Exchange Rate Misalignment Estimates – Sources of Differences*

Yin-Wong Cheung
University of California, Santa Cruz, USA

Eiji Fujii
Kwansei Gakuin University, Japan

This version: May 2011

* Cheung and Fujii gratefully acknowledge the financial support of, respectively, the faculty research funds of the University of California, Santa Cruz and of the JSPS' Grant-in-Aid for Scientific Research (#14530039).

Corresponding addresses:
Yin-Wong Cheung – Economics Department, University of California, Santa Cruz, CA 9506, USA. Email: cheung@ucsc.edu
Eiji Fujii – School of Economics, Kwansei Gakuin University, 1-155 Uegahara 1-bancho, Nishinomiya, Hyogo 662-8501, Japan. Tel: +81 798 54 7257. Fax: +81 798 51 0944. E-mail: efujii@kwansei.ac.jp.

Exchange Rate Misalignment Estimates – Sources of Differences*

Abstract

We investigate the implications of the new price information in the latest International Comparison Program (ICP) survey for evaluating the year 2005 exchange rate misalignment estimates. A decomposition exercise reveals that the misalignment revisions are substantially affected by the ICP price updates. Two measurement-related and four economic factors are used to explain the differences in misalignment estimates. We found that, in general, these factors a) explain the misalignment revisions between the two WDI datasets better than the differences of misalignment estimates between WDI and PWT datasets, and b) explain the positive changes better than the negative ones. These factors could explain upto 42% of the differences between these misalignment estimates.

JEL Classifications: F31, F41, E01, C31

Keywords: Penn Effect Regression, Data Revision, PPP-Based data, Measurement Factors, Economic Factors

1. Introduction

Since it was established in 1968, the International Comparison Program (ICP) has conducted periodic surveys on national prices. The survey results are used to produce internationally comparable price indices, which are labeled purchasing power parities (PPPs). Using, say, the US as the numeraire country, a country's national price level is given by its PPP normalized by its US dollar exchange rate. The PPP-based gross domestic product (GDP) – which allows the international comparison of real incomes and economic sizes – is the GDP in local currency units normalized by its national price level.[1] Similarly, economic welfare and productivity could be compared across countries using data on *per capita* PPP-based GDP.

The *Penn World Table* (*PWT*, http://pwt.econ.upenn.edu/) and the *World Development Indicators* (*WDI*, http://data.worldbank.org/data-catalog/world-development-indicators) are the two main data sources for these internationally comparable price and output measures. These data are commonly used in both academic and policy related cross-country growth and welfare comparison exercises (Barro 1991; Levine and Renelt 1992). More recently, PPP-based GDP data were included in assessing quota subscriptions of International Monetary Fund member countries (IMF, 2011; Silver 2010). In addition to growth and development analyses, these internationally comparable data are employed in exercises evaluating exchange rate misalignment. Frankel (2006), Cheung, Chinn and Fujii (2007) and Coudert and Couharde (2007), for example, used these data to assess the degree of the renminbi (RMB, the Chinese currency) undervaluation.

Despite the effort to make national price data comparable, it is a daunting task to aggregate and compare prices of vastly dissimilar products from countries of different economic characteristics and over time. To further complicate the issue, the ICP survey took place at irregular intervals and modified its methodology, country coverage, and product sample from one round to another.[2] These modifications make comparing PPPs of different vintages a non-trivial exercise. The PPP and national price level estimates from a new survey could be quite different from those projected from information obtained from previous surveys.

---

[1] The terms PPP and national price level are potentially confusing for some people who are not familiar with the ICP data. In this content, the PPP is a local currency price measure and the national price level is a relative price, which is equivalent to the inverse of the real exchange rate. We will use these terms interchangeably in the text.

[2] For instance, the ICP conducted price surveys in 1970, 1973, 1975, 1980, 1985, 1993 and 2005; which covered, respectively, 10, 16, 34, 60, 64, 117 and 146 countries.

The latest round of ICP survey was conducted in 2005. It incorporated a few major changes in the survey design, and data collection and processing methods. The resulting new PPP estimates represent some substantial and startling data revisions. Two often cited examples are China and India. According to the 2005 round survey data, their 2005 *per capita* GDPs are, respectively, 39% and 38% smaller than previously estimated. Some countries, indeed, have their 2005 per capita GDPs revised up or down by 50% or more (World Bank, 2008a).

There are concerns on the robustness of empirical results derived from older ICP data vintages. For instance, studies have demonstrated that growth rate estimates, the negative growth volatility effect, and growth determinants could change across different vintages of PPP-based data (Ciccone and Jarocinski, 2010 ; Johnson, Papageorgiou, and Subramanian, 2009; Ponomareva and Katayama, 2010) . Chen and Ravallion (2010a, b) show that, using the latest available ICP data, the poverty incidence in 2005 is reduced than that in, say, 1981 but is more prevalent than what past estimates suggested. The data revision also has implications for our understanding of inequality in the world – global inequality according to the new PPP data is more severe than we thought (Milanovic, 2009).

Cheung, Chinn and Fujii (2009, 2010) discuss the implications of the 2005 ICP round assessing currency misalignment. Specifically, they showed that the Chinese currency's misalignment estimate obtained from the revised data is strikingly different from the one obtained in previous studies – the new undervaluation estimate for 2004 turns out to be around 18% and is only about one-third of the "old" estimate of 53%. Even if one allows for the possibility that the 2005 ICP survey overstated China's national price level, the reduction in the misalignment estimate is substantial.[3] It is natural to ask: What are the factors affecting the change in misalignment estimates?

Besides documenting substantial changes, the current exercise studies revisions in exchange rate misalignment estimates. We examine the components of misalignment revisions and the factors affecting the changes in misalignment estimates. The Penn effect regression framework is adopted to decompose revisions in misalignment estimates into changes in real exchange rate data and changes in estimated equilibrium exchange rates.

One factor that could affect data revision is a country's participation in the ICP survey. For instance, China and India mentioned above participated in the 2005 ICP price survey but not in the

[3] Deaton and Heston (2010) suggested that China's national price level – the PPP GDP deflator – could be overstated by 10%. According to Chen and Ravallion (2010b), the PPP consumption deflator could be overstated by about 10%.

previous (1993) one. Prior to the release of the 2005 benchmark information, these two countries' PPP-based national price data were derived from estimation and projection based on partial or incomplete information. These guesstimates could systematically over- or under-estimate the degree of misalignment.

Data quality is another possible factor. World Bank (2008a) shows that large PPP revisions from the 2005 round survey are usually associated with low income countries. These countries tend to offer low quality economic data, which are used to estimate and project these countries' PPPs beyond the survey year. Cheung and Chinn (1996), for example, show that data quality has implications for studying output dynamics. Similarly, Dawson *et al.* (2001) demonstrates that the data quality has some significant implications for estimating the income volatility effect on growth.

Both the participation status and the data quality are related to measurement issues. What are the economic factors that could affect the currency misalignment estimates? The framework used by Frankel (2006), Cheung, Chinn and Fujii (2007) and Coudert and Couharde (2007) to assess currency misalignment is based on the Penn effect regression – regression of national price levels on *per capita* income levels. Thus, we consider economic factors including the initial level of output, output growth, openness and inflation that could influence the empirical relationship between national price and income levels

2. Preliminaries

2.1 Data

In this exercise, we focus on the year 2005 currency misalignment estimates derived from three versions of PPP-based real exchange rate and output data. We label the first dataset "*WDI* 2007" which contains the year 2005 data downloaded from WDI in July 2007. The second dataset is "*WDI* 2008" that was downloaded in April 2008. The third one is "*PWT* 6.3" extracted from the *PWT* version 6.3 database.[4] The two WDI datasets give the year 2005 PPP-based data before and after incorporating the 2005 ICP survey results. The *PWT* version 6.3 is derived from the pre-2005 survey information. At the time of writing, the *PWT* version 7.0 that includes the data from the latest 2005 ICP round is under preparation and not yet available.

[4] *PWT* version 6.3 provides two China series. However, for the benchmark year 2005, there is no difference between the two versions of price and *per capita* GDP data.

The two WDI datasets are meant to capture the large data revisions introduced by the latest 2005 ICP round. Details of the recent survey are given in the ICP final report and ICP handbook (World Bank, 2008b, c). The *PWT* 6.3 is included to illustrate the difference between the two commonly used datasets for international comparison exercises. While both datasets draw on information from ICP survey, they adopt different statistical procedures to construct their PPP-based national price and output series. For instance, PWT uses the GK method to compute the aggregate price index and WDI uses the GEKS method.[5] The GK method, compared with the GEKS method, tend to understate the internationally comparable prices (overstate incomes) in poor countries relative to rich ones. Deaton and Heston (2010) offer an excellent overview of these aggregation formulations and other issues of constructing PPPs.

2.2 Penn Effect

The basic Penn effect regression equation is given by

$$r_i = \beta_0 + \beta_1 y_i + u_i \qquad (1)$$

where r_i and y_i are, respectively, country *i*'s national price level and real *per capita* income relative to the US. The national price level indeed is the reciprocal of the PPP-based real exchange rate - an increase in r_i means an appreciation of the currency. Henceforth, we call r_i the real exchange rate for brevity.

Apparently coined by Samuelson (1994), the Penn effect refers to the robust empirical positive association between national price levels and real per capita incomes documented by a series of Penn studies (Kravis and Lipsey, 1983, 1987; Kravis, Heston and Summers, 1978; Summers and Heston, 1991). That is, a high income country tends to have a high real exchange rate. The positive empirical relationship could be explained by the differential productivities in tradable and nontradable sectors (Balassa 1964; Samuelson 1964) or by the factor-endowment-based approach developed by Bhagwati (1981) and Kravis and Lipsey (1983).

The Penn effect framework has been adopted in the recent debate on the RMB misalignment (Frankel, 2006; Cheung, Chinn and Fujii, 2007; Coudert and Couharde, 2007). The inference of currency misalignment based on equation (1) hinges upon the robust positive Penn effect and the

---

[5] The GK method refers to the method due to Geary (1958) and Khamis (1972), whereas the GEKS method refers to that due to Gini(1924), Eltetö and Köves (1964), and Szulc (1964). See Deaton and Heston (2010) for details.

implicit assumption that real exchange rates relative to the US may be overvalued or undervalued, but they are at the equilibrium level on average. To ensure data compatibility, the empirical analysis is typically conducted with PPP-based real exchange rates and GDP measures.

The estimated "equilibrium" real exchange according to the Penn effect is given by $\hat{\beta}_0 + \hat{\beta}_1 y_i$, where "^" indicates an estimate. The estimated degree of misalignment is given by the estimated residual $\hat{u}_i$; with a positive value implies overvaluation and a negative value undervaluation.

The results of estimating (1) are presented in Panel A, Table 1. To facilitate comparison between the three datasets, our country sample includes 154 countries for which both real *per capita* income and real exchange rate data are available for 2005. The data sources and country sample are detailed in the Appendix. Some remarks are in order.

On the Penn effect, the estimate $\hat{\beta}_1$ affirms the presence of a positive empirical relationship between a country's income and its real exchange rate, albeit with varying strengths, in all the three datasets. The *WDI* 2008 vintage that includes the 2005 ICP round information has the smallest Penn effect estimate $\hat{\beta}_1$. The decline in the Penn effect is also observed by Cheung, Chinn and Fujii (2010). The $\hat{\beta}_1$-estimates from *WDI* 2007 and *PWT* 6.3 are quite similar to each other. Recall that both *WDI* 2007 and *PWT* 6.3 data are based on the 1993 ICP survey though they employ different index constructing and updating methods. Apparently, the commonality of the ICP survey dominates the estimation of the Penn effect.

The estimated degrees of misalignment of the BRIC countries; namely Brazil, Russia, India and China are given in Panel B, Table 1. The misalignment estimates from the three different datasets exhibit different patterns and offer a few interesting observations.

The Chinese RMB misalignment estimates from both *WDI* 2007 and *PWT* 6.3 are largely in line with those reported in, for example, Frankel (2006) and Cheung, Chinn and Fujii (2007). The estimates indicate a large degree of undervaluation from 50.56% (*PWT* 6.3) to 64.43% (*WDI* 2007). The *WDI* 2008 data that included the latest ICP survey information, however, imply a strikingly different misalignment estimate – the RMB is undervalued by 14.38%, which is less than one quarter of the estimate from *WDI* 2007. The dramatic decrease encores the one reported by Cheung, Chinn and Fujii (2010). The ICP data revision has a much larger impact on misalignment estimates than the use of different index construction methods.

