The Price of Development

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Abstract:

The positive correlation between cross-country price level and per-capita income is generally regarded as a stylized fact renowned as the Penn-Balassa-Samuelson effect. This paper provides evidence that the price-income relationship is non-linear and that it turns negative in low income countries. The result is robust along both cross-section and panel dimensions. Additional robustness checks show that biases in PPP estimation and measurement error in low-income countries do not drive the result. The different stage of development between countries can explain this new finding. The paper shows that a model linking the price level to the process of structural transformation captures the non-monotonic pattern of the data.

Keywords: Balassa-Samuelson; Penn effect; developing countries; non-parametric estimation; purchasing power parity; real exchange rate; structural transformation.

JEL Classifications: E31, F4, O1.

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1 Introduction

It is widely understood that market exchange rates do not give accurate measures of real income in different economies and that adjustment by purchasing power parity (PPP) factors is necessary for such measures. This understanding is based on an observed empirical regularity that richer countries have a higher price level than poorer countries. The positive correlation between cross-country price level and per-capita income is generally regarded as a stylized fact. This result was documented for twelve developed countries in the seminal paper of Bela Balassa (1964), was confirmed for a large sample of countries as soon as data from the International Comparison Program (ICP) became available and is now renowned as the Penn-Balassa-Samuelson effect (Penn- BS).[1]

The paper makes an important qualification to this general understanding. Using non-parametric estimation, it provides evidence that the price-income relationship is non-linear and that it turns negative in low-income countries both along a cross-section and a panel dimension. Standard regression analysis in sub-samples of poor, middle-income, and rich countries is consistent with this finding. The results of the paper are robust to possible sources of bias from PPP estimation and measurement error in low-income countries.

The paper argues that the non-monotonicity of the price-income relationship is due to the different stage of development that characterize low- and high-income countries. The paper presents a model with three sectors (agriculture, manufacturing and services) and traces the effects of different productivity in agriculture and employment shares on the price level of low-income countries. This model seems to capture the non-monotonic pattern of the data, in a way that the standard Balassa-Samuelson hypothesis, focused on just tradables and non-tradables, does not. The intuition is that, when a poor country starts to develop, its productivity growth relies mainly in the agricultural

[1]The Penn-BS effect was documented also by Summers and Heston (1991), Barro (1991), and Rogoff (1996). Samuelson (1994) stresses that the proper name for it would be *Ricardo-Viner-Harrod-Balassa-Samuelson-Penn-Bhagwati-et alt. effect.*

sector. Since that, at an early stage of development, agriculture is mainly non-tradable and represents a big share of expenditure, this productivity growth reduces the relative price of agricultural goods, hence the overall price level.

The Penn-Balassa-Samuelson effect is at the basis of our understanding of long-run real exchange rate movements. The paper makes a significant contribution on the positive side by uncovering a twist to what has long been accepted as a well-established empirical regularity. From a policy point of view, by showing that in poor countries the price-income relationship is negative, the paper suggests that there is a "natural" depreciation of the real exchange rate along the development process. If so, this is an important finding for central banks and governments of low-income countries as they pursue their exchange rate policy. Moreover, the theoretical result of the paper suggests that the process of structural change can be a key determinant of real exchange rate movements in developing countries and that the link between sectoral economic structure and real exchange rate merits further investigation.

The paper is structured as follows: Section 2 shows that the price-income relationship is non-monotonic using both non-parametric and linear estimations. Section 3 establishes that the results are robust to the structure of the Penn World Tables database I use and that the findings are not driven by biases in PPP estimation. Section 4 argues that countries' different economic structure can explain the results, it derives a model that links the price level to the process of structural transformation and analyzes the empirical prediction of the model showing that it can capture the non-monotonicity of the data. Section 5 concludes summarizing the main findings and discussing further research based on these results.

2 The price-income relationship

In this section I show that the price-income relationship is non-monotonic. I provide evidence along a cross-section, panel, and time-series 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.[2] Unless alternatively specified, the database of reference is the Penn World Table (PWT) 7.0 version.

2.1 Cross-section dimension

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.[3] I investigate the price-income relationship 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. This 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 $ (1985 prices), which is equivalent to the income of Senegal in the year 1990.

[2] 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.

[3] This is Penn World Table 5.6 (reference year 1985); he considers the year 1990

In commenting 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.* In this paper we take Rogoff's point further using a non-parametric estimation that shows that the relationship is actually striking when looking at rich countries as a group and negative when looking at poor countries as a group. According to our knowledge, the non-monotonicity of the price-income relationship has not been previously documented in the literature.

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. In this section I use the default STATA bandwidth of 0.8 and in the robustness section I show how using different bandwidths affects the results. It turns out that the current choice is conservative, because a bandwidth of 0.8 provides a lower-bound of the non-monotonic pattern of the data.

Next, I extend the analysis to the PWT 7.0 using only the benchmark countries and the benchmark year.[4] Arguably, this is the best available sample of countries for running this exercise. PWT 7.0 relies on the 2005 ICP round, which provides the most exhaustive dataset for international comparison of real income and prices; moreover, using only the benchmark countries and year minimizes the source of measurement error. I can 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 0.20 with a t-statistic of 9.67 (see figure 3).[5]

Once I allow for non-linearities, the Penn-BS effect breaks down for low income countries. Figure 4 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; this involves 22% of the countries in the sample. The turning point is at 1,396 PPP $ per-capita (2005 prices) equivalent to the income of Zambia in the year 2005. The countries on the downward sloping path are listed in figure 5; we can notice that these are mainly African and Asian (no Latin-American).

Figure 6 reports 95% confidence bands of the LOWESS estimation derived from the standard errors of the smoothed values. The confidence interval confirms the non-monotonic pattern of the data. The Pseudo-R^2 of the non-parametric estimation is 0.66, which is higher than the 0.44 R^2 of the linear model. The F-test comparing the non-parametric model to the linear one rejects the null hypothesis that the non-linear model does not provide a statistically significant better fit.

[4] I exclude countries with less than one million people in the year 2000 and Zimbabwe and Tajikistan which are clear outliers; including these countries would reinforce the findings. The list of the countries included can be found in the appendix.

[5] I run an OLS regression, with robust standard errors, of the log of the price level of GDP (variable p from PWT) and the log of GDP per capita in PPPs at current prices (y from PWT).

Standard cross-country OLS regression supports the finding of the non-parametric estimation. In Table 1, I rank countries by their income level and divide the full sample into three groups.[6] The price-income relationship is negative, sizable, and significant for the countries in the bottom group of income. As the GDP per-capita of the reference group increases the relationship changes sign and the Penn-BS effect becomes larger and more significant. The results of the OLS regressions are consistent with the non-monotonicity of the price-income relationship stressed by the non-parametric estimation.

2.2 Panel and time-series dimensions

In this section, I analyze the price-income relationship in a panel dimension. The ICP collects data prices only in benchmark years. Then, the PWTs estimate prices for other years by rescaling according to the inflation rate differential with the US. Although the reliability of this method is unclear, PWTs are regularly used in empirical analyses with panels; moreover, panel regressions of price on income are commonly used to build measures of real exchange rate over/undervaluation. Thus, it is relevant to assess if the non-monotonicity of the price-income relationship holds along a panel dimension too. [7]

If I extend the analysis to a panel of countries between 1950-2009, standard linear estimation of price on income confirms the positive relationship predicted by the Penn-BS effect: the OLS coefficient is 0.20 with a t-statistic of 27.60 (figure 7).[8] However, non-parametric estimation shows

[6]There are 42 observations per group on average. The first group includes the countries up to the income level of Mongolia, the second one up to Lebanon, the third ones includes the remaining countries with a higher level of income

[7]Feenstra et al. (2011) are working on a new version of the Penn World Tables that will make use of historical ICP benchmarks to extrapolate the time series of prices and real incomes. This new data set will certainly provide better evidence of the price-income relationship in a panel dimension.

[8]This is for a sample of 150 countries from 1950 to 2009 using PWT 7.0. Countries with less than one million people in the year 2000 and clear outliers are excluded; including these outliers would reinforce the findings. I run an OLS regression of the log of the price

that the price-income relationship is non-monotonic along a panel dimension too. The Penn-BS effect holds for middle- and high-income countries, but in low-income countries the relationship is negative (figure 8).

Figure 9 reports the fitted value of the LOWESS estimation. The turning point is at 1600 PPP $ per-capita (2005 prices), which corresponds to the income of Nigeria in the year 2005. 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 9. We can see that some of the countries 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 2) confirms the result of the non-parametric estimation. I show that for developing countries the relationship between price and income is negative and significant with and without country fixed-effects.[9] I do this by running a regression for the full sample, and then for developing countries only.[10] This result comes despite a strict definition of developing countries and a linear restriction on the price-income 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 11). 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 merits further research. It suggests that the development process of a

level of GDP (variable p from PWT) and the log of GDP per capita in PPPs at constant prices ($RGDPCH$ from PWT).

[9]The relative stability of the coefficients and of the standard errors suggests that in developing countries the price-income relationship within-country is very similar to the one between-countries

[10]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. Notice that in the full sample with country fixed effects the coefficient is not significantly different from zero.

country is characterized by a pattern of real exchange rate depreciation; this is consistent with the positive correlation between an undervalued real exchange rate and growth in developing countries documented by the literature as in Rodrik (2008).

3 Robustness checks

In this section I analyze the robustness of the results to possible sources of measurement error. The data involved in the previous estimations are GDP per-capita, exchange rates, and PPPs. Data on GDP are very aggregate and are worldwide computed through the standardized SNA method, they should not be a mayor concern for measurement error.[11] Official exchange rates can be very different from black market exchange rates in developing countries; though this applies mainly until the '80s (Reinhart and Rogoff, 2004), we need to control for this possible source of bias. PPP is clearly the variable that can be mostly affected by measurement error and it is the one I draw more attention on.

In this section I show that the findings of the paper are robust to possible sources of bias from PPP estimation, to the PWT's structure and to black market exchange rates. Moreover, I also show that the non-parametric estimations of section 2 are more likely to be a lower-bound of the true non-monotonicity that characterizes the data.

3.1 Purchasing power parities

The most important source of measurement error comes from the computation of Purchasing Power Parities, above all in low-income countries. Biased

[11] Gollin et al. (2012) analyze the definitions and measurement approaches used in the construction of national accounts data in poor countries. They conclude that these aggregate data are robust to problems associated with informality or household production and that there is no reason to believe that they are intrinsically flawed.

estimates could seriously affect the results of the paper because PPPs enter the numerator of the dependent variable and the denominator of the independent variable.[12] This generates issues of classical measurement error where a high variance of measurement error leads to a biased and inconsistent estimation. Moreover, I control also for the bias generated by the average of the measurement error, not only by its variance.

3.1.1 Bias from the variance of measurement error

Chen et al. (2007) analyze the bias of OLS estimation of price on income when there is a measurement error in the computation of PPPs. They argue that the independent variable is correlated with the error term, so that the standard assumptions for a consistent and unbiased least square estimator break down. They conclude that if the β coefficient of the price-income relationship is positive, the OLS estimate will be biased downwards and can become negative if the variance of the measurement error is high. In fact, they show that:[13]

$$\text{plim } \hat{\beta} = \frac{\beta - \frac{\sigma_\eta^2}{\sigma_{y^*}^2}}{1 + \frac{\sigma_\eta^2}{\sigma_{y^*}^2}} \qquad \text{(A)}$$

where σ_η^2 is the variance of measurement error and $\sigma_{y^*}^2$ is the variance of the "true" real income per-capita.

