

The Big Mac Index Dynamics

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Abstract

The Big Mac Index is a tool that makes exchange-rate theory more palatable. In recent years the Big Mac Index has been used as a practical way to determine the over- or under-valued international currencies according to the theory of Purchasing Power Parity. The theory uses the Big Mac as a tradable single-good basket to equalize the Dollar-value of the hamburger around the world through arbitrage. The enormous popularity of the Big Mac Index arose the questions of how effective the Big Mac price is as an indicator of income level and how accurate the exchange rate movement predictions are based on the Big Mac prices over time? The statistical analysis of this paper is implemented using data from 2013 to 2020 from The Economist and from the World Bank for 42 countries. US Dollar, Euro, British Pound, Chinese Yuan, and Japanese Yen are used as base currencies to track the dynamics of stability and convergence. As a qualitative indicator of movement in the nominal exchange rate, however, there is no significant difference in countries of different income levels and economic stability. The Big Mac Index estimation consists with previous studies in convergence for countries with high income level. Contradictory to previous studies, the Big Mac Index estimation tends to fluctuate for currency in country with high income level like US Dollar only in 2020. The stability of Big Mac Index dynamics from 2013 to 2020 holds for the rest of the other four currencies.

Keywords: Big Mac Index, Exchange Rate Dynamics, Purchasing Power Parity, Stability, Convergence

1. Introduction

Purchasing Power Parity (PPP) is the theory to explain the coefficient of equivalent value between currencies calculated at different price levels in different countries. The law is derived from the assumption of the inevitable elimination of all arbitrage, expressing that PPP is a measure of the relative purchasing power of different currencies, and the comparisons between countries based on the Gross Domestic Product (GDP) per capita is often misleading (Pakko & Pollard, 2003). This happens due to the conversion of the income of a country into the same currency at the official rate. The nominal exchange rate does not reflect the relative ability of the purchasing power of different currencies, so errors can arise when comparing the performance of some countries. Therefore, PPP is recommended as a more appropriate means of the converter in converting GDP in local currency to the base currency (Bojanic et al., 2007).

The precondition of PPP is that the exchange rates of two currencies will naturally adjust to the same level, so that a basket of goods will sell at the same price in the two currencies (the law of one price). In the Big Mac Index, this “basket” of goods is a Big Mac

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burger sold at a McDonald's fast-food chain. Since Big Mac hamburger is a household name, it serves as a homogeneous representative tradable good. The Big Mac Index becomes the exchange rate implied by PPP, which is mostly based on US dollar to estimate. The predictive power of the Big Mac Index and the attributes of Big Mac prices as a proxy for overall price movements are particularly important when used as a measure of real income and for real exchange rate dynamics (Portes & Atal, 2014).

The price of Big Mac hamburger is used as the measurement tool because the hamburger is with global consistent operation in terms of standards and ingredients in more than 120 countries. It means that the price of Big Mac hamburger can serve as PPP is the exchange rate showing the real purchasing power in all countries. The ease and transparency provide the Big Mac Index a quick and rough estimate to forecast foreign exchange rate. (Clements et al., 2012). The price difference of Big Mac hamburger may be distorted by trade barriers on beef, sales taxes, local competition, and changes in the cost of nontrade inputs such as rents (Loveridge & Paredes, 2018). Despite the flaws, Big Mac Index still serves as an easy-to-understand measure of a country's real purchasing power to demonstrate a currency's over or undervaluation.

The Big Mac has been applied in different study reflecting real purchasing power. Jorion & Abuaf (2012) found out the equivalency of wage rate in different countries to buy a Big Mac to demonstrate the existence of wage-rate disparity across countries. Portes & Atal (2014) have found out the per capita Big Mac affordability across countries to measure the per-capita real income disparity, which used Big Mac Index based on the Dollar value to estimate the accuracy and effect of Big Mac Index. They used data tracking from 1986-2012 to confirm the Big Mac Index as an indicator of inflation and exchange rate. They concluded that Big Mac prices lagged 1-year on overall inflation. For high-income countries there were some forecasting power in the Big Mac Index, but it was not applicable for emerging markets. O'Brien & Vargas (2017) used both the "raw" and "adjusted" Big Mac approaches to intrinsic foreign exchange value and found that a multilateral currency misvaluation estimate based on an equal-weight index did not necessarily provide a reasonable approximation to the estimate of a more economically-meaningful currency index. Gharehgozli & Atal (2020) have produced a descriptive study of real-income inequality from households in 29 countries for period 2000 to 2013. Using daily Big Mac Affordability (BMA), they ranked and showed differences in the living standards and the purchasing power of individuals belonging to different income deciles in these countries.

