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Abstract

The present note raises the issue of how best to interpret the World Bank's (WB) much used 'constant USD per capita income' concept and similar series. We find that the guide to its construction appearing on the WB data portal to be sketchy. The procedures essentially convert all host-country national accounts data, in USD terms, to a common base year, currently 2015. Laudably, this renders all data internationally comparable, though one may question its cardinality. We show that the concept relies on the market exchange rate of a host-country in the base year, and hence whenever the WB alters its base year as it does every few years, the 'constant USD' values are directly affected by the shift in a host country's market exchange rate during the interim period. The latter feature injects an element of randomness in the resulting income concept to the extent the observed exchange rates deviate even temporarily from what one may consider their equilibrium level. Consequently, we recommend replacing the market rate by its 'smoothed' version to render the resulting income series more reliable.

JEL Classification: E31, F31, and O11

Key Words: Per capita Income, Constant USD Income, Current USD Income, GDP Deflator

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The WB Constant Dollar Income Concept: An Interpretation

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While the purchasing power parity (PPP) income of a country may well be the best available one-dimensional metric of a nation's prosperity vis-à-vis its peers, the series only goes back to 1990. Economists often require a longer series typically for estimation purposes. Here the World Bank's (WB) 'constant USD' income series (total or per capita, GDP/GNI etc) often becomes the default benchmark index, which for many countries go as far back as 1960. The present note dwells both on its interpretation and measurement of the constant Dollar income. We find its description on the WB data portal to be at best sketchy. On the cardinality of the concept, it relies on the base-year market exchange rate of the host-country, and hence whenever the WB alters the base as it does every few years, the 'constant USD' values are directly affected by the change in the country's market exchange rate in the interim. The latter feature injects an element of unreliability in the resulting income concept to the extent the observed exchange rates may deviate, at least over the period in question, from what one may consider their equilibrium level.

1. What Does the Data Tell Us?

First, we describe below how the World Development Indicators (WDI) data portal appears to compute the constant dollar per capita income values, or any other constant series for that matter. For the ease of notation, we carry out the discussion in the context of a reference host country (without indexing it), whose income is the subject of analysis. The numéraire country is of course the US. Let $\{x_t\}$ denote the host country income in *current* local currency units (LCU) at time-t, while $\{y_t\}$ be its *constant* local currency counterpart. At a given point in time, therefore, the value of the constant series would eliminate all inflation that had occurred since the base change, whenever that may have happened. The object of the present exercise is to examine the construction of the *constant USD value* of the host country income calibrated to a given base year, say 2015, which happens to be the latest base year in the current WDI database. We label the latter value by $\{z_t\}_{2015}$.

Published data appears to show that the series $\{z_t\}$ is derived as:

$$(1) \qquad \{z_t\}_{2015} = [\{y_t\}/ ER^{constant}_{2015}],$$

where $\{ER^{constant}_{2015}\}$ denotes what we call, the 'constant exchange rate deflator', or in other words, the 'constant dollar' exchange rate. The latter in turn appears to be constructed as follows:

$$(2) \qquad \{ER^{constant}_{2015}\} = [(ER^{Market}_{2015}) / (x_{2015}/y_{2015})],$$

where ER^{Market}_{2015} denotes the official exchange rate for 2015, the annual average. First observe that the constant exchange rate, (2), is independent of time, t, and hence, a scalar. This ensures that the constant price income reflects true growth in income as measured by the constant LCU series, $\{y_t\}$. Next, we note that right-hand-side of (2) merely divides the nominal exchange rate of 2015, by the GDP deflator relevant for the period in question, (x_{2015}/y_{2015}), namely inflation between the point of base change in the host country national income accounts and 2015. For Bangladesh data, for example, the values in equation (2) are:

$$(2a) \qquad \{ER^{constant}_{2015}\} = [(77.7021)/(97{,}007.44/52{,}789.06)] = [77.7021/1.8376]$$

$$= 42.2836,$$

where the GDP deflator factor in question happens to be 1.8376. Thus, while the nominal Bangladesh exchange rate in 2015 was 77.7021 BDT per dollar, its 'constant 2015 USD' value came to 42.2836. Unlike the PPP value of a currency, this quantity lacks a natural interpretation as to its cardinality. How well does the resulting 'constant USD income' reflect the wellbeing of the average citizen?