From this expression we can see that as the variance of the measurement error σ_η^2 increases, the estimated $\hat{\beta}$ can become negative. Among the poorest group of countries (the bottom-third) I find an OLS estimation of -0.135. What level of measurement error's variance can drive this result? Assuming that measurement error is correlated to the level of income but not to the

[12] I remind the reader that $p = \frac{PPP}{XRAT}$ and $y = \frac{GDP}{PPP}$

[13] They start specifying the price-income relationship such that $p_i^* = \alpha + \beta y_i^* + \epsilon_i$, where p_i^* is the true price level without measurement error and $y_i^* = Y_i - p_i^*$ is the "true" real income per-capita. Consider the case where the measured price level p_i contains an error such that $p_i = p_i^* + \eta_i$, where η_i has mean zero and is normally distributed; then expression (A) follows.

level of price, we can rewrite expression (A) as: [14]

$$\text{plim}\ \hat{\beta} = \frac{\beta - \frac{\sigma_\eta^2}{\sigma_{y^*}^2}}{1 + \frac{\sigma_\eta^2}{\sigma_{y^*}^2}} = \frac{\beta - \frac{\sigma_\eta^2}{\sigma_Y^2 + \sigma_p^2 + \sigma_\eta^2 + \sigma_{Yp} + \sigma_{Y\eta}}}{1 + \frac{\sigma_\eta^2}{\sigma_Y^2 + \sigma_p^2 + \sigma_\eta^2 + \sigma_{Yp} + \sigma_{Y\eta}}} \qquad \text{(B)}$$

In the sub-sample of countries where the price-income relationship is negative, we have $\sigma_Y^2 = 0.302$, $\sigma_p^2 = 0.067$, $\sigma_{Yp} = 0.27$(remember that all the variables are expressed in logs). I assume that $\sigma_{Y\eta} = \sigma_{Yp} = 0.27$, so that the covariance between the income level and the measurement error of price is equal to the covariance between income and price.

The variance of measurement error that would lead to the negative estimation of -0.135 depends on the value of β_{true}. Let's suppose that β_{true} is equal to the OLS estimation over the full sample (0.20). In this case, in order to get $\hat{\beta} = -0.135$, I would need $\sigma_\eta^2 = 0.57$: the measurement error on prices should have a variance 9 times higher than the variance of the observed prices. If we rather assume that β_{true} is zero, we would need $\sigma_\eta^2 = 0.16$: this value is equal to the variance of price in the full sample of countries; hence the variance of the measurement error in the sub-sample of poor countries should be as big as the overall variance of prices that we observe over the full data set.

Therefore, even if measurement error could potentially drive my result, an implausible variance of the measurement error itself is required to get the negative price-income relationship presented in the paper.

3.1.2 Bias from the mean of measurement error

In Figure 12 we can see that if PPPs are systematically underestimated in poor countries, measurement error would deliver a stronger Penn-BS effect; the reverse would be true if PPPs tend to be overestimated.[15] It is easy to

[14] From Chen et al. specification we have that $y_i^* = Y_i - p_i - \eta_i$, from which expression (B) follows.

[15] The underlying assumption in the figure is that measurement error of PPPs affects poorer countries only.

show that the same argument applies in the case of a negative price-income relationship: if PPPs tend to be more underestimated in poor countries than in middle-income ones, the true price-income relationship would be more negative than the estimated one. Therefore, it is crucial to understand if measurement errors in computing PPPs tend to overestimate or underestimate the true PPPs in low-income countries.

The process of computing PPPs is subject to intrinsic fragilities, making comparisons of real income and prices across countries a difficult exercise. Deaton and Heston (2010) and the ICP Handbook (2007) stress that the main sources of bias in PPPs' estimation are the method of aggregation, quality matching and good representativity.

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) point out, 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 the 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 by prices that are closer to those of rich countries, their consumption is overvalued.

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. Quality mismatch leads to an underestimation of the price level in poor countries.

The representativity of the goods priced could also bias PPPs. In each country the ICP calculates prices for about 155 goods (called basic headings) by collecting prices for 1500-2000 items. A basic heading is the most disaggregated level at which expenditure data are available from national accounts statistics. The ICP collects quotes for different items within each basic head and then aggregates them with different procedures.[16] If an item within the basic heading is representative in some countries but not in others, PPPs may be estimated incorrectly.[17] This is a common problem for all ICP rounds.[18]

Nevertheless, Diewert (2008) argues that if non-representative prices are well-distributed across all countries in a region, they may not cause serious distortions. Moreover, Deaton (2010) computes a Tornqvist index to measure how much different goods moves the overall PPP-index in Africa and Asia.[19] He then concludes that there is no evidence to support the idea that prices in Africa or in the Asia-Pacific region are systematically overstated by the representativity issue.

Feenstra et al. (2012) show that in China the price level has been overstated because of a urban bias in the data collection. In order to account for this bias the PWT introduces a uniform reduction of 20% to the ICP prices. This adjustment is consistent with their estimates of China's real GDP. Our results account for this downward revision. However, there is no clear evidence of price overestimation for other countries due to the urban bias. Actually Atkin

[16]For instance, for the basic heading *rice*, the ICP collects quotes for six different kinds of rice, including long-grained, short-grained, and brown rice. See Rao (2004) for a detailed explanation of the items' methods of aggregation

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

[18]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.

[19]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.

and Donaldson (2012) show that the price of detailed products in Ethiopia and Nigeria are on average 5-12% higher in rural areas.

To summarize, the method of aggregation and quality matching tend to understate PPPs in low-income countries respect to the "true" values. Moreover, there is no evidence that products representativity systematically biases PPPs upwards and that the urban bias affect the countries on the downward sloping path. If that's the case, the non-monotonicity showed in section 2 is actually a lower-bound of the true one.

3.2 PWT structure: benchmark analysis and black market exchange rates

The Penn World Tables (PWT) rely on data from the International Comparison Program (ICP) which collects prices only in benchmark years and benchmark countries. The PWT estimates PPPs for other years through rescaling according to the inflation rate differential with the US. Whereas, the PPPs of countries where the ICP did not collect prices are estimated by a two-stage process based on the relationship between nominal and real shares for the benchmark countries.[20]

In figure 13 I run a non-linear estimation of the price-income relationship only for benchmark years and benchmark countries of subsequent versions of the PWT.[21] As Bergin et alt. (2006) stress, the overall measurement error for benchmark samples is low. Even if I restrict the analysis to these more reliable samples, the non-monotonicity of the price-income relationship is confirmed.

As a robustness check for the panel analysis, I focus on the University of Queensland International Comparisons Database (UQICD). The UQICD

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

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

computes PPPs through an econometric model constructed using information contained in all the benchmark comparisons of the ICP, rather than through extrapolations formed from a single benchmark only. Figure 13 shows the fitted values of a LOWESS estimation from a panel that includes only the benchmark years and the benchmark countries of the ICP rounds in 1985,1996, and 2005. This is a very limited sample of 47 countries that excludes most of the low-income countries of the previous estimations. Despite that, figure 14 confirms the non-monotonicity of the price-income relationship.

Another point worth to highlight is that the exchange rate that PWT uses to compute the price level is the official one. In developing countries the official exchange rate can greatly differ from the one used in daily transactions, above all in the early years of our sample. Nevertheless, this issue does not undermine the finding of the paper. In fact, as Reinhart and Rogoff (2004) argue, multiple exchange rate arrangements decreased greatly over time and the non-monotonicity of the price-income relationship that the paper documents holds also for the year 2005. Moreover, in figure 15 I report the non-parametric estimation of price on income using black market exchange rates for the year 1996.[22] The non-monotonicity of the relationship is confirmed also in this case.

Finally, the analysis in Section 2 refers to the PWT 7.0 database. This 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. The results presented in section 2 holds also for previous versions of the PWTs. [23]

[22]Data on black market rates are taken from Reinhart and Rogoff (1996). Prices are computed dividing PPPs from PWT 6.1 by the black market exchange rates. I choose the year 1996 because this is the oldest benchmark year for which raw PPPs are available.

[23]Details available upon request.

Feenstra, Inklaar and Timmer are working on a new version of the Penn World Tables that will provide price and real GDP data not only on the expenditure side, but also on the output side. Moreover, in order to derive a time series of price and income, it will rely on historical benchmarks of the ICP and not only on national accounts as it is currently the case. It is not clear how these new two dimensions will affect the analysis of the paper. Nevertheless, this new data set will allow further analysis of the price-income relationship.

3.3 LOWESS estimation: alternative bandwidths

In section 2 I briefly discussed the trade off between smoothness and bias in choosing the bandwidth for the LOWESS estimation. A large bandwidth includes observations from other part of the density increasing the risk of bias. A small bandwidth can better capture the true feature of the data, but at the cost of higher variance. The analysis hitherto presented used the default bandwidth of STATA which is 0.8. This is a large value that may lead to a biased estimation of the non-parametric pattern of the data.

In figure 16 I report non-parametric estimations of the same sample of figure 4, but using a bandwidth of 1 and of 0.4. We can see that with a bandwidth of 1, which is the maximum, nothing changes respect to the estimation of figure 4. However in the case of a 0.4 bandwidth, the non-monotonicity of the price-income relationship is stronger: the negative pattern now includes 33% of the sample and it becomes positive only after a level of income of 2,604 PPP$ equivalent to that of Mongolia in the year 2005. This suggests that the non-monotonicity presented in section 2 can be a lower-bound of the true one.

This section has shown that the results of the paper are robust to possible bias in PPPs estimation; that they hold for benchmark years and countries; that are not affected by using black market exchange rates; and that different bandwidths in the non-parametric estimation would reinforce the results. All this provides evidence that the non-monotonicity of the price-income relationship is not a spurious result, but a hitherto undocumented economic fact.

4 Theoretical explanation

4.1 Beyond the Balassa-Samuelson hypothesis

The most accepted explanation of the Penn-BS effect is the Balassa-Samuelson (BS) hypothesis. This explanation focuses on productivity differentials between the tradable and the non-tradable sector. Assuming free labor mobility across sectors and that the law of one price holds for tradables, the BS hypothesis shows that countries with higher relative productivity in the tradable sector have a higher price level. Since richer countries tend to have higher relative productivity in the tradable sector, the price level should then raise with per-capita income.

In order to capture the non-monotonicity of the price-income relationship, this paper argues that we need a modified BS framework that accounts for the relevance of the agricultural sector in poor countries and for the fact that low-income and high-income countries have very different economic structures and are at different stages of development. In table 3, I consider the benchmark countries of PWT 7 for the year 2005. As in table 1, I rank countries by their level of income and divide the sample into three groups. Then, following the tradition of the development macroeconomics literature, I focus on a sectoral division of the economy between agriculture, manufacturing, and services.

