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An Exploration of the Changes in the International Comparison Program's Global Economic Landscape

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Abstract: The Purchasing Power Parity (PPP) rates from the 2011 round of the International Comparison Program (ICP) imply some dramatic revisions to price levels and real incomes across the world as compared to the prior 2005 round. This has important implications for many cross-country comparisons, including measures of poverty and inequality. Without presuming that either round is better methodologically, the paper tries to help the community of ICP users better understand the economic factors underlying the estimated changes in price levels across countries. Differences in domestic inflation rates have played a role, as expected. Two other factors are identified. The excess sensitivity to changes in market exchange rates suggests that the PPPs may put higher weight on internationally traded goods than do domestic deflators. Additionally, faster growing countries have seen a steeper rise in their PPP relative to market exchange rates; this can be explained by a tendency for wage increases in growing economies to lead to a higher price level. Together these factors account for over 70% of the variance in PPP changes even ignoring methodological changes. However, an independent downward drift in price levels is also evident, concentrated in the ICP's Asia region. A possible explanation lies in the Asia region's greater success (relative to other regions) in removing urban bias in the price surveys.

"How on earth do we explain these changes to counterparts, activists, students, and all those in the development community who have been using these numbers?" (Senior World Bank staff member writing to the author in 2014 soon after the release of the 2011 ICP results.)

1. Introduction

It is well understood that international comparisons of GDP at market exchange rates are deceptive about real income disparities. The main reason is that some commodities are not internationally traded, thus removing the economic mechanism for attaining price parity across borders. The expectation is that poorer countries will have lower wage rates and (hence) lower prices of non-traded goods relative to traded ones. Thus the purchasing power parity (PPP) rate differs systematically from the nominal exchange rate. The most common economic rationale is the classic Balassa-Samuelson model of a competitive market economy with mobile factors of production between the sectors producing traded and non-traded-goods.[2]

Motivated by this argument, the International Comparison Program (ICP) collects the primary price data across countries on which the ICP's PPP rates are based.[3] The easiest way to think about PPPs is to focus on the price-level index (PLI) given by the ratio of the PPP rate to the ordinary market (or official) exchange rate (MER). One can think of the PLI as a measure of how cheaply one can live in a country with the $US. The inverse of the PLI is a measure of the real exchange rate—the MER deflated by the PPP rate. This can also be thought of as the extent of the upward adjustment to GDP in switching from the MER to PPP.[4]

PPP estimates from the 2011 ICP were released in World Bank (2014).[5] Many developing countries saw substantial changes to their real incomes. The new PPPs suggest less inequality between the rich world and poor world. Comparing the global distribution of real consumptions using the 2011 PPPs with those for 2005 (updated to 2011 prices), Inklaar and Rao (2017, p.287) find that the global Gini coefficient for 2011 falls from 0.57 to 0.51. Far less

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[2] This was outlined independently by Balassa (1964) and Samuelson (1964). Ravallion (2013a) discusses possible concerns about the relevance of this model to developing countries. An alternative explanation was proposed by Bhagwati (1984) based on factor endowments, leading (labor-intensive) services to be cheaper in poor countries.
[3] The ICP is also the source of price data used for the *Penn World Tables*.
[4] Note that the PLI is the ratio of GDP at MER to GDP at PPP.
[5] The data and methods used are described in World Bank (2014, 2015) and subsequent academic literature, including Deaton and Aten (2017) and Inklaar and Rao (2017). These sources also note differences with past ICP rounds, notably 2005. The latter ICP round is described in World Bank (2008a,b).

poverty is also indicated when judged relative to a poverty line with constant US purchasing power; indeed, by one estimate the new PPPs imply almost half the global poverty rate for 2011 as the old PPPs (Dykstra et al., 2014). Fixing the U.S. purchasing power of the international line is questionable given the higher inflation rates in developing countries (Chen and Ravallion, 2010). A debate ensued about the new ICP and its implications for the global economic landscape. The impact of the new PPPs on global poverty counts has been found to be quite sensitive to the level of the poverty line, as shown by Edward and Sumner (2015).[6]

There have been methodological changes in each ICP round, including changes in how the micro price data are collected in the field and how the PPP aggregates are estimated. With each new round those involved in producing the new PPPs, or advising on them, defend the methodological changes, arguing that the new numbers are more reliable. Some observers have been unconvinced, and have advocated abandoning the PPPs for major global comparisons, such as in measuring poverty.[7]

One might reasonably argue that, given the methodological changes between ICP rounds, one should at least avoid any attempt to compare the PPPs from different rounds, and take the new numbers for granted. This is essentially the position taken by the ICP itself and the World Bank's *World Development Indicators* as a prominent user of the PPPs from the ICP; with each new ICP round, the relative sizes of economies are adjusted accordingly for the new base date, with price adjustments done over time using existing national deflators. With new PPPs everything from past ICP rounds is essentially purged from the data bases.

However, users of these data naturally want to better understand what might explain the revisions (as exemplified by the quote at the beginning of the paper). This is especially so when the global economic landscape changes markedly from one ICP round to the next. It is not very satisfactory intellectually to simply say there were some methodological changes so forget about the past. There are comparability problems over time as in all areas of economic and social measurement (including household surveys, national accounts and consumer price indices). While acknowledging that there have been methodological changes, this paper also argues that we can learn something from the comparisons across ICP rounds. In the case of the ICP, there is a very large body of price quotations underlying the PPPs from each round. It would seem odd to

[6] See the comments on the Dykstra et al. blog post. The calculations are sensitive to the level of the poverty line; Chandy and Kharas (2014) found less impact using a higher line but still found lower poverty using the new PPPs.
[7] See, for example, Allen (2017) and the comments in Ravallion (2017). Also see

simply cast aside all that past price data at each new round. This has motivated a series of recent papers trying to understand changes in PPPs between ICP rounds.[8]

This paper compares the PPPs from the 2011 ICP with those for 2005 and 1993, and examines how much of the variance in the changes in PPPs can be accounted for by a few macroeconomic variables. It is not assumed that one round is better than the other; the aim instead is to try to better understand the changes. The paper first shows that PLIs have been on a rising trend. This is not surprising. Once a developing economy reaches its "Lewis turning point," the Balassa-Samuelson effect will come into play over time, such that the growth comes with rising real wage rates and hence a higher relative price of non-traded goods.[9] Consistent with this hypothesis, the PLI has long been known to have a positive income gradient across countries—giving what is known as the "Penn Effect."[10] Indeed, this has been the international community's main motivation for supporting the ICP in collecting its price data. Otherwise, we will tend to under-state living standards in developing countries. By the same logic, we can also expect to see the PPP rate rising relative to the market exchange rate with sustained growth—indeed, it would surely be odd if it did not. This has been dubbed the <u>Dynamic Penn Effect</u> (DPE) in Ravallion (2013a) who argues that it has been a strong and stable feature of the changes in PPPs between the ICP rounds for 2005, 1993 and 1985.[11]

The DPE is an important example of a macroeconomic factor that should come into play in how the PPPs evolve over time relative to market exchange rates in developing economies. As this paper will show, for the world as a whole, the DPE is also evident in the new PPPs for 2011. It is thus comforting that this macroeconomic factor is evident across all ICP rounds so far.

But there is clearly more to the revisions implied by the 2011 ICP than just the DPE. As the paper shows, the PLI for Asia has <u>not</u> risen over 2005-11. This is surprising given that there was so much growth in that region, and we are seeing rising real wages rates across much of the Asia region. What else might be driving the PPPs?

To help explain the changes in the 2011 ICP, this paper formulates and tests a new hypothesis, namely that there is an implicit preference for more internationally comparable

[8] See Johnson et al. (2013), Ravallion (2013a,b), Inklaar (2013), Deaton and Aten (2017), Inklaar and Rao (2017).
[9] The Lewis turning point refers to the famous development model of Lewis (1954), which postulated that poor countries had a large rural labor surplus and that real wages only start to rise once that surplus is absorbed.
[10] The term "Penn effect" stems from the Penn World Tables (Summers and Heston, 1991), which provided the data that were used to establish this effect empirically. For evidence on the cross-sectional Penn Effect see Summers and Heston (1991), Rogoff (1996), Deaton and Heston (2010) and Crucini and Yilmazkuday (2014).
[11] This was confirmed by Majumder et al. (2015).

traded goods in the ICP. This can be called the hypothesis of Traded-Goods Preference (TGP). This can happen in two ways. First, the PPP is normally expressed in the currency of a specific reference country, which has almost always been the $U.S., and the PPP's weights for a given country reflect the shares of each good in the reference country as well as the country in question. (For example, using a bilateral Törnqvist index one takes the average share as the weight.) If the consumption pattern in the reference country tends to put higher weight on traded goods then this will be reflected in the implicit PPP weight. (While the weights on the various commodities are explicit, the weights on traded versus non-traded goods are implicit.)

Second, in constructing a Consumer Price Index (CPI) one wants to use goods typical of the country in question, while for a PPP one wants to use goods that are consumed in all countries and are reasonably commonly consumed. As a result, the goods lists used by the ICP are often quite different to those used by the CPIs. Furthermore, although there are exceptions, as a generalization we can reasonably expect that internationally-traded goods tend to be more comparable across countries than non-traded goods. Being internationally-traded and being comparable are not, of course, the same thing; the classic example of a nontraded good is a haircut, and this is readily comparable. However, being nontraded does often create comparability problems. An example is the foodgrain teff, the seeds of an annual grass of the same name. Teff is a food staple in Ethiopia but is rarely eaten elsewhere, so it is neither comparable nor internationally traded. Wheat, by contrast, is internationally tradable and readily comparable.

It should be noted that the first reason for TGP does not imply any fault in the ICP's methods, though there may be sensitivity to the choice of reference country. But the second reason does raise concerns.

Differences between rich and poor countries could well be salient to these issues. Using the U.S. as the reference for bilateral comparisons we may well expect a higher implicit weight on traded goods in the PPP for a poor country than for its CPI. Given that the ICP is an international price survey, it can also be expected that the ICP will tend to give priority to internationally traded goods (which are more easily compared across countries) than do typical domestic consumption bundles, especially in poor countries.

The paper does not provide direct evidence for or against the TGP hypothesis, and it is not clear what form such evidence would take given the price data available, noting that one cannot readily assign specific goods in price surveys to the categories “traded” or “non-traded.”[12] However, the paper does test an implication of TGP that would appear hard to understand any other way. Specifically, the paper shows that the TGP hypothesis implies that PPPs should respond to changes in MERs at given domestic inflation rates. And it is shown that this theoretical prediction of “excess sensitivity” is confirmed by the data.

To help understand the intuition for this paper’s test of the TGP hypothesis, consider again the Ethiopian grain teff.[13] To keep the example simple, suppose that the basket of goods in the deflator for Ethiopia is half teff, half wheat. So, under TGP, the ICP price comparison includes only wheat but no teff since this cannot be found elsewhere. Now imagine that there is a shock to the market exchange rate such that the price of wheat, which is internationally traded, doubles, but the price of teff does not change. The national deflator only changes by 50%. But the ICP basket contains only wheat, so the PPP factor changes by 100%. We see clearly that, under the TGP hypothesis, the change in the market exchange rate contains information about why the PPP changed so much—information that is not contained in the national deflator.