The Indian Rupee's misalignment estimates have a pattern similar to the RMB one. Its undervaluation estimate from *WDI* 2008 is about 40% of the ones from *WDI* 2007 and *PWT* 6.3. For Brazilian real and Russian ruble, the use of *WDI* 2008 data does not reduce their degrees of undervaluation. Indeed, the 2005 ICP survey data suggest that these two currencies; especially the Russian Ruble, have a level of undervaluation larger than that previously estimated.

The BRIC countries are fast growing developing countries that are at the same time increasingly integrated with the global economy. Why are the revisions of their misalignment estimates so different? One possible reason is whether they participated in the ICP survey. As noted in the introduction, China and India participated in the 2005 ICP survey but not in the prior 1993 round. Thus, before the 2005 ICP survey results are available, the 2005 PPP-based data of these two countries were constructed from incomplete and dated information. The other two BRIC countries Brazil and Russia, on the other hand, are participants of the 1993 round survey and, thus are among the group of 1993 benchmark countries. On this account, their 2005 PPP-based data in *WDI* 2007 are projected from the prior 1993 ICP survey.

To shed some light on the difference between 1993 benchmark and non-benchmark countries; those participated and those not participated in the 1993 ICP survey, Panel C of Table 1 presents the averages of their (absolute) misalignment estimates. Comparing *WDI* 2007 and *WDI* 2008, the average misalignment estimates of the benchmark and non-benchmark groups are quite similar in magnitude but with opposite signs. The mean absolute averages from *WDI* 2008 are about one-third less than the corresponding ones from *WDI* 2007. The average misalignment estimates from *PWT* 6.3 are smaller than those from the other two datasets and the absolute averages are comparable to those from *WDI* 2007.

Figure 1 presents the misalignment estimates. The countries are ordered according to their misalignment estimates – from the lowest (i.e. the most undervalued) to the highest (i.e. the most overvalued) –derived from the *WDI* 2007 Penn effect regression. The differences in the 2005 misalignment estimates appear substantial and the patterns of the three misalignment estimate series are quite different from each other. Indeed, the correlation coefficient estimate is 0.49 for the *WDI* 2007 and *WDI* 2008 misalignment estimates, is 0.54 for the *WDI* 2007 and *PWT* 6.3, and is 0.52 for the *WDI* 2008 and *PWT* 6.3. The relatively low correlation between misalignment estimates from *WDI* 2007 and *WDI* 2008 may not be too surprising given the substantial 2005 ICP survey update. It is a bit unexpected to observe the low correlation between the misalignment estimates from *WDI* 2007 and *PWT* 6.3, which are based on the same 1993 ICP survey information. In the next section, we investigate sources of the differences of these 2005 misalignment estimates.

3. Sources of Differences

Consider the Penn effect regressions based on two different data vintages:

$$r_{i.v1} = \beta_{0,v1} + \beta_{1,v1} y_{i,v1} + u_{i,v1}$$

and

$$r_{i.v2} = \beta_{0,v2} + \beta_{1,v2} y_{i,v2} + u_{i,v2}$$

where $v1$ denotes the *WDI* 2007 dataset and $v2$ denotes either the *WDI* 2008 or the *PWT* 6.3 dataset. The difference in misalignment estimates is defined by $\Delta\hat{u}_{i,v2,v1} \equiv (\hat{u}_{i,v2} - \hat{u}_{i,v1})$. For brevity, we call $\Delta\hat{u}_{i,v2,v1}$ a) the "WDI revision" when $v2 \equiv$ *WDI* 2008, and b) the "PWT-WDI differential" when $v2 \equiv$ *PWT* 6.3.

The series of WDI revision and PWT-WDI differential are plotted in Figure 2. The countries are arranged according to the sizes of their WDI revisions; from the lowest to the highest. Visually, the variations of these two series are quite dis-similar; the two series has a correlation estimate of 0.51.

The change in misalignment estimates could be expressed as

$$\Delta\hat{u}_{i,v2,v1} = r_{i.v2} - r_{i.v1} - (\hat{r}_{i.v2} - \hat{r}_{i.v1}) \equiv \Delta r_{i,v2,v1} - \Delta\hat{r}_{i,v2,v1}. \quad (2)$$

That is, the change in misalignment estimates could be attributed to changes in real exchange rates or in estimated Penn effect equilibrium values. When the change in estimated misalignment is positive (negative), $\hat{u}_{i,v2}$ represents an estimated level of undervaluation that is smaller (larger) than that implied by $\hat{u}_{i,v1}$.

The change in the estimated Penn effect equilibrium value could be written as

$$\Delta\hat{r}_{i,v2,v1} = [(\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v1})]$$
$$+[(\hat{\beta}_{0,v2} + \hat{\beta}_{1,v2} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2})] \quad (3)$$

where $[(\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v1})]$ represents the change in income assuming the Penn effect regression coefficient estimates do not change and $[(\hat{\beta}_{0,v2} + \hat{\beta}_{1,v2} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2})]$ represents the change in the Penn coefficient estimates assuming the output is at the v2 level.

3.1 Decomposition Results

The decomposition of misalignment estimate revisions into changes in real exchange rates ($\Delta r_{i,v2,v1}$'s) and in estimated equilibrium values ($\Delta \hat{r}_{i,v2,v1}$'s) are presented in Table 2. The components of the change in estimated equilibrium values are given in the last two columns. Panel A gives the results pertaining to WDI revisions; that is the change in misalignment estimates between the *WDI* 2008 and *WDI* 2007 datasets. In addition to the entire country sample, we examine the decomposition for 1993 benchmark and non-benchmark countries and for countries with positive and negative misalignment estimate revisions.

In Panel A, all the changes in the estimated equilibrium values ($\Delta \hat{r}_{i,v2,v1}$'s) are negative and, thus, have a negative impact on the misalignment estimates; that is, they all lead to a greater (smaller) extent of undervaluation (overvaluation) estimates. These changes in estimated equilibrium values are dominated by their respective negative Penn effect component.

Since the sum of cross-country misalignment estimates is zero by construction, the total changes in real exchange rate and in estimated equilibrium rate are equal and in opposite directions.

The ICP survey results, however, have differential implications for revisions experienced by different country groups. On the benchmark and non-benchmark country classification, the misalignment estimate revision, $\Delta \hat{u}_{i,v2,v1}$, for the latter group is much larger in magnitude than the former one and is more heavily influenced by the change in real exchange rates than by the change in estimated equilibrium values.

The countries that have positive misalignment estimate revisions, compared with those with negative ones, are on average affected more heavily by changes in real exchange rates. These countries also tend to have a more substantial change income effect revision than those with negative misalignment estimate revisions.

The decomposition of PWT-WDI differentials is presented in Panel B of Table 3. In contrast to results in Panel A, the difference in estimated equilibrium values implies on average a smaller extent of undervaluation. Indeed, there is only one subgroup for which the difference in the estimated equilibrium value implies a greater extent of undervaluation. In contrast to the results in Panel A, the change in estimated equilibrium values has an income component smaller than the Penn effect component. The differences between these two components, however, are usually smaller than those in Panel A.

Even though both *PWT* 6.3 and *WDI* 2007 datasets are based on the same 1993 ICP survey, they yield different misalignment estimates. The PWT and WDI use different indexing methods to construct the PPP-based real exchange rate. Since different countries could be affected differently, it is hard to predict the implications for misalignment estimates.

Our results show that the difference in misalignment estimates appears larger (in absolute terms) for non-benchmark than for benchmark countries. On average, the *PWT* 6.3 results indicate the non-benchmark countries have a smaller degree of undervaluation than the one from the *WDI* 2007 dataset. The opposite is true for benchmark countries though the difference is smaller in magnitude.

Compared with WDI 2007, PWT 6.3 tends to yield a larger misalignment estimate – for 89 of the total of 154 countries, PWT 6.3 misalignment estimates are larger than the corresponding WDI 2007 estimates.

For both the countries with positive revisions and those with negative revisions, $|\Delta r_{i,v2,v1}|$ is always larger than $|\Delta \hat{r}_{i,v2,v1}|$. That is, the difference in the PPP-based exchange rates contribute more (in absolute term) than the difference in the estimated equilibrium rates to the difference in misalignment estimates.

The decomposition results pertaining to the four BRIC countries are presented in Panel C and graphed in Figure 3. China and India, the two 1993 non-benchmark BRIC countries, have a substantial reduction in their undervaluation estimates – the reduction is between 60% to 78%. Most of the reduction comes from the upward revision of their PPP real exchange rates. Indeed, the revision in China's real exchange rate is almost the same as the revision in its misalignment estimate (0.506 vs 0.500); the change in the estimated equilibrium rate has little impact on misalignment revision. This is because the substantial downward revision of China's income is essentially offset by the change in the Penn effect (the last two columns of Panel C and Figure 3A).

The decrease in Indian Rupee's undervaluation is smaller than the change in its real exchange rate. The change in the Rupee equilibrium rate estimates, which is dominated by the change in Penn effect, offsets about 22% of the effect of real exchange rate revision on its misalignment estimate.

Brazil's and Russia's currency misalignment estimates are less influenced by the revision in PPP real exchange rates following the latest ICP survey. As noted earlier, these two 1993 benchmark countries see an increase, instead of a reduction, in the extent of their undervaluation estimates. The revisions in their equilibrium exchange rate estimates, which are heavily influences by the change in the Penn effect, account for a large (absolute) share of the changes in misalignment estimates (Panel C and Figure 3A). The anecdotal evidence, so far, suggests that the currency misalignment estimates of the two benchmark BRIC countries and the two non-benchmark BRIC countries have been differently affected by the last ICP survey results.

With the exception of Brazil, the magnitudes of misalignment estimate revision are smaller for the PWT-WDI differential than for the WDI revision (Panel C.i and C.ii). Further, the magnitudes of changes in real exchange rates, in estimated equilibrium rates, and the components of changes in estimated equilibrium rates are smaller for the PWT-WDI differential than for the WDI revision. Thus, while the different methods employment by PWT and WDI affect the currency misalignment assessment for these BRIC countries, the effect is less serious than that of the 2005 ICP survey update.

3.2 Regression Analysis I: Measurement Related Factors

In this subsection, we use the regression method to assess the determinants of currency misalignment revision. First, we consider two measurement-related factors; namely a) whether the country is a benchmark country participating in the 1993 ICP survey, and b) the country's data quality. Specifically, we consider

$$\Delta\hat{u}^{+}_{i,v2,v1} = \alpha_0 + \alpha_1 D_{i,nBM} + \alpha_2 Q_i + \varepsilon_i\,, \qquad (4a)$$

and

$$\Delta\hat{u}^{-}_{i,v2,v1} = \alpha_0 + \alpha_1 D_{i,nBM} + \alpha_2 Q_i + \varepsilon_i\,. \qquad (4b)$$

$\Delta\hat{u}^{+}_{i,v2,v1}$ and $\Delta\hat{u}^{-}_{i,v2,v1}$ are, respectively, positive and negative changes in misalignment estimates. $D_{i,nBM}$ is a zero-one dummy variable and assumes the value of one when country *i* is not a benchmark country in the 1993 ICP survey. Q_i is the data quality dummy variable. It is set equal to unity if country *i*'s data quality rating is C, C-, D+, or D and to zero if data quality rating is A, A-, B+, B, or B-. The data quality information is from Summers and Heston (1991). It is perceived that data quality could impact the ability to extract information from national data to infer the 2005 PPP data. The sample correlation between $D_{i,nBM}$ and Q_i is .247. The regression error term is given by ε_i.

The results of estimating (4a) and (4b) are reported in, respectively, Panels A and B of Table 3. The benchmark and data quality dummy variables, $D_{i,nBM}$ and Q_i exhibit different impacts on the positive WDI revisions and PWT-WDI differentials (Panel A).

The two measurement-related variables are individually and jointly significant in the WDI revision regression. They both have positive coefficient estimates and jointly explain 38.4% of the revision variability. The positive $D_{i,nBM}$ effect is in accordance with the decomposition results described in the previous subsection. Compared with benchmark countries, countries that did not participate in the 1993 ICP survey experience larger revisions in their misalignment estimates. Similarly, countries with poor data quality also tend to have their degrees of undervaluation revised more substantially than those with better data quality. Apparently, the statistical procedures used to construct the 2005 data tend to reduce the extent of undervaluation experienced by these non-benchmark countries.

For positive PWT-WDI differentials, the non-benchmark dummy variable is positive but insignificant. The insignificant result could reflect the fact that both datasets are based on the same 1993 ICP survey. The data quality is, however, significantly positive. Its explanatory power is lower than the case of WDI revisions. The result is suggestive of the possibility that the different procedures used by WDI and PWT to estimate the non-survey data are affected differently by data quality. Specifically, poor data quality tends to be associated with a positive PWT-WDI differentials; that is a lower undervaluation estimate.