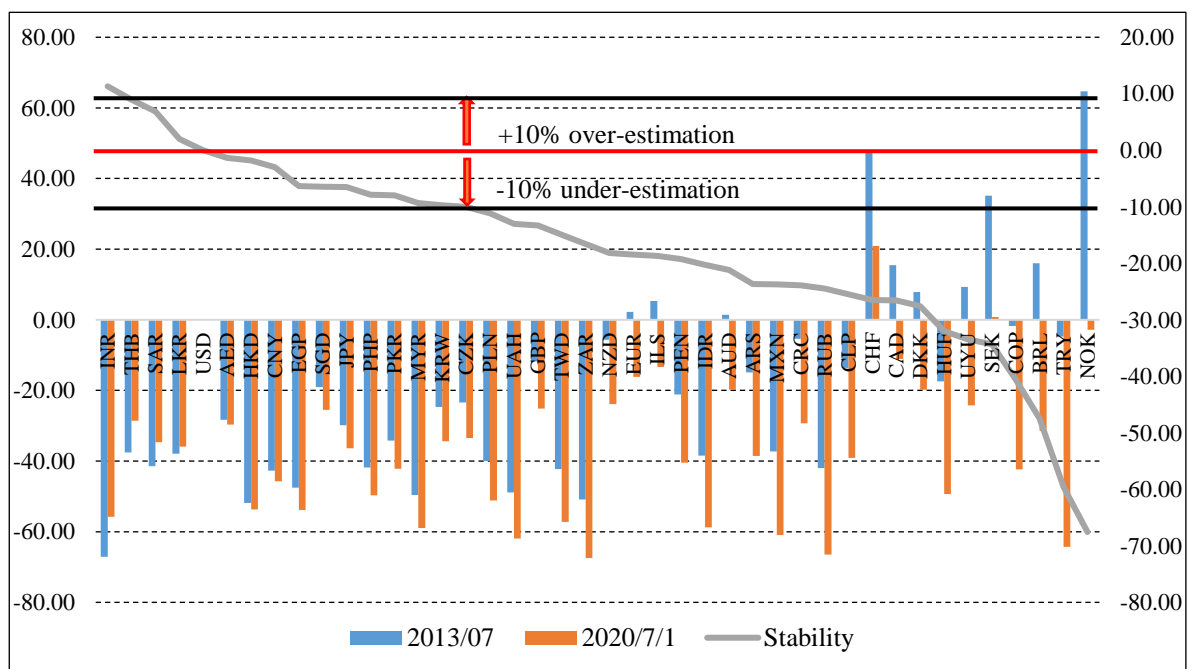
The application of the Big Mac Index in terms of its price-tracking power and exchange rate predictability are mainly dynamic considerations and thus do not undermine the use of the index as a measure of cross-country affordability or real income comparisons. Portes & Atal (2014) used data from 1986 to 2012 to calculate the degree of under-or over-valuation of a set of world currencies and tested whether their evolution tracks the dynamics implied by the Big Mac Index. As an exchange rate prediction tool, they found that, for a particular group of high-income countries, there was some forecasting power in the Big Mac Index as countries gravitate towards a PPP parity rate, but for a large group of emerging markets, their currencies' path diverged from parity.

The purpose of this paper is to track the dynamic stability and convergence of Big Mac Index estimation and to investigate the disparity of real income among countries. Statistical analysis of this paper is implemented using Big Mac Index data from 2013 to 2020 from The Economist and GDP from the World Bank, which selected from 42 countries based on the currencies of US dollars, Euro, British Pound, Chinese Yuan, and Japanese Yen.

2. Big Mac Index Tracking

To conduct the experiments outlined above, namely, the co-movement of Big Mac prices with the predictive power, we used The Economist's proprietary Big Mac dataset of 2013 and 2020 and the World Bank's World Development Indicators for GDP (per capita of nominal and PPP adjusted). According to The Economist, if a currency is conforming to the PPP theory, the undervalued currencies would appreciate and the overvalued currencies would depreciate with an ultimate stable trend and convergent to the basic currency. To test the assumption of The Economist, we calculate the Big Mac Index convergence from 2013 to 2020. During this 7-year period, the stability requires that the variance should be within certain range and the convergence requires that bias-valuation should approach to zero regardless of whether the currencies are over- or under-valued.