We can see that the countries in the bottom group of income have a remarkably different structure in terms of valued added, expenditure, and employment shares. The most significant differences refer to the agricultural sector: the group of countries where the price-income relationship is negative have a 10 times higher valued added share in agriculture, a 5 times higher expenditure share and a 9 times higher employment share than the countries in the top group of income. This clearly reflects the early stage of development that characterizes these countries.

The differences in value added, expenditure and employment shares are associated to a different structure of relative prices. Using disaggregated data kindly provided by the International Comparison Program at the World Bank, I can compute sectoral PPPs and price levels.[24] Perhaps contrary to conventional wisdom, the relative price of agriculture in terms of both services and manufacturing turns to be higher in low-income countries than in rich-countries. [25] Moreover, the average price level of services and manufacturing increases by income group, but the price level of agriculture decreases between the bottom and the intermediate group. Non parametric estimations of sectoral prices on income confirm this pattern: figures 17-19 show that the price dynamics of the agricultural sector accounts for most of the non-monotonicity of the overall price-income relationship.

The explanation for the non-monotonic price-income relationship that this paper proposes is therefore the following: When a poor country starts to develop, its productivity growth relies mainly in the agricultural sector. This allows for a reduction of the relative price of agricultural goods. Since in a country at an early stage of development, agriculture represents a big share of both expenditure and value added production, there is an overall reduction of the price level. After a certain stage of development the share of the

[24]The price level of sector i is given by $p_i = PPP_i/XRAT$ with $p_i^{US} = 1$. In order to preserve aggregation at the GDP level, I use the Geary-Khamis method to compute sectoral PPPs. See the appendix A.5 for a detailed description of goods' sectoral classification; as suggested by Herrendorf and Valentinyi (2011) I map the agricultural sector with the food sector.

[25]Caselli (2005) hints at this possibility in a footnote. Lagakos and Waugh (2012) have a similar finding.

agricultural sector in the economy decreases. Hence the previous effect fades out and productivity gains from the manufacturing sector becomes a more important source of growth, so that we are back to the standard Balassa-Samuelson mechanism.

The two key elements of this explanation are that productivity growth in the agricultural sector is higher than in other sectors and that agricultural goods are not tradable. Duarte and Restuccia (2010) show for a panel of 29 countries between 1956-2004 that productivity growth was 4% in agriculture, 3% in manufacturing and 1.3% in services; moreover Ngai and Pissarides (2007) calibrate US TFP growth between 1929-1998 such that it is 1% higher in agriculture than in manufacturing and 1% higher in manufacturing than in services. As for the non-tradability of agricultural goods, this is a reasonable assumption for low-income countries. As Gollin et al. (2007) stress, FAO reports show that in the year 2000 about 70% of arable land in 159 developing countries was devoted to staple food crops. With the exception of few developing countries, almost all of the resulting production was for domestic consumption. Moreover, food imports and food aid are not a major source of food for poor countries: imports of food supply around 5% of total calories consumed.

4.2 Structural change and the price level

This section develops a model that links the price level of a country to its process of structural transformation. It derives a consumption-based price index from the utility function, within a modified version of the Balassa-Samuelson framework. Then, taking as reference Ngai and Pissarides (2007), it expresses the consumption shares of that index as a function of the employment shares. In this way the price level can reflect a country's stage of development. In the next section, I then test if the price implied by this model can generate a non-monotonic price-income relationship.

Production functions are given by:

$$F_i(k_i, l_i) = A_i k_i^{\alpha} n_i^{1-\alpha}; \quad i = a, m, s \tag{1}$$

Factors' market clearing satisfies:

$$\sum_{i=1}^{m} l_i = 1; \;\; \sum_{i=1}^{m} k_i = k; \tag{2}$$

Moreover, we have that $F_i = c_i$ for $i = a, s$. We also assume that manufacturing produces both a final consumption good and the economy's capital stock so that $\dot{k} = F^m - c_m - (\delta + n)k$.

The underlying assumptions of the model, as in the Balassa-Samuelson framework, are that manufacturing is the only tradable and that trade is balanced period by period. These imply that the effect of trade is to equalize the price of manufacturing across countries and that there is financial autarky, which is probably a reasonable assumption for low-income countries. The purpose of these assumption is to have a model as close as possible to the standard Balassa-Samuelson framework.

The utility function is assumed to have constant elasticities across goods so that:

$$U(c_a, c_m, c_s) = \left[\gamma_a^{\frac{1}{\theta}} c_a^{\frac{\theta-1}{\theta}} + \gamma_m c_m^{\frac{\theta-1}{\theta}} + \gamma_s c_s^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{3}$$

The consumption-based price index P is defined as the minimum expenditure:

$$z = P_a c_a + P_m c_m + P_s c_s \tag{4}$$

such that $c = U(c_a, c_m, c_s) = 1$ given P_i.

So defined, the consumption-based price index measures the least expenditure that buys a unit of the consumption index on which period utility depends. Under standard assumptions the consumption-based price index can be written as: [26]

$$\log P = \gamma_a \log p_a + \gamma_s \log p_s; \tag{5}$$

As in Ngai and Pissarides (2007) we can link the expenditure shares to the employment shares, so that the price index can be finally expressed as: [27]

$$\log P^{BS+} = (\gamma_a + \gamma_s)\left[\log A_m - \left(\frac{l_a}{l_a + l_s}\log A_a + \frac{l_s}{l_a + l_s}\log A_s\right)\right] \tag{6}$$

where l_i is the employment share of sector i, A_i is TFP in sector i. I label it Balassa-Samuelson+ price index.

4.3 Models' predictions of the Price-Income relationship

In this section I compute the price level implied by the standard Balassa-Samuelson hypothesis and by the "Balassa-Samuleson+" hypothesis. I then use these price levels to estimate the price-income relationship non-parametrically and compare the fitted values with the actual pattern of the data.

Under the Balassa-Samuelson hypothesis, the price level of country z is:

$$\log P^{BS} = \gamma_{NT}(\log A_T - \log A_{NT}) \tag{7}$$

where γ_{NT} is the expenditure share of non-tradables.

Notice that (6) and (7) are very similar. The difference is that in the Balassa-Samuelson+ there is a better focus on the agricultural sector and that the sectoral TFPs of agriculture and services are weighted by the relative employ-

[26] See the appendix A.2 for a complete derivation.
[27] See the appendix A.3 for a complete derivation.

ment shares, so that the price index reflects the stage of structural transformation at which countries are. If we shut down the focus on the agricultural sector by setting γ_a and l_a equal to zero, like if it were absorbed by the manufacturing sector, we are back to the standard Balassa-Samuelson hypothesis.

In order to compute these price levels, I obtain sectoral estimates of TFP across countries following the methodology of Herrendorf and Valentinyi (2011).[28] Employment shares are taken by the WDI database and by national sources. The saving rate σ is set equal to the share of investment in GDP. The consumption share in manufacturing γ_m is given by the expenditure share in manufacturing computed from the ICP database.[29]

Figure 20 shows the fitted values of the non-parametric estimation of the price-income relationship, where prices are given by equation (7): I am able to confirm the strictly positive relationship predicted by the Balassa-Samuelson hypothesis.

However, figure 21 shows that the price implied by the "Balassa-Samuleson+" hypothesis allows for more flexibility in the price-income relationship and can generate a negative pattern at low levels of development. Therefore, by taking into account that countries are at a different stage of their process of structural transformation, I am able to match better the actual pattern of the data reported in figure 22.

Table 4 analyzes the quantitative fit: under the BS+ hypothesis 26% of countries in the sample are on the downward sloping path of the price-income relationship; in the standard BS hypothesis this is 0% and in the actual data it is 22% of the sample. The variance of prices generated by the BS+

[28] They elaborate a development accounting framework to compute sectoral productivities using the Penn World Tables; see the appendix for a detailed description

[29] I am able to compute the price levels for 60 countries out of 127 because of the lack of sectoral employment data in many poor countries and lack of investment data in middle-income and former URSS countries; following Caselli (2005) I exclude countries with data on investment starting only after the '70s.

hypothesis is two and half times higher than in the data (1.02 vs 0.41). Finally, the turning point of the BS+ model is around 3,000 PPP$, but in the data it is around 1,400 PPP$.

The quantitative result of the "Balassa-Samuleson+" hypothesis clearly outperforms that of the Balassa-Samuelson hypothesis. The model derived in this paper is relatively simple and a richer approach that accounts for other factors like the tradability of agriculture in rich countries or the reduction of trade costs as a country develops might deliver a better quantitative fit. However the results presented are encouraging and lay the ground for further theoretical and empirical research on the relationship between structural change and the price level.

5 Conclusions

In this paper I show that the relationship between the price and the income level is non-monotonic. To my knowledge this is an original finding and it is a hitherto undocumented empirical regularity. This result contradicts the conventional wisdom of a positive price-income relationship, which draws upon a linear estimation. If I apply a non-parametric estimation, the price-income relationship turns out to be significantly negative in poor countries. This finding is robust along both cross-section and panel dimensions. The new evidence presented in this paper raises general questions about the relationship between the process of economic development and the price level, as well as about the long-run determinants of real exchange rate in poor countries.

The paper shows that a model linking the price level to the process of structural transformation that characterizes developing countries can generate a non-monotonic pattern of the price-income relationship. This result suggests that structural change and, more in general, inter-sectoral dynamics can be important determinants of real exchange rates movements. Nevertheless, a richer theoretical approach could improve the quantitative fit.

For instance the model does not account for the role of trade costs. Trade costs are much higher than is generally recognized, even for traded goods: the classic paper by Anderson and Van Wincoop (2004) estimates that for developed countries, trade costs average 170% of production costs, of which roughly half is international trade costs and half internal trade costs. For developing countries, they claim that this ratio is often higher, and many studies do indeed show strikingly high transport costs for individual developing countries or groups thereof (Limao and Venables, 2001).

Trade costs and the ratio of trade costs to production costs may well vary systematically with the level of development. For example as a low-income country starts developing, its infrastructures improve reducing both internal and external trade costs as well as the ratio of trade costs to production. This might turn to be a key element in explaining the initial negative pattern of the price-income relationship and deserves further investigation.

The tradability of agriculture in more developed countries is another feature that a richer model should account for. In the current model, agriculture is completely non-tradable and this could partly explain the high variance of prices and the turning point's high level of income that the model predicts.

A multisector Eaton-Kortum model of trade as in Michaels et al. (2011) and Tombe (2012) would account for both the endogenous tradability of agriculture and the effect of trade cost. This approach might deliver a better quantitative prediction and the counterfactuals of the model might shed additional light on the sources of the non-monotonic pattern of the data.

Finally, a possible empirical extension of the paper could focus on regional variation within countries like India or China, where there are regions at very different stages of development. This kind of regional variation would be ideal to verify if the process of structural transformation is at the basis of the non-monotonic price-income relationship.

