ratios across goods and countries with results shown in Table 2. I want to emphasize that there is *no implied economic causation* in this regression: we are only looking for and measuring a statistical correlation. Only a small amount of doctoring of the GTAP7 data is done: some nonsensical observations for negative and very high fitted values of η are dropped as are some zero and very large values for *K/L*. 97 percent of the GTAP observations are retained and all observations other than these extreme values are retained.

The (second step) regression results are shown in Table 2, where the second or lower panel adds country fixed effects. Results are highly significant in both economic and in statistical terms. The normalized Beta coefficients make a convincing case that goods that are skilled-labor and capital intensive are systematically goods with high income elasticities of demand. Goods that are unskilled-labor, land, or resource intensive have low income elasticities of demand. For the complete analysis, please see Caron, Fally and Markusen (2011).

6. Summary

As suggested in the introduction, there are bits-and-pieces of theoretical and empirical analysis about the role or roles for per-capita income in determining trade flows. But there is little unity and by and large per-capita income is not given much of a place as an important determinant of trade. This paper tries to unify and connect the bits, and to offer further ideas about how per-capita income might matter. I offer a "generic" model that I hope might prove useful for graduate teaching, a sort of all-in-one model that nests a number of other contributions.

The model imposes a variant of Stone-Geary preferences (used before by a number of authors) on top of a traditional 2x2x2 Heckscher-Ohlin model. Maintained hypotheses are that labor endowments in the HO model are proportional to the number of households and that the skill/capital-intensive good in the HO model is the high income-elasticity-of-demand good. The latter assumption is testable and fasifiable. Results from the model offer a strictly demand-side explanation for a range of phenomena including (a) home bias in consumption, (b) the mystery of the missing trade, (c) a growing skill premium in an environment of growing productivity and (d) a role for the intra-country distribution of income similar to that found in the product-quality literature (higher inequality - more demand for luxury goods).

TABLE 2: Income elasticities of demand regressed on factor intensities

$\ln e_{ik}$ regressed on $\ln v_{ijk}$ i = sector, j = factor, k = country

(from Caron, Fally, Markusen)

DEPENDENT VARIABLE: LOG (estimated) INCOME ELASTICITIES USING AIDS, EVALUATED AT COUNTRY MEAN INCOME

	Coef.	Robust Std. Err.	P>t	Beta		
Log skilled labor	0.061	0.004	0	0.251	No. of obs	5879
Log capital	0.047	0.005	0	0.126	F(5, 5873)	457.63
Log unskilled labor	-0.019	0.006	0.001	-0.060	R-squared	0.263
Log land	-0.027	0.002	0	-0.296		
Log resources	-0.022	0.001	0	-0.202		
constant	0.816	0.018	0	.		

DEPENDENT VARIABLE: LOG (estimated) INCOME ELASTICITIES USING AIDS, EVALUATED AT COUNTRY MEAN INCOME COUNTRY FIXED EFFECTS ADDED

	Coef.	Robust Std. Err.	P>t	Beta		
Log skilled labor	0.103	0.005	0	0.427	No. of obs	5879
Log capital	0.041	0.005	0	0.109	F(116, 5762)	30.68
Log unskilled labor	-0.041	0.006	0	-0.125	R-squared	0.415
Log land	-0.031	0.002	0	-0.343		
Log resources	-0.040	0.002	0	-0.367		
constant	0.793	0.029	0			

N.B.: factor intensities are indirect, including intermediate use:
income elasticity evaluated at mean world PCI

I then add an assumption of increasing returns to scale in the capital-intensive, high-income-elasticity industry with free entry and exit of firms, Cournot pricing and segmented markets: a common framework in the so-called new trade theory and strategic trade-policy literatures. This generates some interesting and testable results, in particular higher markups and higher price levels in higher per-capita-income countries, and more trade between higher per-capita-income countries, aggregate income held constant. As in the case of the competitive examples, some of the implications have already received good empirical support.

In both competitive and imperfect-competition cases, the effects of growth are quite different depending on whether it is growth in productivity or in neutral factor accumulation. This is potentially quite important in forecasting forward using econometric or CGE models: who would have predicted ten years ago that China would now be the world's largest car market? The paper gives a couple of suggestions about how the model might be useful in further calibration and estimation research and for including and interpreting per-capita income coefficients in gravity models. Models and econometric estimates based on homothetic demand and can significantly mis-predict the effects of growth through productivity and technical change.

