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The Penn-Balassa-Samuelson Effect in Developing Countries: Price and Income Revisited

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Abstract
It is conventional wisdom that richer countries have a higher price level than poorer countries. This paper provides evidence that the price-income relationship is non-linear and that it turns negative, or at best flat, in low income countries. The result is robust along both cross-section and time-series dimensions. Additional robustness checks show that biases in PPP estimation and measurement error in low-income countries do not drive the result.

Keywords: Balassa-Samuelson, Penn effect, developing countries, non-parametric estimation, purchasing power parity, real exchange rate
JEL Classifications: E31, F4, O1

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1 Introduction

The positive price-income relation is generally regarded as a stylized fact. This result was documented for twelve developed countries in the seminal paper of Bela Balassa (1964) and was confirmed for a large sample of countries as soon as data from the International Comparison Program (ICP) became available.[1] The relationship now appears in most international macroeconomics textbooks and is one of the basic concepts taught in undergraduate programs. Nevertheless, the literature has paid little attention to the price-income relationship in developing countries. This paper provides evidence that the conventionally accepted positive relationship does not hold for a large group of low income countries.

The main finding of the paper is that using non-parametric estimation to allow for non-linearities, the price-income relationship in poor countries is negative in a panel perspective or, at most flat if considering a cross-section dimension. This result is robust to biases in PPP estimation and measurement error in low-income countries.

The result of the paper is related to the literature on the determinants of real exchange rates. The Penn-Balassa-Samuelson observation (Penn-BS[2]) that richer countries tend to have higher price levels is at the basis of our understanding of real exchange rate movements. By showing that in poor countries the price-income relationship is negative, this paper raises general questions about the relation between economic development and the price level. These results suggest that there may be additional determinants to real exchange rate movements in developing countries that merit further investigation.

[1] The result was documented by Summers and Heston (1991), Barro (1991), and Rogoff (1996).

[2] Samuelson (1994) stresses that the proper name for the positive relation between price level and income would be *Ricardo-Viner-Harrod-Balassa-Samuelson-Penn-Bhagwati-et alt. effect*

The paper is structured as follows: Section 2 shows the negative price-income relationship in developing countries using both non-parametric and linear estimations. Section 3 establishes that the results are robust to the structure of the Penn World Tables database we use and that the findings are not driven by biases in PPP estimation that arise from the method of aggregation, quality matching, or goods representativity in poor countries. Section 4 concludes, summarizing the main findings and discussing possible explanations for these results.

2 The price-income relationship

In this section I show that the price-income relationship in developing countries is negative or, at best, flat. I provide evidence along a panel, a time-series, and a cross-section dimension through both linear and non-linear estimation. Following the literature on the Penn-BS effect, I measure income per capita in purchasing power parity (PPP) and define the price level as the ratio of the PPP to the exchange rate with the US dollar.[3] Unless alternatively specified, the database of reference is the Penn World Table (PWT) 7.0 version.

In Figure 1 we can see an example of the little attention that the literature has paid to the Penn-BS effect in developing countries. The figure illustrates the positive price-income relationship provided in Rogoff's (1996) excellent review of the purchasing power parity puzzle. Since observations with an income per capita lower than Syria are gathered in a cloud of points, it is difficult to properly disentangle the relationship between price and income in poor countries.

Therefore, in Figure 2, using the same data-set as in Rogoff (1996), I plot the *log*-values of income per capita. I investigate the price-income re-

[3]I use income per capita at constant prices for the panel and time-series analysis and income at current prices for the cross-section analysis.

lationship using a non-parametric estimation technique known as LOWESS (locally weighted scatter smooth), which allows me to impose as little structure as possible on the functional form. The estimation suggests that the Penn-BS effect does not hold in the poorest 25% of countries in the sample, where the relationship is actually downward sloping. The minimum point of the curve corresponds to an income level of around 1350 PPP $, which is equivalent to the income of Senegal in the year 1990.[4]

The LOWESS estimation works as follows: Consider an independent variable x_n and a dependent variable y_n. For each observation y_n the LOWESS estimation technique runs a regression of x_n using few data points around x_n. The regression is weighted so that the central point $(x_n; y_n)$ receives the highest weight and points further away get less weight. The fitted value of this regression evaluated at y_n represents the smoothed value y_n^S which is used to construct the non-parametric curve that links y and x. The procedure is repeated for each observation $(x_n; y_n)$. The number of regressions is equal to the number of observations, and the smoothed curve is the set of all $(x_n; y_n^S)$.

LOWESS estimation requires that the bandwidth of observations included in the regression of each point be chosen. Specifying a large bandwidth provides a smoother estimation, but increases the risk of bias by including observations from other parts of the density. A small bandwidth can better identify genuine features of the underlying density, but increases the variance of the estimation. I use the default STATA bandwidth of 0.8, and results are robust to changes in the bandwidth.

Next, I extend the analysis to a panel of 150 countries from 1950 to

[4]In his comments on the result of figure 1, Rogoff (1996) stressed that " *The relationship between income and prices is quite striking over the full data set (...); it is far less impressive when one looks either at the rich countries as a group, or at developing countries as group.* Here we show that the relationship is strong when looking at rich countries as a group and negative when looking at poor countries as a group.

2009 using the Penn World Table 7.0 (PWT).[5] I confirm the strong positive relationship predicted by the Penn-BS effect by running a standard linear estimation of price on income: the OLS coefficient is 0.10 with a t-statistic of 27.60[6].

Once I allow for non-linearities, the Penn-BS effect breaks down for low income countries. Figure 6 shows the results of running a LOWESS estimation between price and income imposing little restriction on the functional form. We can see that the expected upward sloping relationship holds only for middle- and high-income countries. The relationship is downward sloping for low-income countries. Figure 7 reports the fitted value of the LOWESS estimation. The minimum point is at 1600 PPP $ per-capita (2005 prices), which corresponds to the income of Nigeria in the year 2005.

