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VIOLATING PURCHASING POWER PARITY*

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Abstract

This paper demonstrates that deviations from the law of one price are an important source of violations of absolute PPP across countries. Using highly disaggregated U.S. export data, we document evidence of systematic international price discrimination based on the local wage of consumers in the destination market. We show that most violations from absolute PPP can also be explained by international differences in wages. We find very little additional explanation is due to differences in income per capita. Developing and calibrating a model of pricing-to-market based on search frictions and international productivity differences, we show that pricing-to-market accounts for 62 percent of the relationship between national price levels and income and 100 percent of the deviation from the law of one price. In contrast, the textbook Harrod-Balassa-Samuelson effect accounts for the remaining 38 percent of the relationship between national price levels and income.

JEL classifications: E31, F12. **Keywords:** PPP, Pricing-To-Market, Law of One Price.

1. Introduction

Absolute purchasing power parity (PPP) is one of the best known and most easily rejected ideas in economics. Across countries, there are substantial differences in the general price level so that the same basket of goods sells for a different price depending on the country in which it is sold.[1] A well-documented feature of this dispersion in prices is that price levels are strongly positively correlated with real per capita GDP, so that agents in low-income countries pay considerably less for the same basket of goods than agents in high-income countries.[2]

The dominant explanation for the relationship between income per capita and the price level is based on international differences in total factor productivity in the tradable sector. According to Harrod (1933), Balassa (1964), and Samuelson (1964) (HBS hereafter), rich countries are relatively more productive in tradables than nontradables. If the law of one price holds in the tradable sector, then international relative wages are determined by productivity differences in tradables. If productivity differences are relatively small in the nontradable sector, this implies that both nontradables and the common basket of goods are less expensive in low-income countries.

A central feature of the HBS explanation is the assumption that the law of one price holds for tradable goods. This is clearly violated in the data; substantial deviations from the law of one price exist for both tradables and nontradables. Using highly disaggregated data, Heston, Atten, and Nuxoll (1995) and Crucini, Telmer, and Zachariadis (2001) find that international deviations from the law of one price for tradables and nontradables are of nearly the same magnitude. Using data from the U.N. International Comparison Programme, Eaton and Kortum (2001) document

[1] For instance, in nearly half the countries in the Penn World Tables in 2000, a common basket of goods was less than one-third as expensive as in the United States, when prices are converted using nominal exchange rates. These substantial departures from PPP are quite persistent, as 10 years earlier, in 28 of the 51 countries for which we have data, the price level was still less than a third of the US price level. These countries with low price levels also have very low income, with GDP per capita on average one-tenth that of the U.S. level.

[2] See Kravis and Lipsey (1983, 1987, and 1988). Rogoff (1996) provides a review of PPP.

substantial dispersion in the price of highly tradable investment goods across countries. They also find evidence that low-income countries pay less than high-income countries for investment goods. Pharmaceutical drug prices provide a striking example of the dispersion in international prices for identical goods, as well as evidence of international price discrimination based on income (Danzon and Furukawa 2003).

In this paper we explore the quantitative contribution of deviations from the law of one price in tradables to the relationship between national price level and income. Using highly disaggregated data on exports from the United States to different countries, we document that U.S. exporters systematically charge higher prices for the same good when exporting to high-income countries. These data are well suited to isolating the role of this type of pricing-to-market because they measure export prices at the U.S. border before any local nontraded inputs are added. We find pricing-to-market to be substantial, since the richest country in our sample pays, on average, 49 percent more than the poorest country for the same good.

Next, we develop a model of pricing-to-market based on search frictions and international productivity differences similar to Alessandria (2002). In our model, countries differ in total factor productivity. Additionally, consumers have imperfect information on where to find goods at the lowest price and must actively search. When deciding the optimal trade-off between additional searching or accepting a higher price, consumers consider the opportunity cost of search. Since search takes time, this opportunity cost depends on the forgone wage, and hence the price consumers accept also depends on the local wage. Consumers from more productive countries have relatively high wages; so they are willing to accept higher prices to avoid diverting more resources from labor to search. Firms take this into account and set relatively high prices in these high-income countries. This produces a tight link between prices and the local wage.

That it is wages, and not income per capita, that generates pricing-to-market is confirmed by the data. That is, using a subset of PWT countries for which we also have manufacturing wages, we find that international differences in wages explain substantially more of the violations from absolute PPP than income per capita. Moreover, in a simple linear regression of prices on both wages and income per capita, we find that the coefficient on income per capita is no longer significant.

We also use our model to quantitatively distinguish between the traditional HBS effect and our pricing-to-market channel. With no HBS effect, we find that the pricing-to-market accounts for approximately 44 percent of the deviations from PPP and 87 percent of the deviations from the LOP in the data. With technological progress that is faster in the tradable sector, we find that pricing-to-market of the form considered here accounts for 62 percent of the violations of absolute PPP and nearly 100 percent of the deviations from the LOP. In contrast, changes in the price of nontradables to tradables, as emphasized by HBS, account for only 38 percent of violations of absolute PPP.

Pricing-to-market is the dominant factor explaining PPP deviations because it is both empirically substantial and applies to all goods, not just a subset of nontraded goods. In our pricing-to-market model, technological progress biased toward tradables has an important two-fold role in explaining violations from PPP. First, there is the traditional HBS mechanism making nontradables relatively more expensive in high-income countries. Second, with technological progress biased towards tradables, the wage gap between countries is relatively large compared to real income. These larger international wage differences lead to larger deviations from the LOP for both tradables and nontradables. Consequently, with pricing-to-market we find that tradable productivity growth only needs to be about 60 percent faster than nontradable productivity growth to explain the relationship between PPP and income, whereas with the traditional HBS model, tradable productivity must grow 10 times faster than nontradable productivity.

A few existing theories present alternatives to HBS in explaining the systematic deviations from absolute PPP. Kravis and Lipsey (1983) and Bhagwati (1984) attribute these deviations to substantial differences in factor endowments.[3] Dornbusch (1988) and Neary (1988), building on the ideas of Linder (1961), focus on differences in tastes across countries. Bergstrand (1991) explains price levels in a model with nonhomothetic preferences in which nontraded goods are luxuries and traded goods are necessities. Bergstrand finds evidence that demand considerations are important determinants of national differences in price levels. Along with the HBS theory, these competing theories assume that the law of one price holds for tradables and therefore cannot account for the large and persistent deviations from the law of one price in traded goods.

Our explanation for deviations from absolute PPP complements previous theories based on supply and demand considerations. In our model, high-income countries have a comparative advantage in the production of market goods relative to search services. Since search services are not traded, they are less expensive in low-income countries, and this makes demand by low-income consumers more elastic. To consume goods, consumers must produce nontraded search services. As in HBS then, the true cost of a final good includes a nontraded search component. However, unlike in HBS, because consumers have imperfect information on where to buy goods inexpensively, firms can price discriminate internationally so that the price of the traded good differs across countries.

This paper is also related to two other recent literatures that have emphasized the role of absolute PPP in understanding economic growth and international fluctuations. In the growth literature, international prices are often used both to make welfare comparisons across countries and to measure total factor productivity. Hsieh and Klenow (2003) and Eaton and Kortum (2001) demonstrate that the variation in prices of tradables across countries is important for explaining cross-country variation in incomes. In the international business-cycle literature, recent work by

[3] These authors propose a model with two internationally immobile factors. Poor countries are abundantly endowed with labor relative to capital. If consumption tastes are the same in rich and poor countries and factor endowments so dissimilar that they specialize in different tradables, wages will be lower in poor countries, as will the price of the relatively labor-intensive nontradable.

Engel (1993, 1999), Asea and Mendoza (1994), and Chari, Kehoe, McGrattan (2002) has found that the HBS model cannot account for fluctuations in real exchange rates at business-cycle frequencies. Alessandria (2002) shows that pricing-to-market of the form considered here increases the volatility of international relative prices over the business cycle.

The paper is organized as follows. The next section discusses the aggregate and disaggregate data relationship between prices, income, and wages. In section 3, we introduce a two-country, three-good model of international price discrimination. Section 4 discusses and evaluates the quantitative implications of the model in relation to the empirical findings of section 2. Section 5 concludes.

2. Empirics

The data show a strong positive relationship between the price levels of tradables and the income levels of countries, both at the aggregate level and in the micro data. Aggregate macro evidence is presented in Figures 1 and 2. Figure 1 shows a strong positive relationship between PPP price levels and income levels in the cross-section of countries using data from Penn World Table 6.1, where prices are based on ICP data on final prices of goods. A linear regression of the relationship in Figure 1 produces a significant elasticity estimate of 0.393. Although nontradables contribute to this relationship, the price of observable tradables shows a similar relationship. For example, Figure 2 shows a positive relationship between aggregate equipment prices and income per capita in a cross-section of countries. Since a price measure for tradables is unavailable, and equipment is considered more tradable than consumption goods, the price level for equipment is used. A linear regression of the relationship in Figure 2 produces a significant elasticity estimate of 0.13.

These aggregate data suffer from three important problems for evaluating the source of the relationship between prices and income. First, although equipment is an important component, it is not the only component of tradables.

Second, the equipment priced in different countries may be of very different quality. If wealthier countries consume higher quality tradables, on average, prices may reflect quality variation. Thus, the positive price-income relationship observed for tradables may not be at odds with the HBS model at all, but could simply be an artifact of these three data issues. Indeed, Eaton and Kortum (2001) and Hsieh and Klenow (2003) cite quality variation as a potential explanation for the aggregate relationship.