Taken together, the paper shows that these three economic factors—differences in domestic inflation rates, the DPE and TGP—can account for a large share of the variance in changes in the (log) PPP between 2005 and 2011. The adjusted R^2 is 0.96, although this falls to 0.72 when one removes a few outliers. Changes in the MER are doing much of the work; for the PLIs the R^2 drops to 0.22.

However, on controlling for these three factors, the paper also finds evidence of a downward drift in the new price levels for some countries relative to their growth rates and also allowing for the TGP. The drift is especially strong for Asia (East, South and West Asia). One clue lies in that fact that the “Asia drift” is very much associated with the geographic structure of ICP implementation. In particular, while for about 70% of countries the price surveys are only done in urban areas (often just major cities) it appears that the Asia region did a much better job of covering rural areas in 2011, as is argued by the Asian Development Bank (2014). This appears to help explain the otherwise puzzling Asia drift relative to macroeconomics aggregates identified in this paper.

[12] The distinction between traded and non-traded goods does not have a clear mapping into standard commodity groupings. For example, food is both traded and non-traded. Today many “services” are internationally traded.
[13] The author is grateful to a reviewer for suggesting this expository example.

The following section looks at what has been happening to the PLIs over successive ICP rounds back to 1993 although that round is considered less reliable than 2005 and 2011, and the bulk of the attention here is on the 2011 round relative to 2005. The rest of the paper tries to better understand these changes. Section 3 looks at the relationship between changes in PPPs and domestic inflation rates as measured using CPIs. Section 4 then augments this relationship to allow for changes in market exchange rates, which become relevant under the TGP. Section 5 then brings the DPE into the story. A relatively parsimonious model emerges in which changes in the PLI are explained in terms of both changes GDP per capita in $US and the differences between inflation rates for the GDP deflator and market exchange rates. Section 6 shows that there are still some significant regional drifts. Section 7 looks at the implications of this paper's findings for the recent literature on the role played by methodological changes in the 2011 ICP relative to 2005. Section 8 concludes.

2. Rising price levels in the world relative to the U.S.

One of the main empirical facts that this paper tries to understand is the persistent rise we have seen across multiple ICP rounds in the PLI (the PPP relative to the MER). Between the 2005 and 2011 rounds of the ICP the mean across countries in the proportionate change in the PLI for GDP was 1.33% per annum (with a standard error of 0.22%). While this paper focuses more on the 2011 and 2005 rounds, it is notable that the mean rate of change was almost identical between 1993 and 2005 (1.35% per annum, with a standard error of 0.22% per annum).

The distributions around these means are also similar (Figure 1). However, these aggregates hide a huge dispersion at each new round and negligible correlation across time, both of which are evident in Figure 2, which plots the country-level annualized changes in the log PLI between 2005 and 2011 (vertical axis) against those between 1993 and 2005 (horizontal axis).

The ICP price data are collected in a decentralized way by country statistics offices under supervision from ICP regional offices. (For example, the Asian Development Bank in Manila runs the ICP for all of Asia, including South and West Asia.) Overall guidelines are provided by the central global office (housed in the World Bank since the 2005 round), although regional and country offices still appear to have a degree of independence in implementation. The global office does the linkage across regions, which moves the PPP distributions of entire regions, keeping relativities fixed within regions.

Given the importance of the ICP regional groupings to the implementation of the ICP it is of interest to also summarize the changes in PLIs at that level across the last three ICP rounds. Table 1 gives the annualized differences in the log PLI by ICP region. For comparison purposes, the table also gives results for 1993-2005. There are a number of significant regional effects but with little clear pattern. Notice that Asia's PLI rose over 1993-2005 then stabilized over 2005-2011.

3. PPP revisions and domestic inflation rates

The relationship between "PPP inflation" and "CPI inflation" is of interest from two perspectives. First, ICP users have almost invariably made their PPP conversions at one date (typically the ICP base date) and then used country-specific deflators over time. The longstanding view has been that consistency with national prices trumps international prices, as argued by Nuxoll (1994), amongst others. The large literature on growth empirics using *Penn World Tables* has followed this approach. This is also the practice in the World Bank's global poverty monitoring (see, for example, Chen and Ravallion, 2010a). However, this practice is not beyond question. Inter-temporal comparisons using national deflators may cease to be consistent with international prices, as discussed in Johnson et al. (2013). Inconsistencies between PPP inflation rates and CPI rates also entail that the choice of base year matters to both growth empirics and calculations of global poverty and inequality measures.

Second, the near-universal practice in measuring the extent of the revisions at each ICP round is to compare the newly-reported PPP to an "extrapolated" PPP based solely on how a domestic deflator such as the CPI moved between ICP rounds (relative to the U.S.). This is how the *World Development Indicators* (WDI) updates PPPs between ICP rounds (as in, for example, World Bank, 2013). In theory, an inter-temporal price index could provide reliable extrapolations, but it is far from clear that the relative inflation factors will adequately reflect the changes in the relative price of non-traded goods in growing economies. Both the underlying prices and the aggregation methods used are quite different between the national deflators and the PPPs constructed by the ICP. The WDI practice does not have an especially good record when compared to actual PPP changes, and Ravallion (2013a) argues that the method can be improved by allowing for the DPE, which is sufficiently stable over time to allow more accurate extrapolations. (The discussion returns to this issue.)

Turning to the data, one finds a strong and significant correlation between PPP inflation and CPI inflation between the 1993 and 2005 rounds; the regression coefficient for PPP inflation on CPI inflation is 0.905, with a White standard error of 0.032. The R^2 is 0.91. Figure 4(a) gives the graph. This changed noticeably with the 2011 ICP, as can be seen in Figure 4(b).[14] The unexplained variance is much higher than for the prior rounds; the R^2 fell to 0.49. The regression coefficient falls to 0.750 (s.e.=0.072).[15] It might be conjectured that a stronger relationship is found for the consumption PPP, but this is not the case. The corresponding regression coefficient actually falls, to 0.654 (s.e.=0.083).[16]

This fall in the explanatory power of CPI inflation rates for PPP changes is not a concern *per se*. There was greater variance in CPI inflation rates in the 1993-2005 period. It might be conjectured that there is an attenuation bias in the regression coefficient on CPI inflation due to (classical) measurement errors in the latter. Deaton and Aten (2017) point to the widespread use of the Laspeyres formula for CPIs, which does not allow for substitution possibilities when relative prices change. Errors can also come from the prices themselves. My understanding is that the PPPs were generally collected by the same units within government that collect the CPI price data, so one would expect the measurement errors in prices to be positively correlated, working against the attenuation bias. The net bias is ambiguous. Nor is it obvious why measurement errors would be a greater problem in the more recent data.

Nonetheless, measurement errors in the CPI must be of some concern. Deaton and Aten (2017) argue that switching to the implicit deflator in the national accounts may help reduce the effects of measurement error in the CPI inflation rates.[17] The regression coefficient of PPP inflation on the annualized rate of change in the GDP deflator is noticeably higher at 0.866 (s.e.=0.194) although the unexplained variance rises markedly, with R^2=0.108.

To explore this issue further, consider the following regression:

$$\Delta_t \ln PPP_{it} = \delta_t(1-US_i) + \alpha_{1t}\Delta_t \ln(DEF_{it} / DEF_t^{US}) + \varepsilon_{it} \tag{1}$$

[14] This drops four outliers (with unusually large reductions in the PPPs in 2011).
[15] When relevant, all standard errors reported in this paper are White heteroskedasticity-consistent.
[16] The difference in the interval of time between ICP rounds (six years for the 2000, versus 12 for 2005) may well be a factor; on the presumption that taking an average over a longer period would give greater precision, this may help explain the lower variance for the earlier period.
[17] The Deaton and Aten argument rests on the fact that the implicit deflator obtained by dividing the current price aggregate in the national accounts by the corresponding constant price aggregate is a currently weighted Paasche index, as distinct from the more widely used Laspeyres formula used for CPIs.

The "Δ_t" is the annualized change relative to the prior ICP round, τ_t years earlier; thus $\Delta_t x \equiv \Delta x_t / \tau_t$. PPP_{it} and DEF_{it} are the PPP and domestic deflator (respectively) for country *i* in the ICP round for date *t*. US_i is a dummy variable for the United States and DEF_{it}^{US} is the U.S. deflator. The parameter δ_t gives the "PPP drift" relative to domestic price inflation. (The parameter α_{1t} can be interpreted as the elasticity of the PPP to the domestic inflation rate; the discussion will return to this parameter.)

Two observations can be made about Equation (1). First, the model is constrained to assure that the predicted change in the PPP is zero for the U.S., noting that PPP=1 for the U.S. (by construction) in all rounds. (In all regressions reported below the data are transformed such that the predicted value of the PPP or PLI for the U.S. is fixed over time.) Second, the relationship is allowed to change between ICP rounds, reflecting both methodological revisions and real effects.

Controlling for CPI inflation, the estimated drift in the 2011 PPPs (relative to 2005) is $\hat{\delta} = -3.610\%$ per annum with s.e.=1.428%.[18] By contrast, the PPPs had a positive drift relative to inflation rates over 1993-2005. The estimated drift in the 2005 ICP round is $\hat{\delta} = 2.073\%$ (s.e.=0.318) per annum. So we can understand why the ICP has seemed to some observers like a roller coaster ride, with PPPs rising in the 2005 round relative to inflation rates, but falling in the 2011 round. The rest of this paper will explore these changes further, points to other relevant factors besides the inflation rate.

4. PPPs and market exchange rates

We have seen that the 2011 ICP round shows a weaker relationship with domestic price changes than the prior round. There are a number of sources of discrepancies between the rates of change in domestic CPIs and PPPs as documented in the prior section. The PPP is a multilateral index while the CPI only reflects data for the country concerned. The PPP reflects differences in the weights for the country in question and those in the comparator countries, while CPI weights naturally relate only to that country. For example, Deaton and Aten (2017) show that if one is using a Törnqvist index for the PPPs for two countries then the change (log

[18] Using the GDP deflator instead one obtains $\hat{\delta} = -4.520\%$ per annum with s.e.=1.663%.

difference) in the PPP for a given country will depend on both the difference in the CPI inflation rates and the differences in the weights used by the two CPIs. The extrapolation of PPPs using CPI inflation rates will only be exact if relative prices do not change in the two countries and the consumption patterns are the same. When comparing rich and poor countries large differences in consumption patterns can be expected.

The CPI and PPP indices can also differ because the underlying prices are different even if the weights are not. There are inherent differences between unilateral indices such as the CPIs and multilateral indices such as the PPPs. As Deaton and Aten (2017, p.252) explain:

> "Cross-country indexes must match goods that are (a) identical in both locations, (b) reasonably commonly consumed in both places, so that the comparison lists for the ICP are usually quite different from the comparison lists of the CPI."