This new finding is empirically relevant because the downward sloping arm of the curve includes 30% of the total observations, and 40% of the countries in the sample. The countries on the downward sloping arm and their frequencies are reported in Figure 8. We can notice that the countries involved are mainly African and Asian (no Latin-American). Some of them are persistently on the downward-sloping arm (i.e. Nigeria and Tanzania); others moved along the curve (i.e. China and Vietnam).

Standard panel-data analysis (Table 1) supports the finding of non-parametric estimation. I show that for developing countries the relationship between price and income is negative, sizable, and significant with and without country fixed-effects. I do this by running a regression for the full sample, and then for developing countries only.[7] This result comes despite a strict definition of developing countries and a linear restriction on the price-income

[5] I exclude countries with less than one million people in the year 2000 and clear outliers; including these outliers would reinforce the findings

[6] I run an OLS regression of the log of the price level of GDP (variable p from PWT) and the log of GDP per capita in PPPs at constant prices ($RGDPCH$ from PWT).

[7] I define developing countries as those with a GNI per-capita less than 11,115 US$ (2007), which is the World Bank's threshold for high income countries.

relationship.

Time-series analysis on selected countries supports the finding that the development process of low-income countries presents a negative relationship between price and income; in developed countries this relationship is positive (Figure 7). This is consistent with larger and more significant coefficients in the panel regression of developing countries when I use country fixed-effects. This is a striking result that, to my knowledge, has not been previously shown and that merits further research.

The cross-section dimension of the price-income relationship confirms that the result presented in Figure 5 is not spurious. Figure 8 reports non-parametric estimates at 10-year intervals.[8] Observe that at low levels of income, the price-income relationship is constantly negative or, at most, flat.

Cross-country OLS regression confirms this finding. In Table 2, I rank countries by their income level, dividing the full sample into three groups for the year 2005.[9] We can see that the price income relationship is negative and significant for the countries in the first third. As the income of the reference group increases, the Penn-BS effect becomes larger and more significant. This is consistent with the U-shape relationship of the panel dimension.

Figure 8 shows that the inflection point of the price-income relationship has been decreasing over the years, so that the percentage of countries on the downward sloping arm has decreased too. In 1955 countries with lass than 11% of US income were on the downward sloping arm; this involved 27% of the countries in the sample. In 2005 countries with less than 4% of US income were on the downward sloping arm; this involved 20% of countries

[8] I use PWT 5.6 in the estimations for 1955, 1965, 1975, and 1985, PWT 6.1 for 1995, and PWT 7.0 for year 2005. The rationale is to use a version in which the benchmark year is closest to the analyzed one. Using a unique PWT version would deliver similar results, but it is methodologically less appropriate.

[9] I use the benchmark year of PWT7 and drop Zimbabwe and Tajikistan which are clear outliers; including these countries would reinforce the findings. There are 49 observations per group, on average

in the sample. Moreover, in the last decades the upward sloping part of the curve has become steeper.

This change is consistent with Bergin, Glick, and Taylor (2006), who show that the Penn-BS effect is specific to recent times. They provide evidence that the price-income relation has increased in magnitude and in significance over the last decades. Their result can be reconciled with the findings of this paper by the progressive leftward shifting of the inflection point.

3 Robustness checks

The results of this paper are concerned with low-income countries, where the quality of data is usually poor. I therefore focus robustness checks on sources of measurement error. In this section I show that the findings of the paper do not depend on the structure of the PWT, and are robust to possible sources of bias in PPP estimation like the method of aggregation, quality matching, and goods representativity.

3.1 Penn World Tables' structure

The first potential source of measurement error is the structure of the Penn World Table (PWT) itself. Price data are only collected in benchmark years by the International Comparison Program (ICP) and estimated for other years by rescaling according to the inflation rate differential with the US. Although the reliability of this method is unclear, the PWTs are regularly used in empirical analyses with a time series dimension. Another source of measurement error could be non-benchmark countries. The PPP of countries where the ICP did not collect prices is estimated by a two-stage process based on the relationship between nominal and real shares for the benchmark countries.[10]

[10]For details on the estimation procedure see the appendix to PWT.

Nevertheless, the structure of the PWT does not drive the results. In Figure 9 I run a non-linear estimation of the price-income relationship only for benchmark years and benchmark countries of subsequent versions of the PWT.[11] Figure 10 shows the fitted values of a panel estimation that includes only the countries that were used as a benchmark in all PWT versions. Even if I limit the analysis to these reliable samples, the findings presented in the previous section are confirmed.

3.2 Purchasing power parities bias

Another important source of measurement error is in the estimation of PPPs. Biased estimates could seriously affect results because PPPs enter the numerator of the price level (the variable on the y-axis) and the denominator of income (variable on the x-axis). In Figure 11 we can see that if PPPs are underestimated in poor countries, the measurement error would work against our findings, so that the results presented would actually be reinforced. The reverse would be true if PPPs tend to be overestimated.

The PWT 7.0 database used in Section 2 relies on the 2005 ICP round, which provides arguably the best available data for international comparisons of real income. The PPPs of many developing countries were revised upwards after this round, and these countries have a lower real income than was previously thought (Deaton, 2010). Although higher PPPs in poor countries work in favor of my findings, the last ICP round does not drive the results of the paper. Figure 12 presents a LOWESS estimation using PWT 6.3, which relies on the previous ICP round. As we can see, the downward pattern is slightly less pronounced than in Figure 5, but it is still present.

[11] I use PWT 5.6 for 1985, PWT 6.1 for 1996, and PWT 7 for 2005

3.2.1 Method of aggregation

The PWTs compute PPPs using the Geary-Khamis (GK) method of aggregation: the PPP index of a country is computed as a modified Paasche index that compares domestic prices with world prices. In the GK method the world price of a good is defined as a weighted average of its price in all countries and the weights are given by a country's share in the global consumption of that good.