Finally, the ICP data use final goods prices. Thus, these prices include variations in shipping costs, tax structures, and costs of nontradable components (e.g., distribution, retailing, etc.) Shipping costs (Clark, Dollar and Micco, 2004) and tariffs (Easterly and Rebelo, 1993) tend to be larger for exports to poorer countries. Thus, if firms price discriminate, the aggregate data may underestimate the amount of price discrimination. Eaton and Kortum and Hsieh and Klenow have conjectured that inexpensive nontradable distribution costs lead to lower final prices of tradables in low-income countries. However, large productivity differences in distribution, retailing, etc. between rich and poor countries may actually make distribution services, the relevant nontradables, relatively more expensive in poor countries. For example, Burstein, Neves, and Rebelo (2003) find that distribution costs amounted to an additional 64 percent of the price of goods in Argentina compared to just 45 percent in the U.S. In any case, the measured price-income relationship could be distorted by differing costs included in final goods prices.

The micro data we analyze, U.S. Exports Harmonized System (1989-2001) data (see Feenstra et al. (2002)), helps us to bypass each of the above potential problems in determining the source of the relationship between prices and income but yields similar results. Beyond allowing us to examine the international deviations of the law of one price in addition to deviations from PPP, these microdata have significant advantages over the aggregate data in the three dimensions mentioned above.

First, the data are comprehensive of all U.S. domestic exports (i.e., excluding re-exports) and therefore include only tradable goods as well as a broad range of tradables beyond investment goods. We have annual totals of the quantities and value of commodities exported to all 182 destination countries. We can link these export data to GDP per capita for 128 countries from the Penn World Table 6.1. For 28 of these countries we also have manufacturing wage data from the U.S. Bureau of Labor Statistics.

Second, the issue of quality is mitigated for two reasons. First, the data all come from the United States, and so the goods are likely to be more homogeneous in quality than goods coming from all countries (including the destination country) as with the ICP equipment prices. Second, the data include 10,741 commodities classified using the 10-digit Harmonized System product codes, and so it is extremely disaggregated. We drop any commodity with a description containing words like "other,"[4] "not elsewhere specified or included," "NESOI," and "parts" because they are likely to be heterogeneous groups. We also drop commodities containing "$" (e.g., goods categorized by their price level). This reduced set of 5,527 detailed product groups is more likely to be homogeneous goods.[5] (Appendix A provides the names of 30 randomly selected goods from the dataset as an example of the level of detail.)

Finally, export prices are based on free-along-side ship values,[6] and so they do not include transportation costs, tariffs, and nontradable components such as distribution and retailing costs in the importing country. One complication, however, is that we do not directly observe prices. Instead, the data include the total value and quantity sold, and so we calculate unit values.

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[4] We allow the phrase "other than" because it specifies a higher level of detail.

[5] Several variations of standards for determining "homogeneous" goods (i.e., dropping goods based on the detailed product description only, dropping goods based on the abridged production description only, and dropping goods that lacked units) as well as several methods for dealing with the role of outliers (i.e., dropping low value observations, dropping low quantity observations, dropping commodities whose price variation was deemed unrealistic, and robust regression) were examined. While their magnitudes vary somewhat, the fact that coefficients were quantitatively important and significant was robust to these different specifications.

[6] The free-alongside-ship value is the selling price or cost if not sold, including inland freight, insurance, and other charges to the U.S. port of export, but excluding unconditional discounts and commissions. It is essentially the price received by the exporting country before shipment.

We present three essential findings from the data: 1) rich countries typically pay higher prices for the same exports than poor countries and the relationship is strong, sizable, and significant; 2) this relationship is linked more closely to the destination countries' levels of wages than their income per capita levels.; and 3) this relationship is not likely driven by unobserved variation in quality. Indeed, any unobserved variation in quality may very well understate the relationship.

For expositional purposes, consider the case of a monopolist selling the identical good i in different markets (e.g., countries) j. Given a common cost but different demand, the firm will, in general, charge price p equal to a market-varying markup μ over a common marginal cost c. Hence, marginal costs may vary across goods, and markups will vary across goods and destination markets:

$$\ln p_{ijt} = \ln c_{it} + \mu_{ijt}$$

The purpose is to examine whether μ_{ijt}, the markup charged on good i at time t to destination country j is related to the level of income per capita or wages of that country. We focus on the 28 countries for which both wage and income per capita data are available, which nonetheless constitute 76 percent of all exports in the full sample. Results using GDP per capita for all 128 countries for which GDP per capita data are available are comparable[7] and are presented in Appendix B.

Table 1 presents the estimated coefficients from regressions of log price level on log income and/or log wages, where variation in $\ln c_{it}$ is controlled through fixed effects for each commodity-year combination. We measure incomes in prices in both PPP and exchange rate terms, since it is not entirely obvious which method of deflation is most appropriate given the model we present in Section 3. The first row of the table gives the estimates using all the (homogeneous good) data and

[7] The qualitative findings in the full sample (128 countries) match the reduced sample (28 countries) for GDP per capita, but the magnitudes of estimates were much more sensitive to the choice of which goods to define as "homogeneous", and to outliers. (Robust regressions produced the strongest results, for example.) To get rid of outliers, believed to be the result of measurement error, we dropped commodities with no units given from the full country sample.

measuring log incomes and wages in PPP terms. The "GDP per Capita Only" estimate, from a regression where log GDP per capita is the only regressor (in addition to the fixed effects), yields an elasticity estimate of 18.2 percent. The "Wage Only" estimate is somewhat smaller at 16.6 percent. Though both estimates are highly significant, when we include log wages and log GDP per capita together in the same regression, log wages win the horse race hands down. These estimates are presented in the right-most two columns. The estimated coefficient on wages remains at nearly the same level (15.5 percent) and is highly significant, while the GDP per capita coefficient estimates become much smaller (2.1 percent) and is much less significant.[8]

The second and third rows of the uppermost table show that these results do not hinge on outliers. If we drop observations where the total value exported to a given country is less than 1 percent or 5 percent of the total value of the commodity exported to all countries in a given year, many observations are dropped but the quantitative estimates remain similar and highly significant.

The lower table presents analogous results except that income and wages have been converted to a common currency using nominal exchange rates for these regressions. In these estimates, the pattern between log wages and log income per capita is unchanged, but all of the measured elasticities are smaller in exchange rate terms (13.6 percent for income per capita and 12.6 percent for wages) than the estimates using PPP-based measures (again, 18.2 percent for income per capita and 16.6 percent for wages).

Based on the estimates in Table 1, the magnitude of the price-wage relationship is potentially large. In 2000, the difference in log wages between the richest and poorest countries in the data set (Germany and Sri Lanka, respectively) was 3.9 measured in exchange rate terms (2.4 in PPP terms). Hence, the implied price differences in U.S. exports to these countries would be 49 percent

[8] Nevertheless, the estimate of this coefficient usually (the lower table in Table 1 shows an exception) remains statistically significant. Since our data is for manufacturing wages, it may be that the data are an imperfect proxy for the average wage overall and so some of the average wage variation that is independent of our proxy is captured by income per capita.

(40 percent using PPP).

Although the data are extremely disaggregated, as stated above, one might still suspect that the positive relationships uncovered are driven by unobserved variation in quality, with wealthy countries tending to import higher quality (and thus higher priced) goods within the 10-digit commodity categories. Since any variation in quality within 10-digit categories is unobservable, this cannot be ruled out. However, in terms of observable variation in quality the tendency is actually in the *opposite* direction. That is, *poorer countries import higher quality (e.g., higher priced) goods from the U. S.,* on average.

To show this, we replicate the regressions using broader categories of goods. Table 2 shows that estimates from fixed effect regressions like those in Table 1 are systematically lower for regressions using these aggregated heterogeneous categories than for those with disaggregated categories. The aggregated product categories are produced by dropping digits from the 10-digit classification system and summing the quantities and values exported across all categories.[9] For example, in the 9-digit case, all categories that are identical up to the first nine digits are summed together into a single observation. Only 307 commodities are unique up to all ten digits and these are combined into 133 heterogenous 9-digit categories. As more digits are dropped, the categories become broader and more heterogeneous, more goods are combined into groups, and more observations can be included in the regressions. For example, at five digits artificial Christmas trees are simply artificial Christmas trees, while at seven digits these are subdivided into plastic and nonplastic artificial Christmas trees, one of which may have higher average prices and therefore be considered higher quality artificial Christmas trees. (A random selection showing how categories are combined at different levels

[9] A nice feature of this approach is that it answers an easy question in relation to the data, "What would the regressions look like if the data were less disaggregated?" Unfortunately, aggregation effectively reweights observations by the quantity transacted. An alternative approach, which gives every observation the same weight in both regressions, is to run regressions on the disaggregate data and compare 1) the estimates of regressions with fixed effects for each disaggregated commodity and 2) the regressions with fixed effects for the larger aggregated commodities. The disaggregated and aggregated (at different levels) estimates were nearly identical and so would imply no quality bias in either direction.

is given in Appendix C.) For all of these aggregations, the estimates in Table 2 are systematically lower using the heterogeneous categories than with the disaggregated data. Hence, we conclude that poorer countries may actually import higher quality goods from the U.S.

The relationship is so surprising that the claim bears further explaining. The data are not implying that poor countries tend to consume higher quality goods on average than wealthy countries do, only that they tend to *import* (from the U. S.) higher quality goods. Perhaps, poor countries have inexpensive domestic substitutes for low-quality but not high quality goods. Hence, imports from the U.S. are weighted toward high-quality goods. That is, the U.S. has a stronger comparative advantage in high quality goods relative to poor countries than relative to other high-income countries. Another possibility is that as countries develop, they invest in capital that is closer to the frontier than the installed base of capital in developed countries. If a substantial fraction of developed country trade involves replacing existing capital rather than upgrading, we could expect to see this quality effect. However, explaining the source of this effect is outside the scope of this paper.

Again, we cannot definitively rule out or sign a bias that might come from unobserved variation in quality in our goods categories. However, if our 10-digit categories are indeed aggregations of goods that are heterogeneous in quality, a natural prior given the evidence would be to assume that they follow the pattern observed at all other levels of aggregation. In that case, we view the estimates in Table 1 as conservative estimates of the extent of the true price-income relationship.