The origins and implications of these differences are not well understood in the literature. One way of thinking about the difference is to draw on the distinction made by Deaton and Heston (2010) between "representativeness" and "comparability" in constructing price indices; the former relates to how well the commodity bundle represents consumption patterns in each country, while the latter refers to the comparability of bundles across borders. Comparability naturally has higher weight for international price indices—ICP price surveys would prefer to find the same commodity in different places to compare its prices—than national ones, where representativeness is all one cares about in selecting bundles to be priced. Indeed, there is no reason for a governmental statistics office to care about international comparability of the goods in its price schedule for the CPI.

This raises the possibility of TGP—that the ICP puts higher weight on internationally-traded goods than most domestic CPIs. As noted in the Introduction this can arise either from the use of a reference country with a higher share of consumption devoted to traded goods or it can stem from differences in the types of goods that the ICP picks. The latter claim is more contentious, so it calls for elaboration.

Traded goods are more-or-less automatically comparable across borders, while non-traded goods may or may not be. Some non-traded goods can differ greatly between countries in their availability and characteristics. The product specifications used by the ICP in defining the goods to be priced emphasize goods with the same characteristics in different countries. To the extent that these are more likely to be internationally-traded goods than non-traded goods we will have a bias due to TGP. One implication is that structural changes in developing economies can create divergence between PPPs and CPIs as more goods become tradable over time in a developing country. A higher weight on traded goods in the international price indices may well explain the PLI drift in the 2011 ICP.

Empirical implications of the TGP hypothesis: The key testable implication of the TGP hypothesis is that the PPP revisions will exhibit excess sensitivity to changes in market exchange rates once one controls for changes in the domestic deflator. The MER changes between ICP rounds provide extra information, on top of the domestic inflation rate, for explaining changes in PPPs between ICP rounds. Excess sensitivity to changes in the MER will be evident to the extent that traded goods tend to get a higher weight in the ICP's PPPs than in domestic CPIs. Of course, the CPI should still matter as it should be picking up domestic price movements due to non-traded goods (or imperfect substitutes). Both PPPs and CPI's positively weight both traded and non-traded goods, but with different weights under the TGP. The Appendix provides a more formal derivation of the econometric model for PPP changes implied by the TGP hypothesis.

On incorporating the test for TGP, one has the following augmenting version of (1):

$$\Delta \ln PPP_{it} = \delta_t (1 - US_i) + \alpha_{1t} \Delta_t \ln(DEF_{it} / DEF_t^{US}) + \alpha_{2t} \Delta_t \ln MER_{it} + \mu_{it} \quad (2)$$

The new term is the proportionate change in the MER ($\Delta_t \ln MER_{it}$). The parameters α_{1t} and α_{2t} are interpreted as the global average weights on CPI inflation and MER inflation in determining the rate of PPP inflation in round *t* relative to the prior round. The expectation is that $\alpha_{1t} > 0$ but that (under TGP) PPP inflation puts higher weight on traded goods' prices than do domestic CPIs, so $\alpha_{2t} > 0$. The derivation of (2) implies that $\alpha_{1t} + \alpha_{2t} = 1$. The new drift parameter δ_t in (2) will include the global inflation rate for traded goods and the error term (μ_{it}) will include heterogeneity across countries in the weights for a given round (Appendix). Notice that the existence of non-traded goods is key to identifying the parameters in (2). If all goods are traded and the law of one price holds then one cannot separately identify the parameters.

One can also write (2) in terms of changes in the PLI:[19]

[19] One can test the null that $\alpha_1 + \alpha_2 = 1$ by regressing $\Delta \ln PLI_{it}$ on $\Delta \ln(DEF_{it} / MER_{it})$ and $\Delta \ln MER_{it}$. The tests reported below are the t-tests on the coefficient on the latter variable.

$$\begin{aligned}\Delta_t \ln PLI_{it} &= \delta_t(1-US_i) + \alpha_{1t}\Delta_t \ln(DEF_{it} / DEF_t^{US}) + (\alpha_{2t}-1)\Delta_t \ln MER_{it} + \mu_{it} \\ &= \alpha_{0t} + \alpha_{1t}\Delta_t \ln\left(\frac{DEF_{it}}{DEF_t^{US} MER_{it}}\right) + \mu_{it} \text{ if } \alpha_{1t}+\alpha_{2t}=1\end{aligned} \tag{3}$$

This suggests an interpretation as the relationship between the two ways that the "real exchange rate" has been defined in applied work. The first is the MER normalized by the PPP (giving the inverse of the PLI) while the second is obtained when the MER is normalized instead by the domestic price deflator such as the CPI. (This is a measure of the "real exchange rate" one often finds in applied work.) We can postulate that there is some increasing relationship between these two measures of the real exchange rate. The parameter α_{1t} can now be interpreted as the elasticity of MER_{it} / PPP_{it} with respect to MER_{it} / DEF_{it}.

It is now clear that, under TGP, the regression of the "PPP inflation rate" on the "CPI inflation rate" is miss-specified. Since we can also expect that $\Delta \ln CPI_{it}$ and $\Delta \ln MER_{it}$ will be positively correlated, failing to control for exchange rate inflation will overestimate how much the PPPs have reflected the CPI inflation rates.

Empirical results: Over the period 2005-11, MERs changed little on average, though they had been increasing on average in the prior period between ICP round (1993-2005). CPI inflation rates were lower in the later period. However, comparing 2005-11 and 1993-2005 the difference between the CPI and MER inflation rates rose sharply. Over 1993-05, the difference grew at an average annual rate of 2.354% (s.e.=0.313) while for the period 2005-11 the rate more than doubled to 5.766 (s.e.-0.273). This implies upward pressure on the PLI even if the 2011 round did not change its implicit weighting on traded goods.

Table 2 presents the regression specification in Equation (2).[20] Column (1) gives the regression of the change in the log PPP over 2005-11 on both the change in the log of the MER as well as CPI inflation rate (log difference in CPI). The result of Column (1) is distorted by four outliers with large declines in the MER of more than 40% per year ($\Delta_t \ln MER_{it} < -0.4$); see Figure 5. Dropping these, we get the results in Column (2). The homogeneity restriction that the coefficients sum to unity is not rejected. The implied elasticity is 0.33 with a standard error of

[20] Notice that, since the change in market exchange rates is a regressor, these can be equivalently thought of as regressions for the log PLI; just add unity to the coefficient on $\Delta \ln MER_{it}$ to switch to a regression using $\Delta \ln PPP_{it}$ as the dependent variable; naturally the R^2 changes.

0.07. This is both significantly positive and significantly less than unity at the 1% level. Column (3) gives the result when we confine the sample to the developing world (i.e., excluding the ICP's region 4, comprising Europe and the OECD). Now we find a slightly higher weight on CPI inflation at 0.38. Measurement errors in the CPI inflation rates may well be attenuating its coefficient in the regression for PPP inflation. The elasticity rises notably when one uses the GDP deflator instead of the CPI. For the sample of developing countries, the results suggest that the weight on non-traded goods in the ICP is about half that in the CPIs.

Columns (1) and (2) of Table 3 give the corresponding regression using the 2005 revisions relative to 1993. (We return to Columns (3) and (4) in the next section.) The model is fairly stable between ICP rounds except for the drift effects. Unlike the latest round, a positive PLI drift is indicated for the world as a whole outside the U.S. over 1993-2005. Again the sum of the coefficients on $\Delta \ln DEF$ and $\Delta \ln MER$ is very close to unity. The results for the earlier round give an elasticity to CPI inflation of 0.36 and this is again both significantly positive and significantly less than unity at the 1% level. This is slightly higher than for the later period. However, if we exclude Europe/OECD we see the expected increase in the coefficient, from 0.35 to 0.38 in the more recent period.

The empirical results for both the 2011 and 2005 revisions are consistent with the implications of the TGP hypothesis, i.e., the ICP appears to put a higher weight on internationally-traded goods than do national CPIs, as is evident in the excess sensitivity to MER changes revealed by the above analysis. The downward PLI drift for the developing world emerges strongly when one uses the GDP deflator. There is no sign of PLI drift for Europe/OECD when one allows for TGP in the ICP. When (2) is estimated with separate drift parameters one obtains $\hat{\delta} = 0.220\%$ (s.e.=0.383%) per annum for Europe/OECD (excluding U.S.) and -1.064 (0.496) for other countries.

Allowing for the implications of TGP, the 2011 ICP revisions have a larger unexplained variance than was the case for 2005. While only 5% of the variance in PPP inflation rates of 1993-2005 is left unexplained, the proportion rises to 30% or more over 2005-11.

5. An empirical model encompassing the Dynamic Penn Effect

As discussed in the Introduction, one reason for rising PLIs in developing countries is economic growth. Recall that the DPE postulates that the Penn Effect also holds over time, whereby faster growing developing countries tend to see rising price levels (Ravallion, 2013a). Figure 3 plots the relationship found in the data between $\Delta \ln PLI_{it}$ and growth rates for both periods; for 1993-2005 the estimate of slope is 0.283 (s.e.=0.054; R^2=0.212); for the latest period the coefficient is slightly lower at 0.237 (0.039). While the DPE is similar (only slightly lower in 2005-11) the rate of change in price levels at given growth rates has changed; the vertical level of the relationship has shifted. Panel (b) in Figure 3 gives both the actual DPE for 2005-11 and the predicted DPE using the relationship found for 1993-2005. As can be seen in Figure 3(b) there has been a roughly parallel downward shift with the 2011 round.

To explore this change further, let us re-define the drift as the parameter δ_t in the following regression:

$$\Delta_t \ln PLI_{it} = \delta_t(1-US_i) + \beta_t \Delta_t \ln(Y_{it}/Y_t^{US}) + \varepsilon_{it} \tag{4}$$

Here PLI_{it} and Y_{it} are the PLI and GDP per capita in \$US (respectively) for country *i* in the ICP round for date *t*. In Equation (4), both the PPP and GDP are normalized by the MER. Alternatively equation (4) can be written in the equivalent form as a regression of $\Delta \ln PLI_{it}$ on the growth rate of GDP per capita at PPP, namely:

$$\Delta_t \ln PLI_{it} = \left(\frac{\delta_t}{1-\beta_t}\right)(1-US_i) + \left(\frac{\beta_t}{1-\beta_t}\right)\Delta_t \ln(Y_{it}^{PPP}/Y_t^{US}) + \frac{\varepsilon_{it}}{1-\beta_t} \tag{5}$$

where Y_{it}^{PPP} is GDP per capita at PPP. The coefficients in equation (5) are identified from those of (4). However, (5) will not in general give the same results as (4) given that the appearance of the PPP on both sides of the regression in (5) (in the numerator of PLI_{it} and denominator of Y_{it}^{PPP}) imparts a downward bias to the coefficient in (5). This paper only uses the form in (4).

The DPE and TGP can be thought of as competing models. However, there are two reasons for also considering an encompassing model. First, one might expect the growth rate to have an effect conditional on the changes in the CPI and MER. The GDP growth rates could be correlated with the error term in equation (2) given that this contains country-specific weights. If traded goods tend to appear more often in the lists for more rapidly growing economies, such that the weight on the MER rises, then this will be picked up by GDP growth rates.

