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# Currency indexes and consistent currency misvaluation: Illustrations using Big Mac data

Thomas J. O'Brien[a,*], Santiago Ruiz de Vargas[b]

[a] Department of Finance, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT 06269-1041, United States
[b] Advisory Services, NOERR AG, Wirtschaftsprüfungsgesellschaft, Steuerberatungsgesellschaft, Brienner Str. 28, 80333 Munich, Germany

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ABSTRACT

A currency's misvaluation versus an index of other currencies, termed the currency's *multilateral* misvaluation, depends on the index weights. This study clarifies the idea of consistency in multilateral misvaluation and provides instructive empirical illustrations using several currency index weighting methods. For both of the *Economist*'s Big Mac approaches ("raw" and Adjusted) to intrinsic foreign exchange value, the study finds that a multilateral currency misvaluation estimate based on an equal-weight index does not necessarily provide a reasonable approximation to the estimate of a more economically-meaningful currency index.

## 1. Introduction

A currency misvaluation is implied by a difference between an actual foreign exchange (FX) rate and its intrinsic FX value. The intrinsic FX value between two currencies is based on an economic model, like absolute purchasing power parity (PPP) for example, and is the basis for estimating the currencies' bilateral misvaluation versus each other. An estimate of a reference currency's *multilateral* misvaluation, versus an index basket of other currencies, may then be found using index weights and the index currencies' estimates of bilateral misvaluation versus the reference currency. A currency's multilateral misvaluation may be quite different from the currency's bilateral misvaluation versus another individual currency. For example, the Chinese yuan might be fairly valued versus a currency index, but be undervalued by 8% versus the US dollar.

Published currency indexes, such as the Federal Reserve's, are widely used in economic and financial research and typically use trade weights. For example, Cline and Williamson (2008) use trade-weighted currency indexes to estimate the Chinese yuan's multilateral misvaluation. However, trade-weighted currency indexes have two problems. First, in a global economy, weighting an index's currency positions by trade is less meaningful than weighting by a measure of global economic significance, like GDP (Ho, 2012). Second, because trade-weighted indexes have economy-specific weights, two currencies' multilateral misvaluation estimates will generally be inconsistent with an estimate of bilateral misvaluation between the two currencies. That is, the Chinese yuan's multilateral misvaluation estimate versus a Chinese trade-weighted index and the US dollar's multilateral misvaluation estimate versus a U.S. trade-weighted index will generally be inconsistent with a bilateral misvaluation estimate of the Chinese yuan versus the US dollar.

This article makes two contributions. First, the article clarifies the notion of consistency in currency misvaluation estimates.

* Corresponding author.
*E-mail addresses:* thomas.obrien@uconn.edu (T.J. O'Brien), santiago.ruizdevargas@noerr.com (S. Ruiz de Vargas).

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Second, the article provides instructive empirical illustrations of multilateral misvaluation using some economically-meaningful currency indexes that ensure consistency among currency misvaluation estimates, with weighting by: (1) total GDP; (2) equity market capitalization; and (3) financial wealth. The currency indexes typically yield different multilateral misvaluation estimates for a given currency, and one cannot say which estimate is the best; each index yields multilateral misvaluation estimates that are useful from a particular economic perspective.[1]

There are many economic models of intrinsic FX value, but for illustration purposes the study uses the *Economist's* two popular Big Mac methods: (1) The "raw" Big Mac method, which represents the absolute PPP approach to intrinsic FX value; and (2) the Adjusted Big Mac method, which represents the Balassa (1964); Samuelson (1964) approach to intrinsic FX value, where a cross-sectional linear regression is used to adjust PPP deviations for differences in per capita GDP. In principle, bilateral misvaluation estimates of the Adjusted Big Mac method improve on those of the raw Big Mac method.

An equal-weight currency index is easier apply than any of the economically-meaningful indexes, which require data for the weights. Moreover, an equal-weight index yields multilateral misvaluation estimates that closely approximate those based on the Adjusted Big Mac (Balassa-Samuelson) regression residuals (O'Brien and Ruiz de Vargas, 2017). For these reasons, we ask following question: Does an equal-weight index give multilateral misvaluation estimates that also approximate those of the economically-meaningful indexes? Although what constitutes a reasonable approximation depends on the user and the context of the application, the study finds the answer is "not necessarily". Instead, the approximation's closeness (or lack thereof) depends on the currency, the index method, and especially the market conditions.

The study's insights may point financial managers, policy-makers, and researchers to improved applications and new research in the following fields: international capital budgeting (for expansion/contraction of international operations), corporate FX risk management, international portfolio management, cross-border valuation, the economics of international trade and finance, and perhaps others.

## 2. Consistency in currency misvaluation

A difference between an actual FX rate and its intrinsic FX value implies a currency misvaluation. Specifically, the percentage bilateral misvaluation of currency $C$ versus reference currency $R$, denoted $m^{R/C}$, is equal to $X^{R/C} \div X_I^{R/C} - 1$, where (in direct terms of currency $R$) $X^{R/C}$ is the actual FX rate and $X_I^{R/C}$ is the intrinsic FX rate. (The subscript $I$ denotes the intrinsic FX rate, whereas no subscript denotes the actual FX rate.) Symmetrically, the percentage bilateral misvaluation of currency $R$ versus currency $C$ is $m^{C/R} = X^{C/R} \div X_I^{C/R} - 1$. Applying the misvaluation concept to a currency basket ($B$) results in the percentage misvaluation of the basket versus currency $R$, $m^{R/B} = X^{R/B} \div X_I^{R/B} - 1$, and the percentage misvaluation of currency $R$ versus the basket, $m^{B/R} = X^{B/R} \div X_I^{B/R} - 1$.

With a set of bilateral misvaluation estimates for an index's currencies versus a reference currency, the index's misvaluation versus the reference currency may be found using the bilateral misvaluation estimates and the weights of the currency positions in the index. In economic terms, each currency's position in the index basket converts to an amount of the reference currency, proportional to the currency's weight in the index, using the currency's bilateral *intrinsic* FX value versus the reference currency.

It is necessary to distinguish between: (1) currency $R$'s *overall* misvaluation, denoted $m^{O/R}$, which is versus a basket that *includes* currency $R$ itself; and (2) currency $R$'s *multilateral* misvaluation, denoted $m^{M/R}$, which is versus the same basket except that it *excludes* currency $R$.[2]

The weights of the currencies in the multilateral basket have the same proportions to each other as in the overall basket. A currency's *overall* misvaluation, versus an index that contains the currency itself, is not useful in practice, especially if the currency has a large index weight. However, if the weights are the same from the perspective of any currency, an overall index basket is useful analytically, because of the consistency relationship between bilateral and *overall* misvaluation in Eq. (1):

$$1 + m^{R/C} = \frac{(1 + m^{O/C})}{(1 + m^{O/R})} \tag{1}$$

In words, Eq. (1) says that the percentage bilateral misvaluation of currency $C$ versus currency $R$ must be consistent with the percentage *overall* misvaluations of currency $C$ and currency $R$ versus an index basket with the same weights from either currency perspective. To illustrate, if currency $C$ is overvalued by 6.8% versus an *overall* basket, and currency $R$ is overvalued by 26.2% versus the same *overall* basket, it follows by Eq. (1) that currency $C$'s bilateral misvaluation versus currency $R$ is 1.068 / 1.262 – 1 = –0.154, or –15.4%; that is, currency $C$ is 15.4% undervalued versus currency $R$.