Figure 1 shows the Big Mac Index related to US Dollar during the period from 2013 to 2020. Based on the PPP theory, the stability can be defined with the tolerance from -10% to +10% because parity requires an overvalued (undervalued) bias in Dollar in order to be stable. The trend in Figure 1 shows that most countries are depreciated during the 7-year period. Observing the stability, there are 13 countries distributed within -10% to +10%, namely, Thailand (+8.97%), Saudi Arabia (+6.85%), Sri Lanka (+2.00%), UAE (-1.37%), Hong Kong (-1.78%), China (-2.98%), Egypt (-6.33%), Singapore (-6.45%), Japan (-6.48%), Philippine (-7.89%), Pakistan (-7.96%), Malaysia (-9.35%), and South Korea (-9.74%). Most of them are emerging countries. Those more economically stable and relatively high-income countries like Norway (-67.56%), Sweden (-34.31%), Denmark (-27.61%), Canada (-26.53), and Switzerland (-26.51%), on the contrary, are most deviated from the PPP theory.



Source: The Economist and the IMF, July 2013-2020

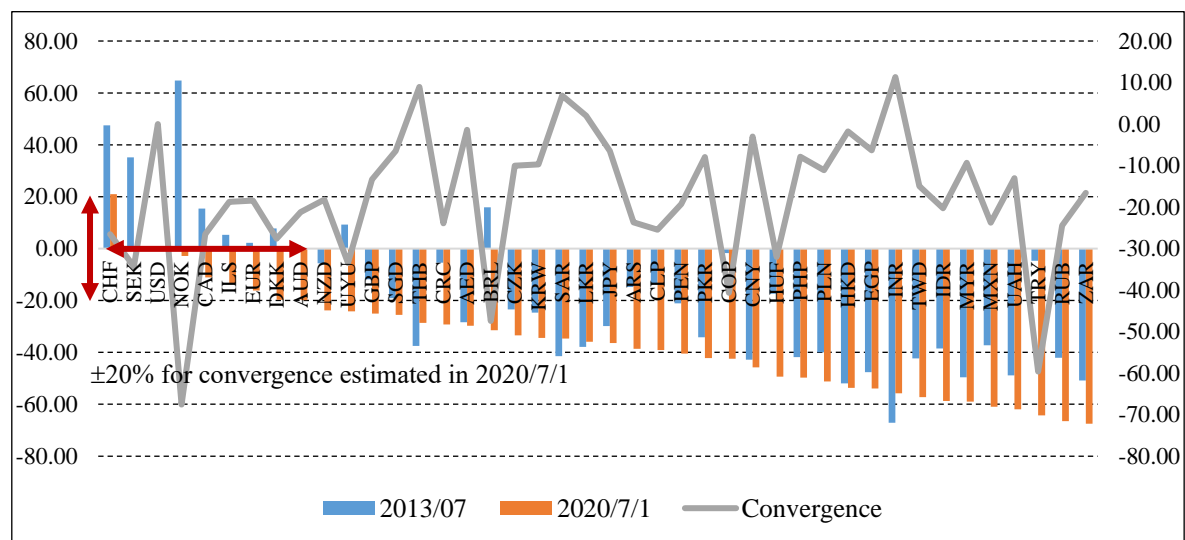
Figure 1. Big Mac Index stability during 2013-2020 (based on US Dollar)

The stability of more established economics between 2013 and 2020 shows the great fluctuation during the 7 years and does not effective. Switzerland Franc (CHF), the second overvalued currency in 2013, however, has been on a depreciation path (-26.51%) but still away from parity (from +47.46% to +20.94%). Most high-income countries show the same

trend of CHF, which fluctuate from great extent, for instance, Denmark (DKK), Canada (CAD), Australia (AUD), Euro area (EUR), New Zealand (NZD), and Britain (GBP). It can be concluded that Big Mac Index based on US Dollar shows a trend of depreciation. Big Mac Index as an exchange rate prediction tool, for a particular group of emerging markets, there is some forecasting power in the BMI as countries gravitate towards a PPP parity rate. For more stable and established countries, however, their currencies' path diverged from parity.