Finally, new econometric results on the crucial (to some theoretical results) relationship between a good's skill and capital-intensity in production and its income elasticity of demand in consumption are presented. The estimates indicate a positive and economically and statistically significant relationship (a causal relationship is neither assumed nor implied at this point). Thus the results affirm the empirical relevance of the model, which offers much needed insights into most of the issues discussed in this paper, such as skill premiums, missing trade and cross-country differences in markups.

APPENDIX

Beginning with the *fitted* shares of consumption σ_i^k from (20) and the *observed* shares in world consumption σ_i^w, the fitted or predicted consumption vector for country k is given by

$$C_i^k = \sigma_i^k M^k = \frac{\sigma_i^k}{\sigma_i^w} \sigma_i^w M^k \tag{A1}$$

where

$$\sigma_i^w M^k = \frac{X_i^w}{M^w} M^k = \frac{M^k}{M^w} X_i^w = s^k X_i^w \tag{A2}$$

Substituting (A2) into (A1), we have the predicted value of consumption.

$$C_i^k = \left[\frac{\sigma_i^k}{\sigma_i^w}\right] s^k X_i^w \qquad C^k = s^k [\Sigma^k] X^w \qquad \sum_k C^k = [I] X^w \tag{A3}$$

where Σ is a diagonal matrix with its ith diagonal element equal to σ_i^k / σ_i^w. Let the predicted factor content of world consumption be given by

$$V^w = [A] X^w \qquad \text{so} \qquad s^k [A] X^w - s^k V^w = 0 \tag{A4}$$

Adding the right-hand equation of (A4) to (X - C), the predicted factor-content of trade is then

$$\begin{aligned} [A]E &= [A](X^k - C^k) = [A](X^k - s^k \Sigma^k X^w) \\ &= (V^k - s^k V^w) + s^k [A][I - \Sigma^k] X^w \end{aligned} \tag{A5}$$

where I is the identity matrix.

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Figure 1: Preferences and their properties