On the positive front, observe that, the 'constant USD 2015' values eliminate inflation from the host country GDP data. Further, the procedure ensures that *at the reference point*, namely 2015 here, the 'constant dollar' income becomes identical to the current dollar income.[3] In other words, the procedure effectively converts the host-country national accounts data from its actual base to a new common base of 2015, *in USD terms*, for all countries in the WDI dataset rendering them directly comparable.

Restating equation (1), we also see that

$$(1a) \qquad \{z_t\}_{2015} = [(y_t / ER^{Market}_{2015})\ (x_{2015}/y_{2015})],$$

which illustrates that the 'constant USD' income is inversely related to the market exchange rate of the base year. Thus, any base change, e.g., the recent switch from 2010 to 2015 in Sept/Oct 2021, would directly impact the value of the resulting 'constant USD income' of all countries.[4] Two countries whose exchange rates are differentially affected by transient shocks, even though their long-run paths may turn out to be very similar, would be affected very differently by this construction. Exchange rates, unlike most macro aggregates (e.g., GDP), are known to be highly sensitive to speculative shocks, geopolitics, and the like (Benigno et al, 2011).

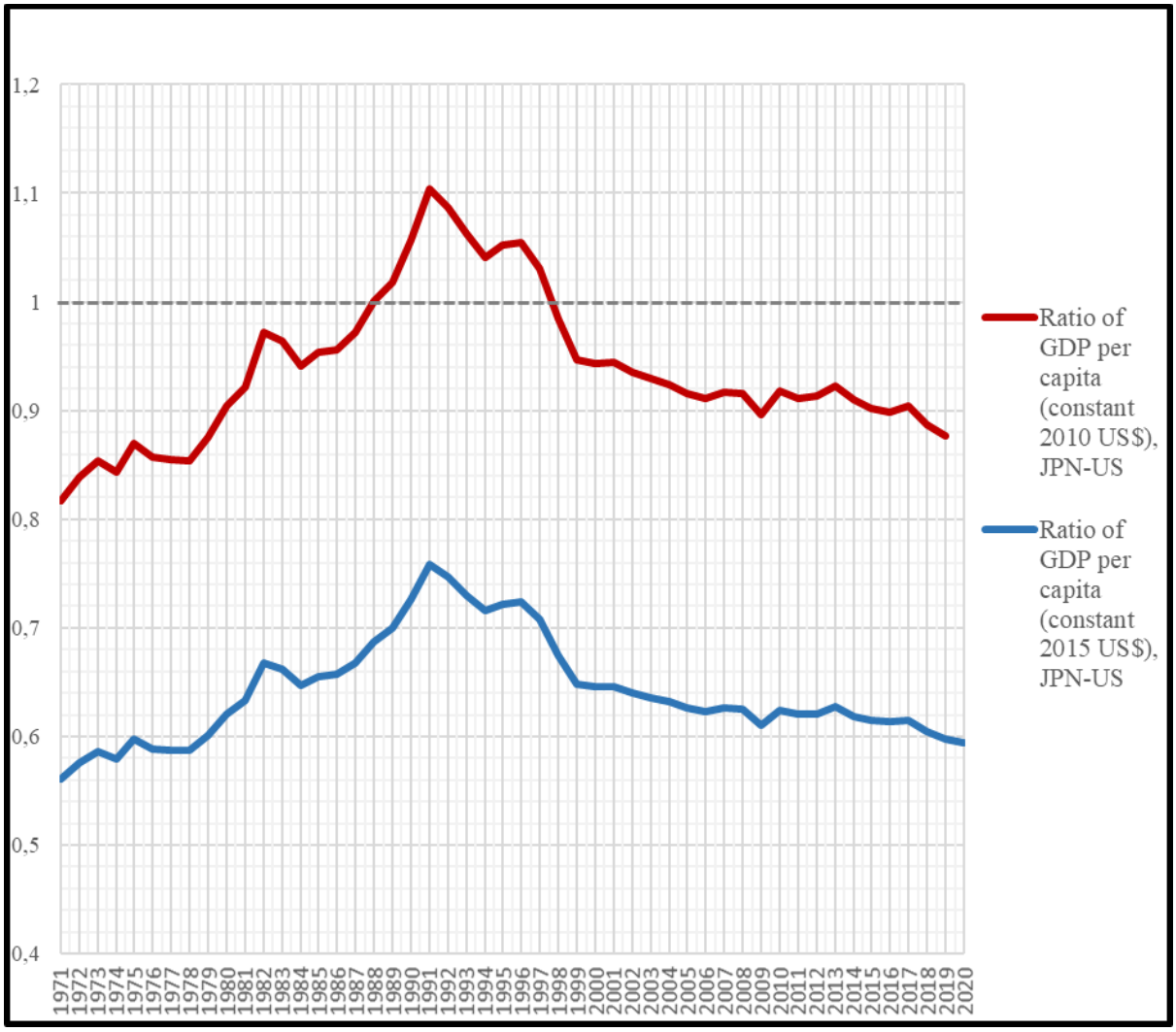
To illustrate a famous example, Figure 1 tracks constant price Japanese per capita income data (relative to the US) between 1971-2020. It is seen that, using the constant 2010 USD series, Japan's per capita GDP appeared to have just eclipsed that of the US in 1988, while peaking in