The two measurement-related variables offer a relatively weak explanatory power for negative revisions in misalignment estimates. The non-benchmark dummy variable is not significant in Panel B of Table 3. The data quality dummy variable, on the other hand, has a negative effect on revisions in misalignment estimates. The adjusted R-squares estimates are smaller than the corresponding ones in Panel A.

The results from Panels A and B strongly suggest that benchmark membership and data quality have unequal impact on positive and negative revisions. These results mirror the different decomposition patterns presented in the previous section. Indeed, we rejected the hypothesis that the coefficients of $D_{i,nBM}$ and Q_i are the same across the positive and negative revisions in misalignment estimates when these data were pooled together in the regression analysis.

3.3 *Regression Analysis II: Economic Factors*

The effects of economic factors on misalignment estimate revisions are examined using the regressions

$$\Delta\hat{u}^{+}_{i,v2,v1} = \alpha_0 + \beta_1 IY_i + \beta_2 AG_i + \beta_3 OG_i + \beta_4 AI_i + \varepsilon_i \,, \quad (5a)$$

and

$$\Delta\hat{u}^{-}_{i,v2,v1} = \alpha_0 + \beta_1 IY_i + \beta_2 AG_i + \beta_3 OG_i + \beta_4 AI_i + \varepsilon_i \,. \quad (5b)$$

The economic factors included in the regression analysis are a) IY_i, the initial output level given by the 1993 real *per capita* GDP, b) AG_i, the average growth rate given by the average annual real *per capita* GDP growth rate between 1993 and 2005, c) OG_i, the average growth in openness which is given by the average annual growth rate of the degree of openness measured by the ratio of the sum of exports and imports to GDP, and d) AI_i, the average inflation rate given by the average annual inflation rate between 1993 and 2005.

The choice of the two output variables is directly motivated by the Penn effect, which implies a positive empirical relationship between real exchange rates and income levels. When growth is accompanied with a shift of consumption towards nontradables (Bergstrand, 1991; Bergin, Glick and Taylor, 2006), it could affect the PPP-based real exchange rate via the direct income channel and the change in consumption composition channel. The usual national price index may capture the general price pattern but not the shift in consumption composition. If it is the case, the WDI 2007 dataset that use the usual national price information to derive its post-1993 data may understate the 2005 PPP-based real exchange rates of fast growing countries and, hence, tend to overstate their degrees of undervaluation.

Under the convergence hypothesis, a country with a lower level of initial output tends to experience a high rate of growth. The migration from low to high income is likely to be accompanied by a large shift in consumption composition. Thus, we anticipate that the level of initial output and the average growth rate have, respectively, a negative and a positive impact on the WDI revision between the 2008 and 2007 datasets.

Trade openness is perceived to be another factor that affects a country's price level. Kravis and Lipsey (1987), for instance, notes trade openness would move a country's price level towards the world price level by promoting the convergence of prices of tradables. It could have a positive effect on prices for low income countries and a negative effect for high income countries. The inclusion of trade openness in Penn effect type regressions is reported in, for example, Broda (2006) and Aizenman (2008). In the current exercise, we perceive that the change in the degree of trade openness could have either a positive or negative misalignment estimate revision effect. It is because the implication of trade openness for measuring the PPP-based data is not that clear cut.

The inflation variable is included to capture the inflation content of price index used to infer PPP-based data. With a benign and moderate inflation rate, the changes in individual prices are relatively small. These small changes and the price stickiness inertia could prevent individual prices from adjusting freely and reflecting the appropriate relative prices. The situation is quite different under a high inflation environment. With large price variations, individual prices are prone to adjust both their absolute and relative levels. Since the relative price is a key factor in measuring the PPP-based price level, we expect a country with a high inflation rate is likely to experience a small price revision and, hence, a small revision in its misalignment estimates.

The implications of these economic factors for the PWT-WDI differential are less clear cut. The main difference between the PWT and WDI 2005 data is the way national price levels are constructed from the 1993 ICP survey and updated from subsequent national accounting information. It is not clear how these economic factors interact with these statistical procedures and their impacts on misalignment estimates. Nonetheless, we will study the PWT-WDI differentials using (5a) and (5b) and compare the results with those from the WDI revisions.

The results of estimating (5a) and (5b) are presented in Table 4. Among the four economic factors, only the initial output level displays a significant effect on positive WDI revisions. It has a negative coefficient estimate; that is, a lower initial output level implies a larger reduction in the undervaluation estimate. The finding is in line with the view that the commonly used price indexes could underestimate the PPP-based real exchange rates of countries with low initial output level. Thus, the PPPs from the 2005 ICP survey for these countries tend to be higher than those estimated from national data and correspond to a lower degree of undervaluation.

Similar to WDI revisions, positive PWT-WDI differentials are negatively affected by initial output levels. The average economic growth variable is negatively significant by itself but not in the presence of other economic factors. Compared with WDI revisions, the initial output level offers a noticeable lower level of explanatory power for PWT-WDI differentials.

The results in Panel B show that the negative WDI revisions and PWT-WDI differentials are affected by some of these economic factors though the explanatory power as measured by the adjusted R-squares estimate is not high. The initial output has a positive effect, which is different from that in Panel A. For countries that have their degrees of undervaluation revised up by the WDI 2008 or PWT 6.3 dataset, a lower level of initial output implies a greater degree of undervaluation in 2005. The effect is different from the countries that have their degrees of undervaluation revised down.

Taken results in both Panel A and Panel B into consideration, an alternative interpretation is that, compared with high income countries, countries with a low initial output level in the WDI 2008 and

PWT 6.3 dataset have misalignment estimates further away from the corresponding ones derived from the WDI 2007 dataset. That is, a low initial output is associated with a large data revision.

The average growth rate effect in Panel B is positive though it is not statistically significant in all the cases under consideration. The positive effect is in line with the view that the usual price index tends to understate the PPP of a high growth country. However, the result, combined with the mostly negative growth rate effect in Panel A, also indicates a large data revision for countries with a high growth rate.

The average inflation rate is the other economic variable that is significant in Panel B. It has a significant effect on the negative PWT-WDI differential by itself and in the presence of the other three factors. That is for a countries with a higher inflation rate, the PWT dataset tends to yield a larger undervaluation estimate than the WDI data.

In sum, there is evidence that the misalignment revision is affected by some of the selected economic factors. These economic factors display different effects for positive and negative changes in misalignment estimates. Their explanatory powers appear to be weaker than the measurement-related variables in Table 3. In Subsection 3.1 and Table 2, it is documented that, in general, changes in the measured PPP-based exchange rates, rather than the changes in estimated equilibrium rates, have a strong effect on misalignment revisions. The better performance of the measurement-related variables could reflect the stronger role of the changes in price levels observed in the decomposition exercise.

3.4 Regression Analysis III: A Combined Model

In the last two subsections, it is shown that revisions in misalignment estimates are affected by measurement-related and economic factors. The observed effects, however, tend to vary across positive and negative revisions. Since each of these two types of factors exhibits some explanatory power, the results in Tables 3 and 4 may be affected by the omission of either the measurement-related or economic factors. For instance, the significance of, say, the measurement-related factors may be spurious and attributable to their association with the underlying economic factors. To examine the possible interaction between these two types of factors and the implications for explaining misalignment estimate revision, we study the combined explanatory power of these two types of factors. To this end, we estimate the regression specifications

$$\Delta\hat{u}^{+}_{i,v2,v1} = \alpha_0 + \alpha_1 D_{i,nBM} + \alpha_2 Q_i + \beta_1 IY_i + \beta_2 AG_i + \beta_3 OG_i + \beta_4 AI_i + \varepsilon_i \,, \qquad (6a)$$

and

$$\Delta\hat{u}^{-}_{i,v2,v1} = \alpha_0 + \alpha_1 D_{i,nBM} + \alpha_2 Q_i + \beta_1 IY_i + \beta_2 AG_i + \beta_3 OG_i + \beta_4 AI_i + \varepsilon_i \,. \qquad (6b)$$

Essentially, (6a) is a combination of (4a) and (5a) and (6b) is a combination of (4b) and (5b). By pooling these two types of factors, we could study the marginal explanatory power of the measurement-related and economic factors.

The results of estimating (6a) and (6b) and their parsimonious specifications are presented in Table 5. The non-benchmark and low data quality dummy variables, $D_{i,nBM}$ and Q_i, have significantly positive effects on positive WDI revisions (Panel A). The result reinforces the measurement-related variable effects in Panel A of Table 3. In the presence of $D_{i,nBM}$ and Q_i, the average economic growth rate is the only significant economic factor and has a positive effect. The adjusted R-squares estimates are quite large and above the 40% level. They are larger than the corresponding individual adjusted R-squares estimates but less than their sum. The evidence indicates that the measurement-related factors and the economic growth rate have some common information about misalignment estimate revision. However, they also have their own unique information about the revision in misalignment estimates.

In the case of positive PWT-WDI differentials, the initial output factor is the only significant factor and has a negative coefficient estimate. Apparently, the low data quality effect in Table 3 is spurious and becomes insignificant in the presence of economic factors. In passing, we note that dropping the insignificant variables from the reported parsimonious specification could lead to a substantial decrease of its adjusted R-squares estimate. Thus, even though the average openness growth rate and average inflation rate are not statistically significant, their presence in the regression with other factors improve the model's ability to explain revisions in misalignment estimates.

In the last two sub-sections, it is noted that the selected factors explain better the positive changes in misalignment estimates than the negative ones. The same phenomenon is observed in Table 5. The adjusted R-squares estimates of the parsimonious specifications in Panel B are noticeably smaller than those in Panel A. The low data quality variable has a negative effect while the average economic growth rate has a positive impact on WDI revision regression in Panel B. Again, we note that dropping the insignificant variables from the reported parsimonious specification could lead to a substantial decrease of its adjusted R-squares estimate.

Both the initial output level and the average economic growth have a positive effect on negative PWT-WDI differentials. These negative revisions are, on the other hand, negatively affected by the average inflation rate. While the average growth and inflation effects are in accordance with those we stipulated for WDI revisions, the initial output effect is not. These economic factors explain about 20% of the variability of negative PWT-WDI differentials.

Comparing the results for WDI revisions and PWT-WDI differentials, we observe that WDI revisions are affected by both the measurement-related and economic factors and PWT-WDI differentials are not influenced by the measurement-related factors in the presence of economic variables. At the same time, these selected factors have differential impacts on positive and negative revisions,

Figure 4 displays the actual and model-predicted misalignment estimate revisions for the four BRIC countries. In each chart, actual misalignment revisions are plotted against their predicted values calculated from the respective models with measurement-related factors, with economic factors, and with the combination of these two types of factors.

For the WDI revisions, the Chinese and Indian misalignment estimate revisions are quite well explained by these models (Figure 4.A). The magnitudes of these two misalignment revisions are quite comparable to those predicted by measurement-related factors, economic factors, and their combination.

The predictions of these models, however, do not work very well for Brazil and Russia. Especially for Brazil, the models' predicted values are quite different from the actual misalignment revisions experienced by these two countries.

A comparison of Figures 4.A and 4.B reaffirms the previous observation that these models are better at describing WDI revisions than PWT-WDI differentials. Specifically, in Figure 4.B, the gaps between the predicted values and the actual revision numbers are usually noticeably larger than those in Figure 4.A. These models, in general, are less capable of capturing the BRIC countries' PWT-WDI differentials.

3.5 Some Additional Analyses

A few additional analyses were conducted to assess the robustness of the results presented in the previous subsections. While the Penn effect is a well-established empirical relationship, some studies including Kravis and Lipsey (1987) and Cheung, Chinn and Fujii (2007) have noted that advanced and developing countries could exhibit different degrees of real exchange rate and income interaction. If it is the case, then the exchange rate misalignment assessment exercise based on equation (1) could be imprecise. Naturally, it has implications for the observed revision of misalignment estimates. To explore this possibility, we consider the modified Penn effect regression given by

$$r_i = \beta_0 + \gamma_0 D_{i,ADV} + \beta_1 y_i + \gamma_1 D_{i,ADV} y_i + u_i \,, \qquad (7)$$

where $D_{i,ADV}$ assumes the value of one if country *i* is an advanced country according to the IMF classification and the value of zero otherwise.[6]

The estimation results of (7) summarized in Table 6 indicate that either the advanced country dummy variable $D_{i,ADV}$ or the interaction variable $D_{i,ADV} y_i$ or both are statistically significant. For all the three datasets, $D_{i,ADV}$ is significant and the intercept estimates are different for advanced and developing countries. The interaction variable $D_{i,ADV} y_i$, however, is only significant and indicative of a strong Penn effect implied by the slope coefficient for the *WDI 2007* data. The *WDI 2008* and *PWT 6.3* data yield a positive, but insignificant, $D_{i,ADV} y_i$ effect. For each dataset, the extended model (7) obtains a higher adjusted R-squares estimate than the corresponding one given in Table 1.