Engel's curve: Oy_0A

m_0: minimum income for consuming X

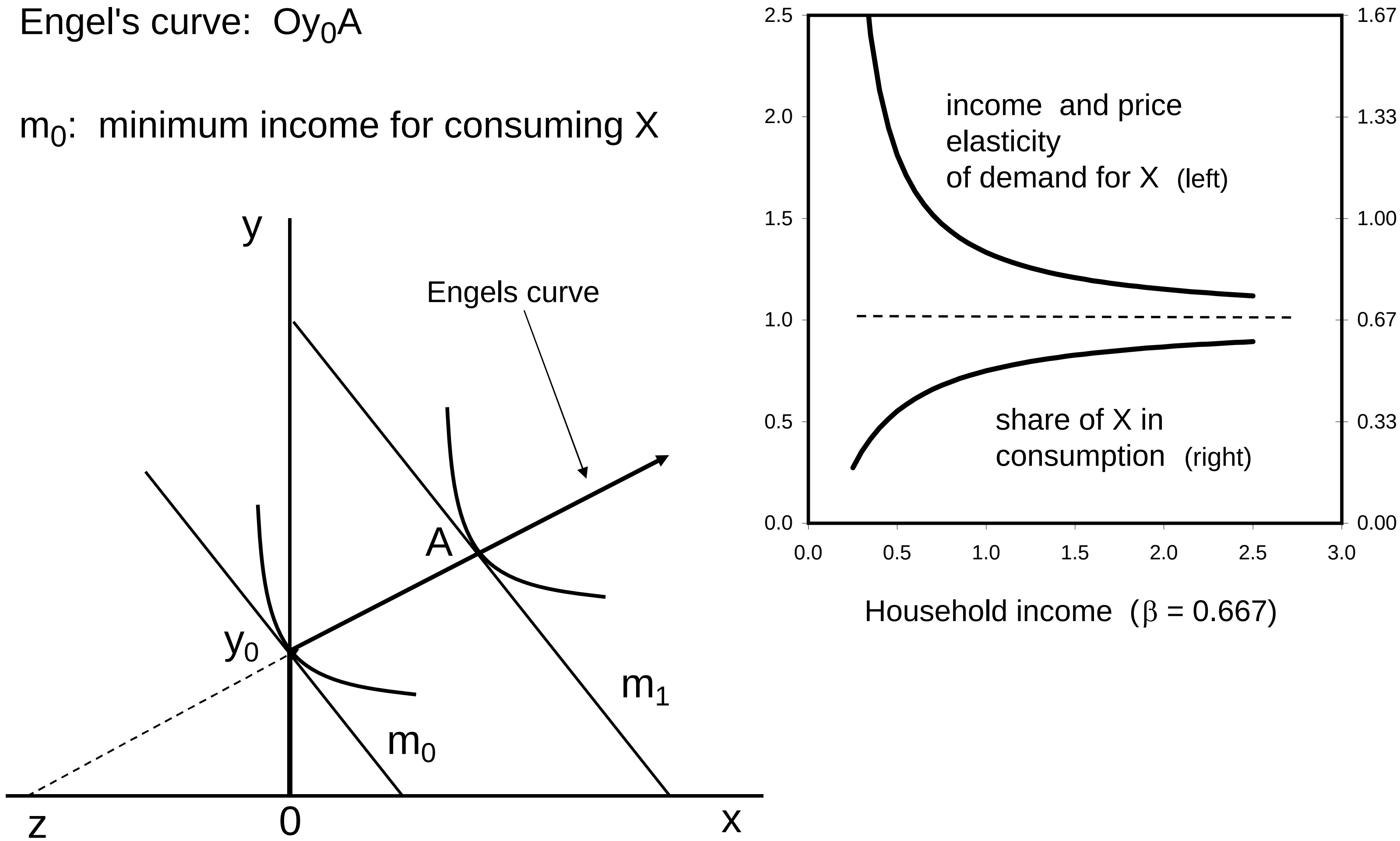

Figure 2: Growth through productivity versus factor accumulation

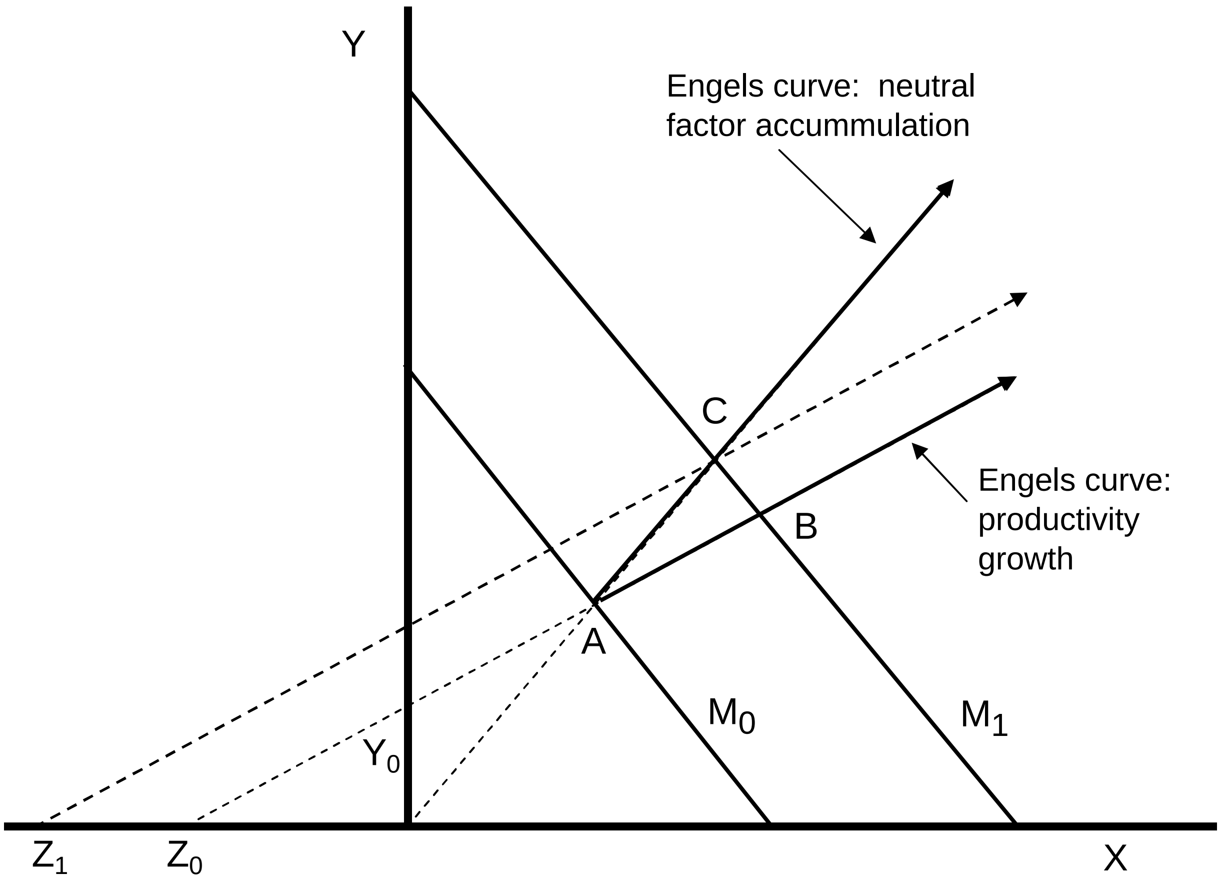

Figure 3: Wage gap from the demand side (identical countries)