Second, there has been a debate about whether it is GDP growth rates or domestic inflation rates that best explain PPP changes. Recall that a common method used to update PPPs between ICP rounds is to apply the domestic inflation rates relative to the U.S., as used by the World Bank's *World Development Indicators* (such as World Bank, 2013). Ravallion (2013a) found that the inflation rate had little independent explanatory power once one allowed for the DPE. Inklaar (2013) questioned this finding and argued that the growth rate did not have extra power over the inflation rate. However, Inklaar (2013) did not estimate the required encompassing model—the nested test that would tell us which variable was doing the work. Ravallion (2013b) provided that test and confirmed that the DPE was the more important factor. I will also use the encompassing model in attempting to isolate the methodological changes between 2005 and 2011. Readers do not need to take a position on the Inklaar-Ravallion debate—I allow both views.

Motivated by these observations, the encompassing model is:[21]

$$\begin{aligned}\Delta_t \ln PLI_{it} = \delta_t(1-US_i) + \alpha_{1t}\Delta_t \ln(DEF_{it}/DEF_t^{US}) + (\alpha_{2t}-1)\Delta_t \ln MER_{it} \\ + \beta_t\Delta_t \ln(Y_{it}/Y_t^{US}) + \nu_{it}\end{aligned} \qquad (6)$$

The new regressor is the GDP growth rate $\Delta_t \ln(Y_{it}/Y_t^{US})$ Under the (testable) homogeneity restriction ($\alpha_{1t}+\alpha_{2t}=1$) all variables are real, with the three variables, the PPP, the CPI and GDP, having the same deflator, the MER. Another way of saying this is that the nominal PPP is homogeneous of degree zero in the CPI and nominal GDP.

Table 4, Column (1), reports estimates of this augmented specification for the changes in the log PLI between 2005 and 2011 including GDP growth as in equation (6). Column (2) gives the result on dropping the four outliers mentioned above, while Column (4) gives the results dropping the "rich countries" (the ICP's Region 4, comprising Europe and OECD). The DPE is

[21] Use of the log PLI as the dependent variable for the encompassing model is consistent with Penn Effect regressions are normally estimated in the literature. However, the regression is the same if one switches to log PPP; one just adds $\Delta \ln MER_{it}$ to both sides to get back to the form in Tables 2 and 3. I will include the corresponding values of the adjusted R^2 to enable comparisons with the regressions in Table 2.

evident; the GDP growth rate is a strong predictor of the PPP changes. When weighted by its regression coefficient the variance in GDP growth rates represents 92% to the variance in the changes in log PLIs. However, the growth rates are correlated with the inflation rates so the net increment to R^2 from incorporating the DPE is smaller. Adjusted R^2 for changes in log PPP rates rises from 0.675 (Table 2, Column 2) to 0.711 (Table 4, Column 2). The proportionate change in the ordinary exchange rates has independent explanatory power, consistent with the TGP hypothesis. Incorporating the DPE brings down the estimated effect of CPI inflation relative to MER inflation. The coefficient on CPI inflation is small and not significantly different from zero when one controls for GDP growth as well as MER changes.[22] The aforementioned problems of attenuation bias in the impact of CPI inflation are still in play. If one uses instead the inflation rates based on GDP deflators then its coefficient in the regression matching Column (2) doubles to 0.194 (s.e.=0.104). However, this effect is still not strong in size or statistical significance (only significantly different from zero at the 6% level). A stronger effect emerges for the developing country sample (Column 5).

While there is little sign of PLI drift in 2011 using CPI inflation in the model allowing for the DPE, it again re-emerges on switching to the GDP deflators. For the developing world the downward PLI drift in the 2011 ICP is even stronger when one switches to GDP deflators, at 1.5% per annum (Table 4, Column 5).

Some differences with earlier ICP rounds are notable. Columns (3) and (4) of Table 3 give the results for 2005 relative to 1993. The coefficient on CPI inflation is now positive as expected. For the earlier period the sum of the coefficients on $\Delta \ln CPI$ and $\Delta \ln MER$ in the regression for $\Delta \ln PPP$ is close to unity.[23] Imposing this homogeneity restriction one obtains $\hat{\alpha}_1 = 0.209$ (s.e.=0.072)—lower than when the DPE is ignored, but still both significantly positive and less than unity. This also holds excluding rich countries (Column (4), Table 3). By contrast to the 2005 round, the revisions in 2011 imply near zero elasticity of the real exchange rate deflated by the PPP to that obtained using the CPI deflator once one allows for the DPE.

[22] In Column (6) if one imposes $\alpha_1 + \alpha_2 = 1$ (the restriction passes statistically; t=0.50) then the coefficient is 0.183 (s.e.=0.117) but this is not significantly different from zero at the 10% level.

[23] The test gives t=0.36.

Adding the extra controls, it is again confirmed that there is a positive PLI drift in the data for the earlier period. Also, while the DPE helps in explaining the changes, the share of unexplained variance is still substantially larger for the 2011 revisions than for 2005.

On controlling for these extra covariates of price levels there is no sign of a correlation between the implied revisions to the PLI and initial GDP per capita. This can be assessed by studying the residuals from the regressions in Table 4. A positive (negative) residual implies an upward (downward) revision in the 2011 PLI relative to what one would have expected based on the regressors and the 2005 PLI. Figure 6(a) plots the residuals from the regression in Column (2) of Table 4 against (log) GDP per capita in 2005. (The Figure looks similar using GDP per capita at PPP.) We see no sign of the pattern of downward revisions in poorer countries. Indeed, upward revisions appear more likely in low-income countries; if one drops the high-income countries (Europe/OECD) then the correlation coefficient rises to -0.30 (Figure 6(b)), which is significant at the 1% level. Average upward revisions are implied for the poorest countries, with downward revisions on average only emerging at levels of GDP per capita above about $3,000 per year. The last row of Table 4 gives the coefficient on log GDP per capita for 2005 as an extra regressor; consistently with Figure 6(b) we see a significant negative correlation emerging for the developing countries. In other words, the implied PLI revisions controlling for both the TGP and DPE tended to be upwards for the poorest countries outside Europe and the OECD.

6. Region-specific PLI drifts relative to the encompassing model

The global drift in PPPs could reflect global factors, such as changes in traded goods prices. However, there are large differences across regions. Table 5 augments the regressions in Table 4 by introducing dummy variables for the ICP regions for both periods to allow for region-specific drifts.[24] The homogeneity restriction is imposed ($\alpha_1 + \alpha_2 = 1$). Results are given for both the DPE alone (equation (4)) and the encompassing model, combining both the DPE and TGP (equation (6)).

[24] Again the regressions are constrained to return a predicted value of zero for the change in the PLI for the U.S. Thus, for the regional breakdown in Table 5, a complete set of regional dummy variables is included. With no constant term, and the dummy variable for the U.S. is subtracted from that for ICP region 4 (Europe/OECD).

Whether one allows for TGP or DPE, there is no sign of PLI drift for Europe/OECD. However, adding the control for TGP increases the extent of PLI drift for Asia and Western Asia, but reduces the positive drifts for Latin America and Iran/Georgia.

There could still be region-specific economic effects not picked up adequately by the covariates. One test for this is to exploit the fact that there is enough non-overlap in the regional groupings to add most World Bank regions.[25] These will help pick up omitted regional economic factors. Column (6) of Table 5 gives the regression including dummy variables for the Bank's regions. These make very little difference to the results. In particular, the two "Asia effects" are associated with the ICP regional groupings not the Bank's. The fact that the Asia regional drifts in the 2011 ICP are for the ICP regions, not World Bank regions, suggests that they may be related to differences in ICP implementation between the regional ICP authorities.[26]

The regional pattern in the drift coefficients is negatively correlated with average GDP, although not significantly so.[27] On controlling for ICP regions there is (again) no significant correlation between the residuals and GDP per capita (r=-0.08, though rising to -0.16 when Europe/OECD is excluded). We see no sign that downward revisions are more likely in poorer countries within ICP regions.

China is of special interest since the 2005 ICP had been urban biased, as shown by Chen and Ravallion (2010b), while the 2011 round was more representative of the country as a whole. (Including rural prices will tend to reduce the PLI.) Could this explain the "Asia PLI drift"? On adding a dummy variable for China to the regression in Column (1) of Table 5 the coefficient is 0.025 (s.e.=0.005); China's PLI revision is positive. Of course, this is with a region effect for Asia, which also includes China. If one drops China from the Asia dummy variable then the China effect is negative, but not significantly different from zero (a coefficient of -0.008, with s.e.=0.008). So the negative Asia effect is really "Asia except China."

[25] The exception is the Bank's Sub-Saharan Africa, which overlaps too much with the ICP's "Africa" region to credibly separate their effects; 44 of the 49 countries in the ICP's Africa region are in the World Bank's Sub-Saharan Africa.

[26] The Asia ICP office and the global office were invited to comment on this paper. The head of the Asia ICP office declined to do so. The global office kindly sent comments but they did not offer an explanation for the Asia drift.

[27] The correlation coefficients between the seven region drift coefficients in Column (5) of Table and mean log GDP per capita in 2005 $US is -0.187; using GDP at PPP it is -0.143. Neither are significant at even the 10% level (prob.=0.69 and 0.76 respectively).

7. On the role of changes in ICP methodology

We have seen that there is an unexplained “Asia drift,” and that this is associated with the regional implementation of the ICP. Could this be explained by the methodological changes implemented by the 2011 ICP? The change that has received most attention in the literature describing the ICP 2011 concerns the way that the PPPs from different regions are combined (World Bank, 2015; Deaton and Aten, 2017; Inklaar and Rao, 2017). In the 2005 round the inter-regional linkage used a set of 18 “ring countries” spanning all ICP regional units. These 18 countries did their own pricing exercise for a common list of goods. At the regional linkage stage, relative PPPs were kept fixed within the ICP regional groupings.[28] In 2011, a Global Core List (GCL) was introduced, priced in all countries, though still maintaining within-region fixity (meaning that PPP relativities within regions are preserved when forming the global PPPs).[29]

The introduction of the GCL can be seen as an improvement in that all countries are included when forming the inter-regional linkage. However, when using any global list it may be very hard to find all goods in all countries, and this was clearly the case in practice. Many of the items in the GCL were of limited relevance to many developing countries, making it very hard to find the items in the GCL.[30] There is a risk that any local replacement items will be of lower quality, putting downward pressure on the PLI. The presence of missing values also puts a lot of weight on the methodology used for imputation. Past ICP methods have used simple averages of price quotations within each of the basic headings of the national accounts and do not appear to have made adjustments for the likely quality bias when replacing missing prices in the field.[31]

Deaton and Aten (2017) argue that the ring method used by the 2005 ICP resulted in an over-pricing in poor countries, which was corrected by the 2011 ICP round. Inklaar and Rao (2017) make a similar argument. The over-pricing is seen to stem from the fact that the global list included many luxury goods that are hard to find in poor countries. It is claimed that these goods will only be found in a few exclusive places in poor countries and will be over-priced there.