Norway Krone (NOK) in particular, the most overestimated currency to US Dollar in 2013 has been depreciated -67.56% (from +64.74% to -2.82%), which shows large span in the convergence while Big Mac Index closer to the basic currency. Sweden Krona (SEK) is another case with the same trend which depreciated -34.31% during the seven years and moved closer to their PPP rates (+0.80% overestimation only)

For the convergence, we define the Big Mac Index estimated in 2020/7/1 as termination and the Big Mac Index estimation for all countries are convergent with $\pm 20\%$ at the termination. Figure 2 shows the Big Mac Index and convergence during 2013 to 2020 based on US Dollar. Sweden Krona (SEK) is the best case of convergence in 2020/7/1 with only +0.8% overestimation on US Dollar. Those countries qualified for the convergence are Norway (NOK), Canada (CAD), Israel (ILS), Euro area (EUR), Denmark (DKK), and Australia (AUD) with underestimation ranging from -2.82% to -19.82%. As an exchange rate prediction tool, we find that there is some forecasting power in the Big Mac Index as countries gravitate towards a PPP parity rate for a particular group of high-income countries. But this is not the case for a large group of emerging markets since their currencies' path significantly diverged from parity.



Source: The Economist and the IMF, July 2013-2020

Figure 2. Big Mac Index convergence during 2013-2020 (based on US Dollar)

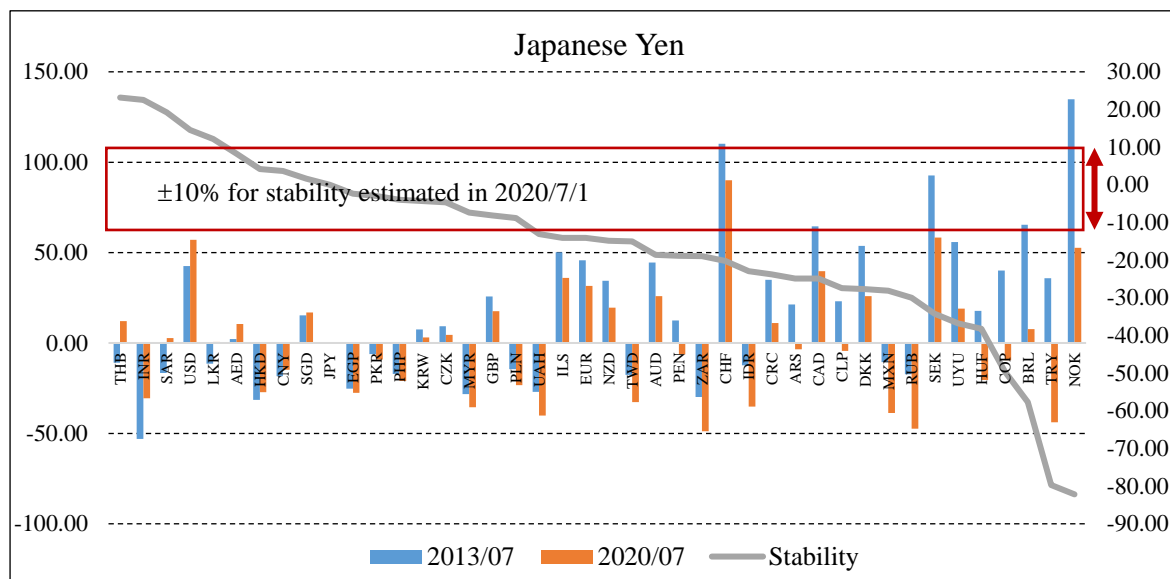
3. Comparison of Stability and Convergence across Base Currencies

The previous section demonstrates the stability and convergence of Big Mac Index based on US Dollar and most of the currencies are undervalued. We find out the consistence among other base currencies that have the most far-reaching influence on international trade markets, including Euro, British Pound, Chinese Yuan, and Japanese Yen. Figure 3 demonstrates the stability of Big Mas Index for 42 countries based on the four currencies respectively.



Sources: The Economist and the IMF

Figure 3. Big Mac Index stability during 2013-2020 (based on different currency) (Cont.)