The estimated elasticities will be used as benchmarks for quantitatively evaluating the explanatory power of the model developed in Section 4. We therefore summarize the main findings of this section:

- The macro data yield an elasticity of violations of PPP with respect to PPP income per capita levels of 39 percent.

- The elasticity of deviation in the law of one price with respect to PPP income per capita is about 20 percent.
- The corresponding law of one price elasticity is slightly smaller with respect to wages (16 percent in exchange-rate terms), but the relationship is stronger.
- The elasticities are smaller (14 percent for income per capita and 13 percent for wages) if exchange-rate conversions are used.

The micro evidence shows that pricing-to-market is an important source of the violations from PPP. In thinking about a model of pricing-to-market, the fact that wages are the important driving factor points toward a model where variations in time costs yield variations in the price elasticity of demand across countries (as in our search model), rather than a model where nonhomothetic preferences and income effects drive these differences in the elasticity of demand.

3. Model

This section develops a two-country, three-good model in which there is a positive relationship between disaggregate and aggregate international relative prices and wages and income as a result of pricing-to-market. In this model, firms charge higher prices on average in those countries where wages are higher. Consumers in these high wage countries accept these higher prices because they have a high opportunity cost of time and are thus less willing to search repeatedly.

There are three imperfectly substitutable goods $j = \{1, 2, 3\}$ and two countries denoted $i = \{1, 2\}$. Goods 1 and 2 are tradables with good 1 produced exclusively in country 1 and good 2 produced exclusively in country 2. Both countries can produce good 3, but it is not tradable. Including both tradables and nontradables allows us to distinguish between pricing-to-market and the traditional HBS effect.

In each country, there are many stores, each specializing in the sale of a single type of good. For simplicity we assume that the measure of each type of store in each country is the same. Households do not know the price charged at any store and must physically visit a store to discover its price. As in Diamond (1971), because search takes time and is imprecise, stores have some monopoly power over consumers and thus may charge different prices for the same good.[10]

Households must send out shoppers to search for the lowest price quotes and purchase goods. Each shopper can buy at most one unit of the good. Shopping therefore takes time away from work and is imperfect in the sense that consumers do not simultaneously receive price quotes from all the stores in the market. We model search as noisy, as in Burdett and Judd (1983), so that a fraction q of shoppers receive a single price quote while the remaining shoppers $(1-q)$ receive two price quotes. The probability a shopper receives a single price quote is random and equals q. After receiving either one or two price quotes, the shopper must decide whether to purchase a single good at the lowest price quote received or return home empty-handed.

Although without searching, agents do not know the price charged at a specific store, they do have perfect information about the *distribution* of prices in the economy. The distribution of prices p set by stores selling good j in country i is denoted by $G_{ij}(p)$. Search is directed in the sense that a shopper from country j looking for good i receives only domestic price quotes for good j, i.e., price quotes from the distribution $G_{ij}(.)$. Since the shopper can buy at most one unit of the good, only the lowest price quote received by a shopper is relevant to the shopper's purchase decision. The distribution of lowest price quotes received by shoppers is then

$$H_{ij}(p) = qG_{ij}(p) + (1-q)\left[1 - (1 - G_{ij}(p))^2\right].$$

From the firm's perspective, noisy search makes the consumers heterogenous in that some

[10] In principle one could allow for more heterogeneity in the types of tradable goods produced in each country, but this would complicate the analysis without changing our result: the price charged would still depend on the opportunity cost of search of consumers.

shoppers will only have one price quote, while others will have multiple price quotes. Consumers with multiple price quotes will differ in their second price quote. As firms can not distinguish between these different customers, the price they charge will influence both the profit per sale and the share of shoppers with multiple price quotes that they attract.

A. Consumer's Problem

The structure of the consumer's problem is similar to that in Alessandria (2002). In each country, there are many identical families. We use lower case variables to denote the decision rules of individual households and upper case variables to denote aggregate decision rules. Each family is composed of a large number of agents, normalized to a continuum of measure one.[11] The problem of a family is to divide between shoppers and workers and to give shoppers instructions on which prices to accept. A household in country i must choose the number of agents n_{ij} to send out shopping for each good j and the number of agents l_i to send out working, which generates the following constraint:

$$(1) \quad \sum_j n_{ij} + l_i = 1,$$

Alessandria (2002) shows that it is optimal to send each agent shopping for good j with a reservation price rule to purchase only if the lowest price quote is below some reservation level, r_{ij}. The consumption of good j by country i consumers depends therefore on both the reservation price and the measure of shoppers. Because there are many shoppers sent out for each good, there is no uncertainty in the amount of goods consumed, which equals:

$$(2) \quad c_{ij} = n_{ij} H_{ij} \left(r_{ij} \right).$$

[11] We assume each family is comprised of only agents from the same country.

Given the reservation price, the average purchase price is evaluated from the truncated distribution of lowest prices:

$$(3) \quad p_{ij}\left(r_{ij}\right) = \frac{\int_0^{r_{ij}} p dH_{ij}\left(p\right)}{H_{ij}\left(r_{ij}\right)},$$

which is clearly increasing in reservation price.

The representative home family chooses reservation prices and shoppers for each good to solve the following problem:

$$\begin{aligned} U_i &= \max_{\{r_i, c_i\}} U\left(c_{i1}, c_{i2}, c_{i3}\right) \\ \text{subject to} &: \left\{ \begin{array}{l} \sum_j p_{ij}\left(r_{ij}\right) c_{ij} = w_i l_i + \Pi_i, \\ \text{equations (1), (2), (3)} \end{array} \right. \end{aligned}$$

where U_i is the utility function in country i and Π_i is the profits earned by country i firms.

In this framework, consumers can adjust consumption along two margins, either by changing the number of shoppers or the price they will accept. If there is an interior solution, the problem generates the following first order conditions:

$$\begin{aligned} (4) \qquad r_{ij} &= \frac{w_i}{H\left(r_{ij}\right)} + p_{ij}\left(r_{ij}\right), \qquad j = 1, 2, 3 \\ (5) \qquad \frac{U_{i1}}{U_{ij}} &= \frac{r_{i1}}{r_{ij}}, \qquad j = 2, 3 \end{aligned}$$

where U_{ij} is the marginal utility of good j.

Equation (4) is an arbitrage condition that implies, at the margin, the family is indifferent between increasing consumption by purchasing at the reservation price or sending out additional shoppers, whose opportunity cost of search is measured in terms of the forgone wage, and purchasing at the average price of the good in the market. With a reservation price of r_{ij}, the family expects to send out $1/H(r_{ij})$ shoppers to purchase a single unit. Since the reservation price is linked to the true cost of the good, it is this cost that matters at the margin; therefore, the family chooses consumption so that the marginal rate of substitution between any two goods equals the ratio of their reservation prices as in equation (5).

Our focus is on difference in prices across countries with different incomes and therefore we have focused on a representative consumer in each country. However, it is straightforward to extend the model to permit heterogeneity in wages. In this case, we see from equation (4) that consumers with high wages will search less intensively than consumers with low wages. McKenzie and Schargrodsky (2004) find evidence of precisely this behavior. Using a unique dataset on consumer purchasing behavior in Argentina, they find that consumers in the 10th percentile of income spend about 30 percent more time shopping per purchase than consumers in the 90th percentile of income.

B. Firm's Problem

There are many firms in each country specialized in the production of either the country's tradable or nontradable good. The firms within a country are *ex ante* identical. Labor is the only input into production, and one unit of labor in country j produces a_j^T units of the tradable good (good j) and and a_j^{NT} units of the nontradable good (good 3). To focus on international price discrimination, we assume that firms can costlessly sell their goods in either country through the pre-established outlets.[12]

We focus on the problem of a representative firm in country j selling the tradable good (good j) in country i. Even though firms produce the same good, the search frictions give each firm some monopoly power and leads firms to behave as monopolistic competitors.[13] Each firm takes the

[12] Introducing domestic intermediaries to purchase abroad and sell domestically would not alter our results as firms selling to the intermediaries would take into account the elasticity of demand of domestic consumers when setting prices.

[13] Our model is similar in spirit to the traditional macro model with monopolistic competition and Dixit-Stiglitz preferences. The main difference is that the elasticity of substitution between varieties depends endogenously on the search structure.

distribution of prices charged by other firms selling the same good, G_{ij}, the number of price quotes that it delivers, the reservation price of consumers, R_{ij}, and the unit cost of production, w_i/a_i^T, as given. Given the constant returns to scale production, the amount of sales does not influence a firm's unit cost. Thus, the firm's problem becomes one of maximizing profits per customer that receives a price quote. The representative firm from country 1 selling in country i solves:

$$\pi_{ij} = \max_p \left(p - \frac{w_j}{a_j^T} \right) Q_{ij}(p),$$

where $Q_{ij}(p)$ is defined as the probability that a firm makes a sale when charging a price p and equals:

$$Q_{ij}(p) = \begin{cases} \frac{q}{2-q} + \frac{2(1-q)}{2-q} \left[1 - G_{ij}(p)\right] & \text{for } p \leq R_{ij}, \\ 0 & \text{otherwise.} \end{cases}$$

Because each shopper expects to receive $2 - q$ price quotes, the probability that a customer has a single price quote is $q/(2-q)$. As long as the firm's price is below the reservation price, the firm will sell to all customers with one price quote. By increasing its price, the firm increases its revenue per sale but decreases the likelihood of a sale, since it increases the probability that those customers with two price quotes have a second price quote that is lower than the firm's price.

Burdett and Judd (1983) have shown that given a reservation price and cost of production, a unique distribution of prices exists and that firms choose their price by randomizing over the support of the distribution. The following proposition summarizes the characteristics of the distribution of prices.