This paper lays the ground for further theoretical and empirical research on the relationship between economic development and the price level. The results presented, 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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A Appendix

A.1 Countries in the cross-section analysis of section

Albania	Congo, Rep. of	Israel	Namibia	Sudan
Angola	Cote d'Ivoire	Italy	Nepal	Swaziland
Argentina	Croatia	Japan	Netherlands	Sweden
Armenia	Czech Republic	Jordan	New Zealand	Switzerland
Australia	Denmark	Kazakhstan	Niger	Syria
Austria	Ecuador	Kenya	Nigeria	Taiwan
Azerbaijan	Egypt	Korea, Rep. of	Norway	Tanzania
Bangladesh	Estonia	Kuwait	Oman	Thailand
Belarus	Ethiopia	Kyrgyzstan	Pakistan	Togo
Belgium	Finland	Laos	Paraguay	Tunisia
Benin	France	Latvia	Peru	Turkey
Bolivia	Gabon	Lebanon	Philippines	Uganda
Bosnia and Herz.	Gambia, The	Lesotho	Poland	Ukraine
Botswana	Georgia	Liberia	Portugal	Sweden
Brazil	Germany	Lithuania	Romania	Switzerland
Bulgaria	Ghana	Macedonia	Russia	Syria
Burkina Faso	Greece	Madagascar	Rwanda	Taiwan
Cambodia	Guinea	Malawi	Saudi Arabia	Tanzania
Cameroon	Guinea-Bissau	Malaysia	Senegal	United Kingdom
Canada	Hong Kong	Mali	Serbia	United States
Central Afr. Rep.	Hungary	Mauritania	Sierra Leone	Uruguay
Chad	Guinea-Bissau	Mauritius	Singapore	Venezuela
Chile	India	Mexico	Slovak Rep.	Vietnam
China Version 1	Indonesia	Moldova	Slovenia	Yemen
China Version 2	Iran	Mongolia	South Africa	Zambia
Colombia	Iraq	Morocco	Spain	
Congo, Dem. Rep.	Ireland	Mozambique	Sri Lanka	

A.2 The Consumption-Based Price Index

The consumption-based price index P is defined as the minimum expenditure:

$$z = P_a c_a + P_m c_m + P_s c_s \tag{8}$$

such that $c = \phi(c_a, c_m, c_s) = 1$ given P_i.

So defined, the consumption-based price index measures the least expenditure that buys a unit of the consumption index on which period utility depends.

From consumer's utility maximization we know that:

$$\frac{MU_i}{MU_j} = \frac{P_i}{P_j} \tag{9}$$

so that:

$$\left(\frac{\gamma_a}{\gamma_m}\right)^{\frac{1}{\theta}} \left(\frac{c_m}{c_a}\right)^{\frac{1}{\theta}} = \frac{P_a}{P_m}; \quad c_a = \frac{\gamma_a}{\gamma_m} c_m \left(\frac{P_a}{P_m}\right)^{-\theta} \tag{10}$$

and

$$\left(\frac{\gamma_s}{\gamma_m}\right)^{\frac{1}{\theta}} \left(\frac{c_m}{c_s}\right)^{\frac{1}{\theta}} = \frac{P_s}{P_m}; \quad c_s = \frac{\gamma_s}{\gamma_m} c_m \left(\frac{P_s}{P_m}\right)^{-\theta} \tag{11}$$

Substituting c_a and c_s from (10) and (11) into (8) we have:

$$z = \frac{P_a^{1-\theta}}{P_m^{-\theta}} \frac{\gamma_a}{\gamma_m} c_m + P_m c_m + \frac{P_s^{1-\theta}}{P_m^{-\theta}} \frac{\gamma_s}{\gamma_m} c_m \tag{12}$$

so that rearranging:

$$c_m = \frac{\gamma_m P_m^{-\theta} z}{\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta}} \tag{13}$$

and consequently:

$$c_a = \frac{\gamma_a P_a^{-\theta} z}{\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta}} \tag{14}$$

$$c_s = \frac{\gamma_s P_s^{-\theta} z}{\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta}} \tag{15}$$

Equations (13), (14), and (15) are the demands that maximize c given spending z. The highest value of the utility function c given z, thus is found by substituting these demands into (3):

$$\left[\gamma_a^{\frac{1}{\theta}} \left(\frac{\gamma_a P_a^{-\theta} z}{x}\right)^{\frac{\theta-1}{\theta}} + \gamma_m^{\frac{1}{\theta}} \left(\frac{\gamma_m P_m^{-\theta} z}{x}\right)^{\frac{\theta-1}{\theta}} + \gamma_s^{\frac{1}{\theta}} \left(\frac{\gamma_s P_s^{-\theta} z}{x}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{16}$$

where $x = \gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta}$.

Since P is defined as the minimum expenditure z such that $c = 1$ we have:

$$\left[\gamma_a^{\frac{1}{\theta}} \left(\frac{\gamma_a P_a^{-\theta} P}{x}\right)^{\frac{\theta-1}{\theta}} + \gamma_m^{\frac{1}{\theta}} \left(\frac{\gamma_m P_m^{-\theta} P}{x}\right)^{\frac{\theta-1}{\theta}} + \gamma_s^{\frac{1}{\theta}} \left(\frac{\gamma_s P_s^{-\theta} P}{x}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} = 1 \tag{17}$$

from which the solution for P is:

$$P = \left(\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{18}$$

This is the consumption-based price index consistent with the CES utility function specified in equation (3). When $\theta = 1$ the utility function becomes Cobb-Douglas; in this case the price index becomes:

$$\log P = \frac{\log(\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta})}{1-\theta} \tag{19}$$

Applying L'Hopital's rule we have:

$$\lim_{\theta \to 1} \frac{\log(\gamma_a P_a^{1-\theta} + \gamma_m P_m^{1-\theta} + \gamma_s P_s^{1-\theta})}{1-\theta} = \frac{f(\theta)}{g(\theta)} = \lim_{\theta \to 1} \frac{f'(\theta)}{g'(\theta)} = \gamma_a \log P_a + \gamma_m \log P_m + \gamma_s \log P_s \tag{20}$$

so that for the Cobb-Douglas case, the consumption-based price index is given by:

$$\log P = \gamma_a \log P_a + \gamma_m \log P_m + \gamma_s \log P_s \tag{21}$$

Accounting for the cross-country equalization of the price of manufacturing through trade and normalizing it to one, the consumption-based price index can be written as:

$$\log P = \gamma_a \log p_a + \gamma_s \log p_s \tag{22}$$

A.3 Relative prices, consumption shares and employment

From the supply-side, static efficiency condition requires equal marginal rate of technical substitution across sectors, so that $k_i = k$; while free movement of capital and labor leads to equal remuneration of the factors of production. Therefore, firms' profit maximization implies:

$$\frac{P_a}{P_m} = \frac{A_m}{A_a} \tag{23}$$

$$\frac{P_s}{P_m} = \frac{A_s}{A_a} \tag{24}$$

From consumer's optimality conditions (10) and (11) we can define the relative expenditure of agriculture and services respect to manufacturing as:

$$\frac{P_a c_a}{P_m c_m} = \frac{\gamma_a}{\gamma_m}\left(\frac{P_a}{P_m}\right)^{1-\theta} \equiv x_a \tag{25}$$

$$\frac{P_s c_s}{P_m c_m} = \frac{\gamma_s}{\gamma_m}\left(\frac{P_s}{P_m}\right)^{1-\theta} \equiv x_s \tag{26}$$

We then define $X = x_a + x_s + x_m$, where clearly $x_m = 1$. We also define:

$$c \equiv \sum_{i=1}^{m} P_i c_i; \qquad y \equiv \sum_{i=1}^{m} P_i F^i \tag{27}$$

Using equations (25) and (26) and the efficiency conditions, we can rewrite equations (28) as:

$$c = P_m c_m X; \quad y = P_m A_m k^{\alpha} \tag{28}$$

Notice that the technology parameter for output is TFP in manufacturing not an average of all sectors.

As in Ngai and Pissarides (2007) we can link relative expenditure with the employment shares. If we substitute we substitute $F^i = c_i$ for $i = a, s$ in (25) and (26), using the market clearing conditions in (2), we can show that it results:

$$n_a = \frac{c}{y}\frac{x_a}{X} \tag{29}$$

$$n_s = \frac{c}{y}\frac{x_s}{X} \tag{30}$$

The employment share in the manufacturing sector is derived by firstly observing that $l_m = 1 - l_a - l_s$, so that we have:

$$l_m = \frac{c}{y}\frac{x_m}{X} + \left(1 - \frac{c}{y}\right) \tag{31}$$

Let's consider the case where $\theta = 1$ and manufacturing is the numeraire. In this case the price index is given by $\log P = \gamma_a \log p_a + \gamma_s \log p_s$. By using firm's optimality conditions (23) and (24) as well as (29) and (30) We can write the price level as:

$$\log P = (\gamma_a + \gamma_s)\left[\log A_m - \left(\frac{l_a}{l_a + l_s}\log A_a + \frac{l_s}{l_a + l_s}\log A_s\right)\right] \tag{32}$$

A.4 Sectoral TFPs Methodology

In order to compute sectoral TFPs, I use the methodology of Herrendorf and

Valentinyi (2011) who elaborate a sectoral development accounting framework that allows to compute sectoral TFPs using PWT. The key assumptions of their methodology are: competitive markets; factor's mobility across sectors; Cobb-Douglas production function with factor shares common to all countries.

The production function for sector i in country z is given by:

$$y_i^z = A_i^z (k_i^z)^{\theta_i} (l_i^z)^{\phi_i} (h_i^z)^{1-\theta_i-\phi_i} \tag{33}$$

where k is capital, l is land, and h is human capital.
Under the assumption stated above, Herrendorf and Valentinyi (2011) show that the sectoral factors of production are:

$$k_i^z = \frac{\theta_i p_i^z y_i^z}{\sum_j \theta_j p_j^z y_j^z} \sum_i k_i^z \tag{34}$$

$$l_i^z = \frac{\phi_i p_i^z y_i^z}{\sum_j \phi_j p_j^z y_j^z} \sum_i l_i^z \tag{35}$$

$$h_i^z = \frac{(1-\theta_i-\phi_i) p_i^z y_i^z}{\sum_j (1-\theta_j-\phi_j) p_j^z y_j^z} \sum_i h_i^z \tag{36}$$

In order to compute sectoral TFPs, I take the sectoral factor shares from Herrendorf and Valntinyi (2011), who calculate them from the US input-output tables. Then, following their methodology, I compute the capital stock in the economy k^z with the perpetual inventory method as in Caselli (2005). Land l^z is arable land for agriculture and urban land for manufacturing and services. I take data on arable land from FAOSTAT and following World Bank (2006) estimates, I set urban land equal to 24% of physical capital. Finally, I compute human capital h^z as in Caselli (2005) and it is an increasing function of average years of schooling per worker.