Sources: The Economist and the IMF

Figure 3. Big Mac Index stability during 2013-2020 (based on different currency)

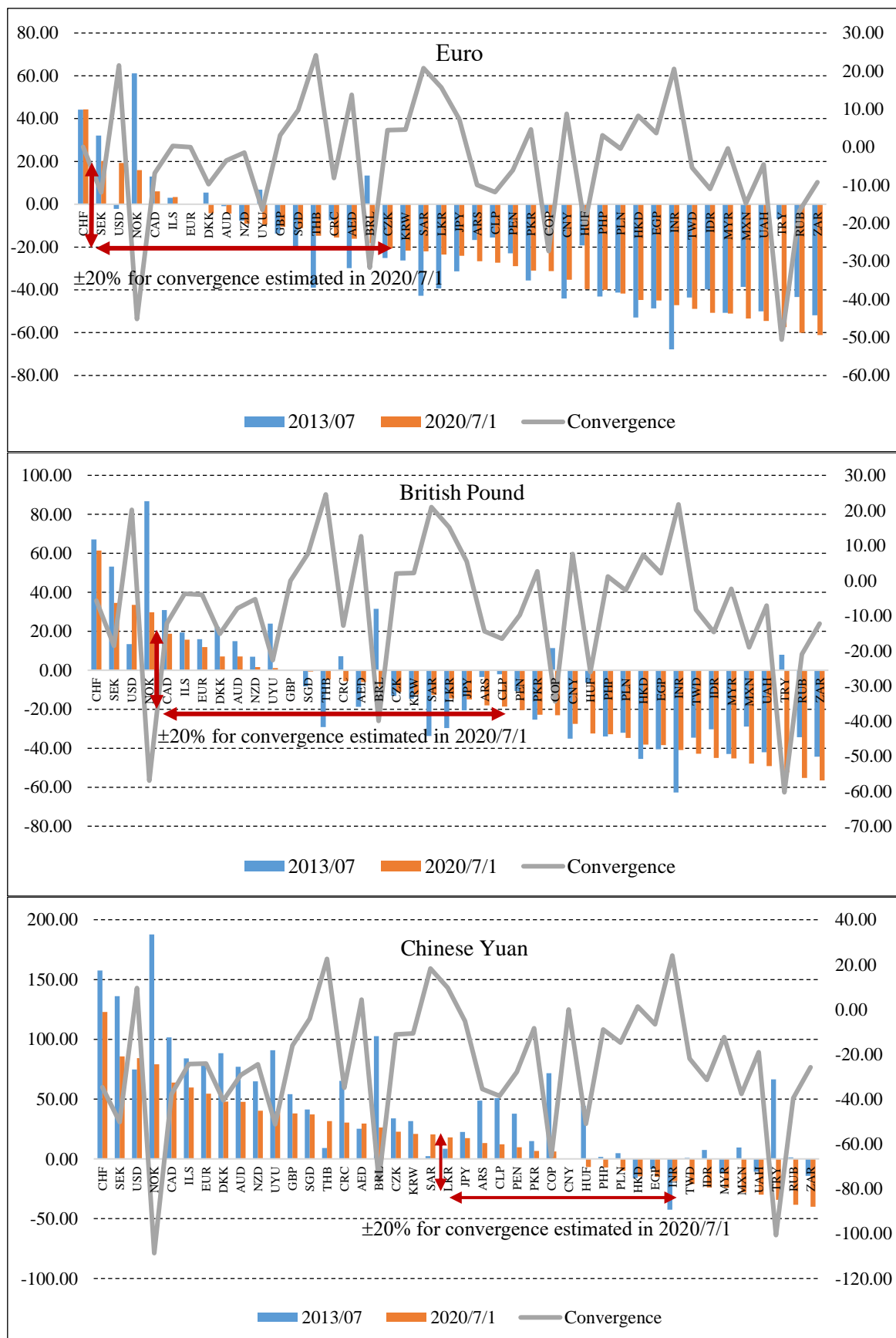
The figures above show a contradictory feature to the US Dollar. From 2013 to 2020, Big Mac Index stability within $\pm 10\%$ estimation bias shows no significantly different among countries of different economic development. The stability inspection of Big Mac Index based on Euro, for example, shows that 10 out of 24 countries are developed countries, including Singapore (+9.71%), Hong Kong (+8.22%), Japan (+7.35%), Britain (+3.09%), Israel (+0.34%), Switzerland (0.08%), New Zealand (-1.41%), Australia (-3.49%), Canada (-6.83%), and Denmark (-9.74%). This is also applicable for British Pound (9 out of 19 countries), Chinese Yuan (5 out of 9 countries), and Japanese Yen (4 out of 12 countries).