Because a currency's bilateral misvaluation with itself is zero, the *multilateral* index's misvaluation versus currency $C$ ($m^{C/M}$) depends on the *overall* index's misvaluation versus currency $C$ ($m^{C/O}$) and currency $C$'s overall index weight ($w_C$), per Eq. (2):

[1] For the international trade perspective, Ho (2012) makes a case for a currency index with total GDP weights. The other two index methods are meaningful in international portfolio investments. A currency index with market capitalization weights is useful to investors with internationally diversified portfolios. Financial wealth weighting yields the currency risk hedging index in the Ross and Walsh (1983) version of the International CAPM.

[2] A multilateral FX rate between a currency and a currency index is sometimes called an *effective exchange rate* (EER). The term is used because a currency's estimated misvaluation versus a currency index is deemed to be more effective than an estimate of bilateral misvaluation, in terms of anticipating trends in trade flows, investment flows, FX rate changes, and so forth (Chinn, 2006).

$$m^{C/M} = \frac{m^{C/O}}{(1 - w_C)} \tag{2}$$

For equal-weight index baskets with many currencies, the difference between overall and multilateral misvaluation is relatively small. But for weighting by measures like GDP, equity market capitalization, or financial wealth, the overall and multilateral misvaluations may be substantially different for currencies with large weights.

For example, let currency $C$ be the US dollar with an overall basket weight of 24.4%, based on the proportion of U.S. GDP to the total GDP of the economies whose currencies are in the index. Assume the US dollar's overall misvaluation versus the GDP-weighted index basket ($m^{O/\$}$) is 6.1%, implying the basket's overall misvaluation versus the US dollar ($m^{\$/O}$) is 1 / (1 + 0.061) – 1 = –0.0575, or –5.75%.[3] Using Eq. (2), the index basket's *multilateral* misvaluation versus the US dollar ($m^{\$/M}$) is equal to –5.75% / (1 – 0.244) = –7.61%, implying (per footnote 3) that the US dollar's multilateral misvaluation ($m^{M/\$}$) is 1 / (1 – 0.0761) – 1 = 0.082, or 8.2%. In summary, the US dollar's overall misvaluation is 6.1%, versus an index basket that includes the US dollar itself, whereas the US dollar's multilateral misvaluation is 8.2%, versus an index basket of only other currencies.

The subscript notation in the analysis below specifies the intrinsic FX valuation method and the currency index type. For the intrinsic FX valuation method, *Adj* represents the Adjusted Big Mac method and *Raw* the raw Big Mac method. For index type: $E$ = equal weights; $G$ = GDP weights; $K$ = market cap weights; and $W$ = financial wealth weights. For example, $m^{M/\$}_{Adj,G}$ represents the US dollar's percentage *multilateral* misvaluation using the Adjusted Big Mac method of intrinsic FX value and GDP weights for the currency index.

## 3. Currency misvaluation and the Big Mac methods: review

This section reviews the two Big Mac methods of intrinsic FX valuation. Our main interest is in the Adjusted Big Mac method, but the logical starting point is the original "raw" Big Mac method, which has been published semiannually by the *Economist* since 1986. The raw Big Mac method views a Big Mac as a composite of traded and nontraded goods. Despite limitations and warnings to "take it with a grain of salt", the raw Big Mac method is simple and overcomes the problem that CPI baskets are usually different across countries. Thus, the raw Big Mac method has been popular with instructors, practitioners, and researchers.[4]

The raw Big Mac method uses domestic and foreign local Big Mac prices to estimate bilateral intrinsic FX rates based on traditional absolute PPP. Let $P$ denote the home Big Mac price in reference currency $R$, and $P^*$ denote the foreign Big Mac price in foreign currency $C$; the raw Big Mac intrinsic FX rate (expressed in direct terms from the perspective of the reference currency) is:

$$X^{R/C}_{Raw} = P/P^* \tag{3}$$

Using FX rates in direct terms of the reference currency, the percentage misvaluation of foreign currency $C$ versus reference currency $R$, $m^{R/C}$, is equal to the ratio of the actual FX rate to the intrinsic FX rate, minus 1. That is, $m^{R/C}_{Raw} = X^{R/C}/X^{R/C}_{Raw} - 1$, where $X^{R/C}$ is the actual FX rate in direct terms of the reference currency.[5] Equivalently, using Eq. (3), $X^{R/C}_{Raw} = (X^{R/C} \times P^*)/P - 1$, where $X^{R/C} \times P^*$ is the foreign Big Mac price expressed in the reference currency.

For example, the Chinese yuan's bilateral misvaluation versus the US dollar is equal to the ratio of the China Big Mac price stated in US dollars to the U.S. Big Mac price. Let $P$ denote the U.S. Big Mac price and $P_C$ ($=X^{\$/¥} \times P^*$) denote the price of a China Big Mac in US dollars, the raw Big Mac model's percentage misvaluation of the yuan versus the US dollar in is shown in Eq. (4):

$$m^{\$/¥}_{Raw} = P_C/P - 1 \tag{4}$$

Based on the July 2015 Big Mac edition, the U.S. and China Big Mac prices of $4.79 and ¥17 implied a raw intrinsic FX rate (in US dollars per yuan) of $4.79 / ¥17 = 0.282 $/¥. The actual FX rate, 6.21 ¥/$, equivalent to 0.161 $/¥, implied that $P_C$ = $2.738. Using Eq. (4), the yuan's raw Big Mac misvaluation versus the US dollar was thus $2.738 / $4.79 – 1 = –0.428, or –42.8%.

The Adjusted Big Mac method accounts for differences in economies' income, using a cross-sectional "line-of-best-fit" between Big Mac prices and per capita GDP estimates (expressed in a reference currency), as in Eq. (5):[6]

$$\hat{P} = \alpha + \beta \bullet GDPp \tag{5}$$

where $\hat{P}$ is the predicted Big Mac price and $GDP_p$ is per capita GDP, with both expressed in the reference currency; and $\alpha$ and $\beta$ are the

[3] It is straightforward to show the relationship between the misvaluation from the two currency directions, $m^{R/C}$and $m^{C/R}$, is given by $(1 + m^{R/C})(1 + m^{C/R}) = 1$. Applying this equation to $R$ = $ and $C = O$ (overall index basket), if the US dollar's misvaluation versus $O$ is 6.1%, $O$'s misvaluation versus the US dollar is 1/(1 + 0.061) – 1 = –0.0575, or –5.75%.