A.5 ICP 2005, classification of goods

Category	Basic Heading	*BS-SC framework:* Sector allocation	*BS-framework:* Tradability
Food	Rice	A	T
	Other cereals and flour	A	T
	Bread	A	T
	Other bakery products	A	T
	Pasta products	A	T
	Beef and veal	A	T
	Pork	A	T
	Lamb, mutton and goat	A	T
	Poultry	A	T
	Other meats and preparations	A	T
	Fresh or frozen fish and seafood	A	T
	Preserved fish and seafood	A	T
	Fresh milk	A	T
	Preserved milk and milk products	A	T
	Cheese	A	T
	Eggs and egg-based products	A	T
	Butter and margarine	A	T
	Other edible oils and fats	A	T
	Fresh or chilled fruit	A	T
	Frozen, preserved or processed fruits	A	T
	Fresh or chilled vegetables	A	T
	Fresh or chilled potatoes	A	T
	Frozen or preserved vegetables	A	T
	Sugar	A	T
	Jams, marmalades and honey	A	T
	Confectionery, chocolate and ice cream	A	T
	Food products n.e.c.	A	T

Category	**Basic Heading**	*BS-SC framework:* **Sector allocation**	*BS-framework:* **Tradability**
Beverages and tobacco	Coffee, tea and cocoa	M	T
	Mineral waters,soft drinks,fruit and veg juices	M	T
	Spirits	M	T
	Wine	M	T
	Beer	M	T
	Tobacco	M	T
Clothing and footwear	Clothing materials and accessories	M	T
	Garments	M	T
	Cleaning and repair of clothing	S	NT
	Footwear	M	T
	Repair and hire of footwear	S	NT
Housing, water, electricity and gas	Actual and imputed rentals for housing	S	NT
	Maintenance and repair of the dwelling	S	NT
	Water supply and miscellaneous services relating to the dwelling	S	NT
	Miscellaneous services relating to the dwelling	S	NT
	Electricity	M	T
	Gas	M	T
	Other fuels	M	T
Furniture, household equipment and maintenance	Furniture and furnishings	M	T
	Carpets and other floor coverings	M	T
	Repair of furniture, furnishings and floor coverings	S	NT
	Household textiles	M	T
	Major household appliances whether electric or not	M	T
	Small electric household appliances	M	T

Category	**Basic Heading**	*BS-SC framework:* **Sector allocation**	*BS-framework:* **Tradability**
Furniture, household equipment and maintenance	Repair of household appliances	S	NT
	Glassware, tableware and household utensils	M	T
	Major tools and equipment	M	T
	Small tools and miscellaneous accessories	M	T
	Non-durable household goods	M	T
	Domestic services	S	NT
	Household services	S	NT
Health	Pharmaceutical products	M	T
	Other medical products	M	T
	Therapeutical appliances and equipment	M	T
	Medical Services	S	NT
	Dental services	S	NT
	Paramedical services	S	NT
	Hospital services	S	NT
Transport	Motor cars	M	T
	Motor cycles	M	T
	Bicycles	M	T
	Fuels and lubricants for personal transport equipment	M	T
	Maintenance and repair of personal transport equipment	S	NT
	Other services in respect of personal transport equipment	S	NT
	Passenger transport by railway	S	NT
	Passenger transport by road	S	NT
	Passenger transport by air	S	NT

Category	Basic Heading	*BS-SC framework:* **Sector allocation**	*BS-framework:* **Tradability**
Transport	Passenger transport by sea and inland waterway	S	NT
	Combined passenger transport	S	NT
	Other purchased transport services	S	NT
Communication	Postal services	S	NT
	Telephone and telefax equipment	M	T
	Telephone and telefax services	S	NT
Recreation and culture	Audio-visual, photographic and information processing equipment	M	T
	Recording media	M	T
	Repair of audio-visual, photographic and information processing equipment	S	NT
	Major durables for outdoor and indoor recreation	M	T
	Other recreational items and equipment	M	T
	Gardens and pets	S	NT
	Veterinary and other services for pets	S	NT
	Recreational and sporting services	S	NT
	Cultural services	S	NT
	Games of chance	S	NT
	Newspapers, books and stationery	S	NT
	Package holidays	S	NT
Education	Education	S	NT
Restaurant and hotels	Catering services	S	NT
	Accommodation services	S	NT
Miscellaneous goods and services	Hairdressing salons and personal grooming establishments	S	NT
	Appliances, articles and products for personal care	S	NT

Category	Basic Heading	*BS-SC framework:* **Sector allocation**	*BS-framework:* **Tradability**
Miscellaneous goods and services	Prostitution	S	NT
	Jewellery, clocks and watches	M	T
	Other personal effects	M	T
	Social protection	S	NT
	Insurance	S	NT
	FISIM	S	NT
	Other financial services n.e.c	S	NT
	Other services n.e.c.	S	NT
Government expenditure	Government compensation of employees	S	NT
	Government intermediate consumption	M	T
	Government gross operating surplus	S	NT
	Government net taxes on production	S	NT
	Government receipts from sales	S	NT
Capital formation	Metal products and equipment	M	T
	Transport equipment	M	T
	Residential buildings	M	T
	Non-residential buildings	M	T
	Civil engineering works	M	T
	Other products	M	T
Inventories	Changes in inventories and acquisitions	M	T

A=agriculture; M=manufacturing; S=services; T=tradable; NT=non-tradable.

The sectoral allocation and the tradability allocation apply respectively to the estimation of the Balassa-Samuelson-Structural-Change and the Balassa-Samuelson framework in section 5.

B Figures and Tables

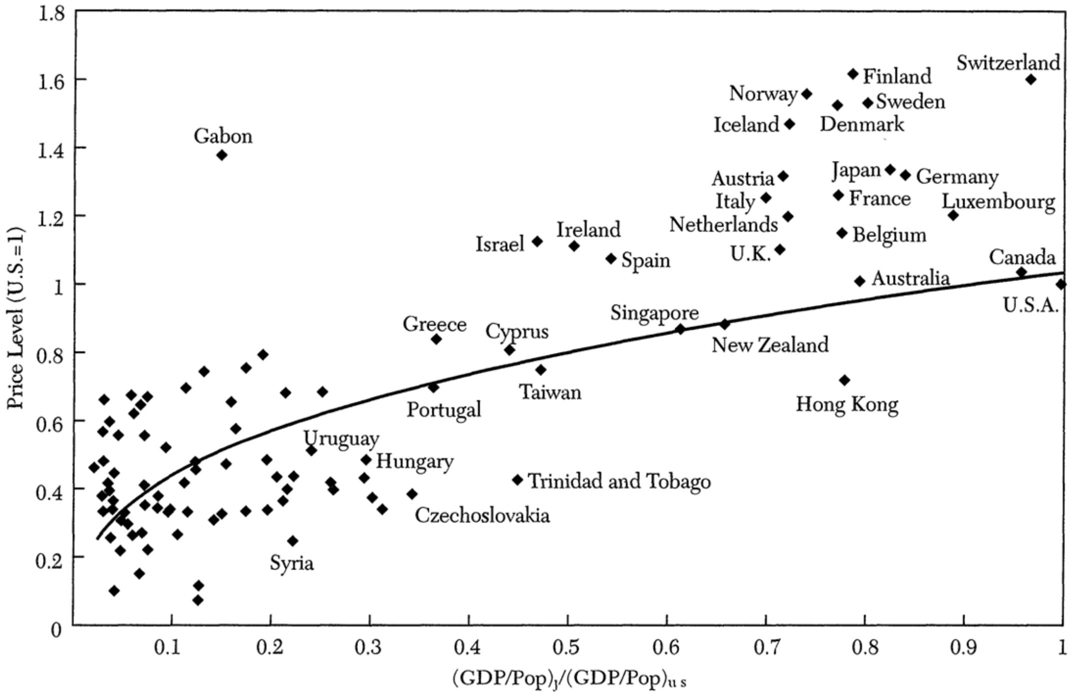

Figure 1: Price Level and Income - Rogoff (1996)

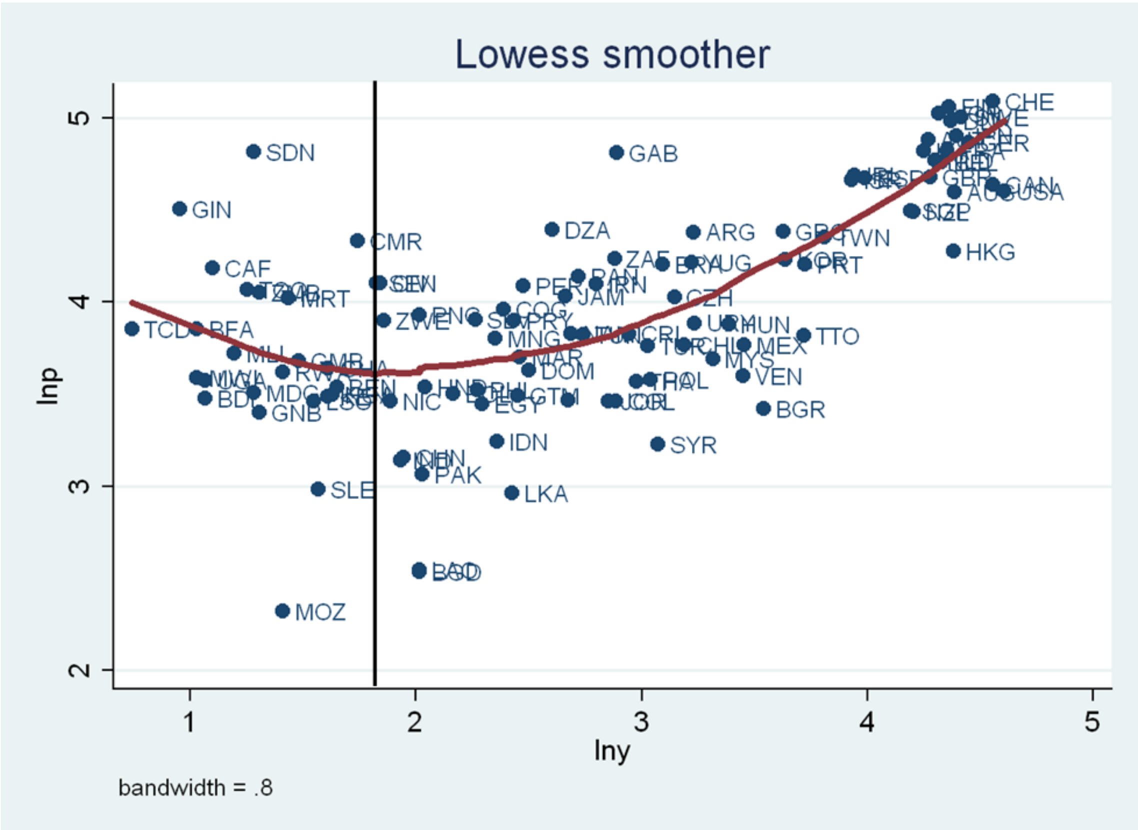

Figure 2: Price Level and Income - Rogoff (1996); log-income & non-param. estimation