Proposition: Given R_{ij} and $\frac{w_j}{a_j^T}$, $\exists$ $G_{ij}(p), \pi_{ij}$ and $\underline{P}_{ij}$ so firms are indifferent charging

$p \in \left[\underline{P}_{ij}, R_{ij}\right]$ where

$$G_{ij}(p) = \begin{cases} 0 & p < \underline{P}_{ij} \\ 1 - \frac{q}{2(1-q)} \frac{R_{ij}-p}{p-w_j/a_j^T} & p \in \left[\underline{P}_{ij}, R_{ij}\right] \\ 1 & p > R_{ij} \end{cases}$$

$$\underline{P}_{ij} = \frac{2(1-q)\, w_j/a_j^T + qR_{ij}}{2-q}$$

Firms earn the same profit by charging any price on the support of the distribution. Firms that charge relatively high prices primarily sell to those consumers with a single price quote, while those with relatively low prices attract more of those shoppers with multiple price quotes. Because firms are indifferent between any price, they can use G_{ij} to choose prices by randomizing on the support of the distribution

C. Equilibrium

The total demand for labor by firms producing tradables in country i is:

$$L_i^T = \frac{N_{1i} + N_{2i}}{a_i^T},$$

and the demand for labor in the nontradable sector is:

$$L_i^{NT} = \frac{N_{i3}}{a_i^{NT}}.$$

The labor market clearing condition is:

$$L_i^T + L_i^{NT} = L_i$$

A symmetric equilibrium is then a distribution of prices, G_{ij}, and wages, w_j; consumer decision rules $\{l_j, n_{ij}, r_{ij}\}$ and aggregate decision rules $\{L_j, N_{ij}, R_{ij}\}$ in each country $j = \{1, 2\}$ for each good $i = \{1, 2, 3\}$ such that: (1) Given prices, wages, and profits, consumer's decision rules solve the household's problem in each country; (2) Given prices and wages, each firm chooses a price to solve each firm's problem; (3) Goods and labor markets clear; and (4) Individual and aggregate decisions are consistent so that all households from the same country behave identically.

Alessandria (2002) shows that the highest price in the market equals the reservation price. This upper bound on prices is an equilibrium because the highest priced firms have no incentive to charge a price above the reservation price, as they would lose all sales.[14] As no shopper returns empty-handed, the marginal cost of each good in each country is the average price paid for it plus the opportunity cost in wage income from shopping for it. At the margin the consumer is indifferent between increasing consumption by using more shoppers or a higher reservation price so that:

$$r_{ij} = w_i + p_{ij}\left(r_{ij}\right)$$

This implies that the true cost of the good is equal to the nontraded search cost plus the actual market price.

Our focus is on the relationship between prices, income and wages. Even though there are many prices charged in each country, we focus only on the mean transaction price as this most closely corresponds to the measure used by the national statistical agencies. By substituting the equilibrium reservation price into the distribution of prices, we can use equation 3 to solve for the

[14] This would not necessarily be true if consumers from both countries could search in the same market. Some firms would choose to sell only to those consumers from the country with the high reservation price.

mean transaction price for tradables of good j (from country j) sold in country i as:

$$(6) \quad p_{ij} = \frac{w_j}{a_j^T} + \frac{qw_i}{1-q}.$$

For nontradables, the mean transaction prices is:

$$(7) \quad p_{i3} = \frac{w_i}{a_i^{NT}} + \frac{qw_i}{1-q}.$$

The average price for good j paid by a consumer in country i, is equal to a markup over the marginal cost of the firm from country j. The markup depends on both the information structure of search and the physical cost of search. Anything that leads the search cost to differ across countries will lead to differences in the mean transaction price. Holding the information structure constant, which is summarized by q, we see that agents in a country with a low wage will, on average, purchase goods at a lower price than agents in a country with a relatively high wage. Consequently, the model predicts a strong relationship between prices and local wages.

Equation (6) also points out the critical differences between our model and the HBS model. In both models, tradables may sell for different prices across countries. In HBS, the price of tradables may differ internationally when there is a nontraded input, such as wholesale or retail distribution, to get the good to the final consumer. Suppose, for instance, that in each country it takes η_i unit of local labor to get a product to a local consumer. Under perfect competition the retail price of a good from country j sold in country i will equal:

$$p_{ij}^{retail} = \frac{w_j}{a_j} + \frac{w_i}{\eta_i},$$

but the price at the border is still:

$$p_{ij}^{border} = \frac{w_j}{a_j}.$$

Thus, HBS generates deviations from the law of one price in tradables because consumers must purchase a nontraded good along with the traded good. In our model of pricing-to-market, the search cost is similar to the nontraded retail or distribution costs in HBS. Unlike the case in HBS, this search cost is borne by the consumer and through the search frictions is incorporated into the price charged at the border.

4. Quantitative Results

In this section we compare the quantitative properties of the model to the observed deviations from the law of one price documented for U.S. exports as well as the observed violations in absolute PPP from the Penn World Tables. We first show that the model can account for a substantial portion of the deviations from the LOP and violations in absolute PPP when the productivity difference across countries is the same in tradables and nontradables. Moreover, we find that our model closely matches the observed relationship between wages and prices. We then use our framework to quantify the importance of pricing-to-market relative to the traditional HBS effect arising from productivity differences that are biased toward tradables. We find that pricing-to-market appears to be the dominant source of the well-established relationship between aggregate prices and income, accounting for approximately 62 percent of this relationship, while the traditional HBS channel accounts for the remaining 38 percent. Finally, we use both our model of pricing-to-market and the traditional HBS model to back out the amount productivity differences must be biased towards tradables to generate the observed relationship between aggregate prices and income in each model. We find that pricing-to-market of the kind considered here substantially reduces the amount that technological differences must be biased toward tradables necessary to explain the data.

A. Calibration

The demand side of the economy is chosen to be consistent with the standard textbook presentation of the HBS model (see Obstfeld and Rogoff 1996). Agents in each country are assumed to have the following symmetric utility function:

$$u\left(c_{i1}, c_{i2}, c_{i3}\right) = \left(c_{i1}^{\rho} + c_{i2}^{\rho}\right)^{\frac{\alpha}{\rho}} c_{i3}^{1-\alpha}.$$

We follow the literature and assume that preferences over tradables and nontradables are Cobb-Douglas so that they are not very substitutable. On the other hand, tradables are often assumed to be perfect substitutes because this eliminates the terms of trade effect. We make a minor departure from this case and choose $\rho = 0.99$, which makes the tradable goods almost perfect substitutes.

We calibrate the size of the tradable sector to match the import and export share of GDP for the median of a subset of OECD countries. We use those OECD countries for which re-exports do not appear to be too large[15] and for which we have manufacturing wage data from the BLS. Table 3 summarizes the trade shares of these countries in 2000. The median country imports and exports approximately one-third of GDP.[16] To be consistent with these shares in our two-country model we set $\alpha = 2/3$ so that nontradables account for one-third of output.[17] We find that the openness of a country does not influence our results substantially and report sensitivity to the trade share.

The production side of the economy depends on the search (q) and goods $\left(a^T\right)$ technologies. For our baseline case we assume that tradable and nontradable technologies are identical, so that $a_i^T = a_i^{NT} = \overline{a}$. Next, we assume both countries are identical so that $a_1^T = a_2^T$. We then examine

[15] This requires dropping the Netherlands, Belgium, and Ireland.

[16] For comparison, the median country in the Penn World Tables imported approximately 38 percent of GDP and exported 42 percent of GDP in 2000.

[17] Stockman and Tesar (1995) calibrate the tradable sector to account for 50 percent of output.

the properties of prices and income as the goods production technologies diverge across countries.

We choose $(q, \overline{a})$, so that the average markup is 11 percent and the maximum price exceeds the average price in the market by 25 percent. This implies that $\overline{a} = 0.2778$ and $q = 0.2857$. In all of our experiments, we hold the noisy search parameter constant and allow market technologies to vary across our two countries.

B. Measuring Prices and Income

Before evaluating the model it is useful to focus on a couple of measurement issues. We base this discussion on the data we have examined and the statistics we have computed. To begin with we have computed the elasticity of deviations from the law of one price with respect to wages. In our framework we measure this as an average of the size of deviations from the law of one price in the average price of the two tradable goods with respect to the difference in wages or:

$$\varepsilon_W = \frac{1}{2}\left(\frac{\ln(P_{11}/P_{21})}{\ln(W_1/W_2)} + \frac{\ln(P_{12}/P_{22})}{\ln(W_1/W_2)}\right).$$

We have also measured elasticities of individual and aggregate prices with respect to income. In this case, we have measured income both at PPP terms and at market exchange rates. To facilitate the discussion, we focus on measuring income at PPP. We follow the convention of the Penn World Tables and compute nominal GDP, Y_i, as the sum of value-added in the final good sector:

$$Y_i = P_{1i}(R_{1i})\,N_{1i} + P_{2i}(R_{2i})\,N_{2i} + P_{i3}(R_{i3})\,N_{i3}$$

To solve for the aggregate price level, P_i, we use a welfare-based price index.[18] This implies:

$$
\begin{aligned}
P_i &= \left(\frac{P_i^T}{\alpha}\right)^{\alpha}\left(\frac{P_{i3}}{1-\alpha}\right)^{1-\alpha} \\
P_i^T &= \left(P_{i1}^{\frac{\rho}{\rho-1}} + P_{i2}^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho-1}{\rho}}
\end{aligned}
$$

To get real income, y_i, we deflate nominal GDP by the welfare based price index (P_i):

$$
y_i = \frac{Y_i}{P_i}
$$

With these measures of real income and aggregate prices, we evaluate the model using the following statistics:

$$
\begin{aligned}
\varepsilon_{PPP} &= \frac{\ln\left(P_1/P_2\right)}{\ln\left(y_1/y_2\right)} \\
\varepsilon_{LOP} &= \frac{1}{2}\left(\frac{\ln\left(P_{11}/P_{21}\right)}{\ln\left(y_1/y_2\right)} + \frac{\ln\left(P_{12}/P_{22}\right)}{\ln\left(y_1/y_2\right)}\right)
\end{aligned}
$$

C. Balanced Technology Gap

In our baseline case, we assume that the productivity gap across countries is the same in the tradable and nontradable sectors $\left(\frac{a_1^T}{a_2^T} = \frac{a_1^{NT}}{a_2^{NT}}\right)$. With tradables accounting for two-thirds of consumption, the model generates quantitatively important deviations from the LOP and violations from absolute PPP. The elasticity of deviations from the LOP with respect to income is approximately 17.4 percent at PPP (14.9 percent at market prices). The elasticity of violations from PPP with respect to income is approximately 16.9 percent at PPP (14.4 percent at market prices). Thus, our model can account for 87 percent of the deviations from the LOP and almost 44 percent of the violations of PPP associated with income levels.