As Deaton and Heston (2010) note, GK indexes tend to understate PPPs and overstate living standards in poor countries. In fact countries with a larger physical volume of consumption get a greater weight in the construction of composite world prices. This implies that the international price used to evaluate consumption in all countries is closer to the price in rich countries. This creates a Gershenkron effect for low income countries: if we measure their consumption with prices that are closer to those of rich countries, their consumption is overvalued. Without this source of bias in PPPs, our result would be stronger.

3.2.2 Quality matching and goods representativity

The method of aggregation is not the only source of bias in PPPs. Quality matching and goods representativity may also affect our results. As Deaton and Heston (2010) stress, one of the most criticized issues of ICP rounds is that lower quality goods and services in poor countries are often matched to higher quality items in rich countries: " *a heart-surgery in Nairobi is unlikely to be of the same quality as in Geneva; also, for many goods the outlets sampled in poor countries may be closer to discount stores than to typical outlet in the US or other rich countries*". Therefore, quality mismatch leads to an underestimation of the price level in poor countries; without a quality matching bias the results of the paper would be reinforced.

The representativity of the goods priced could also affect the results of this

paper. The ICP calculates prices for about 155 goods (called basic headings) in each country by collecting prices for 1500-2000 items. The basic heading is the most disaggregated level at which expenditure data are available from national accounts statistics, and the ICP collects quotes for different items within each basic head. For instance, for the basic head rice, the ICP collects quotes for six different kinds of rice, including long-grained, short-grained, and brown rice. Since national statistics do not have expenditure data on each item, the general price of rice is computed through a country product dummy regression (CPD).[12] If an item within the basic heading is representative in some countries but not in others, PPPs may be estimated incorrectly.[13] This is a common problem for all ICP rounds.[14] However as Diewert (2008) stresses if non-representative prices are well-distributed across all countries in a region, they may not cause serious distortions.

There may be a trade-off between quality matching and goods representativity if there is no control for the latter. For the 2005 round, the ICP approached the quality matching problem by developing Structured Product Descriptions (SPDs). The SPDs provided a precise description of the goods to be priced.[15] Each region of the ICP elaborated its own list of goods in coordination with the national statistical institutes, and PPPs were first computed at regional level; this allowed for better products quality matching within regions.[16] Deaton and Heston (2010) point out that some regions contain countries at very different levels of development and with very different

[12]See Rao (2004) for a detailed explanation of this method.

[13]See for instance the wheat vs. teff example in Deaton and Heston (2010).

[14]The Latin American region tried to overcome this issue in the 2005 round by using an extended CPD method, adding a representativity dummy. The OECD/Eurostat and CIS regions used an EKS method based on Javon indexes of representative products between countries; see Hill (2007b) for a brief description of this method.

[15]The SPDs specify quantity, packaging, source, seasonal availability, product characteristics and brand. Examples of SPDs from Hill(2007a) are as follows: "Men's shirt, well known brands, 100% cotton, light material, classic styling, uniform colour, short sleeves, classic collar, buttons fastener", or " Nescafe' classic: product presentation, tin or glass jar, 100 grams, type 100% Robusta, instant coffee, caffeine, not decaffeinated, brand Nestle'-Nescafe' classic".

[16]The ICP regions are Africa, Asia/Pacific, CIS, South America, OECD/Eurostat, Western Asia.

patterns of consumption and relative prices. Given this heterogeneity, using of more precise definitions of goods is likely to increase the risk of calculating high and unrepresentative prices for some goods.

Regional PPPs need to be linked to provide a global system of PPPs. In previous ICP rounds, regional PPPs were linked retrospectively rather than during the original exercise; different regions were linked in different years through the "bridge country" method, where countries that appeared in more than one region were used as a link. In the ICP 2005, the "bridge country" method was replaced by the "ring countries" method where 18 countries (at least two per region) priced a specially constructed common list of items. Ring-PPPs were then computed and used to link the prices of different regions.

A ring list of SPDs implies that exactly the same item is priced in Japan and in Zambia.[17] This raises issues of representativity that can influence the ring PPPs. Deaton (2010) shows that if we look only at ring-PPPs, the price level of Cameroon is almost as high as that of Honk Kong, and he suggests that the common product list specification may be responsible for such high price levels.

However, the ICP does not use the ring prices country by country. For each region it averages the ratios of the *ring-basic-heading prices* to the *within-region-basic-heading prices*, so that high prices in one country can be offset by low prices elsewhere. Deaton (2010) computes a Tornqvist index to measure how much different goods moves the overall PPP-index in Africa and Asia.[18] Deaton concludes that there is no evidence to support the idea that prices in Africa or in the Asia-Pacific region are systematically over-

[17]For instance the list includes: (*a*) Bordeaux red wine (Bordeaux *superieur* with state certification of origin and quality, alcohol content 11-13%, vintage 2003-2004, with region and wine farmer listed); (*b*) front loading washing machine (capacity 6kg, energy efficiency class A, electronic program selection, free selectable temperature, spin speed up to 1200rpm, medium cluster, well-known brand such as Whirlpool).

[18]He estimates a pairwise Tornqvist index for the ring African countries vs. the UK and at regional level for Africa and Asia-Pacific vs. OECD/Eursotat.

stated. This is consistent with Diewert's (2008) point that unrepresentative items, if well distributed, would not generate serious distortions. Therefore, we can safely assume that the negative/flat price income relationship in poor countries is not driven by issues of quality matching and goods representativity.