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[28] This is a continuing feature of the ICP’s methods that Deaton and Heston (2010) argue is primarily political in motivation not statistical, although see the comments in Ravallion (2010).
[29] This is a continuing feature of the ICP’s methods that Deaton and Heston (2010) argue is primarily political in motivation not statistical, although see the comments in Ravallion (2010).
[30] Across all countries, about half of the prices in the GCL are missing (Inklaar and Rao (2017, p.278).
[31] The country-product dummy (CPD) method has been widely used, and appears to have been the main method used for filling in missing values in the 2005 and 2011 ICP rounds. On the CPD method see Silver (2009).

However, it is unclear why internationally-traded luxury goods will be over-priced in poorer countries. This would happen if there is imperfect competition in the market for luxury goods in poor countries, such that rich people in poor countries are exploited. But I know of no supportive evidence.

It should also be noted that both Deaton and Aten (2017) and Inklaar and Rao (2017) update 2005 PPPs to 2011 using the country-specific inflation factors, relative to the U.S. Drawing on Inklaar (2013), Inklaar and Rao (2017) defend their method of using inflation-based extrapolations as more reliable than those using the DPE, as advocated by Ravallion (2013a). Yet the Balassa-Samuelson model that helped motivate the existence of the ICP predicts that there should be a DPE in growing developing economies. The puzzle is solved once one notes that Inklaar (2013) did not in fact estimate the required nested test and when one does that test one finds that the DPE is the more important macroeconomic factor; indeed, Ravallion (2013b) finds that the DPE leaves virtually nothing to be explained by domestic inflation factors. The present paper has confirmed the importance of the DPE, but has also pointed to the role played by changes in MERs, which is consistent with the hypothesis of an implicit TGP in the price surveys by the ICP. Clearly, if one does not accept that the domestic inflation factors (relative to the U.S) adequately account for the economic factors influencing the PPPs then the use of this method by Deaton and Aten (2017) and Inklaar and Rao (2017) in identifying the contribution of methodological changes becomes questionable.

To explore further the implications of the main methodological changes discussed in this literature, consider the Deaton and Aten explanation for the revisions implied by the 2011 ICP. In their interpretation, the regional structure of the ICP is the key to understanding the revisions. The changes should be primarily between regions. Deaton and Aten argue that we should expect to see strong regional effects in the revisions, with higher recorded prices in Asia and Africa. They argue that the pattern of PPP revisions is consistent with their explanation.[32] They find that once the 2005 PPPs are adjusted for domestic inflation rates the implied revisions in 2011 bring down the price levels in poorer countries relative to richer ones amongst the 18 ring countries. In

[32] To test their explanation, Deaton and Aten compare the PPPs for 2005 for the 18 ring countries to their recalculated 2011 PPPs constructed for the same ring countries using the prices from the global list for 2011. Arguably this is not the most obvious test, which would be to re-run the 2011 ICP exercise globally using as close an approximation as possible to the 2005 ring method. Deaton and Aten do not explain their choice, though it undoubtedly reflects the data available to them.

a further check, Deaton and Aten confirm that the implied revisions are consistent with the regional effects in the cross-country relationship between the PLI and consumption per capita. While Deaton and Aten's tests are consistent with their hypothesis on the use of the ring method in 2005, they do not establish that the 2011 revisions are solely due to an over-estimation of price levels in poor countries in 2005. The 2011 ICP may well be understating prices. As already noted, Deaton and Aten follow past practice in comparing new PPPs to extrapolations based solely on the rate of CPI inflation since the prior ICP round. We have seen that this special case is rejected empirically.

Let us reexamine the Deaton and Aten explanation using the fuller set of data-consistent macroeconomic covariates that the present paper has identified. The implied PPP revisions between 2005 and 2011 for the developing world that are not accountable to the fuller set of covariates do not accord well with the Deaton and Aten explanation. I confirm strong effects associated with country assignment to the ICP's regional administrative groupings as suggested by Deaton and Aten. However, using my full model (incorporating both the DPE and TGP) there is very little sign of the regional pattern implied by the Deaton and Aten explanation for the changes in the 2011 ICP. The revisions do not comply with the pattern they suggest (with no sign of downward revisions in poorer regions/countries) and the bulk of the variance in the unexplained revisions is within regions not between them.[33] Indeed, restricting attention to the developing world, the pattern of revisions in Figure 6(b) is exactly the opposite of that predicted by the Deaton and Aten hypothesis; poorer countries tended to see larger upward revisions to the PLIs in 2011.

Nor did the unexplained revisions to the 2011 ICP simply undo changes introduced in 2005. If one compares the residuals from Column (3) of Table 3 with those from Column (2) of Table 4 then one does find a negative correlation coefficient, but it is small at -0.171 and the regression coefficient of the residuals for 2011 (relative to 2005) on those for 2005 (relative to 1993) is -0.185, with a standard error of 0.114; this is only significantly different from zero at the 11% level. So less than 20% of the upward revision to PLIs in 2005 was un-done in 2011. Confining the calculations to the developing world (i.e., excluding Europe/OECD) the

[33] The regression in Column (1) of Table 5 leaves 44% of the variance in the changes in PLI unexplained. Of the share of the variance that is not explained, namely 77% (Table 5, Column 3), about 60% is within ICP regions.

relationship between the residuals is even weaker with a correlation coefficient of -0.146 and regression coefficient of -0.152 (s.e.=0.121) which is not significantly different from zero.

By one assessment, methodological changes alone contribute rather little to the changes in the PPPs between 2005 and 2011. Inklaar and Rao (2017) attempt to isolate the contribution of methodological change to the differences in price levels between these rounds. To do this they construct counterfactual PPPs for 2005 using methods favored in the 2011 round—what they term "methodological harmonization." On comparing the 2005 counterfactual extrapolated to 2011 with the 2011 ICP results they find that the discrepancies between the two rounds are only modestly attenuated. On average, the price level from ICP 2011 is about 17% lower than based on the "inflation-only" extrapolations from the 2005 ICP; this drops to 15% after their harmonization exercise.[34] So the Inklaar and Rao results do not suggest that the methodological differences they address account for much of the revision to the price levels implied by the 2011 ICP. Of course there are data limitations on how much harmonization is possible, including the absence of prices for a GCL in 2005.

There is another methodological change that might well account for the Asia drift found in this paper. As noted, there has long been a marked "urban bias" in the sampling of outlets for collecting prices in the ICP. Under coverage of rural areas where food and housing prices tend to be lower is an obvious concern. A sizeable urban bias in the 2005 ICP for China was identified by Chen and Ravallion (2010b) (and the global poverty estimates by Chen and Ravallion, 2010a, corrected for this source of bias). When Inklaar and Rao (2017) add a correction for urban bias in the 2005 China ICP (on top of their harmonization exercise) the aforementioned gap in average price levels between the 2005 and 2011 rounds narrows considerably.

Of course, urban bias in the ICP is not just a concern about the China data. Meta data provided by the ICP indicate that only 29% of the 189 countries in the ICP included rural areas in the price surveys.[35] Importantly, however, the problem is less evident in the 2011 ICP for the ICP's Asia region. For Asia (East, South and West) the proportion of countries that included rural areas in their price surveys was 65%; for East and South Asia it was 83%. And for East and South Asia, three of the four countries that did <u>not</u> include rural areas in the sampling of price

[34] Here I am referring only to the identified methodological difference between rounds as achieved by the Inklaar-Rao harmonization. They also do an adjustment for the urban bias in the China ICP for 2005, which I return to.
[35] The OECD price surveys were only done in cities and only one country in Latin America included rural areas. Half the countries in Africa included rural areas in their ICP price surveys.

outlets have very little in the way of rural areas.[36] So for the ICP's Asia region, rural coverage was clearly excellent in 2011. Corresponding counts are not available for 2005 although the Asian Development Bank's (2014) report on its implementation of the 2011 ICP refers a few times to the extra effort made to cover rural areas compared to 2005.

From what we know, it is plausible that the Asia drift (after controlling for the multiple economic influences on the PPPs) reflects this extra effort made by the ICP's Asia office in 2011 to cover rural areas where prices tend to be lower. This too can be seen as a methodological improvement over the 2005 round. However, the fact that it was concentrated in one region creates an inter-regional comparability concern that users should be aware of.

8. Conclusions

The ICP has been a very important source of data on price levels across countries. All defensible international comparisons of monetary aggregates involving non-traded goods require such data. However, the ICP has seemed something like a roller-coaster ride for developing countries and the (large) community of users. The results change in significant ways from one round to the next, and appear to differ between and within regions. Many developing countries saw substantial changes to their real incomes relative to expectations using the ICP's prior round for 2005 (World Bank. 2008). This paper has documented and studied the changes in PPPs in the 2005 and 2011 rounds of the ICP. It has not been presumed that one round is better than the other. Instead, the task here has been to try to explain the observed changes.

The PPPs for developing countries tended to rise relative to domestic inflation rates in the 2005 ICP but they fell again in the 2011 round. The new ICP indicates a downward drift of about 1% per annum in price levels relative to market exchange rates at given growth rates for the developing world, reversing the upward trend seen in the 2005 ICP, relative to the 1993 round.

The downward drift is particularly strong for Asia and is associated with the ICP's country groupings for implementing the price surveys rather than the World Bank's regional groupings. This suggests that differences in ICP implementation have played a role. The precise nature of those differences remains unclear from published sources, but one clue lies in differential improvements in sampling, whereby the Asia region did a better job in covering rural

[36] For East and South Asia, only four countries were purely urban, Singapore, Hong Kong, Macao and Taiwan.

areas in the 2011 round. Then adjustments for the differing degrees of urban bias may be needed to assure valid cross-country comparisons.

In the process of trying to explain the downward drift in price levels, this study has explored the hypothesis that the ICP's price surveys tend to use internationally-traded goods more than is the case for the domestic CPIs for developing countries. This appears to be a plausible conjecture on *a priori* grounds given that the ICP is an international survey of prices, which will understandably put a higher weight on comparability than do national price surveys, for which representativeness is the only concern. While PPPs try to address the problem of the existence of non-traded goods, some of those goods can pose a serious problem for doing any international price surveys. To the extent that internationally-traded goods tend to be more comparable internationally than non-traded goods, there will be a higher weight on traded goods in the PPPs from the ICP. The practice of using a rich country as the reference in price comparisons is likely to also entail higher weight on traded goods in poor countries.

The hypothesis that the ICP gives higher weight on traded goods than is the case for domestic price indices, especially for developing countries, is consistent with the evidence presented here on the predictive power of changes in the market exchange rate controlling for domestic inflation rates. There is clear evidence of excess sensitivity to changes in market exchange rates. To the extent that consumption patterns for tradables and non-tradables vary with consumption or income levels, this finding warns on the need for caution in global poverty comparisons and global inequality measures.