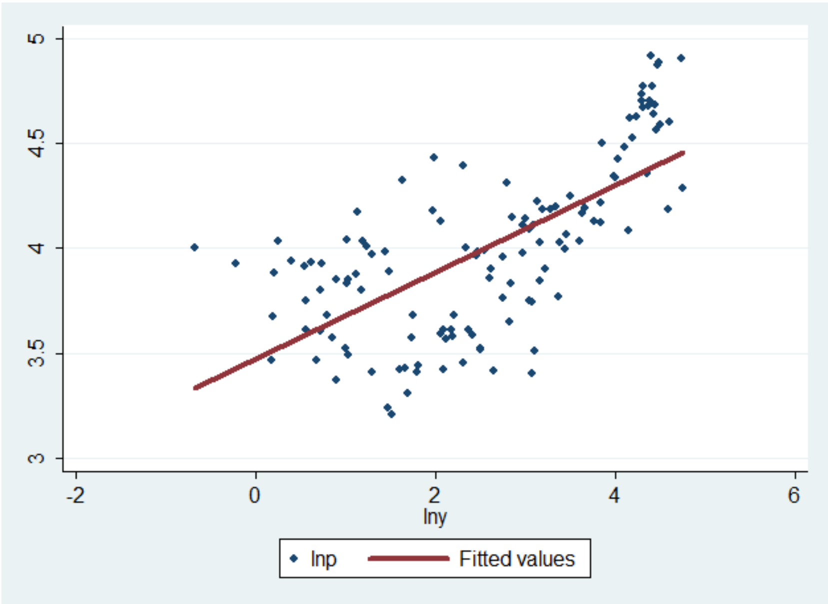

Figure 3: Price level and Income PWT 7.0, benchmark countries, 2005: Linear Estimation

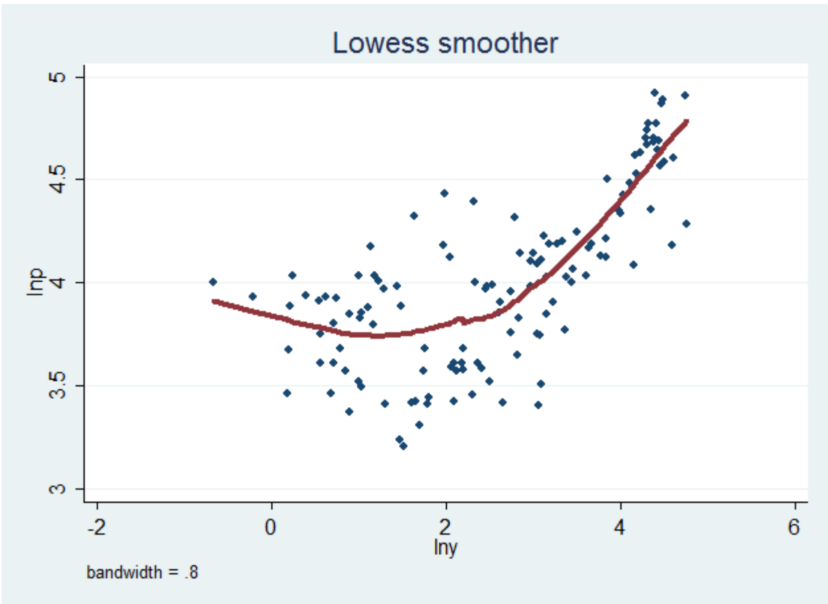

Figure 4: Price level and Income PWT 7.0, benchmark countries, 2005: Non-Parametric Estimation

Country	Country
Bangladesh	Liberia
Benin	Madagascar
Burkina Faso	Malawi
Central African Republic	Mali
Chad	Mauritania
Congo, Dem. Rep.	Mozambique
Cote d`Ivoire	Nepal
Ethiopia	Niger
Gambia, The	Rwanda
Ghana	Sierra Leone
Guinea	Tanzania
Guinea-Bissau	Togo
Kenya	Uganda
Lesotho	Zambia

Figure 5: Countries on the downward sloping arm: cross-section dimension

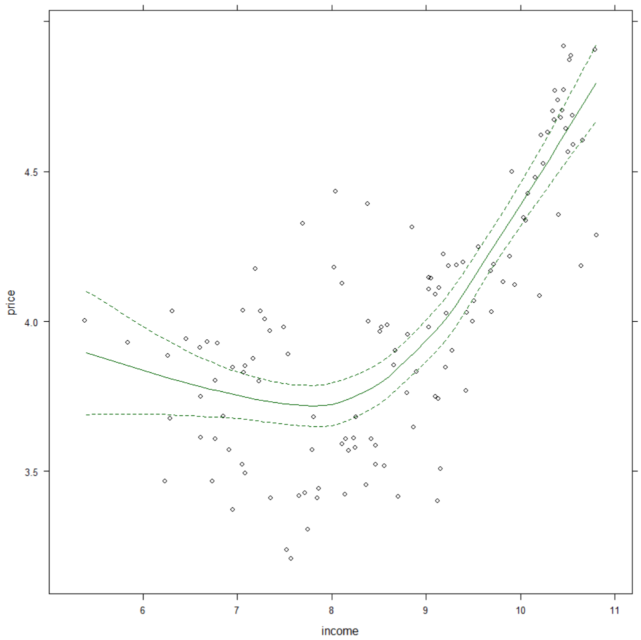

Figure 6: Price and Income PWT 7.0, benchmark countries, 2005: Non-Parametric Estimation, 95% confidence bands

Table 1: Cross-country OLS regression by income ranking, year 2005

Dependent var: ln p	ln y
1st Third	-0.135**
	(-2.05)
2nd Third	0.145
	(1.17)
3rd Third	0.514***
	(6.90)
Full sample	0.20***
	(9.67)

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

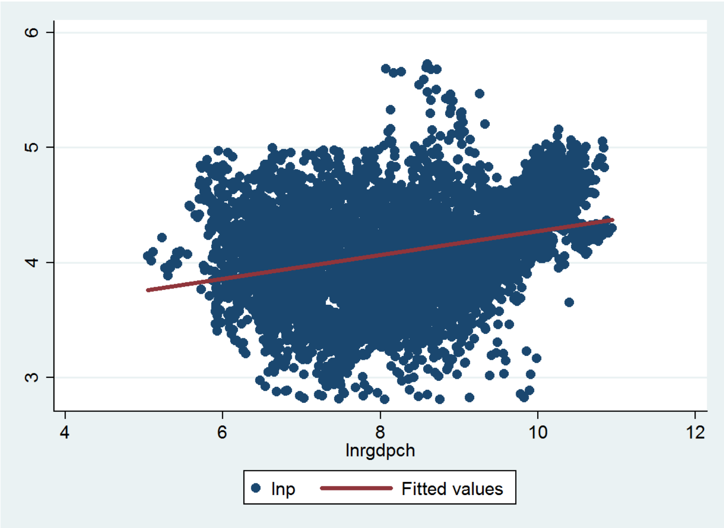

Figure 7: Prices and Income 1950-2009: Non-Parametric Estimation

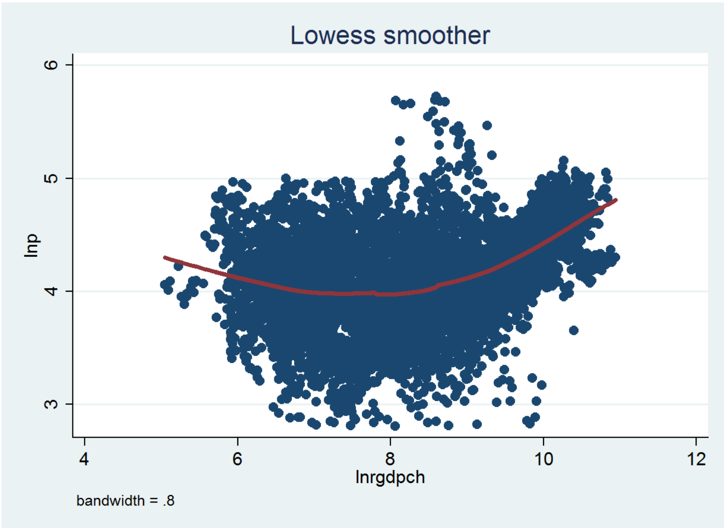

Figure 8: Prices and Income 1950-2009: Non-Parametric Estimation

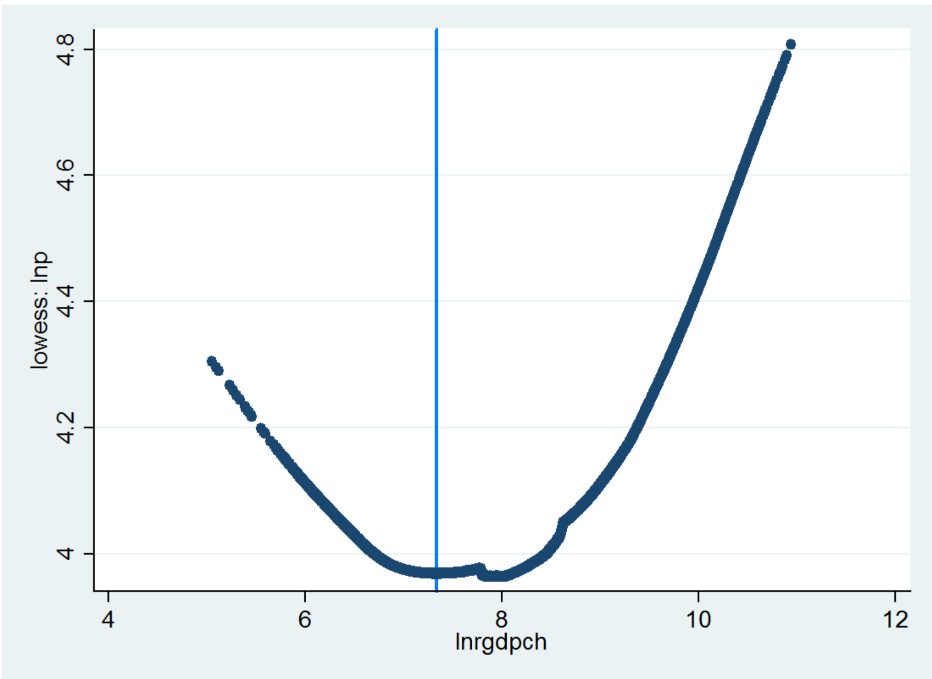

Figure 9: Prices and Income 1950-2009: Non-Parametric Estimation, fitted values

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 10: Countries on the downward sloping arm: panel dimension

Table 2: Panel evidence on price level and real income

Dependent var: ln p	**Full Sample**		**Developing Countries**	
	(1)	(2)	(1)	(2)
ln RGDPCH	0.109***	0.103	-0.125**	-0.138*
	(2.55)	(1.56)	(-1.95)	(-1.78)
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.