[4] For examples of research, see Click (1996); Pakko and Pollard (1996); Rogoff (1996); Cumby (1997); Annaert et al., (1997), Ong (1997); Lutz (2002); Ong (2003); Pakko and Pollard (2003); Taylor and Taylor (2004); Yang (2004); Parsley and Wei (2007); Landry (2008), and Clements and Lan (2010).Clements et al., 2010, 2012) and Clements (2013) provide reviews of the Big Mac literature.

[5] $X^{R/C}/X^{R/C}_{Raw}$ is also known as a real exchange rate. A deviation of the real exchange rate from 1 is a PPP misvaluation.

[6] "Line-of-best-fit" is terminology used by the *Economist*, and refers to a simple OLS regression. The *Economist* introduced the Adjusted Big Mac method in 2011 to try to improve on the bilateral currency misvaluation estimates of the raw Big Mac model. Chong et al. (2012) and Menkhoff et al., 2017 et al. (2017) find that adjusting for $GDP_p$ improves the FX forecast implicit in a currency's misvaluation estimate. Similarly, O'Brien and Ruiz de Vargas (2017) and Clements and Si (2017) found that the Adjusted Big Mac's bilateral misvaluation estimates have forecasted subsequent FX rate changes better than raw Big Mac estimates.

intercept and the slope coefficient estimates.[7]

A currency's regression residual is the actual Big Mac price minus the predicted Big Mac price. The *relative* regression residual is the regression residual divided by the predicted Big Mac price, measuring the currency's percentage misvaluation relative to the "line-of-best-fit". For example, the yuan's relative regression residual is expressed in Eq. (6), where $P_C$ and $\hat{P}_C$ denote the actual and predicted China Big Mac prices in the reference currency:

$$m_{Adj,L}^{O/¥} = (P_C - \hat{P}_C)/\hat{P}_C = P_C/\hat{P}_C - 1 \quad (6)$$

The notation $m_{Adj,L}^{O/¥}$ represents the yuan's relative regression residual, because it estimates the currency's percentage *overall* misvaluation versus the "line-of-best-fit" basket of currencies, which includes the currency itself and the reference currency. (The $L$ subscript is for "line-of-best-fit" basket). O'Brien and Ruiz de Vargas (2017) clarified that the Adjusted Big Mac method calculates the estimated bilateral percentage misvaluation between two currencies using Eq. (1) and the relative regression residual estimates of both currencies' *overall* misvaluation versus the regression "line-of-best-fit" index basket. The misvaluation estimates are consistent, because the "line-of-best-fit" index basket has the same weights from any currency perspective. Unfortunately, the *Economist* reports only bilateral misvaluation estimates and not the regression residual estimates of overall misvaluation.

## 4. Multilateral misvaluation and the Adjusted Big Mac method

The *Economist* uses data for 49 economies to estimate the "line of best fit", including the Eurozone in aggregate and 12 individual Eurozone countries. However, we exclude the individual Eurozone countries, and thus use only 37 economies/currencies to estimate the "line-of-best-fit". For the July 2015 Big Mac data, the estimated "line-of-best-fit" is 2.493 + 0.0359•$GDP_p$, where $GDP_p$ is in $000 s. The r-squared is 0.627.

The relative residual estimates of each currency's percentage *overall* misvaluation versus the 37-currency "line-of-best-fit" basket for July 2015 are shown in Table 1's first data column, labelled $m_{Adj,L}^{O/C}$. Table 1's second data column shows the per capita GDP estimates used in the Adjusted Big Mac analysis for July 2015. For example, China's estimated $GDP_p$ (in US dollars) was $7589, so the predicted China Big Mac price (in US dollars), $\hat{P}_C$, was 2.493 + 0.0359•7.589 = $2.765. The actual price of a China Big Mac in US dollars in July 2015 was $2.74. Per Eq. (6), the yuan's relative regression residual was $2.74 / $2.765 – 1 = –0.01, or a 1% effective *overall* undervaluation versus the regression line basket, as highlighted in Table 1. For the US dollar (the reference currency), the actual U.S. Big Mac price of $4.79, and the predicted U.S. Big Mac price of 2.493 + 0.0359•54.597 = $4.45, the US dollar's July 2015 relative regression residual was $4.79 / $4.45 – 1 = 0.076, or a 7.6% *overall* overvaluation versus the regression line basket, as highlighted in Table 1.

Table 1's third data column shows the Adjusted Big Mac method's bilateral misvaluation estimates for all 37 currencies versus the US dollar ($m_{Adj}^{\$/C}$) for July 2015. For example, using Eq. (1), the yuan's estimated percentage bilateral misvaluation versus the US dollar was $m_{Adj}^{\$/¥} = (1 + m_{Adj,L}^{O/¥}) \div (1 + m_{Adj,L}^{O/\$}) - 1 = (1 - 0.01)/(1 + 0.076) - 1 = -0.080$, or –8.0%. This estimate is highlighted in Table 1.

The last three columns of Table 1 show the July 2015 weights for the three economically-meaningful currency indexes.

Table 2 shows the *multilateral* misvaluation estimates for all 37 currencies for the July 2015 Adjusted Big Mac edition. The currencies' multilateral misvaluation estimates based on the "line-of-best-fit" residuals are shown in the first data column, labelled $m_{Adj,L}^{M/C}$ (%). Each "line-of-best-fit" overall misvaluation residual ($m_{Adj,L}^{O/C}$) (Table 1) is first converted to the overall "line-of-best-fit" basket's misvaluation versus the currency ($m_{Adj,L}^{C/O}$), per footnote 3. Then with $w_C$ = 1 / 37, we use Eq. (2) to find the multilateral basket's misvaluation versus the currency ($m_{Adj,L}^{C/M}$), and finally find the currency's multilateral misvaluation ($m_{Adj,L}^{M/C}$) per footnote 3. For the US dollar, $m_{Adj,L}^{O/\$} = 0.076$ (Table 1) converts to $m_{Adj,L}^{M/\$} = 0.078$ (Table 2).

For each of the other four multilateral misvaluation estimates in Table 2, we do not have an estimate of the currency's overall misvaluation for a starting point, and so we instead directly find the overall index's misvaluation versus currency $C$ as the weighted average of the 37 bilateral misvaluation estimates versus currency $C$. The remaining steps are the same as above. For example, the GDP-weighting of the 37 bilateral misvaluations versus the US dollar (shown in Table 1) yields $m_{Adj,G}^{\$/O} = -5.75\%$ (not shown in a table). As in the example at the end of the second section, this overall GDP-index misvaluation versus the US dollar, along with the U.S. GDP weight of 0.244 (Table 1) and Eq. (2), imply the *multilateral* GDP-index misvaluation versus the US dollar is $m_{Adj,G}^{\$/M} = -5.75\%$ / (1 – 0.244) = –7.61%, which in turn implies (per footnote 3) that the US dollar's multilateral misvaluation, versus the GDP-weighted index of other currencies ($m_{Adj,G}^{M/\$}$), is 1 / (1 – 0.0761) – 1 = 0.082, or 8.2%, as shown in Table 2.