The separation of the advanced countries from developing ones has a systematic effect on the four BRIC countries' misalignment estimates (Panel B). In all cases, there is a discernable decrease in the extent of undervaluation estimates. The Russian Ruble experiences the largest decrease in its extent of undervaluation among the four BRIC currencies in each of the three modified Penn effect regression.

For the benchmark and non-benchmark countries, the misalignment estimates display a pattern similar to the one in Table 1. While the misalignment estimates from (1) and (7) appear different, they have a high correlation estimate between 0.800 and 0.923.

When the WDI revision and PWT-WDI differential constructed from misalignment estimates based on the modified Penn effect regressions are used to repeat the analyses reported in subsections 3.1 to 3.4, the results are qualitative similar to those reported in Tables 2 to 5. These results are provided in the Tables A2-A5 of Appendix C for quick references. Specifically, the changes in misalignment estimates are dominated by differences in PPP-based real exchange rate data rather than differences in estimated equilibrium rates. The effects of measurement-related and economic factors are also comparable to those presented before.

Besides the three PPP-based datasets discussed in the previous subsections, we study the the "*WDI* 2010" dataset downloaded in March 2010 as the most current data to compare the currency misalignment estimates. It turned out that the results pertaining to the *WDI* 2010 data are quite similar to those of the *WDI* 2008. We also considered the 1993 Penn effect regression; these results are

[6] Our sample includes 28 of the 30 advanced countries labeled by the IMF in its *World Economic Outlook* publication. Cyprus and Taiwan were not included due to data unavailability.

qualitatively similar to those of the 2005 regression results. These results are not reported for brevity but are available from the authors.

4. Concluding Remarks

The 2005 ICP survey has led to some large revisions of the previously estimated internationally comparable price indices and the related PPP-based real exchange rates. Do the empirical results based on data derived from previous ICP surveys survive these substantial data revisions?

The current exercise investigates the implications for evaluating exchange rate misalignment. Two WDI datasets and one PWT dataset are used to assess the sensitivity of exchange rate misalignment estimates to different vintages of PPP-based data. One WDI dataset and the PWT dataset are based on the prior 1993 ICP survey and they adopt different methods to derive PPP-based data from the survey results. The other WDI dataset is based on the 2005 ICP survey information. We focus on the year 2005 misalignment estimates from Penn effect regressions.

It is found that, compared with the use of different indexing and projection methods, the ICP update has a more significant effect on the estimated degree of misalignment. Essentially, the ICP update could yield a large change in a country's PPP-based real exchange rate and, hence, its estimated degree of exchange rate misalignment. Our decomposition exercise documents the substantial effect of revision in PPP-based real exchange rates on the revision in misalignment estimates.

We investigated the effect of two measurement-related factors; namely a country's participation in the 1993 ICP survey and its data quality, and four economic factors; namely the initial output level, the average growth rate, the average openness growth rate, and the average inflation growth rate. It is found that revisions related to ICP survey update are associated with both measurement-related and economic factors. The difference between WDI and PWT misalignment estimates that are based on the same ICP survey data is mostly affected by some selected economic factors. Further, these factors explain the positive changes better than the negative ones; the adjusted R-squares estimate of the former could be as high as 42% and that of the latter is about 20%.

The drastic changes in data derived from the 2005 ICP survey undoubtedly raise the concern about the relevance and usefulness of exchange rate misalignment estimates. Note that ICP is conceived to be a good and reliable source for internationally comparable price data, which facilitate cross-country comparison. Our exercise affirms the sensitivity of misalignment estimates to the new (2005) ICP survey results.

Our study sheds some light on the sources of changes in exchange rate misalignment estimates across a few data vintages. While the selected variables offer some explanatory powers, we do not have a strong theory to link these factors to misalignment estimates. For instance, in addition to PPPs, these measurement-related and economic variables could affect a country's PPP-based output and their effects could vary across countries of different economic and structural characteristics. We could not be sure about their exact implications for estimating the Penn effect and, hence the degree of currency misalignment. In view of this, we should avoid over-interpreting these results even though the empirical explanatory power of the selected factors is quite good. Further analyses on the underlying causes of changes in misalignment estimates are warranted.

What does our exercise contribute to the recent debate on currency misalignment? One obvious implication is that the determination of the equilibrium exchange rate and the related misalignment is a difficult task. Even within the relatively simple Penn effect setting, the difference in data construction methods (WDI vs PWT) and data update (different versions of WDI) could lead to some substantial changes in misalignment estimates. May be it is not the revision in misalignment estimates that is surprising – we know that it is hard to absorb substantial data revision. A troubling observation is that measurement-related factors that are not related to the determination of equilibrium exchange rate are significant determinants of these drastic misalignment estimate revisions.

It is anticipated that our exercise would not stop policymakers and commentators to make assertions about a country's extent of misalignment. The current debate on, for example, the Chinese renminbi's valuation is a typical and topical example. Nevertheless, we should be aware of the fragility of the exchange rate misalignment assessment exercise. At the same time, it will be of interest to see what will be the implications of the planned 2011 ICP survey (http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html), which promises innovations and improvements in methodologies and wide country coverage, for the misalignment assessment exercise.

Appendix

*A: The 2005 country sample**

Albania [b, c], Algeria, Angola [b], Argentina, Armenia [c], Australia [a], Austria [a], Azerbaijan [c], Bahrain, Bangladesh, Belarus [c], Belgium [a], Belize [c], Benin, Bolivia, Botswana, Brazil, Bulgaria [c], Burkina Faso [b], Burundi [b], Cambodia [b, c], Cameroon, Canada [a], Cape Verde [b], Central African Republic [b], Chad [b], Chile, China [b], Colombia [b], Comoros [b], Democratic Republic of Congo [b, c], Republic of Congo, Costa Rica, Cote d'Ivoire [b], Croatia [c], Czech Republic [c], Denmark [a], Djibouti [b, c], Dominica, Dominican Republic, Ecuador, Arab Republic of Egypt, El Salvador, Eritrea [c], Estonia [c], Ethiopia [b], Fiji, Finland [a], France [a], Gabon, Gambia [b], Georgia [c], Germany [a], Ghana [b], Greece [a], Guinea, Guinea-Bissau [b], Guyana, Haiti, Honduras, Hong Kong SAR of China [a], Hungary, Iceland [a], India [b], Indonesia, Islamic Republic of Iran, Ireland [a], Israel [a, b], Italy [a], Jamaica, Japan [a], Jordan, Kazakhstan [c], Kenya, Kiribati [c], Republic of Korea [a], Kuwait, Kyrgyz Republic [c], Lao PDR [c], Latvia [c], Lebanon [c], Lesotho [b], Lithuania [c], Luxembourg [a], Macedonia [b, c], Madagascar, Malawi, Malaysia, Mali, Malta [b], Mauritania [b], Mauritius, Mexico, Federate States of Micronesia [c], Moldova [c], Mongolia [c], Morocco, Mozambique [b], Namibia [c], Nepal, Netherlands [a], New Zealand [a], Nicaragua, Niger [b], Nigeria, Norway [a], Pakistan, Panama, Papua New Guinea, Paraguay [b], Peru, Philippines, Poland, Portugal [a], Romania, Russian Federation [c], Rwanda [b], Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore [a], Slovak Republic [c], Slovenia [a,c], Solomon Islands, South Africa [b], Spain [a], Sri Lanka, St. Vincent and the Grenadines, Sudan [b], Swaziland, Sweden [a], Switzerland [a], Syrian Arab Republic, Tajikistan [c], Tanzania, Thailand, Togo [b], Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda [b], Ukraine [c], United Arab Emirates, United Kingdom [a], United States [a], Uruguay, Uzbekistan [c], Vanuatu, Venezuela, Vietnam [c], Republic of Yemen, Zambia.

* Superscripts “a”, “b”, and “c” respectively indicate the advanced economies by the IMF definition, the non-benchmark countries of the 1993 ICP program, and the countries whose data quality rating is not available in Summers and Heston (1991).

B: Data Sources

The data are obtained from the World Bank’s World Development Indicator Database and the Penn World Table 6.3. The two versions of the WDI data were downloaded in July 2007 and in April 2008. The July 2007 vintage (*WDI 2007*) data do not reflect the revisions based on the 2005 International Comparison Program, while the April 2008 vintage (*WDI 2008*) data do. The *PWT 6.3* data were downloaded in December 2010. In addition, we also downloaded the WDI data in December 2010 as the most recent vintage to check robustness of our findings.

C: Results Based on the Modified Penn Effect Regression

The results of analyzing misalignment revisions that are derived from *the modified Penn effect regressions* are presented in the table layout similar to the one used in the main text.

Table A2. The Decomposition of the Differences in the 2005 Misalignment Estimates for the Modified Penn Effect Regression Model

	n	$\Delta\hat{u}_{i,v2,v1}$	$\Delta r_{i,v2,v1}$	$-\Delta\hat{r}_{i,v2,v1}$	$-\Delta income$	$-\Delta Penn$
A. WDI revision						
Total	154	0	.116	-.116	.028	-.145
Benchmark	122	-.063	.046	-.104	.009	-.113
Non-benchmark	32	.243	.386	-.163	.100	-.264
$\Delta\hat{u}^{+}_{i,v2,v1}$	79	.224	.302	-.077	.076	-.154
$\Delta\hat{u}^{-}_{i,v2,v1}$	75	-.236	-.078	-.157	-.022	-.135
B. PWT-WDI differential						
Total	154	0	-.031	.031	-.014	.046
Benchmark	122	-.034	-.064	.030	-.022	.052
Non-benchmark	32	.129	.093	.036	.015	.021
$\Delta\hat{u}^{+}_{i,v2,v1}$	83	.237	.152	.085	.036	.048
$\Delta\hat{u}^{-}_{i,v2,v1}$	71	-.277	-.245	-.031	-.074	.042
C. The BRIC Countries						
i. WDI revision						
China		.465	.506	-.040	.119	-.160
India		.318	.440	-.122	.107	-.229
Brazil		.014	.092	-.077	.007	-.084
Russia		-.150	-.088	-.061	-.016	-.045
ii. PWT-WDI differential						
China		.156	.070	.086	.009	.076
India		.066	.014	.051	.006	.045
Brazil		.094	.020	.074	-.016	.091
Russia		.023	-.062	.086	-.016	.103

Notes: The table entries summarize the decomposition of the changes in misalignment estimates when allowing for different Penn coefficients between advanced and other economies. The "*n*" column gives the number of countries. The "$\Delta\hat{u}_{i,v2,v1}$" column lists the changes in misalignment estimates. It two components; namely the change in PPP-based real exchange rates and the changes in estimated equilibrium rates are given under the $\Delta r_{i,v2,v1}$ and $-\Delta\hat{r}_{i,v2,v1}$ columns. The two components of the change in estimated equilibrium rates are given under the columns "$-\Delta income$" and "$-\Delta Penn$" where give $-\Delta income = -[(\hat{\beta}_{1,v1}y_{i,v2} + \hat{\gamma}_{1,v1}D_{i,ADV}y_{i,v2}) - (\hat{\beta}_{1,v1}y_{i,v1} + \hat{\gamma}_{1,v1}D_{i,ADV}y_{i,v1})]$, and $-\Delta Penn = -[(\hat{\beta}_{0,v2} + \hat{\gamma}_{0,v2}D_{i,ADV} + \hat{\beta}_{1,v2}y_{i,v2} + \hat{\gamma}_{1,v2}D_{i,ADV}y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\gamma}_{0,v1}D_{i,ADV} + \hat{\beta}_{1,v1}y_{i,v2} + \hat{\gamma}_{1,v1}D_{i,ADV}y_{i,v2})]$.

See the text for additional information. The rows labeled “Total,” “Benchmark,” “Non-benchmark,” “$\Delta\hat{u}^{+}_{i,v2,v1}$,” and “$\Delta\hat{u}^{-}_{i,v2,v1}$,” given the averages of all the countries in the sample, the 1993 survey benchmark countries, the non-benchmark countries, countries with positive misalignment revisions, and countries with negative misalignment revisions. The BRIC countries results are given in Panel C.