[18] The price index takes into account only the transaction price of the goods, not the search costs that are borne. It is therefore analogous to the price index used in the data.

The size of deviations from the LOP and violations of PPP differ for a couple of reasons. First, for deviations from the LOP, we take an average over the two tradable goods. Because the cost of production of these two goods differs, in general the size of deviations from the LOP will differ. To measure aggregate prices, we use the appropriate welfare-based price index. As the relative price of the two tradables differs across countries, consumption is not equally divided between these two goods, and the welfare-based indices take this into account. Second, because tradables and nontradables are poor substitutes, the deviations from the LOP are smaller for tradables.

Figure 3 shows that these elasticities increase slightly with the size of the tradable sector. This occurs because the deviations from the law of one price are larger in the tradable sector. Raising the trade share places a larger weight on the deviations from the LOP in tradables. The larger differences in aggregate price levels also lead to smaller differences in PPP-based measures of income, and this raises the elasticity of the LOP with respect to income. Even with a very small tradable share of 25 percent, the model generates nearly one-third of the violations of absolute PPP and 80 percent of the deviations from the LOP.

D. Biased Technology Gap

We now explore the impact on prices when the technology gap across countries is relatively larger in the tradable sector. Figure 4 shows how our measures of elasticities vary with the extent of comparative advantage in nontradables (i.e., the ratio of relative nontradable productivities to relative tradable productivities) which we denote as

$$g_{N/T} = \frac{\ln\left(a_1^{NT}/a_2^{NT}\right)}{\ln\left(a_1^{T}/a_2^{T}\right)}.$$

When $g_{N/T} = 0$, technological differences are completely concentrated in the tradable sector. When $g_{N/T} = 1$, there is no relative bias across sectors in technology levels. For comparison, the elasticity of deviations from PPP in a model without price discrimination is also reported as ε_{PPP}^{STD}.

We find that if the nontraded productivity gap is 60 percent of the traded productivity gap, then our model of pricing-to-market can match the observed relationship between aggregate prices and income. Without pricing-to-market, this level of bias in the technology gap would account for approximately 38 percent of the relationship between aggregate prices and income. To get the HBS model to match the aggregate price-income elasticity, the productivity gap in the tradable sector must be nearly 10 times that in the nontradable sector.

Our model can match the relationship between aggregate prices and income for a relatively small productivity gap between tradables and nontradables for the following three reasons. First, the presence of pricing-to-market implies that all prices are lower in countries with low-income. Based on what we find with a balanced international productivity gap, 44 percent of the relationship between aggregate prices and income can be explained through this channel. Next, the traditional HBS effect makes nontradables relatively more expensive in high-income countries. This effect accounts for 38 percent of the relationship between prices and income. Finally, there is an interaction between the biased productivity gap and pricing-to-market, which accounts for the remaining 18 percent. With biased technological progress our model generates larger deviations from the law of one price with respect to income, $\varepsilon_{LOP} = 0.207$. This stronger effect on deviations from the LOP occurs because the bias in relative technological levels generates a larger gap in wages than in real income. With bigger wage differences across countries, there is more pricing-to-market. Taken together, this implies that pricing-to-market is a relatively more important source of the aggregate price and income relationship than differences in the relative price of nontradables to tradables as emphasized by HBS. However, it also implies that the HBS channel may be more important than previously thought as it generates more pricing-to-market.

E. Lower Trade Share

The trade share is a key determinant of the relationship between prices and income. We have calibrated this to be consistent with the median OECD country; however, countries such as the U.S. and Japan have considerably smaller trade shares. While we have already examined the sensitivity of the model to the trade share in general, we now consider how the trade share influences our results when there is biased technological progress. To do this, we assume that the tradable sector accounts for one-third of the economy. Figure 5 reports how these elasticities vary with the amount the productivity gap is biased towards tradables.

With a lower trade share, biased technological progress has a smaller effect on real income and a larger effect on prices; thus we generate substantially larger effects on prices. In particular, now we find that if the nontradable productivity gap is approximately 77 percent of tradable productivity gap, our model of pricing-to-market matches the elasticity of PPP with respect to income. With this amount of bias in technological differences, the HBS model accounts for 44 percent of the relationship between PPP and income. Thus, even with a substantially lower trade share ,we see that pricing-to-market still appears to explain more than half of the effect of income on prices.

Pricing-to-market is still the dominant source of the relationship between aggregate prices and income because it affects all goods nearly equally so that both tradables and nontradables are less expensive in low-income countries. Raising the share of nontradables in the economy allows for smaller differences in the ratio of the relative price of nontradables to tradables to have a larger effect on aggregate prices. However, the higher share of nontradables also generates a larger gap in relative wages compared to real income across countries. Again, since pricing-to-market is based on wage differentials, this strengthens the pricing-to-market effect so that the elasticity of deviations from the LOP is increasing in the share of nontradables in consumption.

5. Conclusions

This paper provides strong empirical evidence of systematic pricing-to-market based on the wages of consumers in the destination market. Further work needs to be done to determine whether this type of pricing-to-market is common to exports in the rest of the world. We have shown that this pricing-to-market accounts for much of the deviations from absolute PPP in the data. In contrast to previous work, our work finds that wages have substantially more explanatory power for national price levels than income per capita.

We have developed a model of pricing-to-market based on international productivity differences and search frictions. Our model generates a role for local wages in the price-setting behavior of firms. We use our model to differentiate between the traditional explanation of violations of PPP, that is, those due to relatively larger productivity differentials in the tradable sector, and ours based on pricing-to-market. We have shown that pricing-to-market accounts for about 62 percent of the violations from absolute PPP and 100 percent of the deviations from the LOP. In contrast, violations of PPP due to differences in the ratio of the relative price of tradables to nontradables across countries, as emphasized by HBS, accounts for only 38 percent of the violations of PPP.

While the findings here address the source of long-run deviations from absolute PPP, they may also have implications for understanding fluctuations in prices and real exchange rates at business-cycle frequencies. If, as in our search model, it is indeed wages that determine the pricing-to-market relationship, we may expect firms to respond to business cycle variations in setting their prices (see Alessandria, 2002, for example). If instead, prices are set based on the value of consumers' lifetime budget constraints (for which wages and income per capita are only proxies), the pricing-to-market we've uncovered may not be important for business-cycle frequencies. Thus, a topic for future research is to distinguish between wages and other measures of wealth or income as the driving force in this pricing-to-market relationship.

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Figure 1: PPP and Real Income (2000)

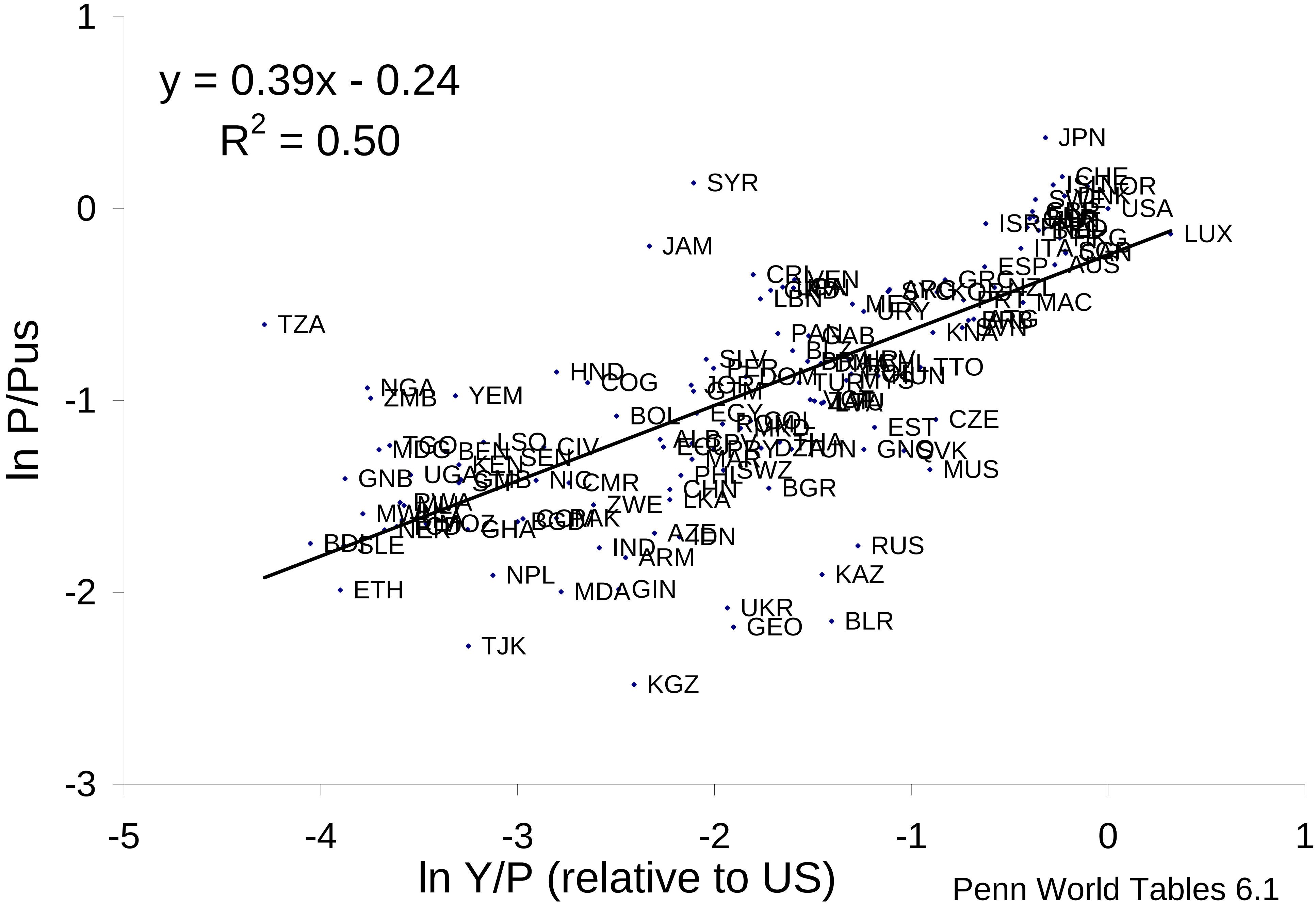

Figure 2:
Investment Prices and Real Income (2000)