[7] The model of intrinsic FX value in Eq. (5) is based on the "Penn effect", which refers to the positive cross-sectional empirical association between traditional absolute PPP deviations and per capita GDPs (Kravis and Heston, 1978; Kravis and Lipsey, 1983, 1987; and Summers and Heston, 1991). Typically, Penn effect researchers use logarithms, whereas the Adjusted Big Mac method does not, perhaps because the *Economist* wants the method to be more "digestible". (When we estimated a log version of Eq. (5), the r-squared was surprisingly much lower.) The Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964), or sometimes the Harrod-Balassa-Samuelson effect, is often used as an explanation (and synonym) for the Penn effect, and is the tendency for a high-income economy to have higher nontraded goods prices, relative to traded goods prices, than a low-income economy. Therefore, absolute PPP does not hold using composite price indices that include both traded and nontraded goods, even if the FX rate and traded goods prices align per the international law of one price. Relative to intrinsic FX value implied by absolute PPP, the currency of a high (low) income economy tends to be overvalued (undervalued). Because there is no derived model of the relation between PPP deviations and per capita GDP (Asea and Corden, 1994; Asea and Mendoza, 1994), the estimated Penn effect regression line serves as an empirical model of intrinsic FX value. For applications, see Rogoff (1996); Frankel (2006); Xu (2009); Zhang (2012), and Cheung and Fujii (2014).

**Table 1**
Adjusted Big Mac method estimates and index weights, July 2015.

| ECONOMY | $m_{Adj,L}^{O/C}$ (%) | $GDPp$ ($) | $m_{Adj}^{\$/C}$ (%) | GDP | MKT CAP | WEALTH |
|---|---|---|---|---|---|---|
| Argentina | 3.8 | 12,873 | –3.6 | 0.8 | 0.1 | 0.1 |
| Australia | –16.3 | 61,219 | –22.3 | 2.0 | 1.9 | 2.6 |
| Brazil | 47.2 | 11,604 | 36.8 | 3.3 | 1.3 | 1.0 |
| Britain | 9.3 | 45,653 | 1.5 | 4.1 | 5.7 | 6.4 |
| Canada | 5.5 | 50,398 | –2.0 | 2.5 | 3.3 | 2.8 |
| Chile | 8.5 | 14,477 | 0.8 | 0.4 | 0.4 | 0.2 |
| China | –1.0 | 7,589 | –8.0 | 14.6 | 7.8 | 9.4 |
| Colombia | 4.8 | 8,076 | –2.6 | 0.5 | 0.2 | 0.3 |
| Czech Republic | –11.3 | 19,563 | –17.6 | 0.3 | 0.0 | 0.1 |
| Denmark | 8.9 | 60,564 | 1.2 | 0.5 | 0.5 | 0.4 |
| Egypt | –17.2 | 3,304 | –23.1 | 0.4 | 0.1 | 0.2 |
| Eurozone | 3.2 | 40,028 | –4.1 | 18.8 | 10.1 | 19.8 |
| Hong Kong | –36.8 | 39,871 | –41.3 | 0.4 | 6.5 | 0.4 |
| Hungary | 6.4 | 13,881 | –1.2 | 0.2 | 0.0 | 0.1 |
| India | –28.2 | 1,627 | –33.3 | 2.9 | 2.4 | 1.4 |
| Indonesia | –12.7 | 3,534 | –18.9 | 1.2 | 0.7 | 0.6 |
| Israel | 21.3 | 36,991 | 12.7 | 0.4 | 0.2 | 0.3 |
| Japan | –21.3 | 36,332 | –26.9 | 6.5 | 6.9 | 8.1 |
| Malaysia | –30.2 | 10,804 | –35.2 | 0.5 | 0.7 | 0.2 |
| Mexico | 8.2 | 10,715 | 0.5 | 1.8 | 0.7 | 0.8 |
| New Zealand | –3.8 | 43,837 | –10.6 | 0.3 | 0.1 | 0.5 |
| Norway | –5.4 | 97,013 | –12.1 | 0.7 | 0.4 | 0.5 |
| Pakistan | 35.5 | 1,343 | 25.8 | 0.4 | 0.1 | 0.2 |
| Peru | 15.3 | 6,458 | 7.1 | 0.3 | 0.1 | 0.2 |
| Philippines | 38.9 | 2,865 | 29.1 | 0.4 | 0.4 | 0.2 |
| Poland | –15.4 | 14,379 | –21.4 | 0.8 | 0.3 | 0.3 |
| Russia | –36.3 | 12,926 | –40.8 | 2.6 | 0.6 | 0.5 |
| Saudi Arabia | –5.0 | 24,454 | –11.8 | 1.1 | 0.8 | 0.3 |
| Singapore | –23.8 | 56,319 | –29.2 | 0.4 | 0.9 | 0.4 |
| South Africa | –23.2 | 6,483 | -28.6 | 0.5 | 0.8 | 0.3 |
| Korea | 7.4 | 28,101 | –0.2 | 2.0 | 1.8 | 1.4 |
| Sweden | 11.7 | 58,491 | 3.8 | 0.8 | 1.0 | 0.9 |
| Switzerland | 21.2 | 87,475 | 12.6 | 1.0 | 2.5 | 1.4 |
| Taiwan | –22.9 | 22,598 | –28.4 | 0.7 | 1.5 | 1.4 |
| Thailand | 17.9 | 5,445 | 9.5 | 0.5 | 0.6 | 0.1 |
| Turkey | 35.1 | 10,482 | 25.5 | 1.1 | 0.4 | 0.4 |
| United States | 7.6 | 54,597 | 0.0 | 24.4 | 38.1 | 35.4 |

Table 1 shows for the July 2015 Adjusted Big Mac method: (1) Currency *C*' s regression residual misvaluation percentage ($m_{Adj,L}^{O/C}$); (2) Per capita GDP in US dollars ($GDP_p$ ($)); (3) Currency *C*' s percentage bilateral misvaluation estimates versus the US dollar, denoted $m_{Adj}^{\$/C}$, and (4) the GDP, equity market cap, and financial wealth weights for the currency indexes. Data sources: Big Mac prices, FX rates, and $GDP_p$ ($) are from the *Economist's* downloadable data spreadsheet. The total GDP weights are based on International Monetary Fund (IMF) nominal estimates of total GDP, using current prices and market FX rates to convert from local currency to US dollars. The equity market cap weight estimates are from *Bloomberg*. The financial wealth weight estimates are from the *Global Wealth Data Book*, published by the Credit Suisse Research Institute.