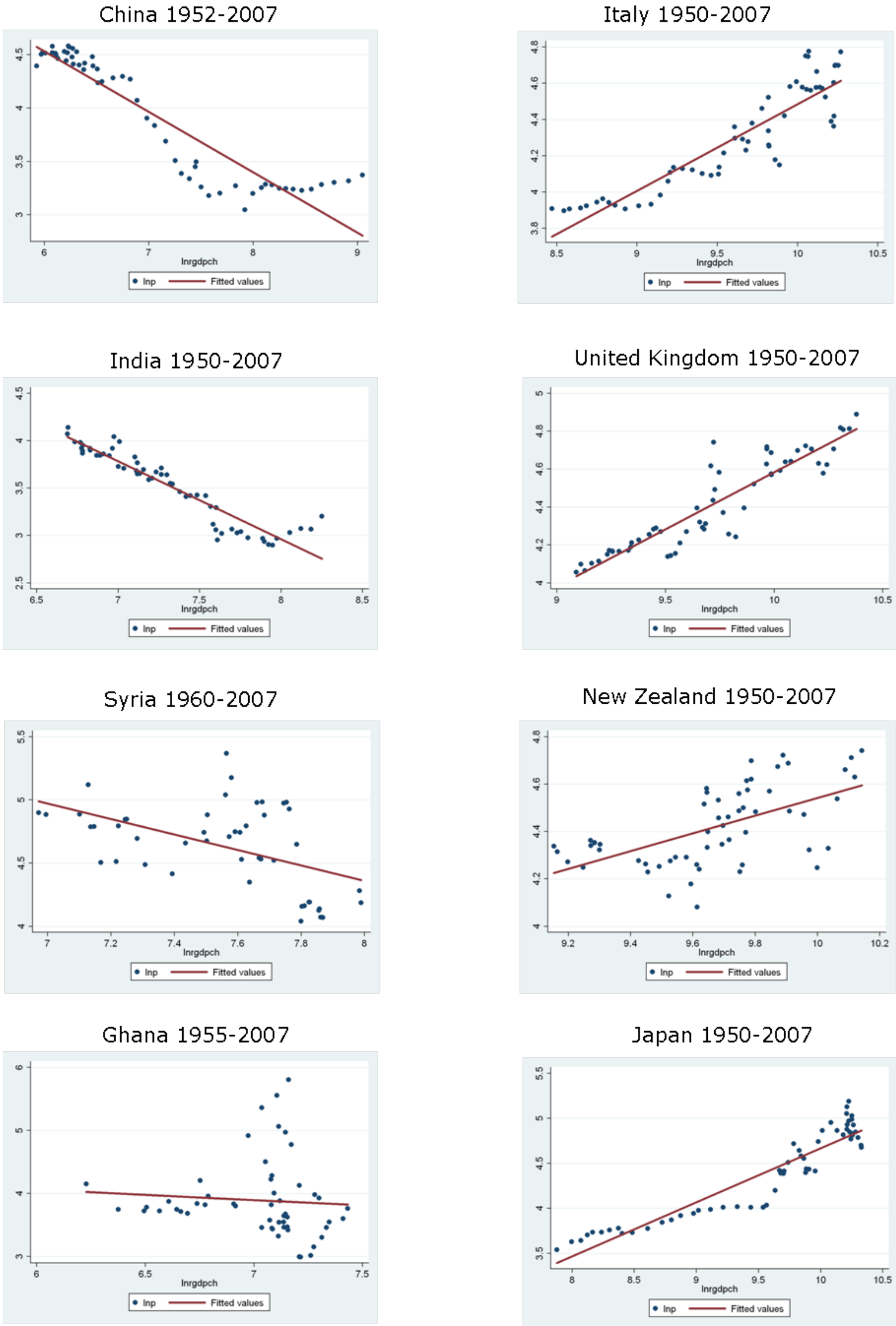

Figure 11: Price-Income, time series dimension: developing vs. developed countries, selected cases

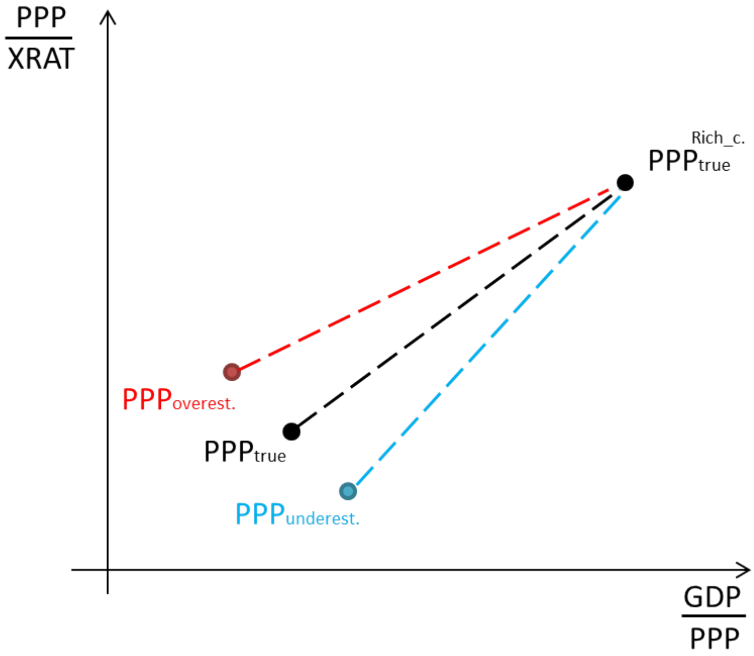

Figure 12: The effect of PPPs bias

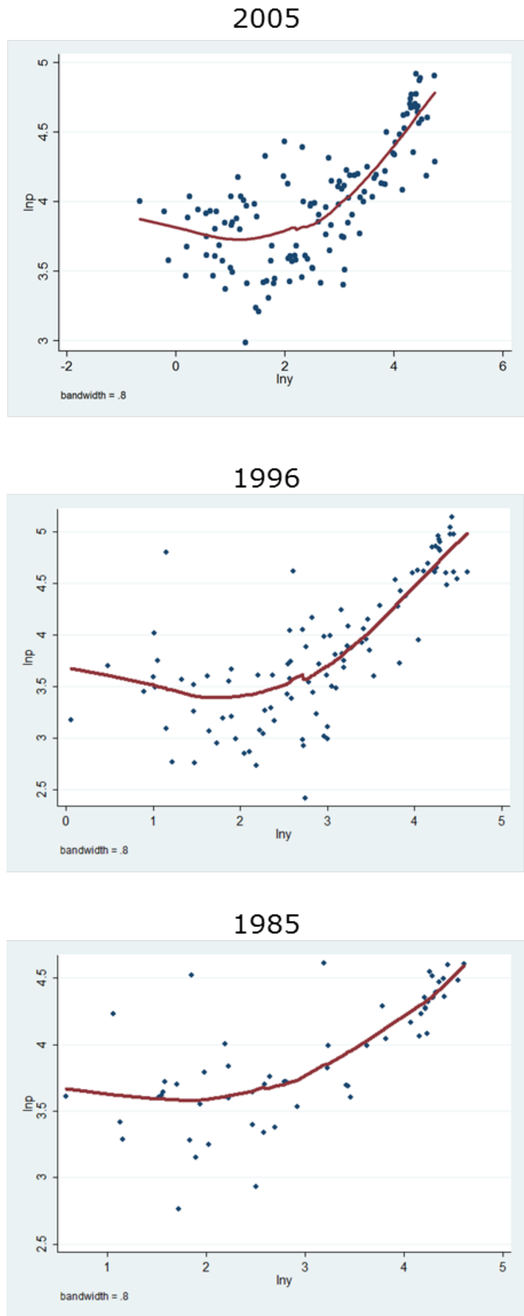

Figure 13: Price and income: benchmark years and countries

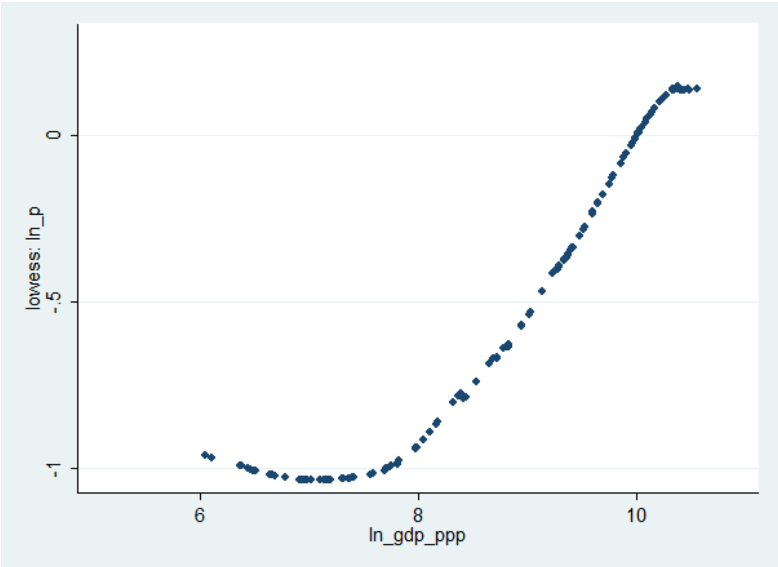

Figure 14: Price and income: panel of benchmark years and countries, UNIQD. Non-parametric estimation, fitted values

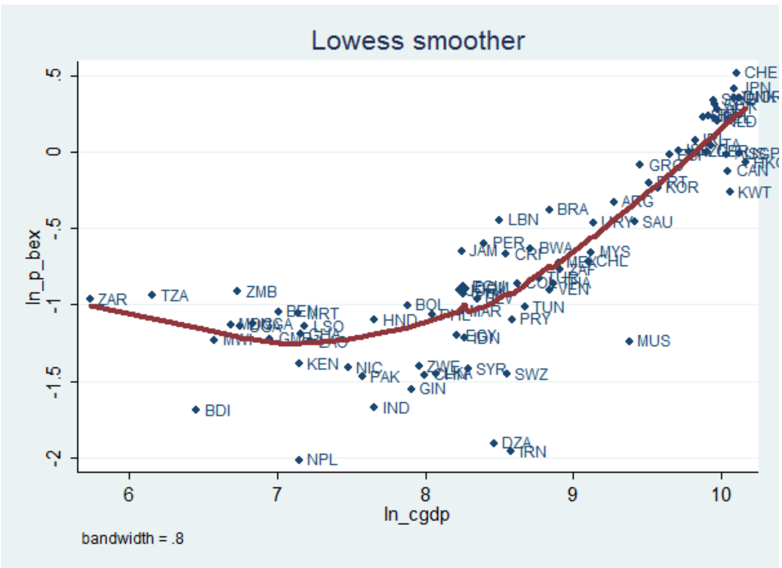

Figure 15: Prices and Income 1996 using black-market exchange rates: Non-Parametric Estimation

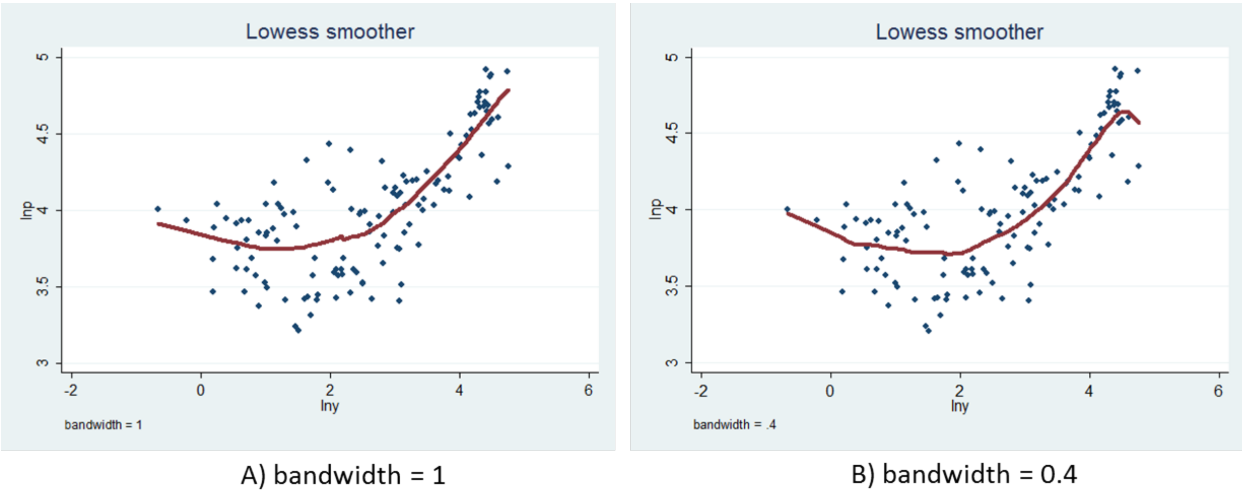

Figure 16: Price and Income, PWT 7.0, benchmark countries, 2005: Non-Parametric Estimation with different bandwidths