Users are asked to fully revise their economic map of the world with each new ICP round. Rather than switch fully to a new round, ignoring the history, it would surely make more sense to use a moving average of PPPs across ICP rounds. This would make the global measures of poverty and inequality less vulnerable to the inevitable errors in the ICP data and the changes in the methods of data collection and analysis.

Greater transparency would also help users understand the changes from one ICP round to another. This can only be assured if users have access to the underlying micro-price data, which has not been the case in the past.

Appendix: Empirical implications of the TGP hypothesis

To outline the argument in Section 4 in more formal terms, suppose we re-group all goods into the traded/non-traded categories. Then consider the following equations for the changes in the PPP and the deflator for country *i* and ICP round *t*:

$$\begin{aligned}\Delta_t \ln PPP_{it} &= ST_{it}^{PPP}\Delta_t \ln P_{it}^{T} + SNT_{it}^{PPP}\Delta_t \ln P_{it}^{NT} + e_{it} \\ \Delta_t \ln DEF_{it} &= ST_{it}^{DEF}\Delta_t \ln P_{it}^{T} + SNT_{it}^{DEF}\Delta_t \ln P_{it}^{NT}\end{aligned} \tag{A1}$$

Here ST_i^{PPP} and SNT_i^{PPP} are the (positive) shares on internationally traded and non-traded goods (respectively) in the PPP rate for country *i* while ST_i^{DEF} and SNT_i^{DEF} are the corresponding (positive) shares in the CPI (with the shares summing to unity for each of PPP and CPI), while $\Delta_t \ln P_{it}^{T}$ and $\Delta_t \ln P_{it}^{NT}$ are the proportionate rates of change in the prices of traded and non-traded goods respectively. The term e_{it} captures the extra terms stemming from the fact that the PPP is a multilateral index. (No such error term is required for the equation for the rate of domestic price inflation, although $\Delta_t \ln P_{it}^{T}$ and $\Delta_t \ln P_{it}^{NT}$ may well be measured with error.) Note that the PPP for country *i* is relative to a reference country. The weights then reflect the shares in the reference country (or group of countries) as well as for country *i*. This fact alone must lead us to expect the PPP weights for a given country in (A1) to differ from the CPI weights.

On invoking the "law-of-one-price" for traded goods, we have:

$$\Delta_t \ln P_{it}^{T} = \Delta_t \ln MER_{it} + \Delta_t \ln P_t^{T} \tag{A2}$$

where $\Delta \ln P_t^{T}$ denotes the rate of change in the world price of traded goods. Then we can readily derive the following equation for the rate of PPP inflation:

$$\Delta_t \ln PPP_{it} = \left(\frac{SNT_{it}^{PPP}}{SNT_{it}^{DEF}}\right)\Delta_t \ln DEF_{it} + \left[ST_{it}^{PPP} - \frac{SNT_{it}^{PPP} ST_i^{DEF}}{SNT_{it}^{DEFI}}\right]\Delta_t \ln MER_{it} + \varepsilon_{it} \tag{A3}$$

where:

$$\varepsilon_{it} = e_{it} - \frac{SNT_{it}^{PPP} ST_{it}^{DEF}}{SNT_{it}^{DEF}} \Delta_t \ln P_t^T \tag{A4}$$

Notice that we cannot set $E(\varepsilon_{it}) = 0$ in general. For example, rising (falling) global prices of traded goods will generate positive (negative) drift in the PPPs.

We see from (A3) that the rate of PPP inflation can be written as a weighted sum of the rates of domestic inflation and the rate of change in the MER. The sum of the weights is unity, so we can re-write (A3) in an equivalent form, in terms of the rate of change in the PLI:

$$\Delta_t \ln PLI_{it} = \Delta_t \ln(PPP_{it} / MER_{it}) = \left(\frac{SNT_{it}^{PPP}}{SNT_{it}^{DEF}} \right) \Delta_t \ln(DEF_{it} \; / MER_{it}) + \varepsilon_{it} \tag{A5}$$

If the domestic price deflator and PPP have the same weights on non-traded goods then the coefficient on the term in $\Delta \ln(DEF_{it} \; / MER_{it})$ in (A5) will be unity. Under the TGP hypothesis, the coefficient is less than unity, though still positive. A higher weight on traded goods in the 2011 ICP will thus yield a higher PLI at any given value of $\Delta \ln(DEF_{it} \; / MER_{it})$.

To obtain a regression specification we need to replace the coefficients in (A3) by their mean across the set of countries in the regression and transform the variables to assure that the PLI=1 for the U.S. This gives the augmented equation (2) in the main text, incorporating the MER changes.

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Table 1: Price level changes between ICP rounds

	(1) Number of countries in 2005 round	(2) Rate of change in PLI 2005-2011 (% per annum)	(3) Rate of change in PLI 1993-2005 (% per annum)
All countries (except U.S)	144	1.327***	1.347***
		(0.223)	(0.218)
Europe/OECD (except U.S.)	43	1.464***	1.823***
		(0.305)	(0.312)
Other countries	104	1.274***	1.132***
		(0.299)	(0.285)
ICP regions			
1: Africa	47	1.112***	1.666***
		(0.317)	(0.403)
2: Asia	22	-0.038	1.514**
		(0.473)	(0.750)
3: CIS	8	4.265***	1.257*
		(0.843)	(0.659)
4: Europe/OECD (excl.U.S)	47	1.433***	1.782***
		(0.304)	(0.312)
5: Latin America	8	5.448***	-0.678
		(0.746)	(0.755)
6: Western Asia	10	-2.255***	-0.788
		(0.743)	(0.646)
7: Iran and Georgia	2	5.075***	1.214*
		(0.972)	(0.708)

Note: Columns (2) and (3) give rates of change in the PLI, measured by (unconditional mean annualized changes in logs). White heteroskedasticity-consistent standard errors in parentheses. ***: significant at the 1% level; ** significant at the 5% level; * at 10%.

Table 2: Regression for annualized difference in log PPP between 2005 and 2011 ICP rounds

	(1)	(2)	(3) Excl. Europe/ OECD	(4)	(5) Excl. Europe/ OECD
Deflator	CPI	CPI	CPI	GDP deflator	GDP deflator
PLI drift ($\hat{\delta}_t$)	0.009	0.002	-0.003	-0.002	-0.012**
	(0.003)	(0.003)	(0.006)	(0.004)	(0.005)
Annualize difference in log deflator ($\hat{\alpha}_{1t}$)	0.093*	0.307***	0.384***	0.345***	0.459***
	(0.050)	(0.090)	(0.116)	(0.076)	(0.088)
Annualized difference in log market exchange rate ($\hat{\alpha}_{2t}$)	0.965***	0.653***	0.620***	0.599***	0.524***
	(0.016)	(0.103)	(0.123)	(0.096)	(0.094)
R^2	0.954	0.679	0.674	0.714	0.717
Adjusted R^2	0.954	0.675	0.667	0.710	0.711
N	141	137	93	134	91
S.E. of regression	0.026	0.025	0.028	0.024	0.026
F-statistic	1439.267	142.306	93.098	163.492	111.532
Prob. F	0.000	0.000	0.000	0.000	0.000
t-test for homogeneity ($\hat{\alpha}_{1t} + \hat{\alpha}_{2t} = 1$)	1.199	-0.707	0.050	-1.091	-0.296
$\hat{\alpha}_{1t}$ imposing homogeneity	0.037**	0.326***	0.382***	0.360***	0.464***
	(0.019)	(0.067)	(0.102)	(0.076)	(0.086)

Note: The dependent variable is the annualized difference in the log price level index (ratio of the PPP rate to the MER) between 2005 and 2011. Regressors are transformed such that the predicted value is zero for the U.S. (as in equation (1) in text). The change in the log of the CPI for the U.S. over 2005-11 was 0.1413, while the change in the GDP deflator was 0.1150. White heteroskedasticity-consistent standard errors. ***: significant at the 1% level; ** significant at the 5% level; * 10% level. Columns (2) and (4) drops four outliers from the regression in Column (1) with unusually large devaluations (see Figure 5 and text). The one remaining outlier amongst these four was also dropped from Column (3) and (5).

Table 3: Regression for annualized difference in log PPP between 1993 and 2005 ICP rounds

	(1)	(2) Excl. Europe/ OECD	(3)	(4) Excl. Europe/ OECD
PLI drift ($\hat{\delta}_t$)	0.014***	0.016***	0.010***	0.013***
	(0.003)	(0.005)	(0.002)	(0.005)
Annualize difference in log Consumer Price Index ($\hat{\alpha}_{1t}$)	0.358***	0.374***	0.206***	0.279***
	(0.062)	(0.086)	(0.074)	(0.094)
Annualized difference in log market exchange rate ($\hat{\alpha}_{2t}$)	0.640***	0.613***	0.799***	0.712***
	(0.068)	(0.098)	(0.079)	(0.107)
Annualized difference in log GDP per capita in $US ($\hat{\beta}$)	n.a.	n.a.	0.242***	0.168***
			(0.065)	(0.066)
R^2	0.952	0.932	0.959	0.937
Adjusted R^2	0.951	0.930	0.957	0.934
N	116	73	115	72
S.E. of regression	0.023	0.026	0.021	0.025
F-statistic	1121.762	482.72	854.103	338.687
Prob. F	0.000	0.000	0.000	0.000
t-test for homogeneity ($\hat{\alpha}_{1t} + \hat{\alpha}_{2t} = 1$)	-0.132	-0.456	-0.362	-0.308
$\hat{\alpha}_{1t}$ imposing homogeneity	0.359***	0.352***	0.209***	0.270***
	(0.068)	(0.105)	(0.072)	(0.090)

Note: The dependent variable is the annualized difference in the log price level index (ratio of the PPP rate to the ordinary exchange rate) between 1993 and 2005. Regressors are transformed such that the predicted value is zero for the U.S. (as in equation (1) in text). The change in the log of the CPI for the U.S. over 1993-2005 was 0.3015, while the changes in the GDP deflator and GDP per capita were 0.1234 and 0.4948 respectively. White heteroskedasticity-consistent standard errors. ***: significant at the 1% level; ** significant at the 5% level; * 10% level.