## 5. Differences in multilateral misvaluation estimates: Adjusted Big Mac

One can easily see the close association in Table 2 between the multilateral misvaluation estimates for the regression "line-of-best-fit" basket ($m_{Adj,L}^{M/C}$) and the equal-weight index basket ($m_{Adj,E}^{M/C}$). The average difference is only 15 basis points. Therefore, even though the *Economist* does not publish the regression residual estimates of overall misvaluation, taking an equal-weight average of the reported bilateral misvaluation estimates versus a currency gives a very good approximation to the currency's multilateral misvaluation estimate based on the currency's regression "line-of-best-fit" residual.

Is an equal-weight index's multilateral misvaluation estimate a reasonable approximation of those for any (or all) the three economically-meaningful indexes? Table 3's first three data columns show the average absolute differences, in basis points, between currencies' multilateral misvaluation estimates of the equal-weight index and each of the three economically-meaningful indexes, for the Adjusted Big Mac July 2015 edition. For the GDP-weighted index, the difference ranges from 29 basis points (Russia) to 373 basis points (Brazil) and averages 127 basis points (all economies). For the market cap-weighted index, the difference ranges from 8 basis points (Czech Republic) to 590 basis points (United States) and averages 133 basis points (all economies). For the wealth-weighted

**Table 2**
Multilateral currency misvaluation estimates Adjusted Big Mac method, July 2015.

| ECONOMY | $m_{Adj,L}^{M/C}$ (%) | $m_{Adj,E}^{M/C}$ (%) | $m_{Adj,G}^{M/C}$ (%) | $m_{Adj,K}^{M/C}$ (%) | $m_{Adj,W}^{M/C}$ (%) |
|---|---|---|---|---|---|
| Argentina | 3.8 | 3.7 | 2.5 | 4.5 | 1.8 |
| Australia | -16.8 | -16.9 | -18.0 | -17.2 | -17.3 |
| Brazil | 49.1 | 48.9 | 45.2 | 53.9 | 43.6 |
| Britain | 9.5 | 9.3 | 7.7 | 10.5 | 7.2 |
| Canada | 5.6 | 5.4 | 4.0 | 6.3 | 3.6 |
| Chile | 8.8 | 8.6 | 7.1 | 9.7 | 6.3 |
| China | -1.0 | -1.2 | -2.7 | -0.7 | -3.0 |
| Colombia | 4.9 | 4.8 | 3.4 | 5.6 | 3.0 |
| Czech Republic | -11.6 | -11.7 | -12.6 | -11.8 | -13.0 |
| Denmark | 9.1 | 8.9 | 7.3 | 10.1 | 6.8 |
| Egypt | -17.6 | -17.7 | -18.4 | -18.1 | -19.4 |
| Eurozone | 3.2 | 3.1 | 2.2 | 3.9 | 1.7 |
| Hong Kong | -37.5 | -37.6 | -37.7 | -38.5 | -38.4 |
| Hungary | 6.5 | 6.4 | 5.0 | 7.4 | 4.3 |
| India | -28.7 | -28.8 | -29.7 | -29.6 | -28.3 |
| Indonesia | -13.1 | -13.2 | -14.0 | -13.3 | -14.4 |
| Israel | 21.9 | 21.8 | 19.6 | 23.9 | 18.8 |
| Japan | -21.8 | -22.0 | -23.0 | -22.5 | -22.3 |
| Malaysia | -30.8 | -30.9 | -31.3 | -31.7 | -30.5 |
| Mexico | 8.4 | 8.3 | 6.7 | 9.4 | 6.1 |
| New Zealand | -4.0 | -4.1 | -5.3 | -3.8 | -5.5 |
| Norway | -5.6 | -5.7 | -6.8 | -5.5 | -7.0 |
| Pakistan | 36.8 | 36.6 | 34.4 | 40.2 | 33.3 |
| Peru | 15.8 | 15.6 | 13.7 | 17.3 | 13.9 |
| Philippines | 40.4 | 40.2 | 37.7 | 44.2 | 35.8 |
| Poland | -15.8 | -15.9 | -17.1 | -16.2 | -16.7 |
| Russia | -36.9 | -37.0 | -37.3 | -38.0 | -38.1 |
| Saudi Arabia | -5.2 | -5.4 | -6.4 | -5.1 | -6.6 |
| Singapore | -24.3 | -24.4 | -24.9 | -25.0 | -24.4 |
| South Africa | -23.7 | -23.8 | -24.7 | -24.3 | -23.5 |
| Korea | 7.6 | 7.4 | 5.9 | 8.5 | 5.5 |
| Sweden | 12.0 | 11.8 | 10.1 | 13.2 | 9.5 |
| Switzerland | 21.8 | 21.6 | 19.8 | 23.8 | 18.4 |
| Taiwan | -23.4 | -23.5 | -24.2 | -24.1 | -24.3 |
| Thailand | 18.4 | 18.3 | 17.6 | 20.1 | 15.3 |
| Turkey | 36.3 | 36.1 | 34.4 | 39.7 | 31.3 |
| United States | 7.8 | 7.6 | 8.2 | 13.5 | 9.0 |

Table 2 shows multilateral misvaluation estimates for the July 2015 Adjusted Big Mac method for five index baskets: (1) The regression "line-of-best-fit" basket ($m_{Adj,L}^{M/C}$); (2) the equal-weight basket ($m_{Adj,E}^{M/C}$); (3) the GDP-weighted index basket ($m_{Adj,G}^{M/C}$); (4) the equity market cap-weighted index basket ($m_{Adj,K}^{M/C}$); and (5) the financial wealth-weighted index basket ($m_{Adj,W}^{M/C}$). Data sources: Big Mac prices, FX rates, and $GDP_p$ ($) are from the *Economist's* downloadable data spreadsheet. The total GDP weights are based on International Monetary Fund (IMF) nominal estimates of total GDP, using current prices and market FX rates to convert from local currency to US dollars. The equity market cap weight estimates are from *Bloomberg*. The financial wealth weight estimates are from the *Global Wealth Data Book*, published by the Credit Suisse Research Institute.

index, the difference ranges from 6 basis points (Singapore) to 530 basis points (Brazil) and averages 188 basis points (all economies).

Overall, the differences between the multilateral misvaluation estimates for the equal-weight index and the economically-meaningful indexes tend to be relatively modest for the Adjusted Big Mac July 15 edition. Moreover, there is no pattern of distinction between the results for emerging and developed economies.