Table 3: Price-income relationship and the stage of development

		1st Third	2nd Third	3rd Third
price-income relationship		-0.135**	0.14	0.51***
Value-added share of GDP				
	Agriculture	30.46	11.09	2.84
	Manufacturing	26.42	37.00	31.95
	Services	43.12	51.92	65.21
Employment share				
	Agriculture	60.61	28.02	6.65
	Manufacturing	10.50	22.10	26.01
	Services	28.33	49.13	66.97
Expenditure share				
	Agriculture	35.08	20.45	8.47
	Manufacturing	41.71	43.86	41.42
	Services	20.28	25.15	29.91
Price level				
	Agriculture	0.67	0.63	1.06
	Manufacturing	0.56	0.63	1.03
	Services	0.19	0.27	0.77

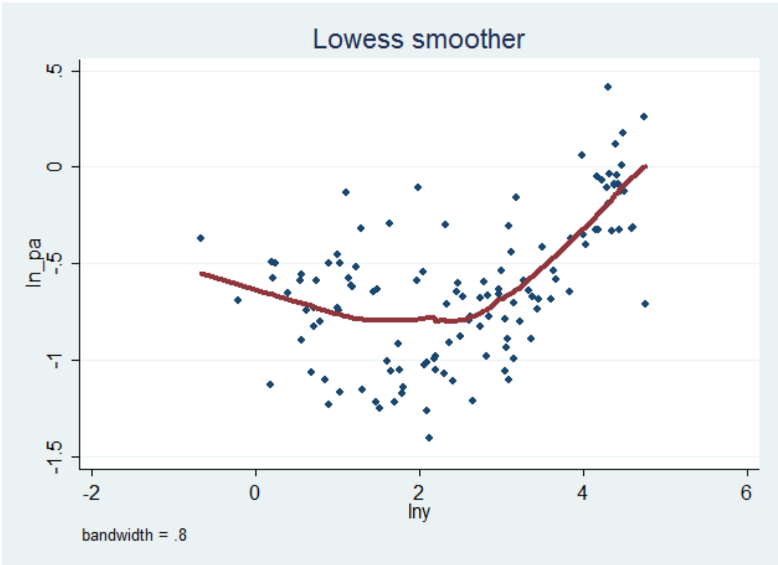

Figure 17: Price of Agriculture and Income: Non-Parametric Estimation

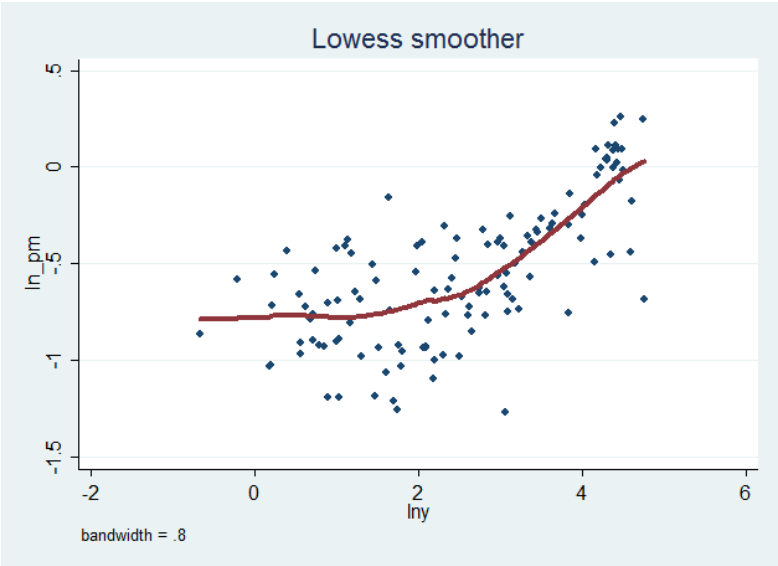

Figure 18: Price of Manufacturing and Income: Non-Parametric Estimation

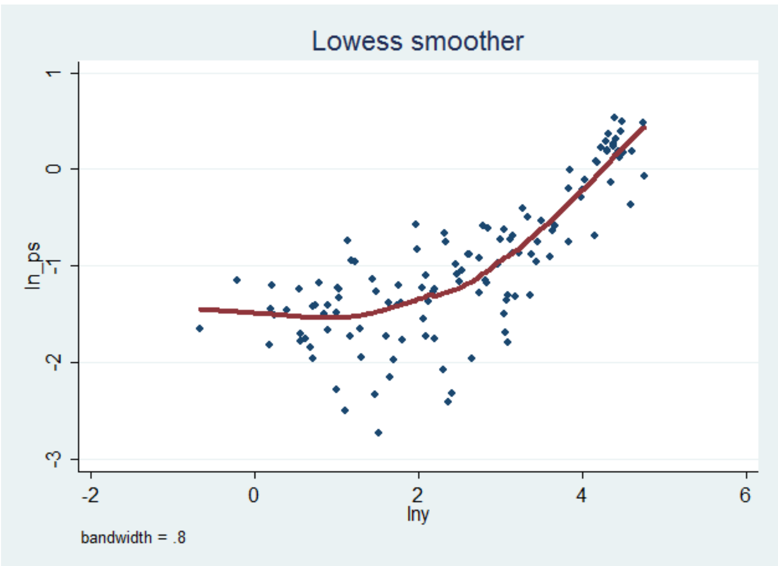

Figure 19: Price of Services and Income: Non-Parametric Estimation

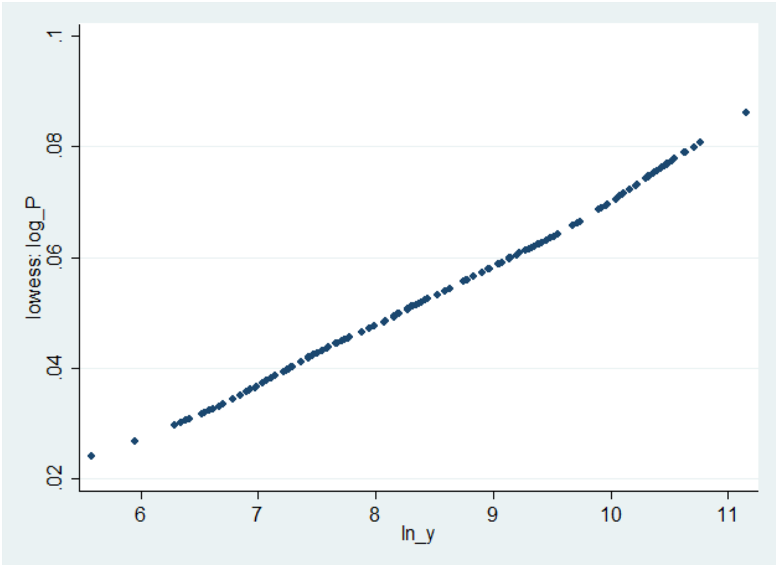

Figure 20: The price level in the Balassa-Samuelson hypothesis: non-parametric estimation of the price-income relationship, fitted values

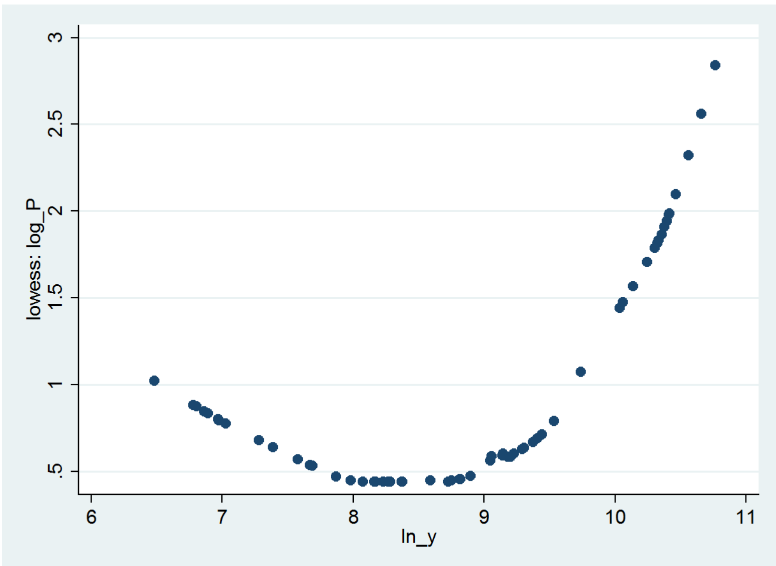

Figure 21: The price level in the Balassa-Samuelson+ hypothesis: non-parametric estimation of the price-income relationship, fitted values

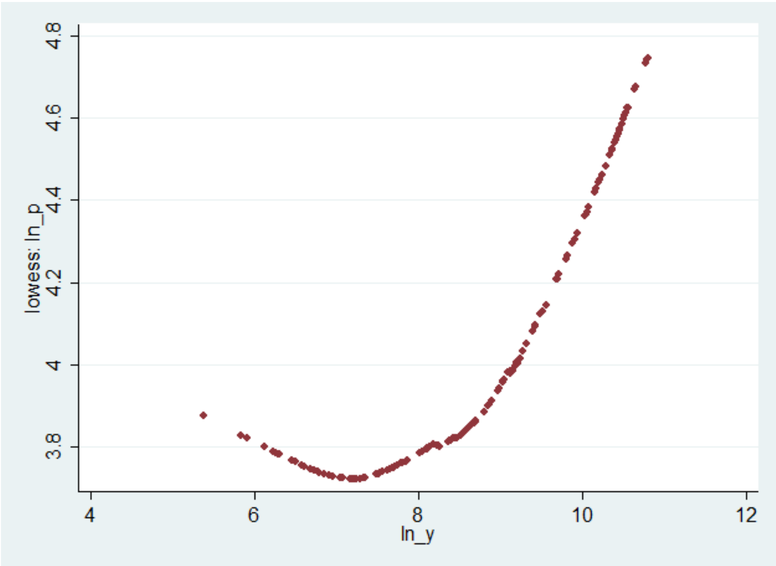

Figure 22: Penn World Table 7.0 (2005): non-parametric estimation of the price-income relationship, fitted values

Table 4: Data and models

	Data	BS+ Model	BS Model
Countries on the downward sloping path	22%	26%	0%
Price, Std. Deviation	0.41	1.02	0.02
Turning point	1,464 PPP$	3,070 PPP	-