Table A3. Revision in Misalignment Estimates - the Role of Measurement-related Factors for the Modified Penn Effect Regression Model

	WDI revision			PWT-WDI differential		
Panel A. $\Delta\hat{u}^{+}_{i,v2,v1}$						
93NBM	.212**		.130*	.047		.018
	(.048)		(.050)	(.051)		(.057)
Low data quality	-	.212**	.164**	-	.168**	.162**
		(.030)	(.029)		(.035)	(.041)
Constant	.159**	.068**	.060**	.223**	.088**	.087**
	(.020)	(.012)	(.010)	(.030)	(.017)	(.017)
Adjusted R^2	.236	.226	.308	-.003	.131	.119
n	79	66	66	83	66	66
Panel B. $\Delta\hat{u}^{-}_{i,v2,v1}$						
93NBM	.009	-	.022	-.019	-	.003
	(.094)		(.146)	(.086)		(.098)
Low data quality	-	-.261**	-.264**	-	-.219**	-.219**
		(.044)	(.046)		(.037)	(.041)
Constant	-.237**	-.049**	.-049**	-.275**	-.063**	-.063**
	(.031)	(.011)	(.011)	(.033)	(.012)	(.012)
Adjusted R^2	-.013	.131	.115	-.013	.119	.102
n	75	55	55	71	55	55

Notes: The entries summarize the results of estimating the equations (4a) and (4b) with $\Delta\hat{u}_{i,v2,v1}$'s derived from the modified Penn effect regression (7). Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (4a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (4b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. "**" and "*" indicate statistical significance at the one and five percent levels, respectively. The entries in the "*n*" row indicate the number of observations. Due to data constraints, the number of observations varies across specifications.

Table A4. Revision in Misalignment Estimates - the Role of Economic Factors for the Modified Penn Effect Regression Model

	WDI revision					PWT-WDI differential				
Panel A. $\Delta\hat{u}^{+}_{i,v2,v1}$										
Initial Output Level	-.084**	-	-	-	-.087**	-.083**	-	-		-.072**
	(.015)				(.016)	(.020)				(.019)
Average growth rate	-	-.081	-	-	.076	-	-.213*	-		.051
		(.096)			(.093)		(.099)			(.079)
Average Openness Growth rate			-.003	-	.043	-		-.144		-.144†
			(.072)		(.056)			(.094)		(.080)
Average inflation rate	-	-	-	.017	.010	-	-	-	.018	.015
				(.017)	(.017)				(.012)	(.014)
Constant	.064*	.245**	.224**	.214**	.029	.091**	.289**	.232**	.228**	.088*
	(.024)	(.033)	(.024)	(.022)	(.037)	(.027)	(.042)	(.025)	(.024)	(.037)
Adjusted R^2	.246	-.001	-.013	.044	.244	.165	.044	.032	.035	.246
n	79	79	76	79	76	83	83	79	83	79
Panel B. $\Delta\hat{u}^{-}_{i,v2,v1}$										
Initial Output Level	.081**	-	-	-	.065**	.075**	-	-	-	.070**
	(.026)				(.020)	(.023)				(.024)
Average growth rate	-	.243†	-	-	.164	-	.192	-	-	.258†
		(.137)			(.125)		(.170)			(.146)
Average Openness Growth rate			.119	-	.098	-		.084	-	-.021
			(.121)		(.125)			(.134)		(.109)
Average inflation rate	-	-	-	-.012	-.014	-	-	-	-.035**	-.044**
				(.020)	(.022)				(.009)	(.011)
Constant	-.068	-.291**	-.222**	-.228**	-.110†	-.110*	-.325**	-.279**	-.251**	-.143*
	(.046)	(.049)	(.027)	(.030)	(.061)	(.043)	(.053)	(.034)	(.029)	(.068)
Adjusted R^2	.120	.030	.000	-.001	.152	.097	.014	-.007	.090	.241
n	75	74	71	75	70	71	70	68	71	67

Notes: The entries summarize the results of estimating the equations (5a) and (5b) with $\Delta\hat{u}_{i,v2,v1}$'s derived from the modified Penn effect regression (7). Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (5a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (5b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. **, * and † indicate the statistical significance at the 1 %, 5% and 10 % levels, respectively. The entries in the "*n*" row indicate the number of observations. Due to data constraints, the number of observations varies across specifications.

Table A5. Revision in Misalignment Estimates – A Combined and Modified Penn Effect Regression Model

	WDI revision		PWT-WDI differential	
Panel A: $\Delta\hat{u}^{+}_{i,v2,v1}$				
93NBM	.104	.129*	-.064	-
	(.063)	(.050)	(.068)	
Low data quality	.149*	.195**	.025	-
	(.069)	(.029)	(.058)	
Initial Output Level	-.027	-	-.082*	-.068**
	(.037)		(.039)	(.020)
Average growth rate	.222**	.179*	.125	-
	(.076)	(.074)	(.109)	
Average Openness	-.010	-	-.168	-.144
Growth rate	(.061)		(.123)	(.080)
Average inflation rate	-.069†	-.071*	-.037	.014
	(.037)	(.032)	(.027)	(.013)
Constant	-.009	.006	.069*	.108**
	(.033)	(.025)	(.045)	(.029)
Adjusted R^2	.346	.356	.171	.252
n	64	66	64	79
Panel B: $\Delta\hat{u}^{-}_{i,v2,v1}$				
93NBM	.114	-	.099	-
	(.115)		(.130)	
Low data quality	-.074	-.158**	-.018	-
	(.074)	(.033)	(.089)	
Initial Output Level	.049	-	.093*	.058*
	(.045)		(.045)	(.023)
Average growth rate	.296	.392†	.191	.282†
	(.210)	(.218)	(.232)	(.147)
Average Openness	.047	.02	-.270	-
Growth rate	(.210)	(.192)	(.196)	
Average inflation rate	-.083**	-.079**	-.014	-.044**
	(.012)	(.007)	(.020)	(.011)
Constant	-.116	-.168**	-.036	-.184**
	(.069)	(.060)	(.077)	(.065)
Adjusted R^2	.296	.295	.202	.223
n	51	51	51	70

Notes: The entries summarize the results of estimating the equations (6a) and (6b) with $\Delta\hat{u}_{i,v2,v1}$'s derived from the modified Penn effect regression (7). Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (6a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. . Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (6b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. **, * and † indicate the statistical significance at the 1 %, 5% and 10 % levels, respectively. The entries in the "*n*" row indicate the number of observations. Due to data constraints, the number of observations varies by specification.

Reference:

Aizenman, Joshua. 2008. Relative Price Levels and Current Accounts**:** An Exploration. *Department of Economics Working Paper* No. 643, University of California, Santa Cruz.

Barro, Robert J. 1991. Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics* 106: 407-444.

Balassa, Bela. 1964. The Purchasing Power Doctrine: A Reappraisal. *Journal of Political Economy* 72: 584-596.

Bergin, Paul R., Reuven Glick, and Alan M. Taylor. 2006. Productivity, Tradability, and the Long-run Price Puzzle. *Journal of Monetary Economics* 53: 2041-2066.

Bergstrand, Jeffrey. 1991. Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence. *American Economic Review* 81 (1): 325–334.

Bhagwati, Jagdish. 1984. Why Are Services Cheaper in the Poor Countries? *Economic Journal* 94 (374): 279-286.

Broda, Christian. 2006. Exchange Rate Regimes and National Price Levels. *Journal of International Economics* 70(1): 52-81.

Chen, Shaohua, and Martin Ravallion. 2010a. China Is Poorer than We Thought, but No Less Successful in the Fight against Poverty. In *Debates on the Measurement of Global Poverty*, edited by Sudhir Anand, Paul Segal, and Joseph E. Stiglitz, 327–40. New York: Oxford University Press.

Chen, Shaohua, and Martin Ravallion. 2010b. The Developing World is Poorer than We Thought, but No Less Successful in the Fight against Poverty. *Quarterly Journal of Economics* 125: 1577-1625.

Cheung, Yin-Wong, Menzie D. Chinn. 1996. Deterministic, Stochastic, and Segmented Trends in Aggregate Output: A Cross-Country Analysis. *Oxford Economic Papers* 48: 134-162.

Cheung, Yin-Wong, Menzie D. Chinn and Eiji Fujii. 2007. The Overvaluation of Renminbi Undervaluation. *Journal of International Money and Finance* 26(5) (September): 762-785.

Cheung, Yin-Wong, Menzie D. Chinn and Eiji Fujii. 2009. Pitfalls in Measuring Exchange Rate Misalignment: The Yuan and Other Currencies. *Open Economies Review* 20: 183–206.

Cheung, Yin-Wong, Menzie D. Chinn and Eiji Fujii, 2010. Measuring Renminbi Misalignment: Where Do We Stand? *Korea and the World Economy* 11: 263-296.

Ciccone, Antonio, and Marek Jarocinksi. 2010. Determinants of Economic Growth: Will Data Tell? *American Economic Journal: Macroeconomics*, 2(4): 223–47.

Coudert, Virginie, Couharde, Cecile, 2007. Real Equilibrium Exchange Rate in China: Is the Renminbi Undervalued? *Journal of Asian Economics* 18 (4): 568–594.

Dawson, John W., Joseph P. DeJuan, John J. Seater, and E. Frank Stephenson. 2001. Economic Information versus Quality Variation in Cross-country Data. *Canadian Journal of Economics* 34(4): 988-1009.

Deaton, Angus and Alan Heston. 2010. Understanding PPPs and PPP-based National Accounts. *American Economic Journal: Macroeconomics* 2: 1–35.

Eltetö, O., and P. Köves. 1964. "On a Problem of Index Number Computation Relating to International Comparison." *Statisztikai Szemle*, 42: 507–18.

Frankel, Jeffrey. 2006. On the Yuan: the Choice between Adjustment under a Fixed Exchange Rate and Adjustment under a Flexible Rate. *CESifo Economic Studies* 52 (2): 246-275.

Geary, Roy C. 1958. A Note on the Comparison of Exchange Rates and Purchasing Power between Countries. *Journal of the Royal Statistical Society*, Series A (General), 121(1): 97–99.

Gini, Corrado. 1924. Quelques considerations au sujet de la construction des Nombres Indices des prix et des questions analogues. *Metron*, 4(1): 3–162.

Khamis, Salem H. 1972. A New System of Index Numbers for National and International Purposes. *Journal of the Royal Statistical Society*, Series A, 135(1): 96–121.

IMF, 2011. IMF Quotas, IMF Factsheet, http://www.imf.org/external/np/exr/facts/quotas.htm

Johnson, Simon, Chris Papageorgiou, and Arvind Subramanian. 2009. Is Newer Better? The Penn World Table Revisions and the Cross-Country Growth Literature. *NBER Working Paper* 15455.

Kravis, Irving B. and Robert E. Lipsey. 1983. *Toward an Explanation of National Price Levels*, Princeton Studies in International Finance No. 52, Princeton, NJ: International Finance Center, Princeton University, 1983.

Kravis, Irving B. and Robert E. Lipsey. 1987. The Assessment of National Price Levels. In *Real Financial Linkages Among Open Economies*, edited by Sven W. Arndt and J. David Richardson. Cambridge, MA: MIT Press, 97-134.

Kravis, Irving B., Alan Heston, and Robert Summers, 1978. *International Comparisons of Real Product and Purchasing Power*, Baltimore: The Johns Hopkins University Press.

Levine, Ross and David Renelt. 1992. A Sensitivity Analysis of Cross-Country Growth Regressions. *American Economic Review* 82(4): 942-963.

Milanovic, Branko. 2009. Global Inequality Recalculated: The Effect of New 2005 PPP Estimates on Global Inequality. *World Bank Policy Research Working Paper* 5061.

Ponomareva, Natalia and Hajime Katayama. 2010. Does the Version of the Penn World Tables Matter? An Analysis of the Relationship between Growth and Volatility. *Canadian Journal of Economics* 43: 152-179.

Ravallion, Martin. 2010. Price Levels and Economic Growth: Making Sense of the PPP Changes between ICP Rounds. *The World Bank Policy Research Working Paper* 5229.

Samuelson, Paul A. 1964. Theoretical Notes on Trade Problems. *Review of Economics and Statistics* 46: 145-154.

Samuelson, Paul A. 1994. Facets of Balassa-Samuelson Thirty Years Later. *Review of International Economics* 2: 201-226.

Silver, Mick. 2010. IMF Applications of Purchasing Power Parity Estimates. *IMF Working Paper* WP/08/253.

Summers, Robert and Alan Heston. 1991. The Penn World Table (Mark 5): An Extended Set of International Comparisons, 1950-1988. *Quarterly Journal of Economics* 106: 327-368.

Szulc, B. 1964. "Indices for Multiregional Comparisons." *Przeglad Statystyczny* 3: 239–54.

World Bank. 2008a. *Comparison of New 2005 PPPs with Previous Estimates: Appendix G Revised: Global Purchasing Power Parities and Real Expenditures.* Washington, DC.

World Bank. 2008b. *Global Purchasing Power Parities and Real Expenditures: 2005 International Comparison Program*. International Comparison Program and International Bank for Reconstruction and Development. Washington, DC.