To assess the robustness of the July 2015 results, we investigated other Big Mac editions. We found that the magnitude of the difference between multilateral misvaluation estimates varies through time, based on market conditions, and that the July 2015 edition reflects a time when the differences were relatively small. The differences were higher for most of the other editions and highest for July 2011. Therefore, we illustrate how much impact that market conditions can have by providing the difference results for the July 2011 edition in Table 3's last three data columns. For the GDP-weighted index, the difference ranges from 24 basis points (China) to 1579 basis points (Argentina) and averages 735 basis points (all economies). For the market cap weighted index, the difference ranges from 563 basis points (Hong Kong) to 4259 basis points (Brazil) and averages 1656 basis points (all economies). For the wealth-weighted index, the difference ranges from 423 basis points (United States) to 1757 basis points (Eurozone) and averages

**Table 3**
Differences in multilateral misvaluation estimates Adjusted Big Mac method, July 2015 and July 2011.

| | JULY 2015 | | | JULY 2011 | | |
|---|---|---|---|---|---|---|
| **ECONOMY** | $m^{M/C}_{Adj,G}$ | $m^{M/C}_{Adj,K}$ | $m^{M/C}_{Adj,W}$ | $m^{M/C}_{Adj,G}$ | $m^{M/C}_{Adj,K}$ | $m^{M/C}_{Adj,W}$ |
| Argentina | 122 | 79 | 186 | 1579 | 2887 | 1030 |
| Australia | 107 | 31 | 45 | 661 | 1317 | 973 |
| Brazil | 373 | 499 | 530 | 942 | 4259 | 750 |
| Britain | 161 | 118 | 210 | 657 | 1228 | 951 |
| Canada | 143 | 90 | 188 | 731 | 1509 | 1010 |
| Chile | 154 | 112 | 231 | 859 | 2105 | 1011 |
| China | 156 | 48 | 185 | 24 | 1186 | 804 |
| Colombia | 138 | 86 | 176 | 1066 | 3234 | 1396 |
| Czech Republic | 90 | 8 | 127 | 818 | 1841 | 1184 |
| Denmark | 159 | 115 | 213 | 725 | 1486 | 1006 |
| Egypt | 64 | 35 | 168 | 678 | 1305 | 942 |
| Eurozone | 93 | 85 | 143 | 1183 | 1876 | 1757 |
| Hong Kong | 13 | 93 | 83 | 399 | 563 | 567 |
| Hungary | 143 | 97 | 209 | 879 | 2127 | 1035 |
| India | 87 | 73 | 51 | 546 | 1009 | 909 |
| Indonesia | 78 | 15 | 119 | 729 | 1503 | 1023 |
| Israel | 215 | 216 | 297 | 795 | 1809 | 1128 |
| Japan | 101 | 51 | 33 | 627 | 1228 | 949 |
| Malaysia | 35 | 78 | 46 | 633 | 1161 | 951 |
| Mexico | 156 | 110 | 213 | 691 | 1353 | 971 |
| New Zealand | 115 | 31 | 139 | 761 | 1596 | 1029 |
| Norway | 101 | 22 | 124 | 806 | 1879 | 1112 |
| Pakistan | 217 | 359 | 322 | 692 | 1379 | 983 |
| Peru | 187 | 165 | 169 | 868 | 2258 | 1185 |
| Philippines | 247 | 398 | 443 | 779 | 1659 | 1067 |
| Poland | 118 | 27 | 75 | 723 | 1469 | 1005 |
| Russia | 29 | 92 | 109 | 666 | 1281 | 950 |
| Saudi Arabia | 102 | 24 | 125 | 602 | 1051 | 877 |
| Singapore | 50 | 59 | 6 | 582 | 1008 | 907 |
| South Africa | 93 | 57 | 24 | 736 | 1508 | 997 |
| Korea | 151 | 104 | 192 | 709 | 1423 | 997 |
| Sweden | 170 | 136 | 231 | 910 | 2601 | 1311 |
| Switzerland | 179 | 215 | 328 | 920 | 2075 | 1074 |
| Taiwan | 63 | 56 | 76 | 572 | 1015 | 814 |
| Thailand | 62 | 187 | 294 | 555 | 1232 | 945 |
| Turkey | 171 | 354 | 489 | 920 | 2071 | 1097 |
| United States | 60 | 590 | 141 | 186 | 787 | 423 |
| **AVERAGE** | **122** | **133** | **182** | **735** | **1656** | **1003** |

For the Adjusted Big Mac method, Table 3 shows absolute differences (in basis points) between the multilateral misvaluation estimates of the three economically-meaningful indexes and the equal-weight index. The first three data columns are for the July 2015 edition; the last three data columns are for the July 2011 edition. Data sources: Big Mac prices, FX rates, and $GDP_p$ ($) are from the *Economist's* downloadable data spreadsheet. The total GDP weights are based on International Monetary Fund (IMF) nominal estimates of total GDP, using current prices and market FX rates to convert from local currency to US dollars. The equity market cap weight estimates are from *Bloomberg*. The financial wealth weight estimates are from the *Global Wealth Data Book*, published by the Credit Suisse Research Institute.

1003 basis points (all economies).

The July 2011 results show substantial differences between the multilateral misvaluation estimates for the equal-weight index and the economically-meaningful indexes. Based on these results, we conclude that for the Adjusted Big Mac method, the equal-weight currency index does not *necessarily* yield multilateral misvaluation estimates that reasonably approximate those of the economically-meaningful currency indexes. Instead, there may be substantial differences, depending on the overall market conditions.[8]

[8] It would be useful to understand what market conditions permit the equal-weight index to give reasonable approximations and what market conditions do not. The answer may be related to the difference in the US dollar's multilateral misvaluation; for example, $m^{M/\$}_{Adj,E}$ = –23.4% in July 2011 and 7.6% in July 2015. Further investigation is beyond the scope of this study but would be an interesting follow-up research project.