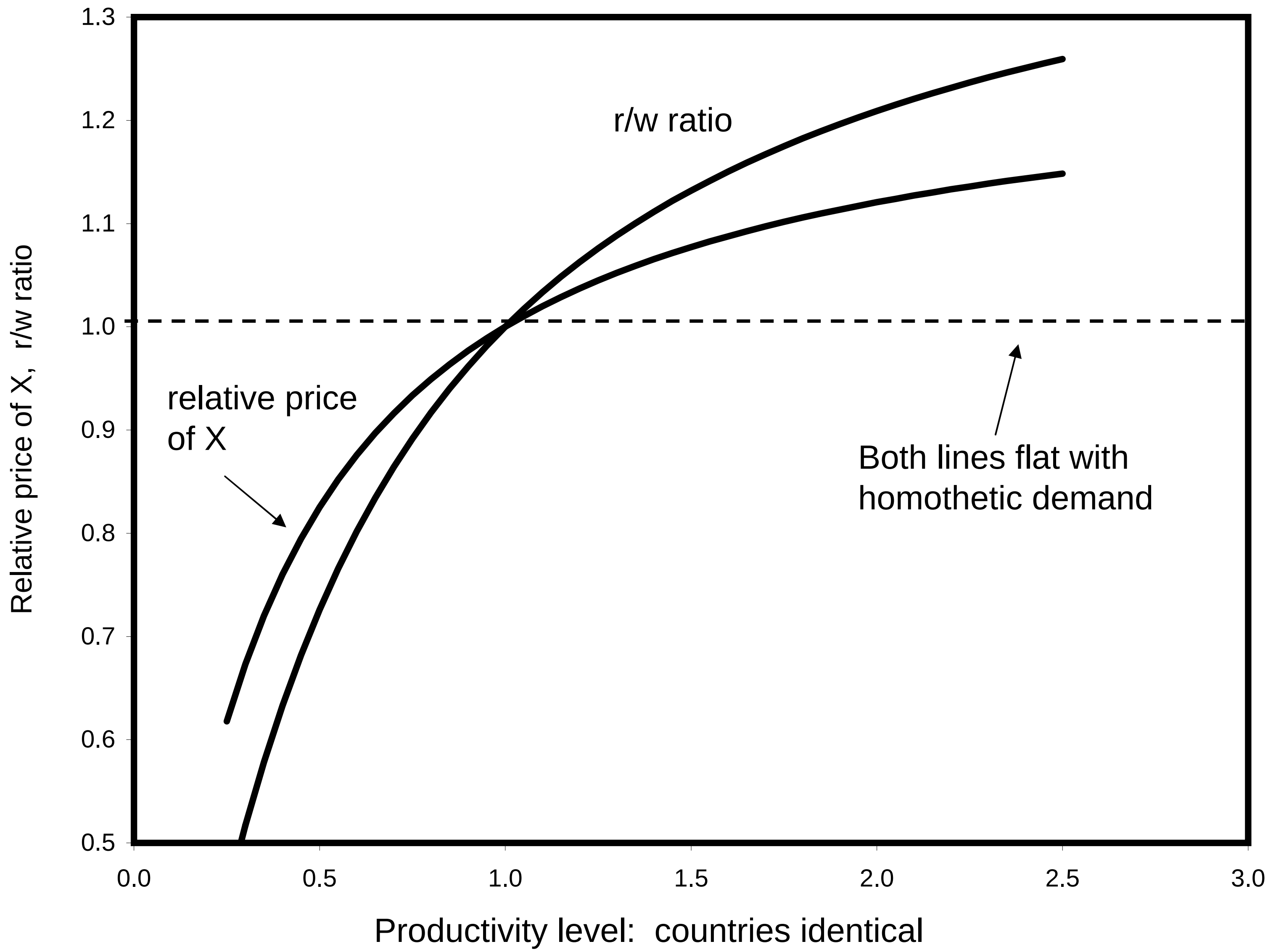

Figure 4: Home bias and the mystery of the missing trade

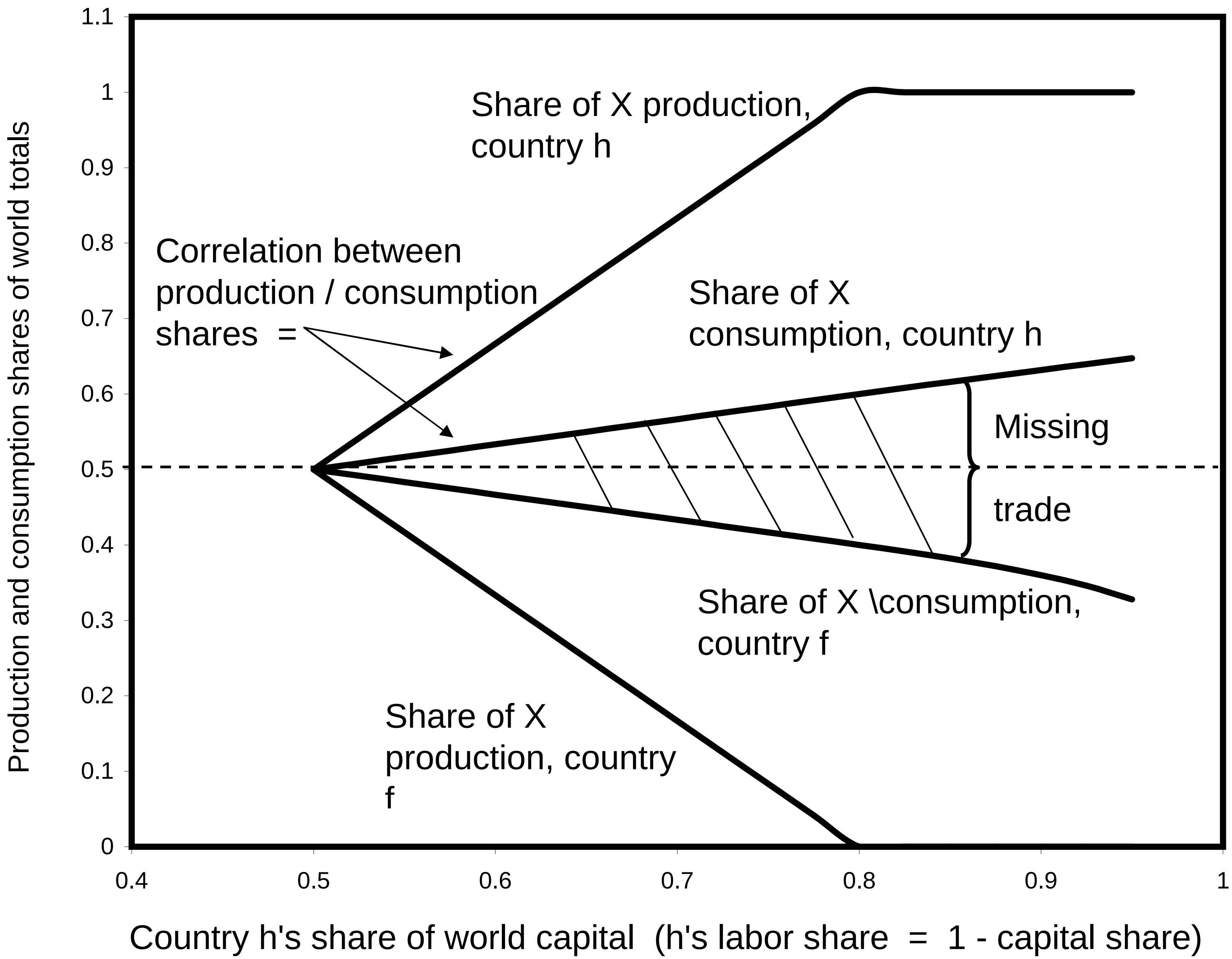

Figure 5: Per-capita income, markups, and price levels
Countries have identical and constant aggregate income