World Bank. 2008c. *ICP 2003-2006 Handbook*, http://go.worldbank.org/MW520NNFK0.

Table 1. The Penn Effect Regression Based on the year 2005 data

	WDI 2007	*WDI* 2008	*PWT* 6.3
A. Estimation results			
GDP per capita	.366**	.249**	.347**
	(.028)	(.019)	(.030)
Constant	-.058	-.143**	-.149*
	(.052)	(.047)	(.063)
Adjusted R^2	.535	.559	.468
Number of observations	154	154	154
B. Implied misalignment (%)			
China	-64.43	-14.38	-50.56
India	-57.09	-22.78	-50.67
Brazil	-2.85	-3.25	2.59
Russia	-15.44	-33.39	-17.73
C. By benchmark status			
Benchmark countries	3.18 [30.35]	-3.19 [22.76]	-.67 [35.38]
Non-benchmark countries	-12.13 [32.86]	12.18 [23.91]	2.58 [31.02]

Notes: The results of estimating the Penn effect regression (1) in the text are presented. Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors in parentheses. "**" and "*" indicate statistical significance at the one and five percent levels, respectively. Panel B gives the misalignment estimates of the four BRIC countries in percentage terms. Positive (negative) misalignment estimates indicate overvaluation (undervaluation). Panel C gives the averages (and mean absolute values in square parentheses) of misalignment estimates of the 1993 benchmark and non-benchmark countries. There are 122 benchmark and 32 non-benchmark countries in the 1993 ICP.

Table 2. The Decomposition of the Differences in the 2005 Misalignment Estimates

	n	$\Delta\hat{u}_{i,v2,v1}$	$\Delta r_{i,v2,v1}$	$-\Delta\hat{r}_{i,v2,v1}$	$-\Delta income$	$-\Delta Penn$
A. WDI revision						
Total	154	0	.116	-.116	.043	-.160
Benchmark	122	-.063	.046	-.109	.015	-.125
Non-benchmark	32	.243	.386	-.143	.148	-.291
$\Delta\hat{u}^{+}_{i,v2,v1}$	80	.243	.298	-.055	.110	-.165
$\Delta\hat{u}^{-}_{i,v2,v1}$	74	-.262	-.079	-.183	-.028	-.154
B. PWT-WDI differential						
Total	154	0	-.031	.031	-.021	.052
Benchmark	122	-.038	-.064	.026	-.031	.057
Non-benchmark	32	.147	.093	.054	.020	.033
$\Delta\hat{u}^{+}_{i,v2,v1}$	89	.250	.145	.105	.050	.054
$\Delta\hat{u}^{-}_{i,v2,v1}$	65	-.342	-.273	-0.69	-.118	.050
C. The BRIC Countries						
i. WDI revision						
China		.500	.506	-.006	.180	-.186
India		.343	.440	-.097	.010	-.107
Brazil		-.004	.092	-.096	.161	-.259
Russia		-.179	-.088	-.091	-.025	-.065
ii. PWT-WDI differential						
China		.138	.070	.068	.015	.053
India		.064	.014	.050	-.025	.059
Brazil		.054	.020	.034	.009	.040
Russia		-.022	-.062	0.40	-.024	.064

Notes: The decomposition of the changes in misalignment estimates is presented. The "n" column gives the number of countries. The "$\Delta\hat{u}_{i,v2,v1}$" column lists the changes in misalignment estimates. It two components; namely the change in PPP-based real exchange rates and the changes in estimated equilibrium rates are given under the $\Delta r_{i,v2,v1}$ and $-\Delta\hat{r}_{i,v2,v1}$ columns. The two components of the change in estimated equilibrium rates are given under the columns "$-\Delta income$" and "$-\Delta Penn$" where give - $\Delta\,\Delta income = -\ [(\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v1})]$ and $-\Delta Penn = -[(\hat{\beta}_{0,v2} + \hat{\beta}_{1,v2} y_{i,v2}) - (\hat{\beta}_{0,v1} + \hat{\beta}_{1,v1} y_{i,v2})]$. See the text for additional information. The rows labeled "Total," "Benchmark," "Non-benchmark," "$\Delta\hat{u}^{+}_{i,v2,v1}$," and "$\Delta\hat{u}^{-}_{i,v2,v1}$," given the averages of all the countries in the sample, the 1993 survey benchmark countries, the non-benchmark countries, countries with positive misalignment revisions, and countries with negative misalignment revisions. The BRIC countries results are given in Panel C.

Table 3. Revision in Misalignment Estimates - the Role of Measurement-Related Factors

	WDI revision			PWT-WDI differential		
Panel A. $\Delta\hat{u}^{+}_{i,v2,v1}$						
93NBM	.258**		.153**	.061		.030
	(.051)		(.054)	(.057)		(.068)
Low data quality	-	.239**	.180**	-	.131**	.120*
		(.032)	(.031)		(.038)	(.047)
Constant	.169**	.081*	.074**	.233**	.136**	.135**
	(.020)	(.011)	(.008)	(.030)	(.014)	(.013)
Adjusted R^2	.291	.288	.384	.001	.073	.064
n	80	67	67	89	72	72
Panel B. $\Delta\hat{u}^{-}_{i,v2,v1}$						
93NBM	.041	-	.067	-.039	-	-.029
	(.095)		(.140)	(.100)		(.113)
Low data quality	-	-.304**	-.312**	-	-.284**	-.280**
		(.046)	(.049)		(.048)	(.051)
Constant	-.267**	-.020*	.-020*	-.338**	-.044	-.044
	(.035)	(.008)	(.008)	(.040)	(.028)	(.028)
Adjusted R^2	-.011	.096	.083	-.014	.069	.050
n	74	54	54	65	49	49

Notes: The results of estimating the equations (4a) and (4b) are presented. Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (4a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (4b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. "**" and "*" indicate statistical significance at the one and five percent levels, respectively. The entries in the "n" row indicate the number of observations. Due to data constraints, the number of observations varies across specifications.

Table 4. Revision in Misalignment Estimates - the Role of Economic Factors

	WDI revision					PWT-WDI differential				
Panel A. $\Delta\hat{u}^{+}_{i,v2,v1}$										
Initial Output Level	-.098**	-	-	-	-.093**	-.089**	-	-		-.071**
	(.016)				(.017)	(.022)				(.020)
Average growth rate	-	-.100	-	-	-.024	-	-.287*	-		-.075
		(.107)			(.104)		(.108)			(.083)
Average Openness			.009	-	.039	-		-.138		-.164
Growth rate			(.086)		(.070)			(.123)		(.101)
Average inflation rate	-	-	-	.021	.012	-	-	-	.023†	.019
				(.015)	(.017)				(.013)	(.015)
Constant	.063**	.268**	.241**	.232**	.068	.100**	.320**	.241**	.239**	.136**
	(.023)	(.036)	(.026)	(.023)	(.035)	(.029)	(.045)	(.027)	(.025)	(.035)
Adjusted R^2	.265	.002	-.013	.060	.268	.133	.071	.017	.049	.239
n	80	80	77	80	77	89	89	85	89	85
Panel B. $\Delta\hat{u}^{-}_{i,v2,v1}$										
Initial Output Level	.104**	-	-	-	.076**	.069*	-	-	-	.066†
	(.030)				(.025)	(.029)				(.034)
Average growth rate	-	.286†	-	-	.244	-	.224*	-	-	.404†
		(.149)			(.131)		(.195)			(.169)
Average Openness			.129	-	.079	-		.123	-	-.005
Growth rate			(.109)		(.108)			(.132)		(.118)
Average inflation rate	-	-	-	-.011	-.014	-	-	-	-037**	-050**
				(.019)	(.021)				(.010)	(.012)
Constant	-.035	-.326**	-.249**	-.255**	-.127	-.178**	-.397**	-.350**	-.311**	-.238*
	(.055)	(.054)	(.030)	(.034)	(.073)	(.064)	(.059)	(.041)	(.035)	(.090)
Adjusted R^2	.136	.036	.003	-.005	.146	.052	.015	-.0003	.082	.199
n	73	73	70	74	69	65	64	62	65	61

Notes: The results of estimating the equations (5a) and (5b) are presented. Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (5a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (5b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. **, * and † indicate the statistical significance at the 1 %, 5% and 10 % levels, respectively. The entries in the "*n*" row indicate the number of observations. Due to data constraints, the number of observations varies across specifications.

Table 5. Revision in Misalignment Estimates – A Combined Model

	WDI revision		PWT-WDI differential	
Panel A: $\Delta\hat{u}^{+}_{i,v2,v1}$				
93NBM	.150*	.164**	-.067	-
	(.067)	(.053)	(.082)	
Low data quality	.198**	.194**	-.031	-
	(.069)	(.031)	(.062)	
Initial Output Level	-.004	-	-.100*	-.074**
	(.037)		(.043)	(.021)
Average growth rate	.215*	.197*	-.005	-
	(.095)	(.084)	(.114)	
Average Openness	-.069	-	-.196	-.166
Growth rate	(.053)		(.158)	(.102)
Average inflation rate	-.140	-	-.049	.021
	(.234)		(.031)	(.015)
Constant	.024	.016	.104*	.111**
	(.026)	(.026)	(.047)	(.028)
Adjusted R^2	.403	.418	.124	.242
n	65	65	70	85
Panel B: $\Delta\hat{u}^{-}_{i,v2,v1}$				
93NBM	.107	-	.061	-
	(.073)		(.172)	
Low data quality	-.065	-.182**	-.188	-
	(.073)	(.043)	(.128)	
Initial Output Level	.070†	-	.072	.053*
	(.041)		(.047)	(.029)
Average growth rate	.335	.398†	.379	.421*
	(.217)	(.229)	(.276)	(.170)
Average Openness	.016	.025	-.293	-
Growth rate	(.135)	(.153)	(.182)	
Average inflation rate	-.066	-.065	-.018	-.051**
	(.053)	(.055)	(.024)	(.012)
Constant	-.104	-.153	-.006	-.277**
	(.072)	(.071)	(.125)	(.079)
Adjusted R^2	.217	.189	.129	.197
n	50	50	45	64

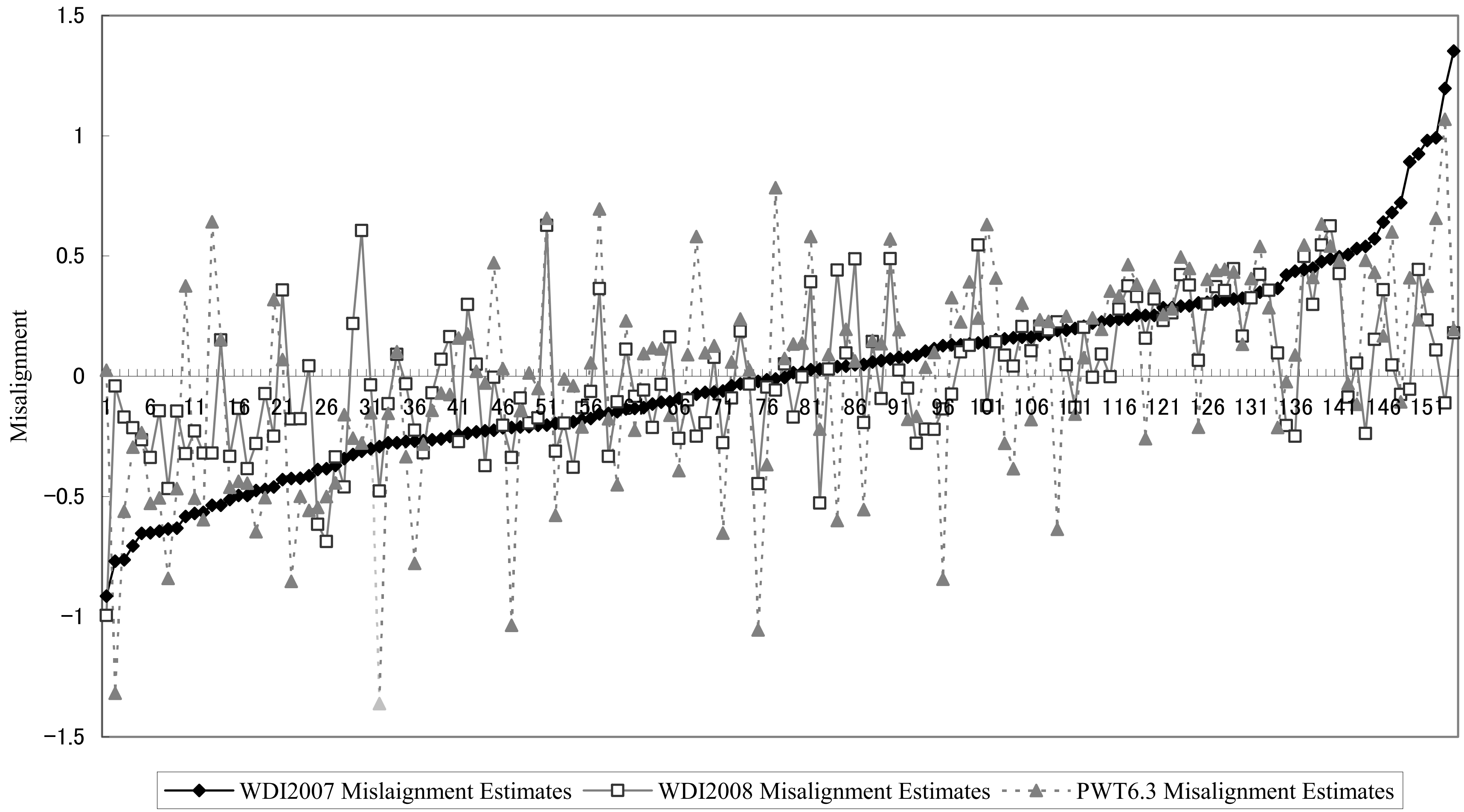
Notes: The results of estimating the equations (6a) and (6b) are presented. Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors of (6a), which has positive changes $\Delta\hat{u}^{+}_{i,v2,v1}$ s as the regressand. . Panel B gives the coefficient estimates and their heteroskedastic-consistent standard errors of (6b), which has negative changes $\Delta\hat{u}^{-}_{i,v2,v1}$ s as the regressand. **, * and † indicate the statistical significance at the 1 %, 5% and 10 % levels, respectively. The entries in the "*n*" row indicate the number of observations. Due to data constraints, the number of observations varies across specifications.