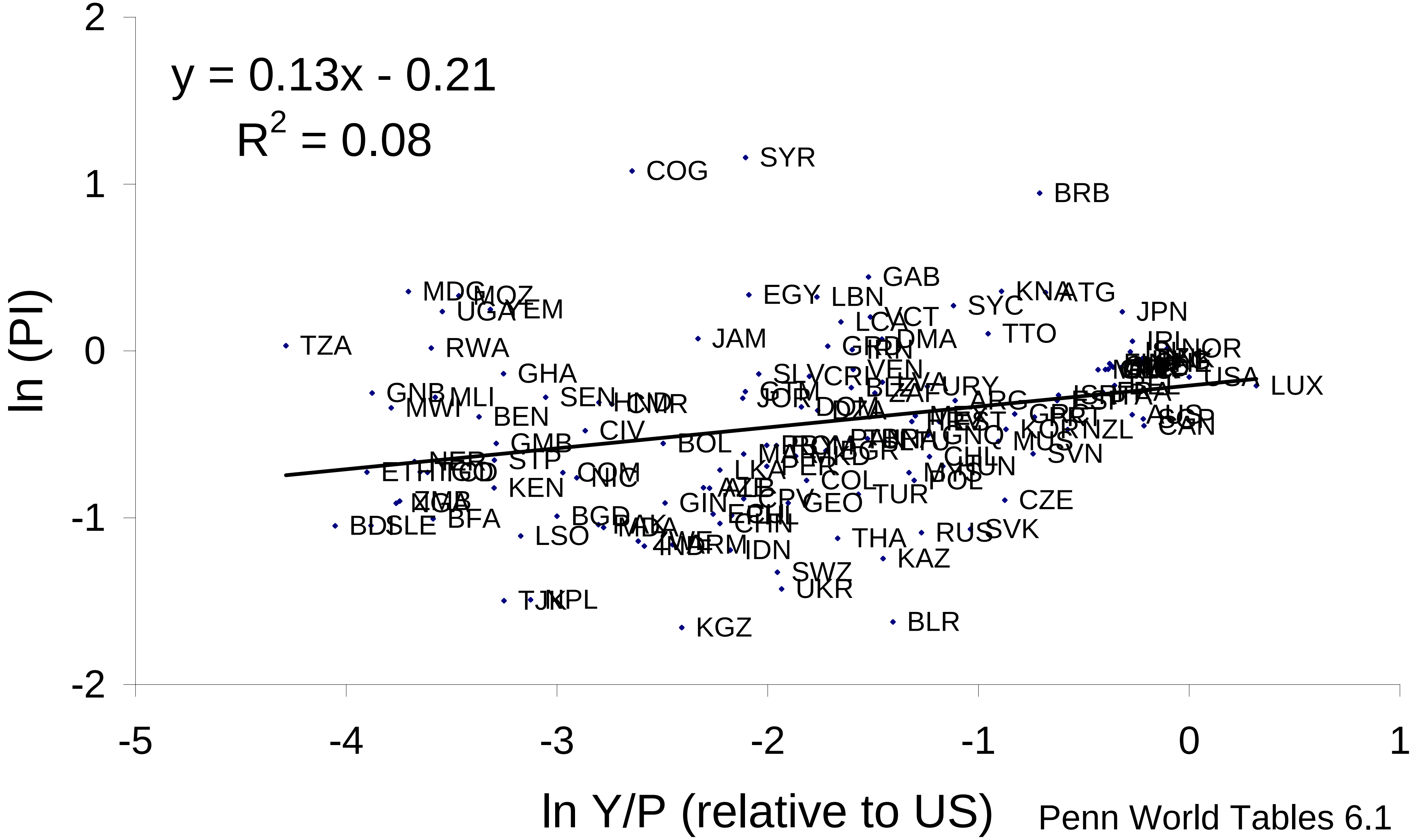

Figure 3: Price Elasticities and Trade Share

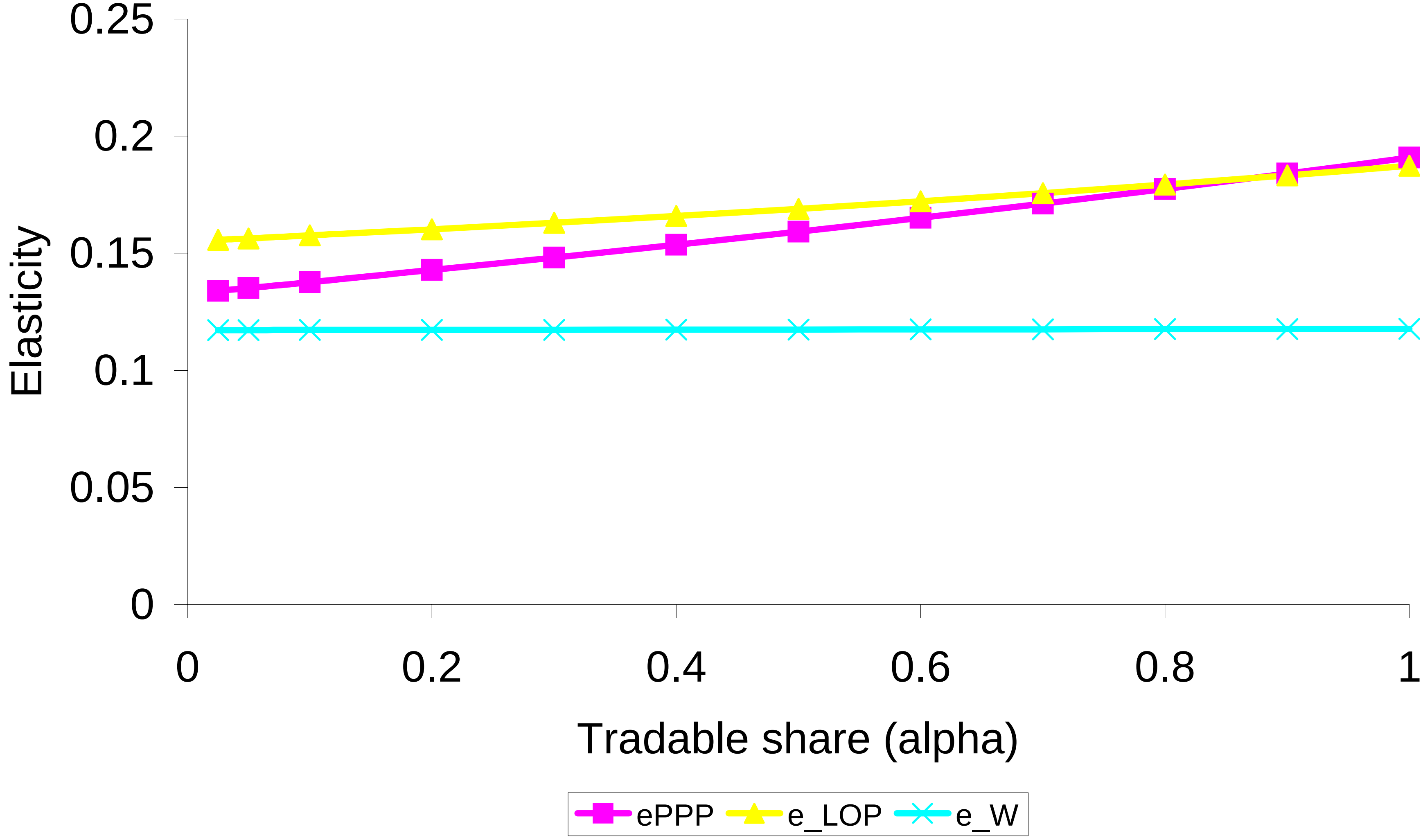

Figure 4: Elasticity and Biased Productivity Growth (Tradables = 2/3 of Y)