In terms of convergence, Figure 4 shows $\pm 20\%$ for convergence estimated in 2020/7/1 based on Euro, British Pound, Chinese Yuan, and Japanese Yen. Israel (ILS) and Denmark (DKK) are the best cases of convergence in 2020/7/1 with only +3.35% overestimation and -4.29% underestimation on Euro respectively. Developed countries show a higher proportion of convergence (10 out of 14 countries) compared with developing ones.

For the convergence on British Pound as base currency, the Big Mac Index is least overestimated for Uruguay (UYU) and least underestimated for Singapore (SGD) with +1.17% and -0.59% in 2020/7/1 respectively. Developed countries and developing countries are nearly the same proportion in convergence (10 out of 19 countries are developed ones).

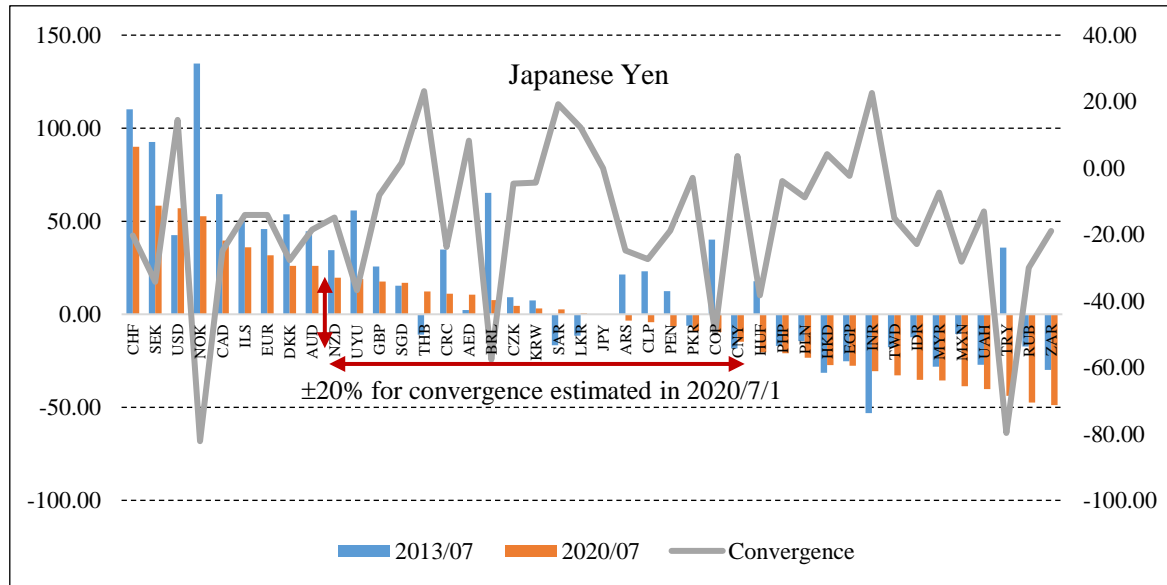
As for the cases of Chinese Yuan and Japanese Yen, the convergence of Big Mac Index estimation differs. Most of developed countries overestimate their currencies against Chinese Yuan except Japan, and the best convergent cases are Colombia (+6.18%) and Hungary (-6.72%). This is also the case of Japanese Yen that only New Zealand (+19.61%), Britain (+17.65%), and Singapore (+16.96%) are within the range of convergence for developed countries. The best convergence cases for Japanese Yen are Sri Lanka (+0.64%) and Argentina (-3.47%).

It can be concluded that developed countries tend to converge their currencies to Euro but do not significantly differ from developing countries in convergence based on British Pound. This is not the case for Chinese Yuan and Japanese Yen because most developed countries overestimate their currencies and the convergence of Big Mac Index does not hold in 2020/7/1.



Sources: The Economist and the IMF

Figure 4. Big Mac Index convergence (based on different currency) (Cont.)



Sources: The Economist and the IMF

Figure 4. Big Mac Index convergence (based on different currency)

4. Measures of Affordability Overtime

Portes & Atal (2014) studied the accuracy of exchange rate movement predictions of Big Mac Index based on US Dollar and found that Big Mac Index tends to lag overall inflation rates. As a guide to exchange rate movements, it supports the theory of PPP but only as a qualitative indicator of movement in the nominal exchange rate in rich and economically stable countries. Big Mac Index proves less effective in forecasting exchange rate movements in emerging markets. Our results from previous section call into questions of the accuracy of Big Mac Index between developed countries and developing countries measured by different currencies.