The process of computing PPPs is subject to intrinsic fragilities, making comparisons of real income a difficult exercise. It is comforting that the results of this paper are robust to the method of aggregation and quality matching and that there is no evidence that product representativity could bias the results of the paper. Given that our findings hold for different benchmark years and countries, there is robust evidence that the negative/flat price-income relationship in poor countries is not a spurious result, but a hitherto undocumented economic fact.

4 Conclusion

In this paper I show that the relationship between the price and the income level in poor countries is negative or, at most, flat. To my knowledge this is an original finding. It contradicts the conventional wisdom of a positive price-income relationship, which draws upon a linear estimation. If I apply non-parametric estimation to a panel of countries, the price-income relationship turns out to be significantly negative in poor countries. This result is robust along both time-series and cross-section dimensions.

This new evidence raises general questions about the process of economic development and the price level, as well as about the long-run determinants of the real exchange rate in poor countries. In fact, the standard Balassa-Samuelson hypothesis cannot explain the negative price-income relationship in poor countries. This hypothesis relies on the assumption that higher income countries have relatively higher productivity in the tradable sector. Accounting for free labor mobility between the tradable and non-tradable

sectors and for the law of one price implies that higher income countries have higher prices in the non-tradable sector, and hence a higher overall price level. For a negative price-income relationship, we would need richer countries to be characterized by lower productivity in the tradable sector, but there is no empirical evidence to support such an assumption.

It might still be possible to explain the negative/flat price-income relationship from a supply-side perspective through a model of endogenous tradability following Bergin, Glick and Taylor (2007). If productivity shocks in poor countries were biased towards non-tradable goods, but were not strong enough to cover the cost of making such goods tradable, productivity growth in the non-tradable sector would be higher than in the tradable sector; this might generate a negative price-income relationship.

Alternatively, it is possible to explain the negative price-income relationship within a demand-side framework as in De Gregorio, Giovannini and Wolf (1994). As income increases in poor countries, it may be that people demand more tradable goods like bicycles, televisions, or watches rather than non-tradables like restaurants, theaters or IT services; so, the relative income elasticity of tradables is higher. Under the assumptions of imperfect capital mobility, imperfect competition, and deviations from the law of one price, as a country becomes richer it increases the demand of tradable goods; this decreases the relative price of non-tradables, hence the general price level.

Another possible explanation could focus on the process of structural transformation and the role played by agriculture. In developing countries, agriculture is mainly at subsistence level, and is a non-tradable activity (Gollin, Parente and Rogerson, 2007). The agricultural sector is relatively less productive than the non-agricultural sector in poor countries (Restuccia, Yang, and Zhu, 2008, and Herrendorf and Valentinyi, 2011). If we consider agriculture as a non-tradable sector in poor countries, in a standard Balassa-Samuelson model the price of non-tradable goods would be higher than was hitherto thought. As a country with a high share of subsistence agriculture

undertakes a development process of structural change, it will first experience a decreasing and then an increasing price-income relationship.

All these explanations are plausible, but another possibility, along the lines of Engel (1999), would be that other factors not related to the relative price of non-tradables have an important impact on the real exchange rate, at least in the short- and medium-run. With this paper we lay the ground for further theoretical and empirical research on the relationship between economic development and the price level.

The results presented in this paper, although surprising, should not be disturbing. It is probable that Samuelson himself would not have been startled. In his 1994 article for the thirty-year anniversary of the Balassa-Samuelson model, he wrote that " *The Penn-Balassa-Samuelson effect is an important phenomenon of actual history but not an inevitable fact of life. It can quantitatively vary and,* ***in different times and places, trace to quite different processes***".

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5 Figures and Tables

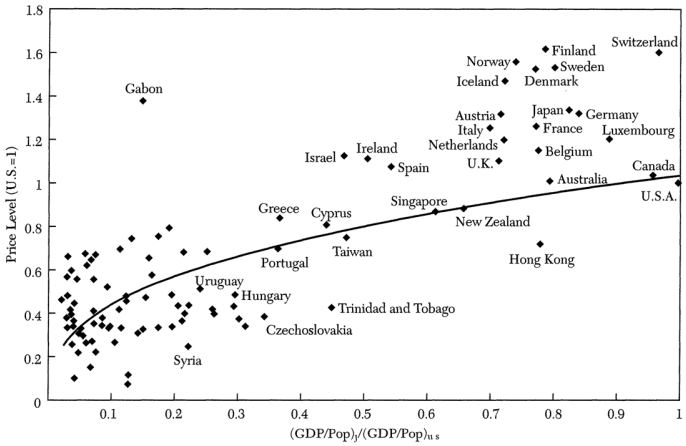

Figure 1: Price Level and Income - Rogoff (1996)

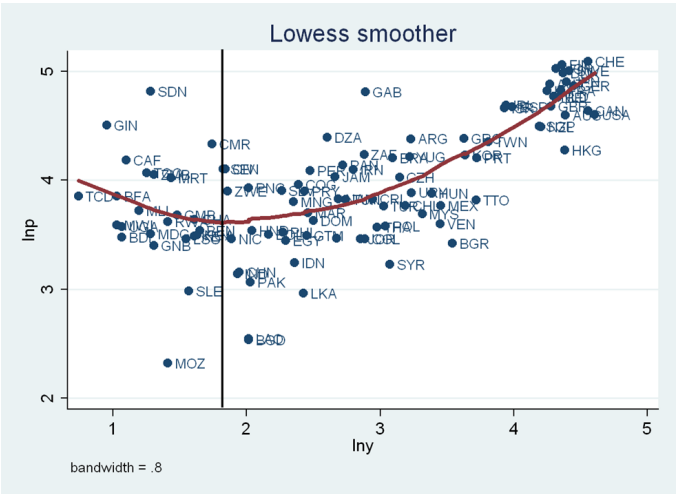

Figure 2: Price Level and Income - Rogoff (1996); log-income & non-param. estimation