Table 6. The Modified Penn Regression Estimation Results

	WDI 2007	*WDI* 2008	*PWT*6.3
A. Estimation results			
GDP per capita	.243**	.131**	.196**
	(.039)	(.017)	(.036)
Advanced*GDP per capita	.381*	.210	.066
	(.166)	(.151)	(.166)
Constant	-.398**	-.497**	-.562**
	(.086)	(.046)	(.088)
Advanced country dummy	.643**	.648**	.707**
	(.107)	(.082)	(.112)
Adjusted R^2	.598	.713	.576
Number of observations	154	154	.154
B. Implied misalignment			
China	-52.93	-6.33	-37.31
India	-53.88	-22.05	-47.27
Brazil	11.33	12.82	20.79
Russia	1.88	-13.15	4.27
C. By benchmark status			
Benchmark	3.72 [25.15]	-2.11 [17.10]	.32 [30.66]
Non-benchmark	-14.19 [33.05]	8.04 [20.30]	-1.23 [28.19]

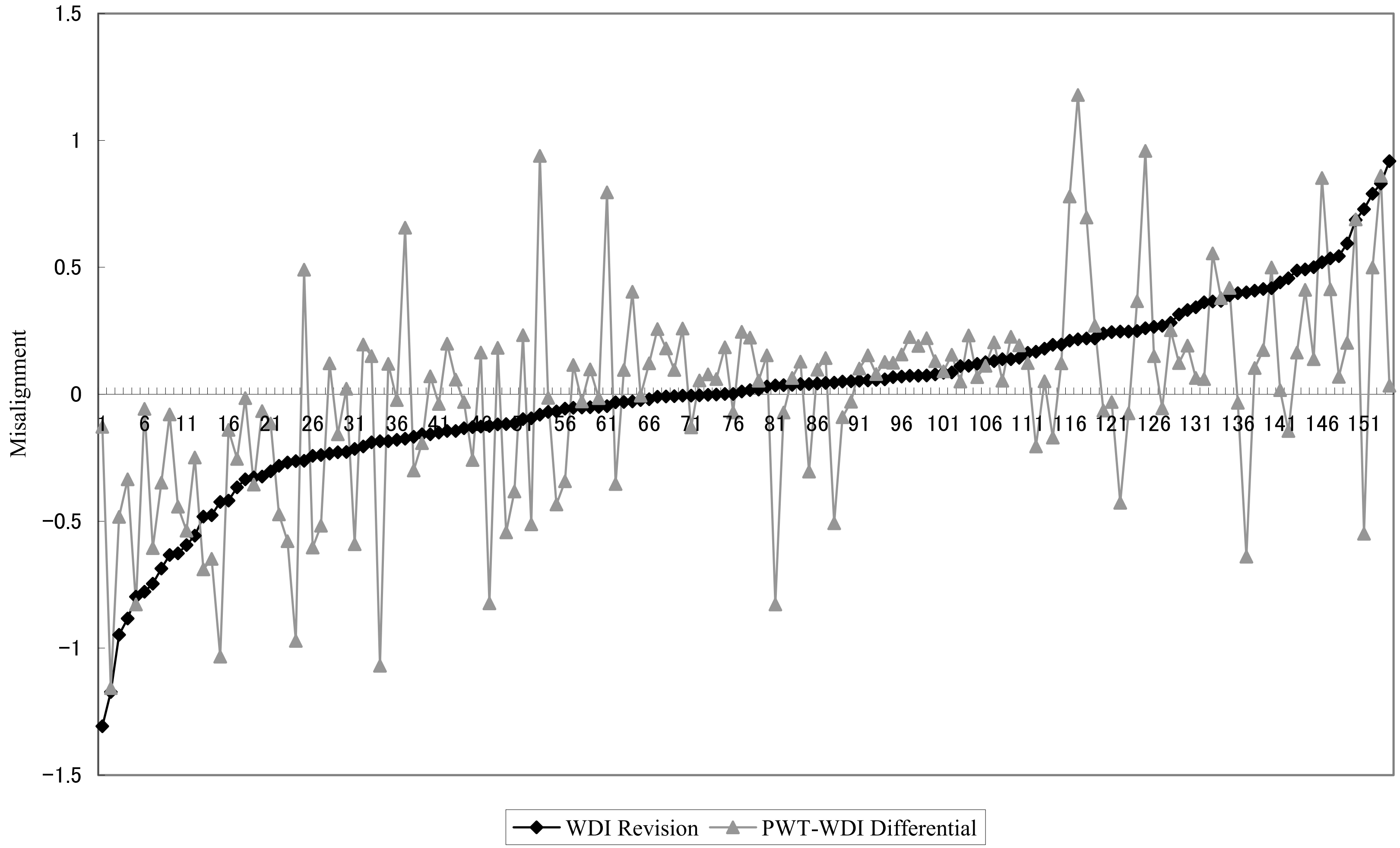
Notes: The results of estimating the Modified Penn effect regression (7) in the text are presented. Panel A gives the coefficient estimates and their heteroskedastic-consistent standard errors in parentheses. "**" and "*" indicate statistical significance at the one and five percent levels, respectively. Panel B gives the misalignment estimates of the four BRIC countries. Positive (negative) misalignment estimates indicate overvaluation (undervaluation). Panel C gives the averages (and mean absolute values in square parentheses) of misalignment estimates of the 1993 benchmark and non-benchmark countries. There are 122 benchmark and 32 non-benchmark countries in the 1993 ICP.

Figure 1. Misalignment Estimates



Notes: The figure plots the misalignment estimates obtained by the Penn effect regression (1) in the main text using the WDI 2007, WDI 2008, and PWT 6.3 datasets.

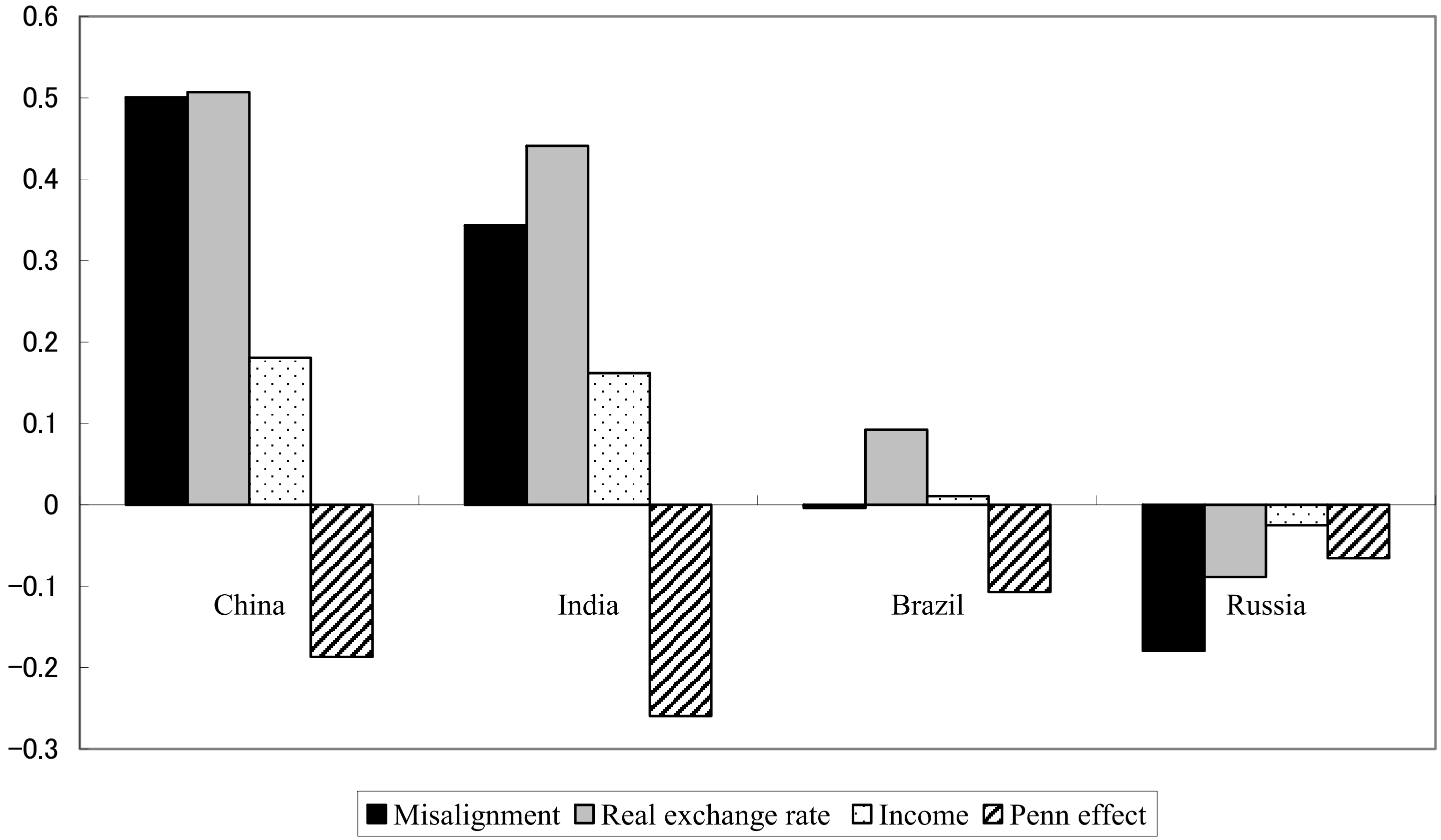
Figure 2. Differences in Misalignment Estimates



Notes: The figure plots the differences in misalignment estimates obtained by three alternative data: WDI 2007, WDI 2008 and PWT6.3. "WDI Revision" gives the differences between the WDI 2008 and WDI 2007 estimates. "PWT-WDI Differential" gives the differences between the PWT 6.3 and WDI 2007 estimates.