**Table 4**
Multilateral misvaluation estimates raw Big Mac method, July 2015.

| ECONOMY | $m_{Raw}^{\$/C}$ (%) | $m_{Raw,E}^{M/C}$ (%) | $m_{Raw,G}^{M/C}$ (%) | $m_{Raw,K}^{M/C}$ (%) | $m_{Raw,W}^{M/C}$ (%) |
|---|---|---|---|---|---|
| Argentina | –36.0 | -12.3 | -21.8 | -25.1 | -26.7 |
| Australia | –18.1 | 13.0 | 3.9 | -2.4 | -4.2 |
| Brazil | –10.6 | 23.7 | 15.3 | 7.3 | 5.6 |
| Britain | –5.8 | 30.6 | 22.8 | 13.7 | 11.9 |
| Canada | –5.3 | 31.3 | 23.6 | 14.3 | 12.6 |
| Chile | –31.8 | -6.3 | -15.9 | -19.8 | -21.4 |
| China | –42.8 | -21.9 | -31.1 | -33.5 | -35.0 |
| Colombia | –39.1 | -16.7 | -26.1 | -28.9 | -30.5 |
| Czech Republic | –40.8 | -19.1 | -28.4 | -31.1 | -32.6 |
| Denmark | 6.0 | 47.7 | 42.0 | 29.5 | 27.8 |
| Egypt | –54.9 | -38.6 | -46.9 | -48.1 | -49.4 |
| Eurozone | –15.4 | 16.9 | 8.5 | 1.2 | -0.7 |
| Hong Kong | –48.3 | -29.5 | -38.4 | -40.2 | -41.6 |
| Hungary | –33.6 | -8.9 | -18.4 | -22.1 | -23.7 |
| India | –61.7 | -48.1 | -55.6 | -56.3 | -57.5 |
| Indonesia | –52.3 | -35.0 | -43.6 | -45.0 | -46.4 |
| Israel | –3.3 | 34.2 | 26.8 | 17.0 | 15.2 |
| Japan | –37.7 | -14.6 | -24.1 | -27.2 | -28.7 |
| Malaysia | –58.0 | -43.0 | -51.0 | -51.9 | -53.2 |
| Mexico | –35.0 | -10.9 | -20.4 | -23.8 | -25.5 |
| New Zealand | –18.4 | 12.6 | 3.5 | -2.8 | -4.5 |
| Norway | 17.9 | 65.0 | 62.3 | 45.8 | 44.4 |
| Pakistan | –28.2 | -1.2 | -10.8 | -15.2 | -16.9 |
| Peru | –34.4 | -10.1 | -19.6 | -23.1 | -24.7 |
| Philippines | –24.7 | 3.6 | -5.8 | -10.9 | -12.6 |
| Poland | –46.9 | -27.5 | -36.5 | -38.5 | -39.9 |
| Russia | –60.7 | -46.6 | -54.3 | -55.1 | -56.2 |
| Saudi Arabia | –33.2 | -8.4 | -17.9 | -21.6 | -23.2 |
| Singapore | –28.2 | -1.3 | -10.8 | -15.3 | -17.0 |
| South Africa | –56.3 | -40.5 | -48.7 | -49.8 | -51.1 |
| Korea | –21.5 | 8.2 | -1.1 | -6.8 | -8.5 |
| Sweden | 7.0 | 49.2 | 43.7 | 30.9 | 29.2 |
| Switzerland | 42.4 | 101.2 | 108.0 | 80.7 | 79.9 |
| Taiwan | –46.8 | -27.4 | -36.5 | -38.4 | -39.9 |
| Thailand | –33.9 | -9.3 | -18.8 | -22.4 | -24.0 |
| Turkey | –19.1 | 11.6 | 2.4 | -3.7 | -5.4 |
| United States | 0 | 39.0 | 37.9 | 35.6 | 30.0 |

For the July 2015 raw Big Mac method, Table 4 shows bilateral misvaluation estimates versus the US dollar ($m_{Raw}^{\$/C}$) and currencies' multilateral misvaluation estimates versus four index baskets: (1) the equal-weight basket ($m_{Raw,E}^{M/C}$); (2) the GDP-weighted index basket ($m_{Raw,G}^{M/C}$); (3) the equity market cap-weighted index basket ($m_{Raw,K}^{M/C}$); and (4) the financial wealth-weighted index basket ($m_{Raw,W}^{M/C}$). Data sources: Big Mac prices, FX rates, and $GDP_p$ ($) are from the *Economist's* downloadable data spreadsheet. The total GDP weights are based on International Monetary Fund (IMF) nominal estimates of total GDP, using current prices and market FX rates to convert from local currency to US dollars. The equity market cap weight estimates are from *Bloomberg*. The financial wealth weight estimates are from the *Global Wealth Data Book*, published by the Credit Suisse Research Institute.

## 6. Differences in multilateral misvaluation estimates: raw Big Mac

Because of the smaller variation in bilateral misvaluation estimates with the Adjusted Big Mac method than with the raw Big Mac method, we expected the raw Big Mac method to show larger differences in the multilateral misvaluation estimates between the equal-weight currency index and the economically-meaningful currency indexes.

Table 4 shows multilateral misvaluation estimates for the four currency index methods and the raw Big Mac method in July 2015. These estimates are calculated in the same fashion as those in Table 2 for the Adjusted Big Mac method. First, calculate the overall index's misvaluation versus currency $C$ as the weighted average of the 37 raw Big Mac bilateral misvaluation estimates versus currency. [Table 4's first data column shows the raw Big Mac bilateral misvaluation estimates for the US dollar ($m_{Raw}^{\$/C}$), as an example.] Next, use $w_C$ to find the multilateral index's misvaluation versus currency $C$ using Eq. (2). The weights are each 1/37 for the equal-weight index (2nd data column); the July 2015 weights for the three economically-meaningful indexes are shown in Table 1. Finally, convert the multilateral index's misvaluation versus currency $C$ to currency' s multilateral misvaluation versus the

**Table 5**
Differences in multilateral misvaluation estimates raw Big Mac method, July 2015 and July 2011.

| | JULY 2015 | | | JULY 2011 | | |
|---|---|---|---|---|---|---|
| **ECONOMY** | $m^{M/C}_{Raw,G}$ | $m^{M/C}_{Raw,K}$ | $m^{M/C}_{Raw,W}$ | $m^{M/C}_{Raw,G}$ | $m^{M/C}_{Raw,K}$ | $m^{M/C}_{Raw,W}$ |
| Argentina | 951 | 1280 | 1439 | 234 | 23 | 575 |
| Australia | 907 | 1543 | 1715 | 213 | 10 | 568 |
| Brazil | 839 | 1639 | 1812 | 133 | 185 | 424 |
| Britain | 778 | 1696 | 1868 | 368 | 110 | 592 |
| Canada | 771 | 1702 | 1873 | 201 | 3 | 564 |
| Chile | 955 | 1346 | 1510 | 358 | 102 | 594 |
| China | 927 | 1167 | 1318 | 380 | 150 | 466 |
| Colombia | 943 | 1229 | 1385 | 252 | 34 | 580 |
| Czech Republic | 937 | 1201 | 1354 | 350 | 97 | 594 |
| Denmark | 571 | 1821 | 1983 | 83 | 65 | 521 |
| Egypt | 835 | 955 | 1084 | 386 | 151 | 478 |
| Eurozone | 840 | 1576 | 1760 | 213 | 165 | 33 |
| Hong Kong | 893 | 1073 | 1215 | 351 | 142 | 418 |
| Hungary | 955 | 1318 | 1480 | 354 | 99 | 594 |
| India | 756 | 825 | 939 | 346 | 141 | 410 |
| Indonesia | 860 | 1002 | 1136 | 400 | 152 | 512 |
| Israel | 742 | 1724 | 1895 | 265 | 42 | 583 |
| Japan | 948 | 1253 | 1410 | 627 | 1228 | 949 |
| Malaysia | 801 | 895 | 1018 | 389 | 151 | 486 |
| Mexico | 953 | 1296 | 1456 | 403 | 152 | 522 |
| New Zealand | 909 | 1539 | 1711 | 307 | 68 | 592 |
| Norway | 269 | 1923 | 2068 | 1250 | 758 | 180 |
| Pakistan | 952 | 1401 | 1568 | 387 | 151 | 480 |
| Peru | 954 | 1305 | 1466 | 387 | 124 | 586 |
| Philippines | 943 | 1451 | 1620 | 404 | 151 | 526 |
| Poland | 903 | 1098 | 1242 | 406 | 146 | 553 |
| Russia | 769 | 845 | 962 | 402 | 152 | 518 |
| Saudi Arabia | 955 | 1324 | 1486 | 401 | 152 | 514 |
| Singapore | 952 | 1400 | 1567 | 386 | 124 | 586 |
| South Africa | 820 | 929 | 1055 | 406 | 150 | 535 |
| Korea | 928 | 1497 | 1668 | 395 | 131 | 579 |
| Sweden | 548 | 1831 | 1992 | 825 | 545 | 61 |
| Switzerland | 677 | 2054 | 2130 | 1084 | 676 | 85 |
| Taiwan | 904 | 1099 | 1243 | 398 | 152 | 507 |
| Thailand | 955 | 1314 | 1476 | 385 | 151 | 477 |
| Turkey | 914 | 1529 | 1701 | 378 | 117 | 590 |
| United States | 110 | 338 | 900 | 354 | 15 | 660 |
| **AVERAGE** | **828** | **1336** | **1500** | **402** | **188** | **500** |