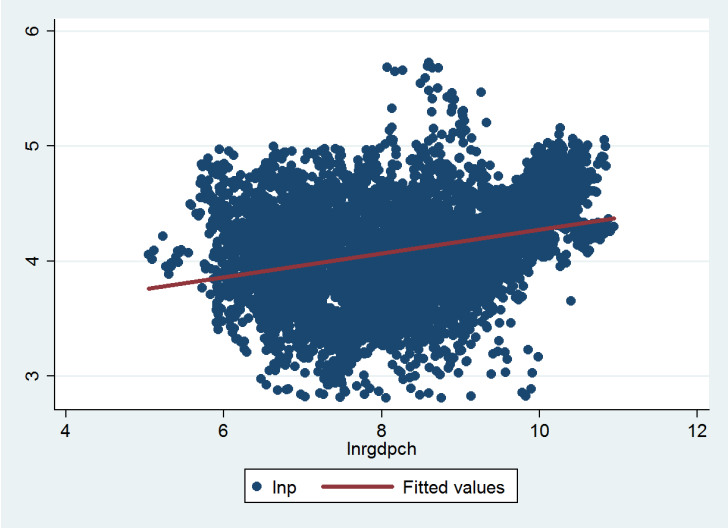

Figure 3: Prices and Income 1950-2009: Linear Estimation

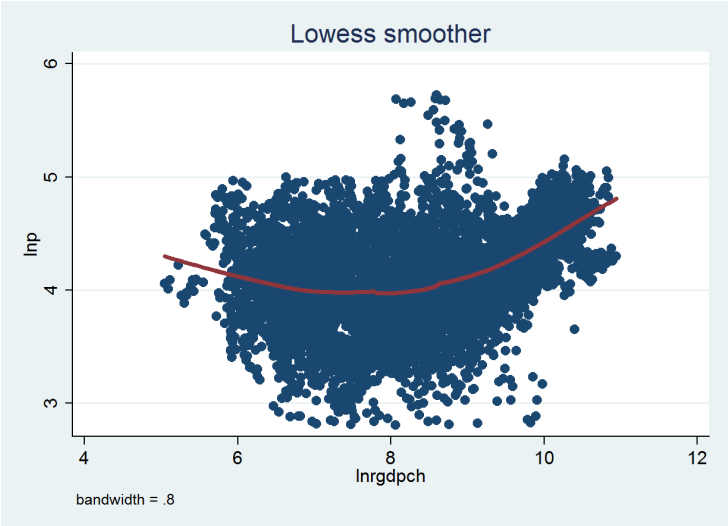

Figure 4: Prices and Income 1950-2009: Non-Parametric Estimation

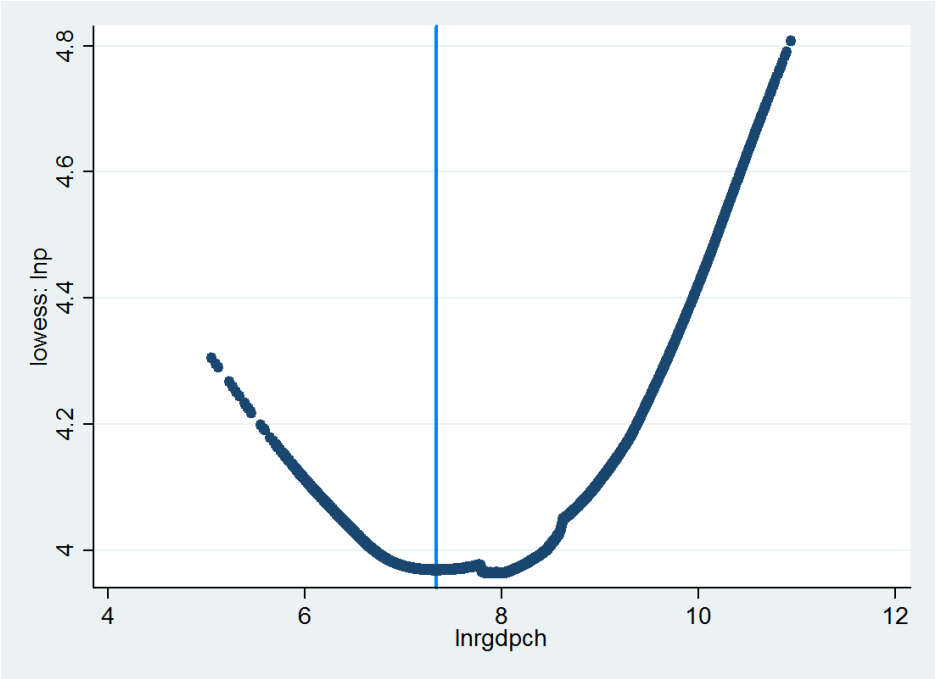

Figure 5: Prices and Income 1950-2009: Non-Parametric Estimation, fitted values

Country	Frequency	Country	Frequency	Country	Frequency
Afghanistan	40	Guinea	24	Pakistan	33
Bangladesh	51	Guinea-Bissau	48	Papua New Guine	15
Benin	51	Haiti	18	Philippines	19
Bosnia and Herzegovin	1	India	45	Rwanda	50
Botswana	12	Indonesia	20	Senegal	50
Burkina Faso	51	Kenya	60	Sierra Leone	49
Burundi	45	Kyrgyzstan	3	Somalia	39
Cambodia	33	Laos	32	Sri Lanka	32
Cameroon	17	Lesotho	50	Sudan	26
Central African Republi	50	Liberia	27	Swaziland	4
Chad	50	Madagascar	50	Taiwan	5
China Version 1	38	Malawi	53	Tajikistan	14
China Version 2	33	Malaysia	7	Tanzania	50
Congo, Dem. Rep.	56	Mali	50	Thailand	20
Congo, Republic of	16	Mauritania	46	Togo	49
Cote d`Ivoire	35	Moldova	1	Tunisia	1
Egypt	28	Morocco	23	Uganda	55
Eritrea	18	Mozambique	26	Uzbekistan	9
Ethiopia	59	Nepal	50	Vietnam	28
Gambia, The	50	Niger	50	Yemen	5
Ghana	48	Nigeria	44	Zambia	25