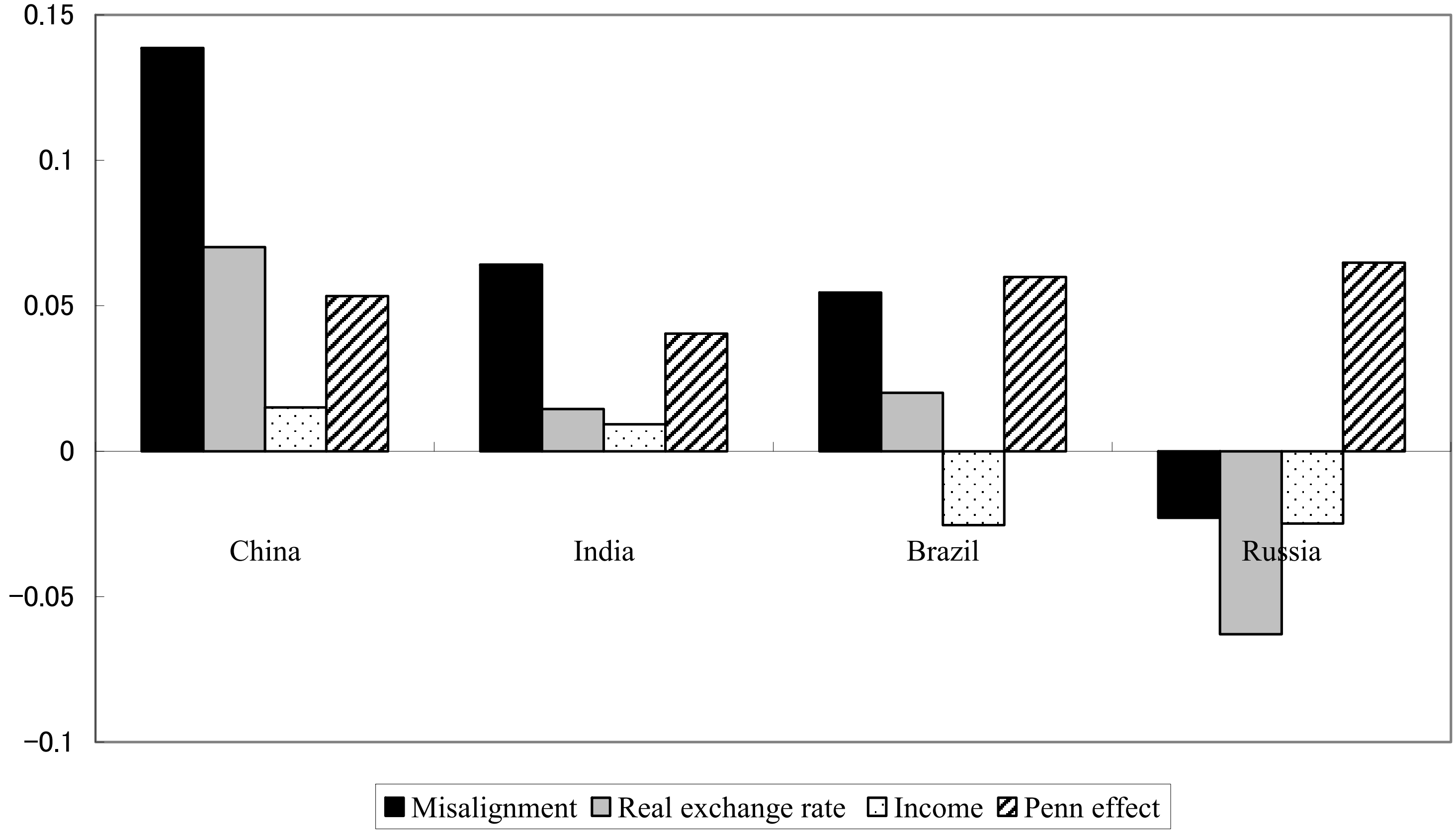
Figure 3. Decomposition of Misalignment Changes for the Four BRIC Countries

A. WDI Revision



Notes: The change in misalignment estimates between WDI 2008 and WDI 2007 and their components are charted for BRIC countries. The decomposition is defined by (2) and (3) in the main text. "Misalignment", "Real exchange rate", "Income," and "Penn effect" respectively correspond to $\Delta\hat{u}_{i,v2,v1}$, $\Delta r_{i,v2,v1}$, -[$(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v2})$ - $(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v1})$], and -[$(\hat{\beta}_{0,v2}+\hat{\beta}_{1,v2}y_{i,v2})$ - $(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v2})$] of those equations.

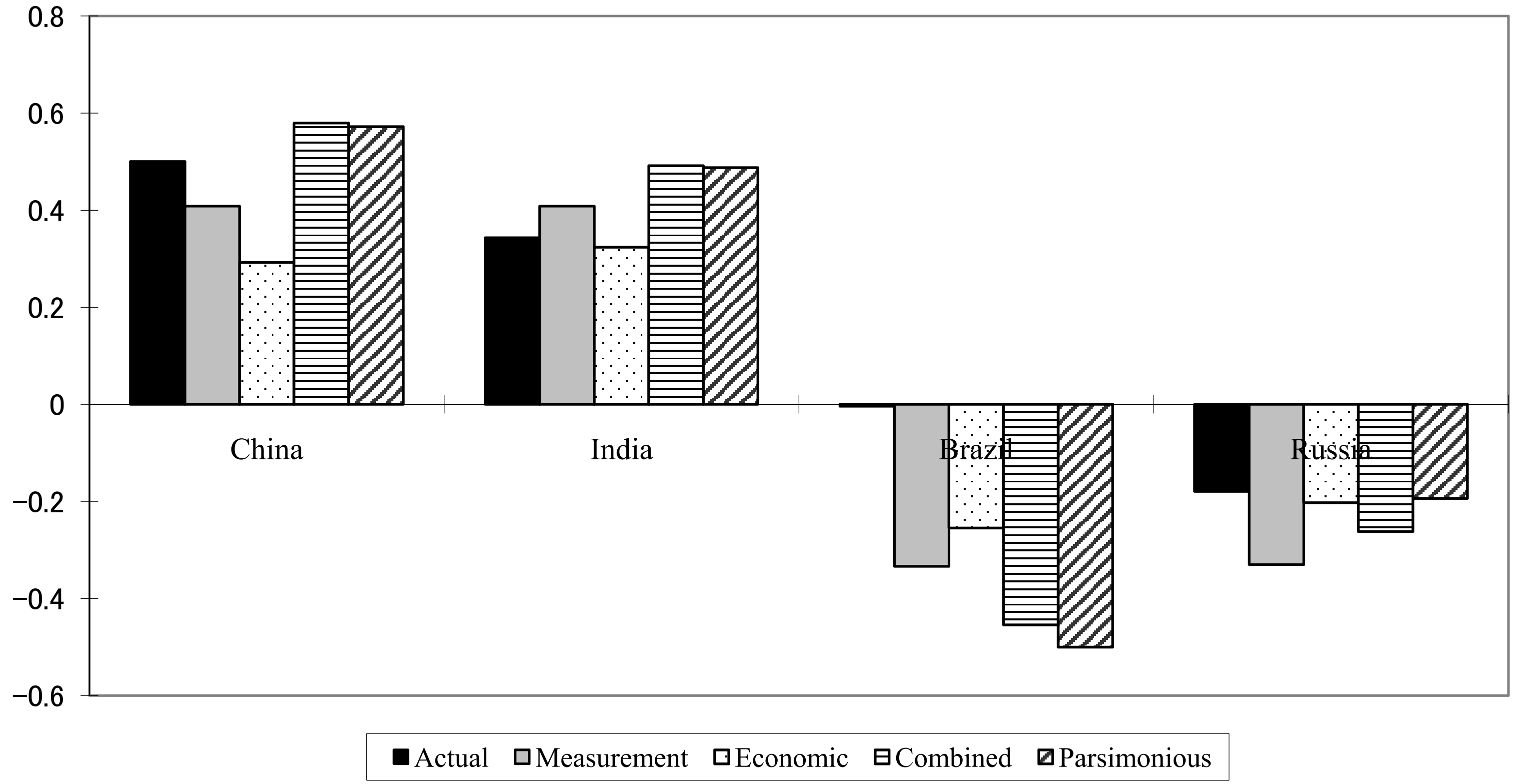
B. PWT-WDI Differential



Notes: The change in misalignment estimates between WDI 2008 and PWT6.3 and their components are charted for BRIC countries. The decomposition is defined by (2) and (3) in the main text. "Misalignment", "Real exchange rate", "Income," and "Penn effect" respectively correspond to $\Delta\hat{u}_{i,v2,v1}$, $\Delta r_{i,v2,v1}$, $-[(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v2})-(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v1})]$, and $-[(\hat{\beta}_{0,v2}+\hat{\beta}_{1,v2}y_{i,v2})-(\hat{\beta}_{0,v1}+\hat{\beta}_{1,v1}y_{i,v2})]$ of those equations.

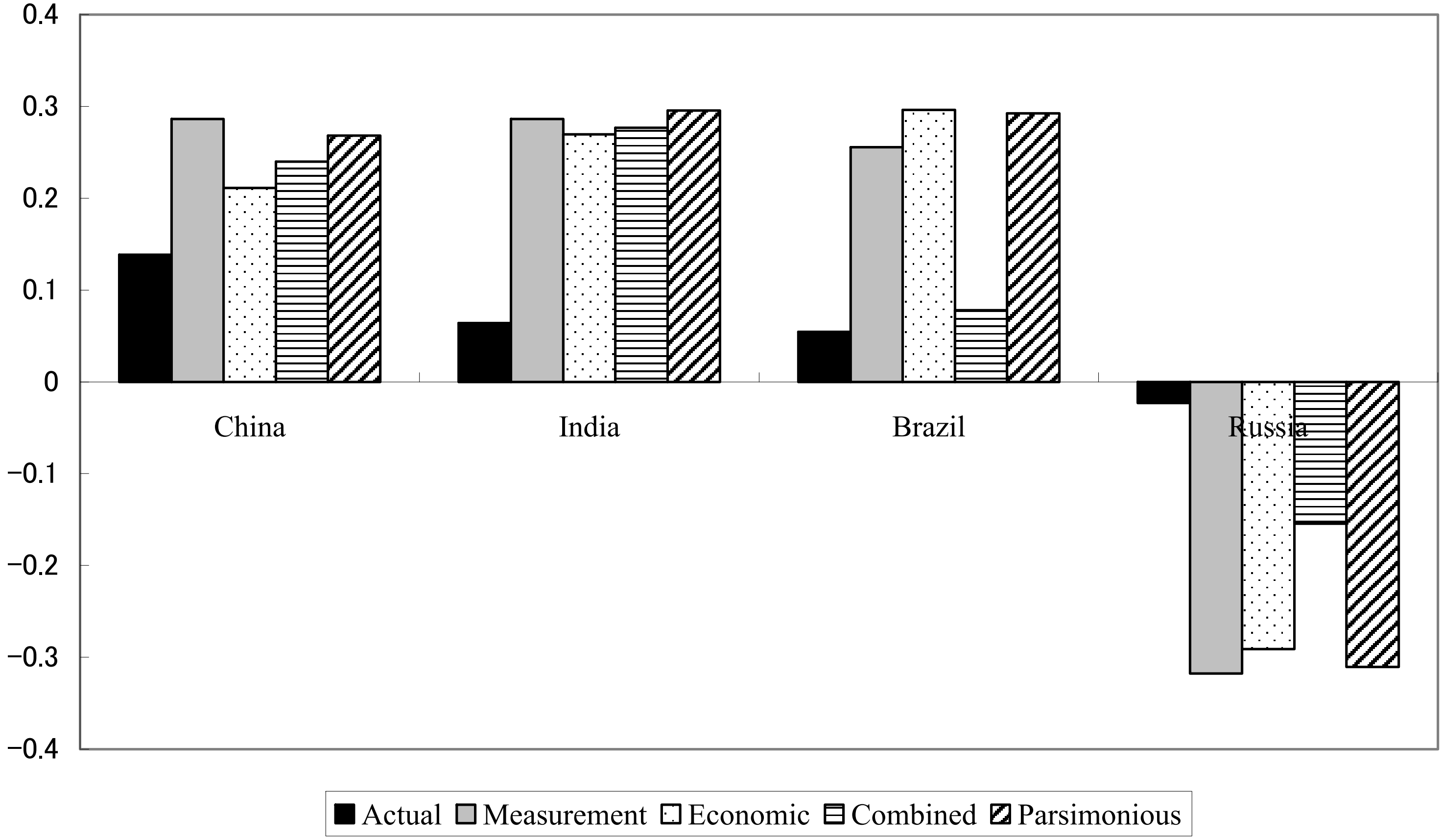
Figure 4. Actual and Predicted Misalignment Changes

A. WDI revision



Notes: The actual and predicted misalignment changes between WDI 2008 and WDI 2007 are charted for BRIC countries. "Measurement", "Economic", and "Combined", respectively, denote the changes in misalignment predicted by (4a) and (4b), (5a) and (5b), and (6a) and (6b) in the main text. "Parsimonious" indicates those that are predicted by the parsimonious specifications of the combined model given in Table 5. While the data quality information for Russia is unavailable, we assume that the country has a similar rating to those of other BRIC countries and assign $Q_i = 1$ for the purpose of the prediction exercise.

B. PWT-WDI differential



Notes: The actual and predicted misalignment changes between WDI 2008 and PWT6.3 are charted for BRIC countries. "Measurement", "Economic", and "Combined" respectively denote the changes in misalignment predicted by (4a) and (4b), (5a) and (5b), and (6a) and (6b) in the main text. "Parsimonious" indicates those that are predicted by the parsimonious specifications of the combined model given in Table 5. While the data quality information for Russia is unavailable, we assume that the country has a similar rating to those of other BRIC countries and assign $Q_i = 1$ for the purpose of the prediction exercise.