[3] Letting t =2015, it follows from (1a) that $\{z_{2015}\}_{2015} = [(x_{2015}/ER^{Market}_{2015})]$ = current USD income.

[4] It seems that WDI changes its base whenever that occurs in the US national accounts.

1991 at 10.4 percentage points above the US level.[5] Fast forward to 2015 constant prices, the 1988 Japanese income was mere 69 percent of the US level, gradually moving up to about 3/4th (76 percent) the US level in 1991 (Ahsan-Ahsan, 2022).

Fig 1 The Per Capita GDP, 1971-2020: Constant 2010 USD vs constant 2015 USD



Source: Authors' construction based on WDI data

How does one explain the sharp contrast? The Yen depreciated against the Dollar by exactly 27.5 percent between 2010 and 2015.[6] Was JPY overvalued in 2010 or undervalued in 2015, and by how much? Regardless of what the precise answer may be, it is hard to think that this

[5] Interestingly Japan's national income accounts changed its latest base year also to 2015, to coincide with the US/WDI base change. Hence the GDP deflator in question is just unity, i.e., $(x_{2015}/y_{2015}) = 1$, both for Japan and the US. Thus using (1a), note that while the Japan-US per capita income ratio for 2015 can be written as $[\{z_t\}^{JP}/\{z_t\}^{US}]_{2015} = [\{1/(ER^{Market}{}_{2015}\}\{(y_t)^{JP}/(y_t)^{US}]_{base2015}$, while for the 2010 base, it would equal $[\{z_t\}^{JP}/\{z_t\}^{US}]_{2010} = [\{1/(ER^{Market}{}_{2010}\}(x_{2010}/y_{2010})^{JP}]\{(y_t)^{JP}/(y_t)^{US}\}_{base\ 2010}$, given that 2010 would have been the base year in the US data as well. Thus its 2010 deflator would also be unity, though not so for Japan. Hence the vertical distance between the two lines in Figure 1 would capture not merely the change in the nominal exchange rate between the two dates, 2010 and 2015, also the 2010 deflator in question in the Japanese data.

[6] The relative income decline was therefore 31.3 percent vis-à-vis the currency decline of 27.5 precent; and thus, the balance of the difference was due to inflation between the previous Japanese base year and 2010.

shift was following the equilibrium exchange rate fundamentals as subsequent corrections have demonstrated.[7]

2. What Do WB Documents Claim?

While the above construction is simple enough, it is frustrating that WB documents offer a vague description of this concept and how it is actually obtained. The only reference we find happens to be a web document that states, "… when we convert the constant price data to U.S. dollars, we preserve the growth rates observed in the local price series. That is, we convert the constant LCU series to an index by dividing each value by its 2015 value (i.e., yielding 2015 = 1), and then multiplying this index by the 2015 current USD value of the series using the 2015 average official exchange rate [(https://datahelpdesk.worldbank.org/ knowledgebase/ articles/114968), accessed 01 Nov 2021].