Figure 6: Countries on the downward sloping arm

Table 1: Panel evidence on price level and real income

Dependent var: ln p	**Full Sample**		**Developing Countries**	
	(1)	(2)	(1)	(2)
ln RGDPCH	0.10***	0.09***	-0.12***	-0.13***
	(9.60)	(8.19)	(-7.29)	(-7.97)
Country, fe	NO	YES	NO	YES
Time dummies	YES	YES	YES	YES
No. of countries	149	149	107	107
Avg obs per country	46.1	46.1	45.7	45.7

*** Significant at the 1% level; robust t-statistics in parenthesis.

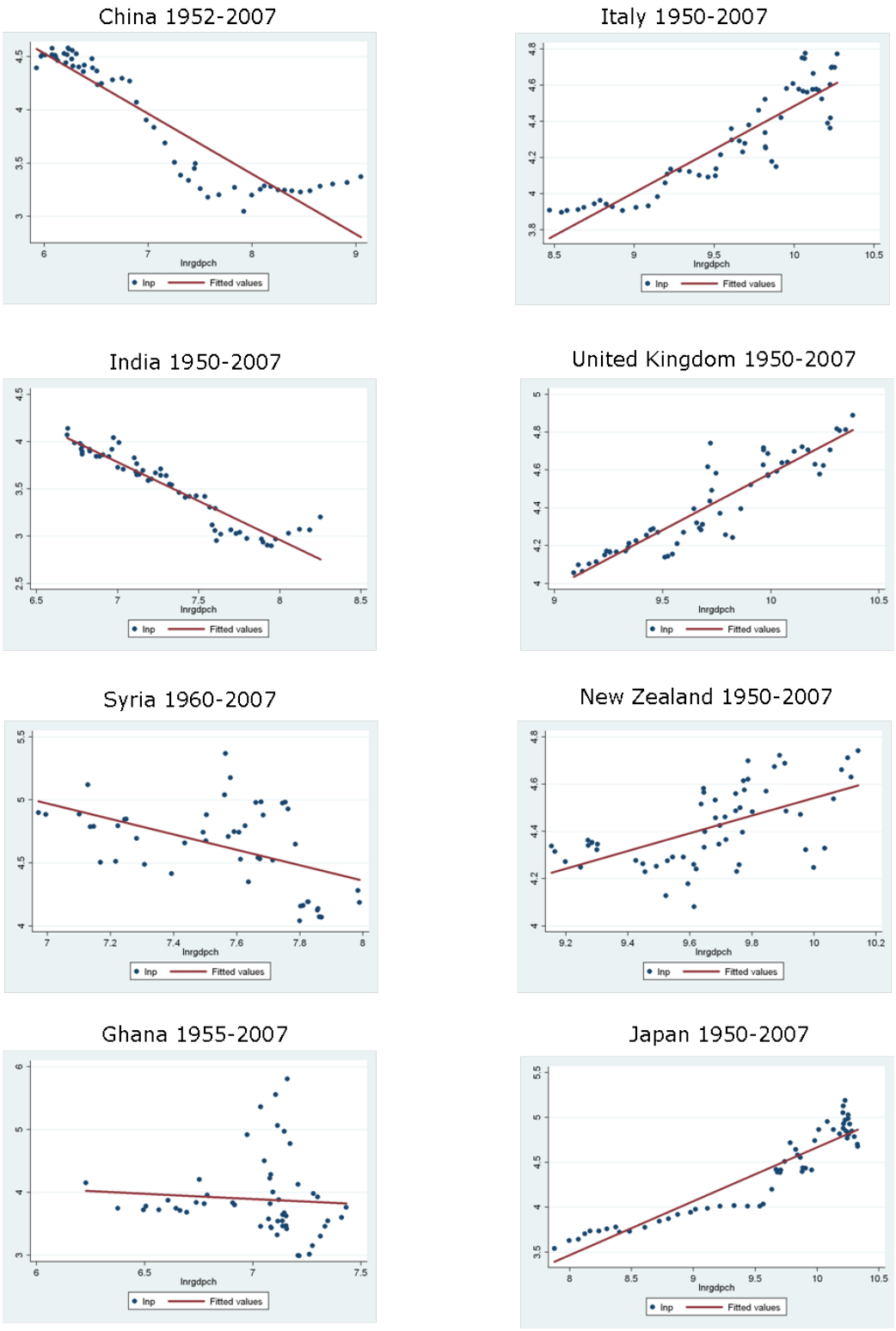

Figure 7: Price-Income, time series dimension: developing vs. developed countries, selected cases