For the raw Big Mac method, Table 5 shows absolute differences (in basis points) between the multilateral misvaluation estimates of the three economically-meaningful indexes and the equal-weight index. The first three data columns are for the July 2015 edition; the last three data columns are for the July 2011 edition. Data sources: Big Mac prices, FX rates, and $GDP_p$ ($) are from the *Economist's* downloadable data spreadsheet. The total GDP weights are based on International Monetary Fund (IMF) nominal estimates of total GDP, using current prices and market FX rates to convert from local currency to US dollars. The equity market cap weight estimates are from *Bloomberg*. The financial wealth weight estimates are from the *Global Wealth Data Book*, published by the Credit Suisse Research Institute.

index, per footnote 3.

Table 4's results for the raw Big Mac method indicate the following: (1) Currencies' multilateral misvaluation estimates tend to be much higher than their bilateral misvaluation estimates versus the US dollar (in the first data column). This tendency is due to the US dollar's sizable multilateral overvaluation versus any of the four currency indexes in July 2015. (2) There is more variation in the currencies' bilateral misvaluation estimates versus the US dollar in the raw Big Mac analysis than for the Adjusted Big Mac analysis, with a tendency for emerging market currencies to be have lower intrinsic FX values versus the US dollar than developed market currencies. Of course, it is this tendency that motivated the Adjusted Big Mac (Balassa-Samuelson) method. (3) The multilateral misvaluation estimates of the equal-weight index tend to be higher than those of the economically-meaningful currency indexes. The equal-weight multilateral misvaluation estimates tend to be closest to the estimates of the GDP-weighted index, followed by the market cap-weighted index, and the largest difference tends to be with the wealth-weighted index.

For the July 2015 raw Big Mac edition, Table 5's first three data columns show substantial differences between the multilateral misvaluation estimates of the three economically-meaningful indexes and those of the equal-weight index. As expected, these

difference tend to be larger than those in Table 3 for the Adjusted Big Mac method. The average difference is 828 basis points for the GDP-weighted currency index, 1336 basis points for the market cap-weighted currency index, and 1500 basis points for the wealth-weighted currency index. For the July 2015 raw Big Mac edition, a currency's multilateral misvaluation estimate with an equal-weight index tends to be an unacceptable approximation for the estimates of any of the three economically meaningful currency indexes.

Surprisingly, the difference results for the July 2011 raw Big Mac edition, shown in Table 5's last three data columns, tend to be *lower* than those for the Adjusted Big Mac method in Table 3. The average difference is 402 basis points for the GDP-weighted currency index, 188 basis points for the market cap-weighted currency index, and 500 basis points for the wealth-weighted currency index.[9]

Taken together, the raw Big Mac findings for the July 2015 and July 2011 editions allow the same conclusion as for the Adjusted Big Mac method: the equal-weight currency index does not necessarily yield multilateral misvaluation estimates that reasonably approximate those of the economically-meaningful currency indexes.

## 7. Summary and conclusion

Researchers, practitioners, and policy-makers often want to know an estimate of a currency's multilateral misvaluation versus other currencies in general, instead of (or in addition to) bilateral misvaluation estimates versus other individual currencies. Publicly-available multilateral currency misvaluation estimates are typically based on trade-weighted currency indexes and are not consistent among different currencies. This study investigates alternative currency index methods that provide consistent multilateral misvaluation estimates.

The currency indexes are as follows: (1) equal weights; (2) GDP weights; (3) equity market cap weights; and (4) financial wealth weights. The equal-weight method is the easiest of the four methods to apply. Moreover, the equal-weight method gives a multilateral misvaluation estimate that closely approximates the estimate based on the regression residual in the Balassa-Samuelson approach to multilateral currency misvaluation.

Therefore, we wondered if the equal-weight method might give multilateral misvaluation estimates that also approximate those from the three economically-meaningful index methods (based on GDP, market cap, and wealth). We investigated the issue with empirical illustrations using the *Economist's* two methods of intrinsic FX value: (1) the Adjusted Big Mac method, which represents the Balassa-Samuelson approach; and (2) the original (raw) Big Mac method, which represents the traditional absolute purchasing power parity approach.

The study finds that an equal-weight currency index does not reliably give multilateral misvaluation estimates that are reasonable approximations to those of any of the economically-meaningful (and consistent) currency indexes. This finding applies for both the Adjusted and raw Big Mac methods. Researchers, practitioners, and policy-makers wanting to estimate a currency's multilateral misvaluation should be aware of the finding. Otherwise, they might opt to use the easier, equal-weight index method, unaware of the method's lack of reliability.

The study's objective is to provide instructive insights on multilateral currency misvaluation consistency and a methodology basis for future applications and research. One identified topic for follow-up research is the investigation of how market conditions affect an equal-weight index's approximations to the multilateral misvaluation estimates of economically-meaningful currency indexes.

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[9] The reason is not clear to us why the July 2011 edition's raw Big Mac differences in Table 5 tend to be lower than the Adjusted Big Mac differences in Table 3, contrary to our expectation and despite the higher variability in bilateral misvaluation estimates for the raw Big Mac method. Perhaps the reason relates to market conditions. Further investigation is beyond this study's scope and left to future research, possibly in connection with the follow-up research suggested in the prior footnote.

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