Is this explanation helpful? Again, rewriting (1a), we have

$$\text{(1b)} \qquad \{z_t\}_{2015} = [(x_{2015}/\ ER^{Market}{}_{2015})\ (y_t/y_{2015})].$$

Now it is transparent that the expression in the second set of brackets, namely (y_t/y_{2015}), is indeed the resulting index cited in the quote. However, in what sense is the factor multiplying the index, $(x_{2015}/\ ER^{Market}{}_{2015})$, a scalar, "the 2015 current USD value of the series". The 'series' in the quote refers to the 'the constant LCU series', but as we see from (1b), mathematically it ought to be the *current* LCU data, x_{2015}. Taken literally, using Bangladesh data (as in equation 2a above), the constant LCU per capita income 2015 was 52,789.06, while the exchange rate was 77.7021. As per the WB quote, this would have yielded a value of USD 679.38, a figure that is not interpretable. But the current USD value (x_{2015}/77.7021) gives us the correct figure, USD 1248.45. The correct statement would have been "… the 2015 current USD value of the *current* LCU series."

From equation (1), it follows that dividing the constant LCU figure of 52,789.06 by the 'constant 2015 exchange rate' of 42.2836, as in equation (2a), yields the correct 'constant 2015 USD per capita income for 2015, namely 1,248.45. By construction, at the point of base change (i.e., 2015), the constant USD and the current USD incomes become equal, which is apparent from the earlier description based on equations (1) and (2) above.

3. Making Sense of the Construct

The short discussion above leaves some concerns as to the interpretation of the constant dollar income idea. As seen from equations (1) and (2), the procedures involved effectively accomplishes a base change, in USD terms, in the host-country data from its historic national

[7] The Japanese example is not so unique. The cited base change in WDI data also affected the Bangladesh-India comparison between 2010 and 2015. While the 2015 constant dollar series show per capita GDP of Bangladesh to have reached about 91% of India's level in 2020, the story is worse for the 2010 base year. Here Bangladesh GDP per capita climbed up to mere two-thirds of India's level,

accounts base to an arbitrary date, such as 2015, the current base year in the US/WDI data. Hence the coinage, 'constant 2015 USD'. The latter step, of course, accomplishes the important task of rendering all data comparable internationally. The latter is a laudable goal, no doubt. But what is constant here? Regardless of the choice of the particular base year, the construction leaves the resulting constant series data exposed to the vagaries of the market exchange rate movement between the two base years (see equation 1a). Consequently, the resulting 'constant USD income' series may itself become volatile between the adjacent dates of base change.

In what sense is the 'constant dollar' exchange rate, namely scaling of the market exchange rate by the host-country GDP deflator (equation 2) meaningful? In a world of predictable exchange rates and further in the unlikely scenario whereby all economic fundamentals in the host country, its trading partners, and the numéraire country remained stable during the period in question (i.e., base year implicit in host country national accounts data and 2015), the host country exchange rate may have been primarily determined by the differential inflation rate between it and the US. But that is a tall order.[8]

4. The 'Smoothed' Constant USD Income: A Definition

Given that this 'constant USD' per capita income measure is inversely related to the market exchange rate of the base year, and the possibility of its vulnerability to volatility caused by transient shocks, it may be best to replace the market rate by a constant 'smoothed' series of the exchange rate. This step may well improve the reliability of the dataset so modified.[9] Let us denote the latter by $\{R^{Smoothed}_{2015}\}$, which is obtained from (R^{Market}_{2015}), again calibrated to the WDI base year, 2015, by adopting standard means such as the moving average and exponential techniques. Therefore, following (1b), the 'smoothed' series, $\{z_t(s)\}_{2015}$, can be written as:[10]

$$(3b) \qquad \{z_t(s)\}_{2015} = [(x_{2015}/ R^{Smoothed}_{2015}) (y_t/y_{2015})].$$

5. Conclusion

The WB constant dollar income methodology, no doubt in practice for a long time, has significant practical advantages, most notably, a device to render the world income database comparable for the given base year. Moreover, the series can go as far as national accounts data is available, and one cannot say the same about PPP data that only goes back to 1990.

[8] After having worked out the above analysis, it occurred to us that there exists an alternative interpretation of the WB constant dollar income concept that does not invoke the idea of a 'constant dollar exchange rate'. See the Appendix.