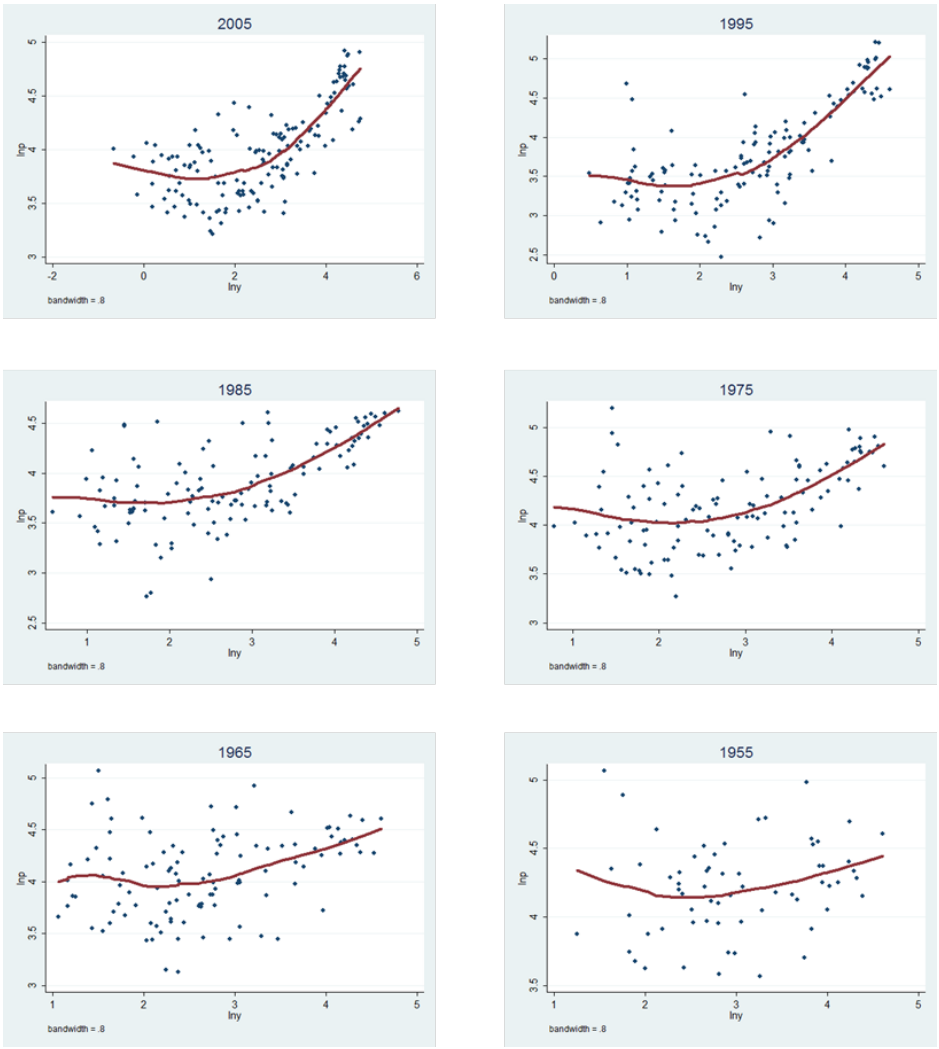

Figure 8: Prices and Income: cross-section estimations. Real income per-capita at current prices

Table 2: Cross-country regression by ranking of income, year 2005

Dependent var: ln p	ln y
1st Third	-0.11*
	(-1.93)
2nd Third	0.13
	(1.17)
3rd Third	0.50***
	(7.17)
Full sample	0.20***
	(9.97)

*** Significant at the 1% level; ** significant at the 5% level; *significant at the 10% level; robust t-statistics in parenthesis.