Table 4: Regression for annualized difference in log PLI between 2005 and 2011 ICP rounds incorporating the Dynamic Penn Effect

	(1)	(2)	(3) Excl. Europe/ OECD	(4)	(5) Excl. Europe/ OECD
Deflator	CPI	CPI	CPI	GDP deflator	GDP deflator
PLI drift ($\hat{\delta}_t$)	-0.003	-0.004	-0.011*	-0.005*	-0.015***
	(0.003)	(0.003)	(0.006)	(0.003)	(0.006)
Annualize difference in log deflator ($\hat{\alpha}_{1t}$)	-0.052	0.085	0.165	0.195*	0.313***
	(0.052)	(0.094)	(0.123)	(0.104)	(0.114)
Annualized difference in log MER ($\hat{\alpha}_{2t}$)	-0.028***	-0.187**	-0.195*	-0.282***	-0.341***
	(0.008)	(0.089)	(0.120)	(0.105)	(0.113)
Annualized diff. in log GDP per capita in $US ($\hat{\beta}$)	0.258***	0.209***	0.216***	0.144**	0.137**
	(0.044)	(0.048)	(0.060)	(0.056)	(0.063)
R^2	0.236	0.254	0.237	0.277	0.280
Adjusted R^2	0.219	0.237	0.211	0.260	0.255
Adjusted R^2 for the logPPP specification	0.963	0.711	0.703	0.722	0.720
N	140	136	92	133	90
S.E. of regression	0.024	0.024	0.026	0.023	0.026
F-statistic	14.027	14.947	9.121	16.441	11.128
Prob. F	0.000	0.000	0.000	0.000	0.000
Coefficient on 2005 GDP per capita as extra regressor	-0.000	-0.001	-0.005***	-0.000	-0.006***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)

Note: The dependent variable is the annualized difference in the log price level index (ratio of the PPP rate to the ordinary exchange rate) between 2005 and 2011. Regressors are transformed such that the predicted value is zero for the U.S. The change in the log of the CPI for the U.S. over 2005-11 was 0.1413, while the changes in the GDP deflator and GDP per capita were 0.1150 and 0.1778 respectively. White heteroskedasticity-consistent standard errors. ***: significant at the 1% level; ** significant at the 5% level; * 10% level. Columns (2) and (4) drop four outliers from the regression in Column (1); see Figure 5 and text. The one remaining outlier amongst these four was also dropped from Column (3) and (5).

Table 5: Regression for annualized difference in log PLI imposing homogeneity and with region-specific drifts 2005-11

	(1) DPE only	(2) TGP only	(3) DPE+TGP	(4) DPE only	(5) DPE+TGP	(6) DPE+TGP
Annualized difference in log GDP per capita in $US ($\hat{\beta}$)	0.285***		0.160***	0.245***	0.126***	0.148***
	(0.051)		(0.059)	(0.045)	(0.052)	(0.056)
Annualized difference between inflation rates for GDP deflator and MER ($\hat{\alpha}_{1t} = 1 - \hat{\alpha}_{2t}$)		0.430***	0.287***		0.293***	0.302***
		(0.082)	(0.094)		(0.093)	(0.091)
PLI drift ($\hat{\delta}_t$)(x100)						
Europe/OECD (excl. U.S.) (x100)	0.322	0.270	0.030			
	(0.285)	(0.383)	(0.299)			
Other countries	-1.001**	-1.064**	-1.585***			
	(0.484)	(0.496)	(0.458)			
ICP regions						
1: Africa				-0.352	-0.876**	-0.961**
				(0.446)	(0.407)	(0.419)
2: Asia				-2.304***	-2.706***	-2.432***
				(0.575)	(0.587)	(0.951)
3: CIS				1.242	0.346	0.995
				(1.010)	(0.889)	(0.940)
4: Europe/OECD (excl. U.S.)				0.395	0.138	0.444
				(0.291)	(0.309)	(0.335)
5: Latin America				2.787***	1.698**	2.514**
				(0.836)	(0.803)	(1.007)
6: Western Asia				-4.087***	-5.332***	-5.086***
				(0.652)	(0.661)	(0.679)
7: Iran and Georgia				2.348**	1.196	2.001**
				(1.024)	(0.756)	(0.873)
World Bank regions						
1: East Asia						-0.417
						(1.051)
2: Eastern Europe and Central Asia						-0.982**
						(0.501)
3: Latin America and Caribbean						-1.144*
						(0.672)
4: Middle East and North Africa						-1.250
						(0.773)
5: South Asia						-1.040
						(0.910)
R^2	0.253	0.276	0.324	0.539	0.605	0.625
Adjusted R^2	0.242	0.265	0.308	0.514	0.579	0.584
N	136	134	133	136	133	133
S.E. of regression	0.024	0.023	0.022	0.019	0.019	0.018
F-statistic	14.926	16.486	15.318	21.058	20.914	14.022
Prob. F	0.000	0.000	0.000	0.000	0.000	0.000

Note: See Table 4.

Figure 1: Densities of changes in log price level index (PLI) between ICP rounds

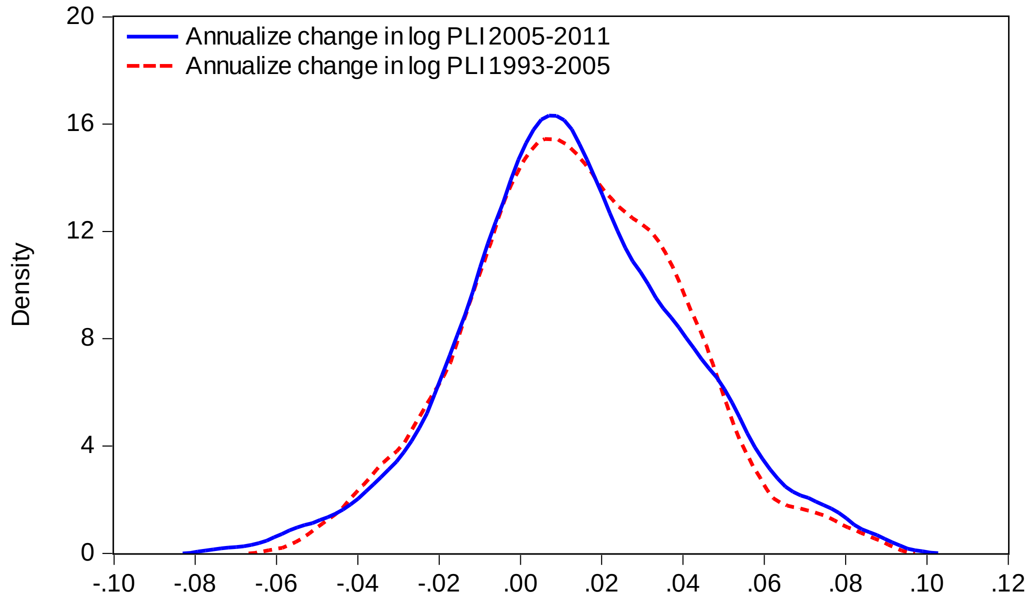


Figure 2: Changes in log PLI at country level between successive ICP rounds

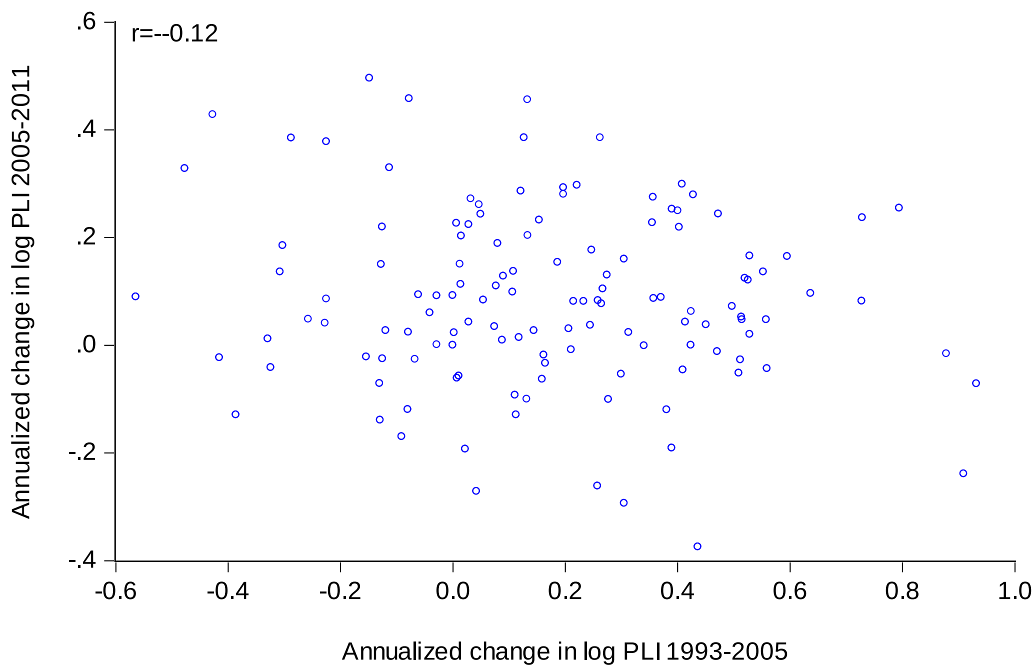
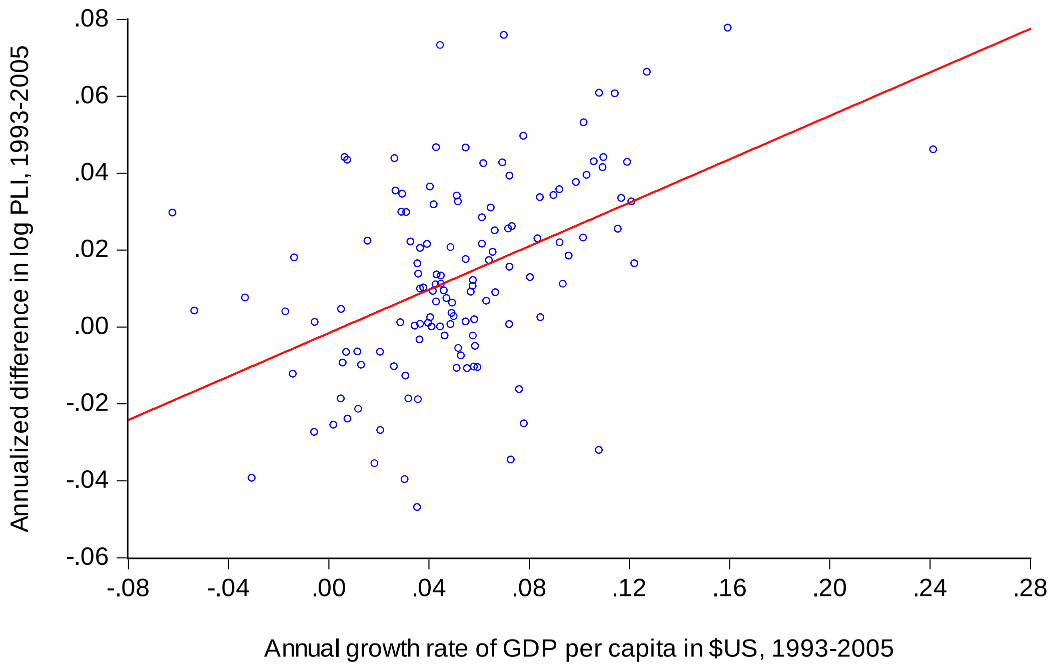