To address this issue further, correlation analysis of GDP per capita (nominal and PPP adjusted) and Big Mac Index estimation are conducted based on different currencies. As a proxy for currency valuation, the Big Mac Index affordability is associated with GDP per capita to reflect real income disparities among countries. According to the theory of PPP, developed countries with higher nominal income levels should overvalue their currencies by Big Mac Index and developing countries should undervalue theirs across five base currencies. The theory of PPP will hold and there should be no significant correlation of Big Mac Index and PPP adjusted GDP per capita.

Table 1 presents the correlation coefficients of Big Mac Index and GDP per capita, measured by nominal and PPP adjusted GDP per capita for 2013 and 2020 respectively. The Big Mac Index is highly correlated with nominal GDP per capita for both 2013 ($r = 0.6966$) and 2020 ($r = 0.7514$), and the latter is slightly higher than the former. The figures for nominal GDP per capita in 2013 and 2020 are higher than the figures for PPP adjusted GDP per capita ($r = 0.4537$ for 2013 and $r = 0.5614$ for 2020 respectively). The results conform to the PPP theory because PPP adjusted GDP per capita would tend to converge towards purchasing power across income levels. Meanwhile, the correlation coefficients of 2020 are all higher than the figures of 2013, suggesting that distortion of the economic index after 7 years converges to its real value.

Correlation coefficients measured by convergence in Table 1 show the correlation

between normal value (overestimation or underestimation of Big Mac Index to the base currency) and GDP per capita (nominal and PPP adjusted) as well as absolute value (absolute value of biased-estimation of Big Mac Index to the base currency) and GDP per capita (nominal and PPP adjusted). Contradictory to previous study (Portes & Atal, 2014), the relationship does not hold for both normal and absolute values to both nominal and PPP adjusted GDP per capita because of insignificant correlation coefficients for all cases ($|r| \leq 3$). Results of correlation analysis in Table 1 do not support the viewpoint that the developed country is to be more stable in local prices and exchange rates, and this is applicable for all base currencies.

Table 1. Correlation Coefficients of Big Mac Index and GDP per capita

Big Mac Index	Nominal GDP per capita	PPP adjusted GDP per capita
2013	0.6966	0.4537
2020	0.7514	0.5614
Convergence (US Dollar)		
Normal value	-0.2515	-0.0224
Absolute value	0.2066	-0.0353
Convergence (Euro)		
Normal value	-0.0491	0.1304
Absolute value	0.0056	-0.0632
Convergence (British Pound)		
Normal value	-0.0888	0.1015
Absolute value	0.0508	-0.0673
Convergence (Chinese Yuan)		
Normal value	-0.2027	0.0156
Absolute value	0.1584	-0.0661
Convergence (Japanese Yen)		
Normal value	-0.1597	0.0485
Absolute value	0.1150	-0.0780

Source: The authors

5. Conclusion

This study aims to characterize the application of the Big Mac Index in terms of its accuracy between developed countries and developing countries. These are mainly dynamic considerations and thus do not undermine the use of the index as a measure of cross-country affordability or real income comparisons. Based on correlation coefficient test, the figures of Big Mac Index in 2013 and 2020 show strong positive relationship with nominal GDP per capita. This indicates that the Big Mac Index overvalues the currencies for developed countries on based currencies. The correlation coefficients of Big Mac Index in 2013 and 2020 are less positive related to PPP adjusted GDP per capita, demonstrating the existence of parity for the two periods. As an exchange rate prediction tool, there is some forecasting power in the Big Mac Index as countries gravitate towards a PPP parity rate for a particular group of emerging markets, but the dynamic paths of currency paths for more stable and established countries diverged from parity.

There is no doubt that any study based on the Big Mac Index considering a time dimension ought to be taken with caution, particularly if they seek to capture or proxy for any features of aggregate price dynamics. A multilateral currency misevaluation estimate

based on an equal-weight index does not necessarily provide a reasonable approximation to the estimate of a more economically-meaningful currency index. Meanwhile, even Big Mac Index shows that US Dollar is less effective to reflect the local purchasing power across countries, declaring a currency to be mispriced is fraught with uncertainties. These uncertainties are explicitly recognized even in a model of pricing a homogeneous commodity around the world. This allows for a common driver of prices, due to a base-currency effect, and country-specific factors that lead to departures from PPP on account of income differences, local taxes, and charges, etc.

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