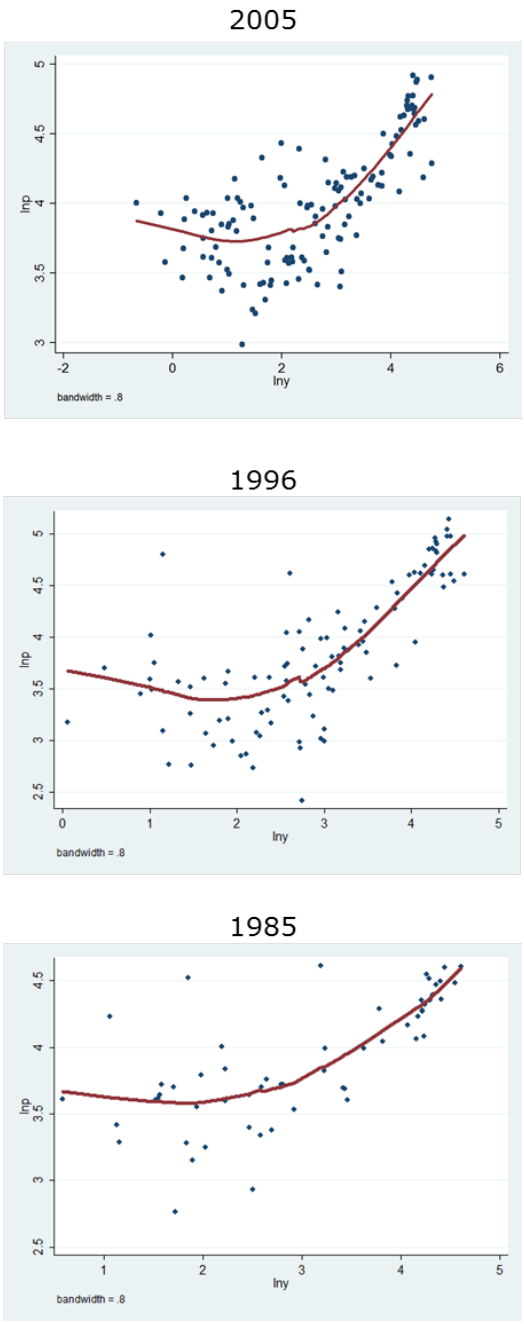

Figure 9: Price and income: benchmark years and countries

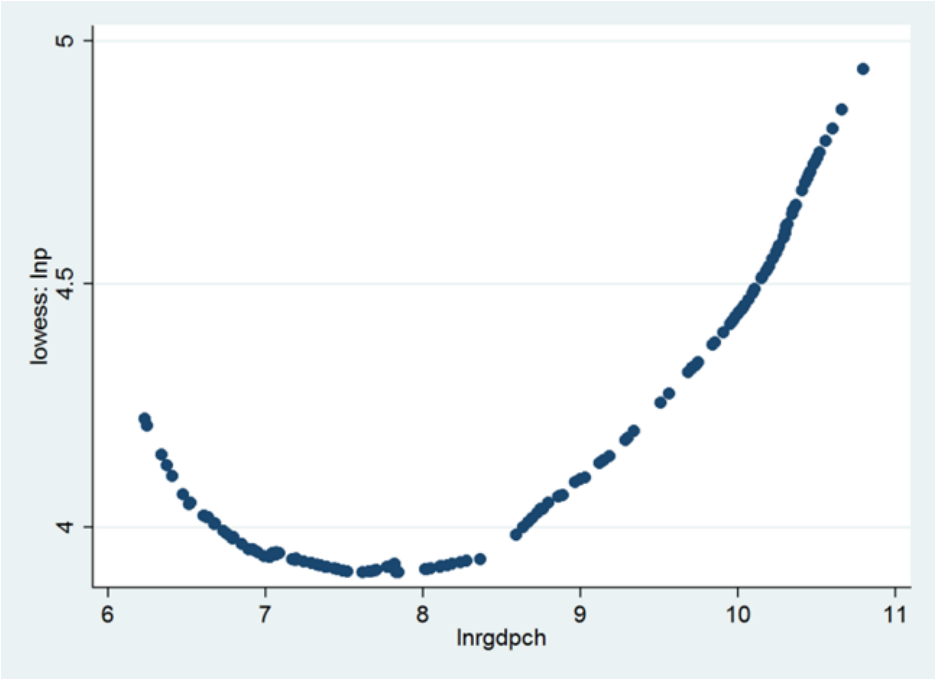

Figure 10: Price and income: panel of benchmark years and countries. Non-parametric estimation, fitted values

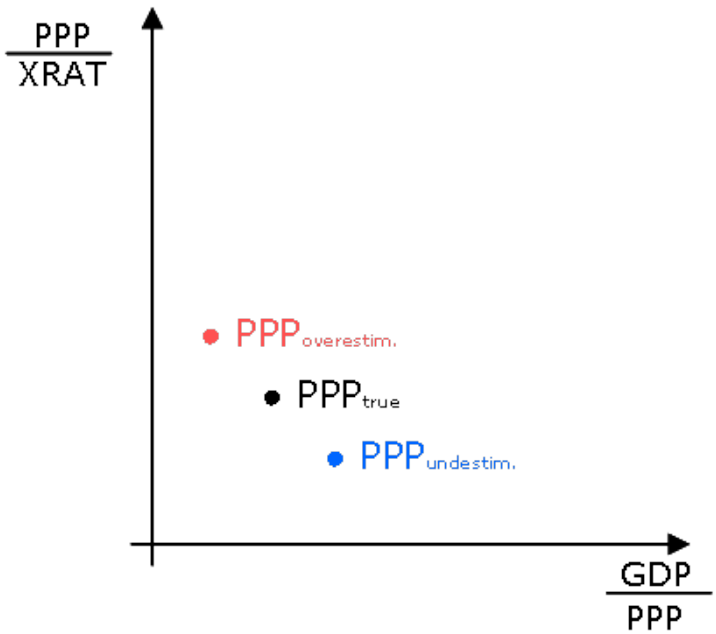

Figure 11: The effect of PPPs bias

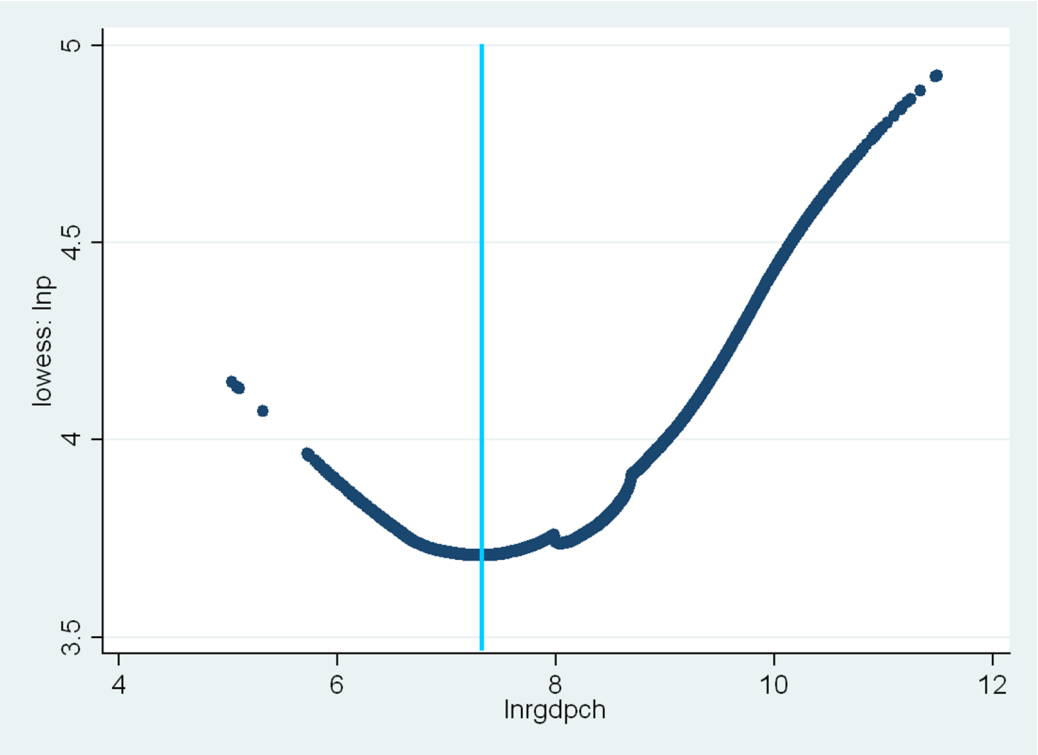

Figure 12: Prices and Income 1950-2007: Non-Parametric Estimation, fitted values. PWT 6.3

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