[9] Our preliminary research shows that that at least in the Japanese context, meaningful moving average concepts (4 or 5-year) or simple exponential (say, with a 'smoothing factor' of 0.5) provide excellent fits to the actual exchange rate data over 1971-2020. In turn, the 'smoothed 2015 constant Japanese per capita income' appears to lie well nested between the 2010 (too high!) and 2015 (too low!) base year values.

[10] Alternatively, in pursuant of the original form, (1a), we would write $\{z_t(s)\}_{2015} = [(y_t/ R^{Smoothed}_{2015}) (x_{2015}/y_{2015})]$.

Researchers almost always prefer time series of a long duration. However, concerns remain on how best to interpret the construction and the sketchy discussion made available by the WB data portal, which inconveniences the research community dependent on such data, but lack a transparent understanding of what the data means. The idea of a 'smoothed' exchange rate replacing the 'spot' exchange rate (actually the annual average) in the WB constant income methodology may well prove to be a durable innovation.[11]

Reference

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Benigno, Ginaluca, Pierpaolo Benigno, and Salvatore Nisticò, (2012), "Risk, Monetary Policy, and the Exchange Rate," *NBER Macroeconomics Annual* 2011, vol 26, 247-309.

Garcia, Carlos, J., Jorge E. Restrepo, and Scott Roger (2011), "How Much Should Inflation Targeters Care About the Exchange Rate?", *Journal of International Money and Finance*, 30 (7), 1590-1617.

[11] There is a long tradition of using smoothed series for variables such as the exchange rate in international monetary economics and related topics. See for example, the paper by Garcia et al(2011).

Appendix: An Alternative Interpretation of the WB Constant Dollar Income Concept and its Derivation

This is an alternative interpretation of how to obtain the 2015 constant USD series for a host country per capita GDP or similar concepts. This requires conversion of the host country *constant* LCU data form its historical base (T) to 2015, which we label 'derived' constant 2015 LCU per capita GDP.

Using the above notation, we can proceed in two simple steps.

Step-1: Convert the host country constant price data, $\{y_t\}_T$, from its historical base (T) to 2015, i.e., $\{y_t\}_{2015}$. First restate

(A.1) $$\{y_t\}_T = (\sum_i p_{iT} * x_{it}),$$

where p_i denotes the price of the i-th good (i = 1, …, M) and x_i, the quantity. Definitionally constant 2015 LCU host country per capita income can be written as

(A.2) $$\{y_t\}_{2015} = (\{y_t\}_T) \times (x_{2015}/y_{2015}) = (\sum_i p_{iT} * x_{it}) \times (\frac{\sum_i p_{i2015} * x_{i2015}}{\sum_i p_{iT} * x_{i2015}}).$$

We refer to the $\{y_t\}_{2015}$ series as the '*derived* constant 2015 LCU per capita GDP in year-t'.

Step-2: It is now evident that the constant 2015 USD per capita GDP in year-t, denoted above by $\{z_t\}_{2015}$ can be obtained by dividing the series in (A.2) by the host country market exchange rate as of 2015, i.e.,

(A.3) $$\{z_t\}_{2015} = [(\{y_t\}_{2015}) / ER^{Market}_{2015}].$$

Given (A.2), it is immediate that mathematically equation (A.3) is equivalent to equation (1a) above.

One can illustrate the calculation above by using the Bangladesh data as reviewed above. Recalling that the per capita constant LCU, $(y_{2015}\}_T$ = 52,789.06 (from eq. 2a), the expression $\{y_t\}_{2015}$ is merely = (52,789.06 ×1.8376) = 97,007.44; (see eq. 2a). Hence from (A.3), $\{z_{2015}\}_{2015}$ = USD 1248.45. Once we have converted the constant LCU data to base of 2015, the 2015 value of current LCU and constant 2015 LCU become identical. This also implies that the per capita income in current USD and '2015 constant USD' would also be identical for that year.

The above is much simpler and hence more intuitive than what has been described in section 1 in the text above, which followed the WB guidance on the matter. However, as we have taken pains to argue, the WB statement as to the meaning of the concept seems far removed from the simple interpretation appearing in a few lines above.