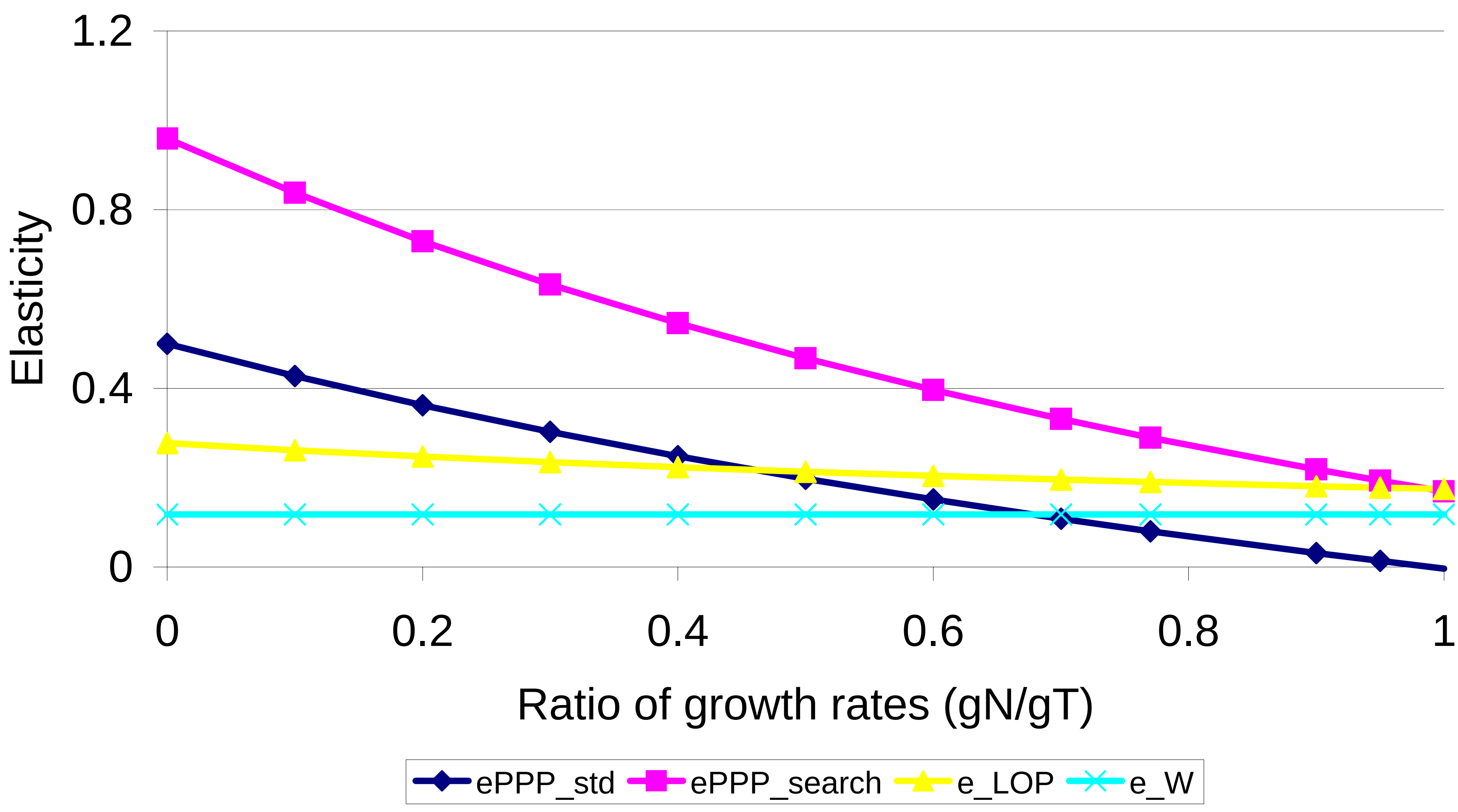

Figure 5: Elasticity and Biased Productivity Growth (Tradables = 1/3 of Y)

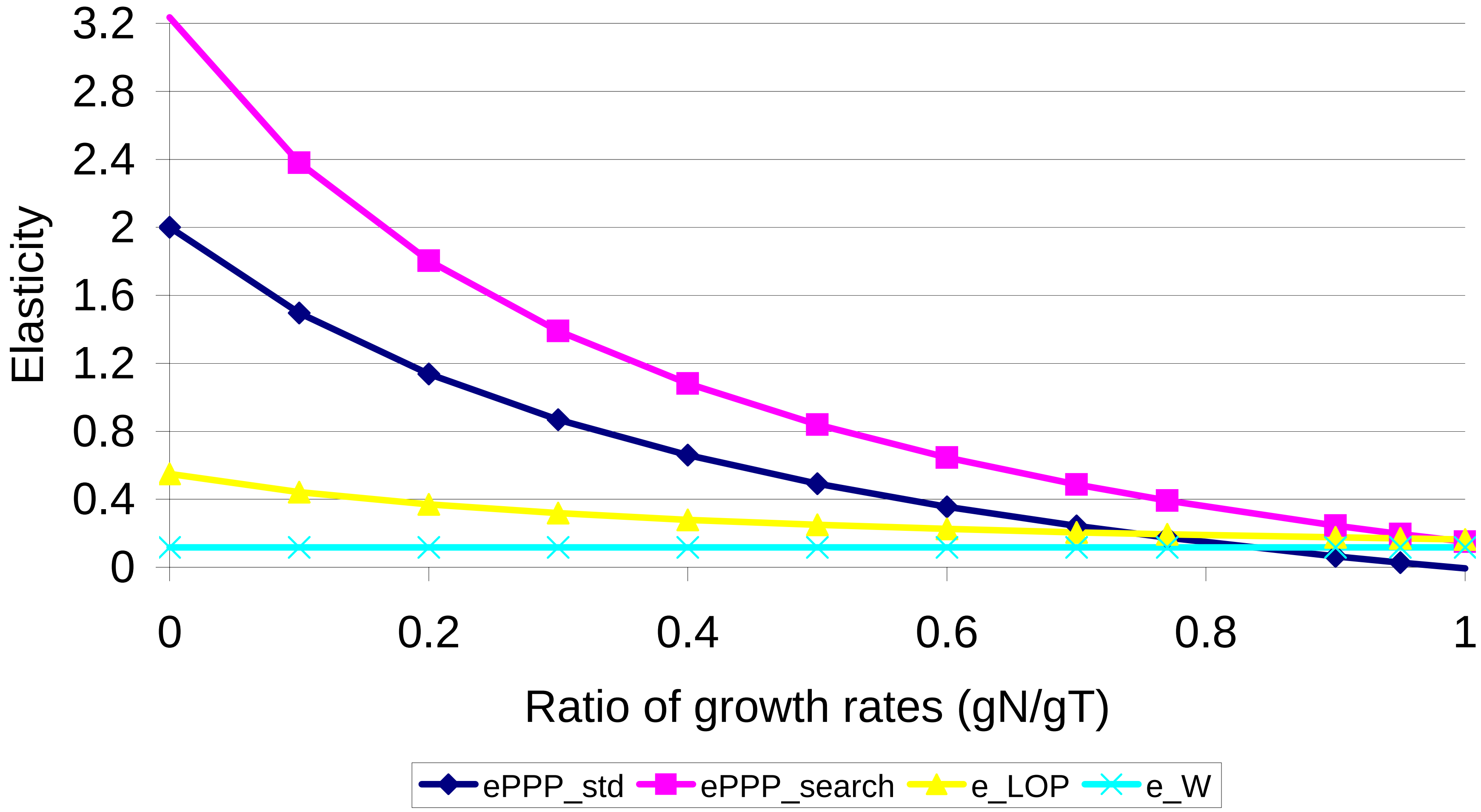

Table 1:
Coefficients from Commodity-Year Fixed Effects Regressions of Log Price on Log Income per Capita and/or Log Wages

Using PPP Income and Wages:

	Number of Obs.	Fraction of Total Value Exported	GDP per Capita Only	Wage Only	Both Together	
					GDP per Capita	Wages
All Homogeneous* Goods to Countries with BLS Wage Data**	582,866	1.000	0.182 (47.2)	0.166 (61.2)	0.021 (3.8)	0.155 (39.1)
Dropping Low Value Country-Commodity Observations						
Country Value<1% of Average Country Value for Commodity	538,104	0.999	0.198 (51.4)	0.169 (63.0)	0.025 (4.5)	0.154 (39.0)
Country Value<5% of Average Country Value for Commodity	442,386	0.996	0.205 (52.8)	0.163 (61.0)	0.047 (8.3)	0.145 (37.5)

Using Exchange Rate Income and Wages:

	Number of Obs.	Fraction of Total Value Exported	GDP per Capita Only	Wage Only	Both Together	
					GDP per Capita	Wages
All Homogeneous* Goods to Countries with BLS Wage Data**	582,866	1.000	0.136 (60.2)	0.126 (68.5)	-0.006 (-1.2)	0.131 (32.7)
Dropping Low Value Country-Commodity Observations						
Country Value<1% of Average Country Value for Commodity	538,104	0.999	0.146 (64.3)	0.131 (71.2)	0.015 (3.2)	0.120 (30.6)
Country Value<5% of Average Country Value for Commodity	442,386	0.996	0.151 (65.4)	0.130 (70.0)	0.038 (7.8)	0.103 (26.0)

*Homogeneous indicates that we have dropped all commodities that included "other," "NESOI," "not elsewhere specified or included," "parts," and "$" in either the detailed or abridged commodity description.

** These countries include: Australia, Austria, Belgium-Luxembourg, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, South Korea, Mexico, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, and the total U.S. exports of these goods.