Figure 3: Dynamic Penn Effect

(a) 1993-2005



(b) 2005-2011

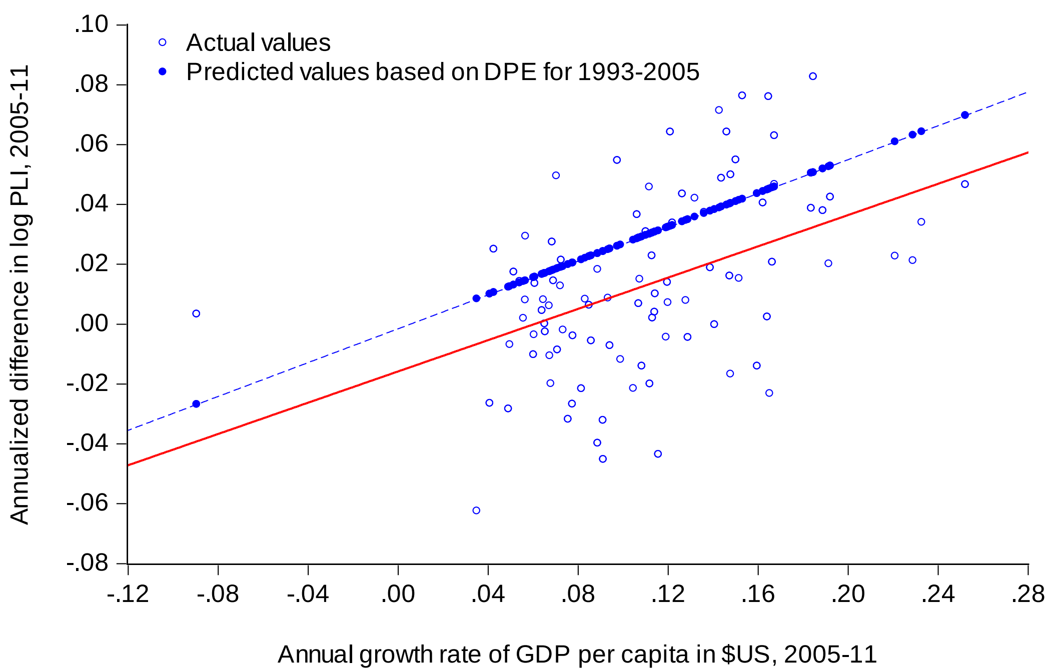
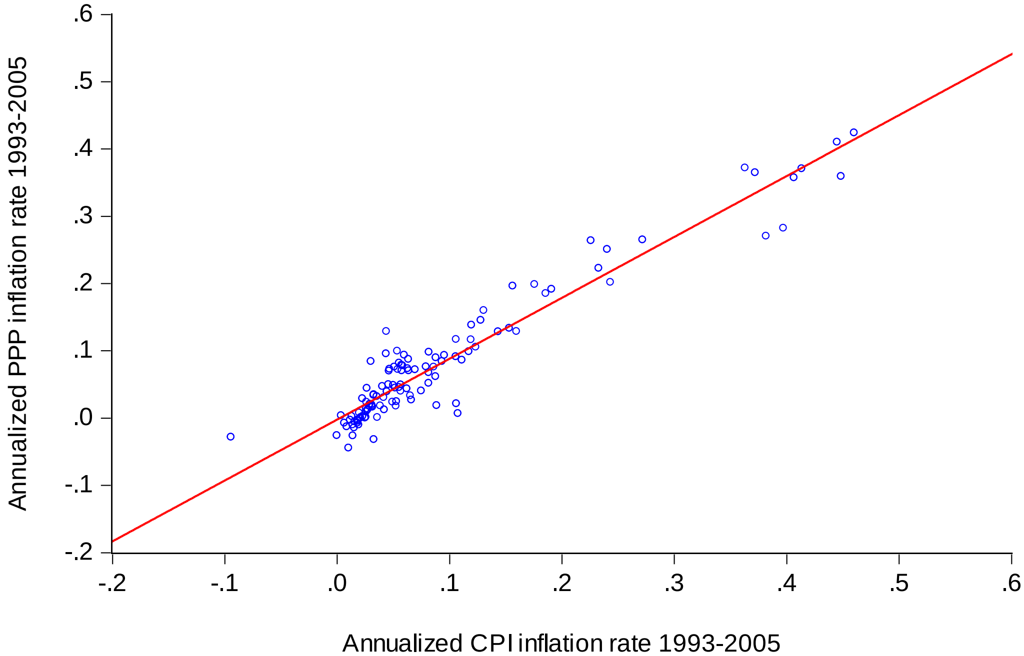


Figure 4: PPP inflation plotted against CPI inflation between ICP rounds

(a) 1993-2005



(b) 2005-2011

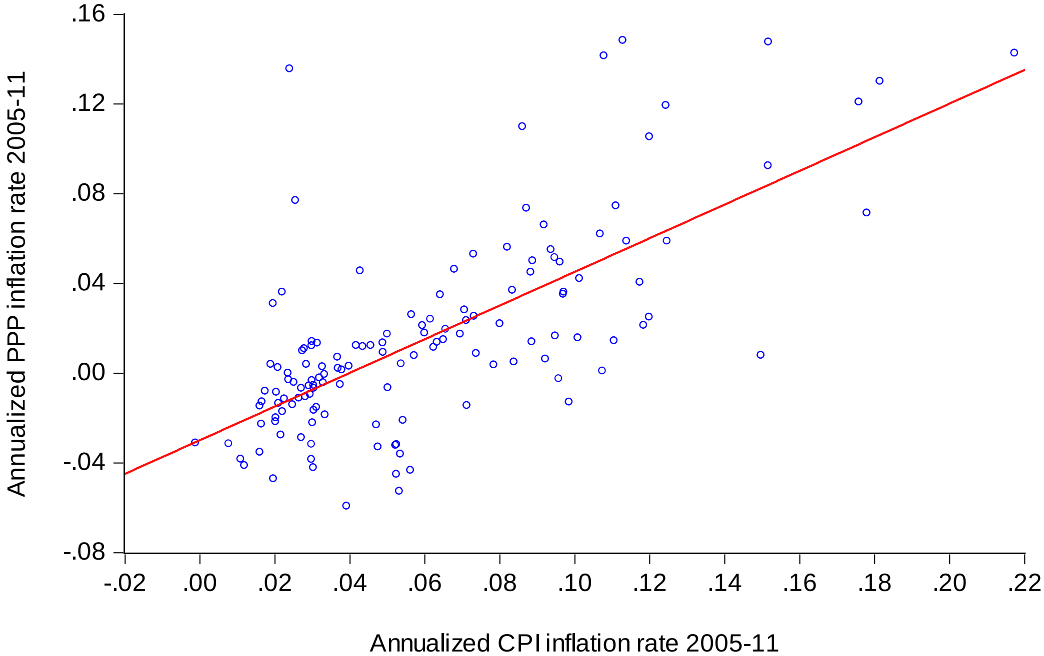


Figure 5: Histogram for annualized change in market exchange rate 2005-11

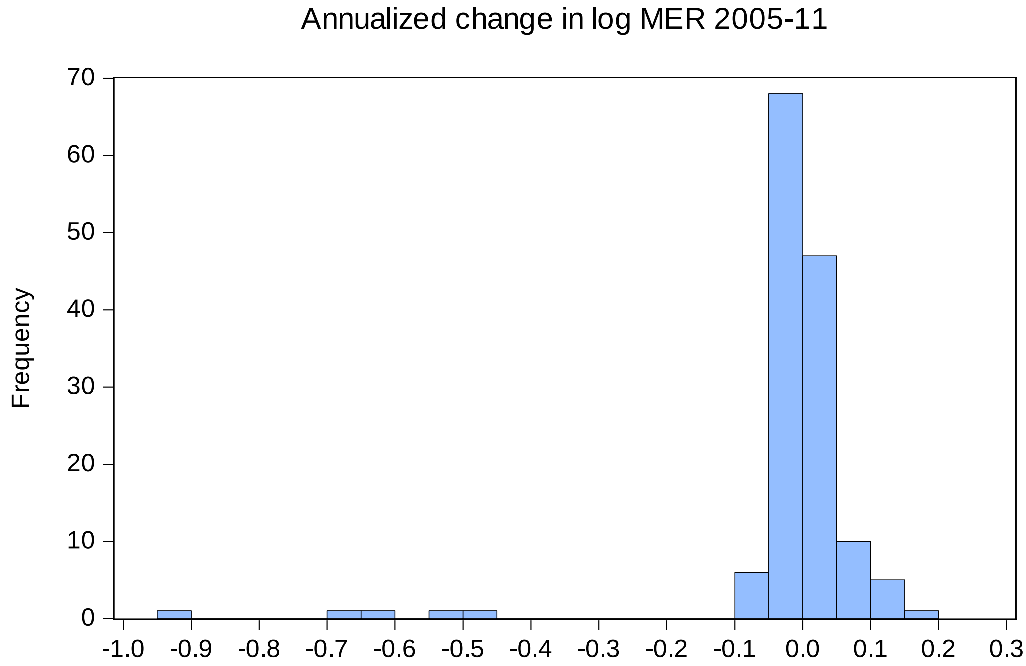
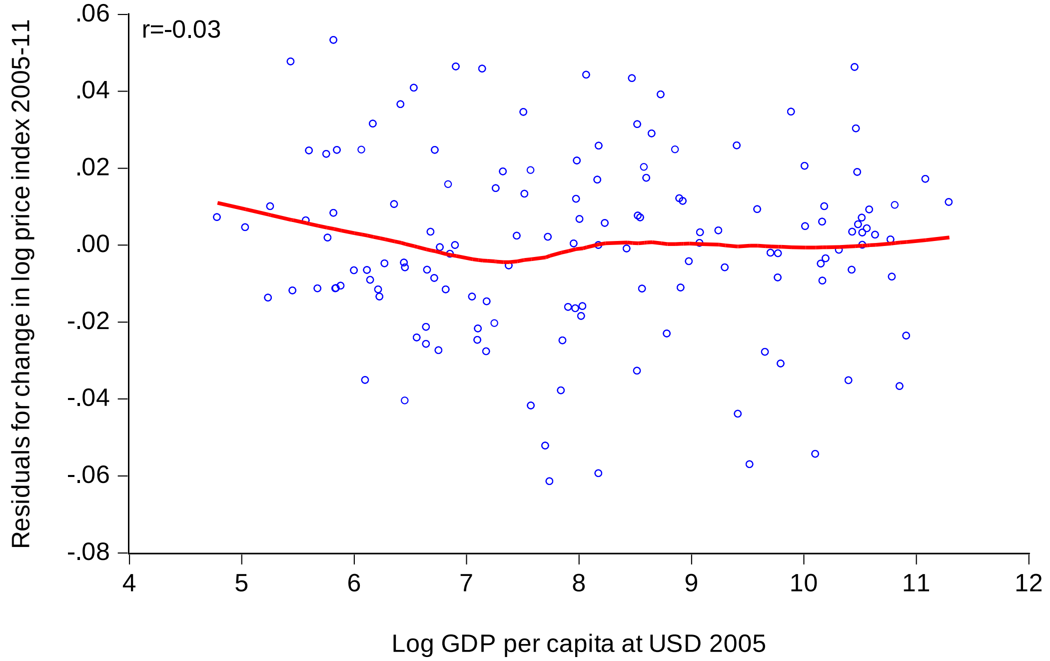


Figure 6: Plot of the residuals for a regression of annualized change in log PLI allowing for the DPE and TGP on GDP per capita in 2005

(a) All countries



(b) Developing countries only (excluding Europe/OECD)