Table 2:
Effect of Quality Aggregation on Coefficients from Regressions of Log Unit Value on Log Wages
(t-stats in parentheses)

	Number of Commodity Groups	Number of Observations	Exchange Rate	PPP
Commodities Combined at the 9-Digit Level				
Individual (10-Digit) Commodities	307	25,463	0.131 (13.7)	0.186 (13.3)
Aggregated (9-Digit) Commodities	133	17,278	0.093 (8.8)	0.134 (8.5)
Commodities Combined at the 7-Digit Level				
Individual (10-Digit) Commodities	1,814	188,877	0.113 (33.6)	0.156 (31.4)
Aggregated (7-Digit) Commodities	567	94,305	0.087 (20.1)	0.124 (19.2)
Commodities Combined at the 5-Digit Level				
Individual (10-Digit) Commodities	3,522	381,406	0.151 (50.0)	0.164 (48.3)
Aggregated (5-Digit) Commodities	844	164,448	0.100 (30.7)	0.136 (27.9)

Table 3:
Imports and Exports as a fraction of GDP (2000)

COUNTRY	Exports	Imports
AUSTRALIA	0.229	0.228
AUSTRIA	0.503	0.509
CANADA	0.461	0.403
DENMARK	0.441	0.381
FINLAND	0.430	0.337
FRANCE	0.285	0.273
GERMANY	0.338	0.334
ITALY	0.283	0.273
JAPAN	0.108	0.094
KOREA	0.448	0.417
MEXICO	0.310	0.330
NEW ZEALAND	0.363	0.345
NORWAY	0.467	0.294
PORTUGAL	0.315	0.428
SPAIN	0.301	0.324
SWEDEN	0.461	0.403
SWITZERLAND	0.456	0.399
TURKEY	0.240	0.315
UNITED KINGDOM	0.281	0.301
UNITED STATES	0.113	0.150
median	0.327	0.332

Appendix A:

Sample of 30 Randomly Selected Goods in Alphabetical Order

1	BARS & RODS OF IRON OR NONALLOY STEEL, HOT-ROLLED, IN IRREGULARLY WOUND COILS, OF CIRCULAR CROSS-SECTION LT 14MM DIAMETER, CONTAINING LT 0.6% CARBON
2	BOVINE LEATHER WITHOUT HAIR ON, PRETANNED EXCEPT VEGETABLE PRETANNED, BUT NOT FURTHER PREPARED
3	BOVINE UPPER LEATHER, WHOLE, WITHOUT HAIR ON, OF A UNIT SURFACE AREA NOT EXCEEDING 28 SQUARE FEET (2.6 M2)
4	CHICKEN CUTS AND EDIBLE OFFAL (EXCEPT LIVERS) FROZEN
5	COPPER POWDERS OF LAMELLAR STRUCTURE; FLAKES
6	DIAMONDS, UNSORTED
7	DIISODECYL ORTHOPHTHALATES
8	ELECTRICAL SPECTROMETERS AND SPECTROGRAPHS USING OPTICAL RADIATIONS (ULTRAVIOLET, VISIBLE, INFRARED)
9	FERROCHROMIUM, 4 PERCENT OR LESS CARBON
10	GRINDERS, POLISHERS AND SANDERS, SUITABLE FOR METAL WORKING, ROTARY TYPE (INC COMBINED ROTARY-PERCUSSION) PNEUMATIC TOOLS FOR WORKING IN THE HAND
11	HOMOGENIZED COMPOSITE FOOD PREPARATIONS (SEE NOTE 3)
12	KRAFT FOLDING CARTON STOCK, CLAY COATED, BLEACHED AND OVER 95% CHEMICAL FIBERS, WEIGHING 150 G/M2 OR LESS, IN ROLLS OR SHEETS
13	METHYLCHLOROFORM (1,1,1-TRICHLOROETHANE)
14	MONOLITHIC I/C'S, DIGITAL, SILICON, (MOS), FIELD EFFECT TRANSISTOR, VOLATILE MEMORY, DYNAMIC READ-WRITE RANDOM ACCESS (DRAM) NOT OVER 300,000 BITS
15	OPTICAL SCANNERS AND MAGNETIC INK RECOGNITION DEVICES, ENTERED WITH THE REST OF A SYSTEM
16	ORIGINAL ENGRAVINGS, PRINTS AND LITHOGRAPHS, FRAMED OR NOT FRAMED
17	PAVERS, FINISHERS AND SPREADERS FOR CONCRETE, FOR PUBLIC WORKS, BUILDING OR SIMILAR USE
18	POCKET LIGHTERS, GAS FUELED, REFILLABLE
19	POLYMERS OF VINYL ACETATE, IN AQUEOUS DISPERSION
20	POWER SUPPLIES FOR ADP, SUITABLE FOR PHYSICAL INCORPORATION INTO AUTOMATIC DATA PROCESSING MACHINES,WITH A POWER OUTPUT NOT EXCEEDING 50W
21	SKINS OF SWINE, EXCEPT LIVERS, EDIBLE, FROZEN
22	SOBUTENE-ISOPRENE (BUTYL) RUBBER (IIR)
23	SWEET CORN, UNCOOKED OR COOKED BY STEAMING OR BOILING IN WATER, FROZEN
24	SWITCHES, PUSH-BUTTON, RATED AT NOT OVER 5 A, FOR A VOLTAGE NOT EXCEEDING 1,000 V
25	SYNTHETIC FILAMENT YARN EXCEPT SEWING THREAD, NOT FOR RETAIL SALE, SINGLE MONO,MULTIFILAMENT, OF POLYESTER UNTWISTED OR WITH A TWIST OF LT 5 TURNS/MTR
26	SYNTHETIC FILAMENT YARN EXCEPT SEWING THREAD, NOT FOR RETAIL SALE, SINGLE, MULTIFILAMENT, WITH A TWIST OF GE 5 TURNS PER M OF POLYETHYLENE, PROPYLENE
27	TABLE OR KITCHEN GLASSWARE OTHER THAN DRINKING GLASSES, OF LEAD CRYSTAL
28	TILTING ARBOR TABLE SAWS, WOODWORKING, NEW
29	TURNIP SEED OF A KIND USED FOR SOWING
30	WOVEN FABRIC OF COTTON CONTAINING LT 85% BY WEIGHT OF COTTON WEIGHING GT 200G/M2 DYED PLAIN WEAVE POPLIN OR BROADCLOTH MIXED WITH MMF

Appendix B:

Coefficients from Commodity-Year Fixed Effects Regressions of Log Price on Log Income per Capita for All Countries with Income per Capita Data

	Number of Obs.	Fraction of Total Value Exported	PPP	Exchange Rate
All Homogeneous* Goods to Countries with PWT Income/Capita Data**	644,118	1.000	0.083 (49.9)	0.055 (52.3)
Dropping Low Value Country-Commodity Observations				
Country Value<1% of Average Country Value for Commodity	585,007	0.999	0.091 (53.5)	0.059 (55.9)
Country Value<5% of Average Country Value for Commodity	452,608	0.994	0.096 (52.3)	0.062 (55.2)

*Homogeneous indicates that we have dropped all commodities that included "other," "NESOI," "not elsewhere specified or included," "parts," and "$" in either the detailed or abridged commodity description. In addition, we have dropped all goods that did not have units listed.

**The regressions include 128 countries.

Additional Notes: Log incomes per capita in exchange rate terms ranged from 9.1 to 15.2 (6.2 to 10.7 in PPP terms) in 2000. The estimated price elasticity with respect to income in exchange rate (PPP) terms of 0.055 (0.083) would therefore imply a 34 percent (37 percent) price difference between the richest and poorest countries.

Appendix C:
Random Sample of Five Quality Groupings

HS Code	9-Digit Group*	7-Digit Group	5-Digit Group	Commodity Description
2601110030	A	A	A	IRON ORE NONAGGLOMERATED CONCENTRATES
2601110060	B	A	A	IRON ORE NONAGGLOMERATED COARSE
2601110090	C	A	A	IRON ORE NONAGGLOMERATED NOT COARSE
2601120030	D	B	A	IRON ORE AGGLOMERATED PELLETS
2601120060	E	B	A	IRON ORE AGGLOMERATED BRIQUETTES
2601120090	F	B	A	IRON ORE AGGLOMERATED NOT PELLETS OR BRIQUETTES
7204410020	G	C	B	NO 1 BUNDLES STEEL SCRAP
7204410040	H	C	B	NO 2 BUNDLES STEEL SCRAP
7204410060	I	C	B	BORINGS, SHOVELINGS AND TURNINGS STEEL SCRAP
7204410080	J	C	B	SHAVINGS, CHIPS, MILLING WASTE, SAWDUST, FILINGS, TRIMMINGS, STAMPINGS STEEL SCRAP
7204490020	K	D	B	NO 1 HEAVY MELTING STEEL SCRAP
7204490040	L	D	B	NO 2 HEAVY MELTING STEEL SCRAP
7204490060	M	D	B	CUT PLATE AND STRUCTURAL STEEL SCRAP
7204490070	N	D	B	SHREDDED STEEL SCRAP
9505104010	O	E	C	ARTIFICIAL CHRISTMAS TREES, OF PLASTIC
9505105010	P	F	C	ARTIFICIAL CHRISTMAS TREES, EXCEPT OF PLASTIC
0203210000	Q	G	D	CARCASSES AND HALF-CARCASSES OF SWINE, FROZEN
0203221000	R	H	D	HAMS, SHOULDERS AND CUTS THEREOF, OF SWINE, BONE IN, PROCESSED, FROZEN
0203229000	S	I	D	HAMS, SHOULDERS AND CUTS THEREOF, OF SWINE, BONE IN, EXCEPT PROCESSED, FROZEN
5209413000	T	J	E	WOVEN FABRIC OF COTTON CONTAINING 85% OR MORE BY WEIGHT OF COTTON WEIGHING MORE THAN 200G/M2 OF DIFFERENT COLORS PLAIN WV CERTIFIED HAND-LOOMED FABRIC
5209420030	U	K	E	WOVEN FABRIC OF COTTON CONTAINING 85% OR GT BY WEIGHT OF COTTON WEIGHING GT 200G/M2 OF YARNS OF DIFFERENT COLORS DENIM WEIGHING LE 360G/M2
5209420050	V	K	E	WOVEN FABRIC OF COTTON CONTAINING 85% OR MORE BY WEIGHT OF COTTON WEIGHING 360 G/M2 OF YARNS OF DIFFERENT COLORS DENIM
5209430000	W	L	E	WOVEN FABRICS OF COTTON, 85% OR MORE COTTON BY WEIGHT, WITH YARNS OF DIFFERENT COLORS, 3-THREAD OR 4-THREAD TWILL INCLUDING CROSS TWILL, OVER 200 G/M2

* A relatively small fraction (about 5 percent) of all goods are unique up to 10 digits. In the random sample of five 5-digit groups chosen, none of the goods were unique up to 10 digits in the Harmonized System Code.