Would You Like Fries With Burgernomics? Exploring the Big Mac Index and its Surrounding Studies

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1 Introduction

In 1986, economists from the *Economist* created a lighthearted guide called the Big Mac Index to show whether currencies are at the "correct" level.[1] Since then, many economists have studied the Big Mac index in more detail, through including the prices of individual ingredients in the Big Mac index and measuring the performance of the Big Mac index. This paper will summarize the Big Mac index and its surrounding studies. Section 2 introduces the Big Mac index and applies it to a particular country. Section 3 explains deviations from PPP and non-traded goods. Section 4 covers economic studies done on the Big Mac Index.[2]

2 Introducing the Big Mac Index

Purchasing-power parity (PPP) is the theory that explains the movements in the exchange rate between two countries' currencies by changes in the countries' price levels, usually through a market "basket" approach. Two currencies are in equilibrium when items in a market "basket" are equivalently priced after accounting for the exchange rate.[3] The Big Mac index is based on PPP, where the only item within the basket is a Big Mac. Thus, two currencies are in equilibrium when the price of the Big Mac equalizes after accounting for exchange rate. The Big Mac index is calculated for 48 different countries (including "Euro area").

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[1] The original post: "On the Hamburger Standard," *Economist*, 1986.

[2] The Big Mac index has become a global standard. The *Economist* (1986) claims it is the subject of at least 20 academic studies, two of which will be mentioned in this paper.

[3] Definition given by Krugman et. al. Mathematically, PPP is expressed as $P_{US} = E * P_{Euro}$ where E is the exchange rate of USD/Euro.
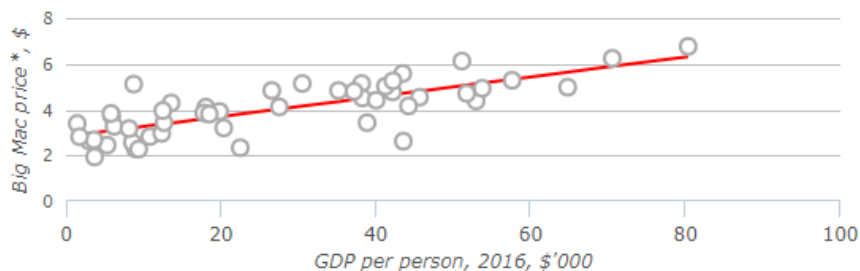
Figure 1: Big Mac prices vs GDP per person in 2016. Source: *Economist*

There are two versions of the Big Mac index: the raw index and the adjusted index. The raw index only accounts for the average price of the Big Mac within a country. The adjusted index uses the relationship between prices and GDP per person. The prices for a Big Mac are given based on the regression between Big Mac prices and GDP per person, shown in Figure 1. This is an attempt to adjust for the differences in input prices, such as labor costs, in different countries. For example, richer countries would price the Big Mac to be more expensive due to higher labor costs. Symmetrically, poorer countries would have lower prices of the Big Mac due to lower labor costs.

Absolute PPP tells us that the prices for a Big Mac are equal around the world, but that is not the case. To observe this, let the USD be the base currency. Figure 2 shows the prices of Big Macs around the world relative to the price of a Big Mac in the United States in terms of over- or undervaluation against the dollar when using the raw index. Upon first glance, the Big Mac prices in many countries, especially in East Asia and Eastern Europe, are undervalued relative to the dollar. When we use the adjusted index, half of the countries overvalue the price of the Big Mac relative to the dollar. There are 16 countries that are within ±10% of over-/ undervaluation relative to the dollar. This is seen in Figure 3.[4]

Using the Big Mac Index interactive app, I take a further look into two countries: China and the US.[5] Once again, assume US is the base currency. First, we look into the raw index. In 2018, the average Big Mac price in the US is \$5.28, while the average price of the Big Mac price in China is \$3.17 (or 20.40 RMB). We plug these values into the PPP equation

$$P_{US} = E * P_{CN}$$

$$5.28 = E * (20.40)$$

$$E_{implied} = 0.26$$

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[4]Graphics are taken from "Big Mac Index", *Economist*, 2018.

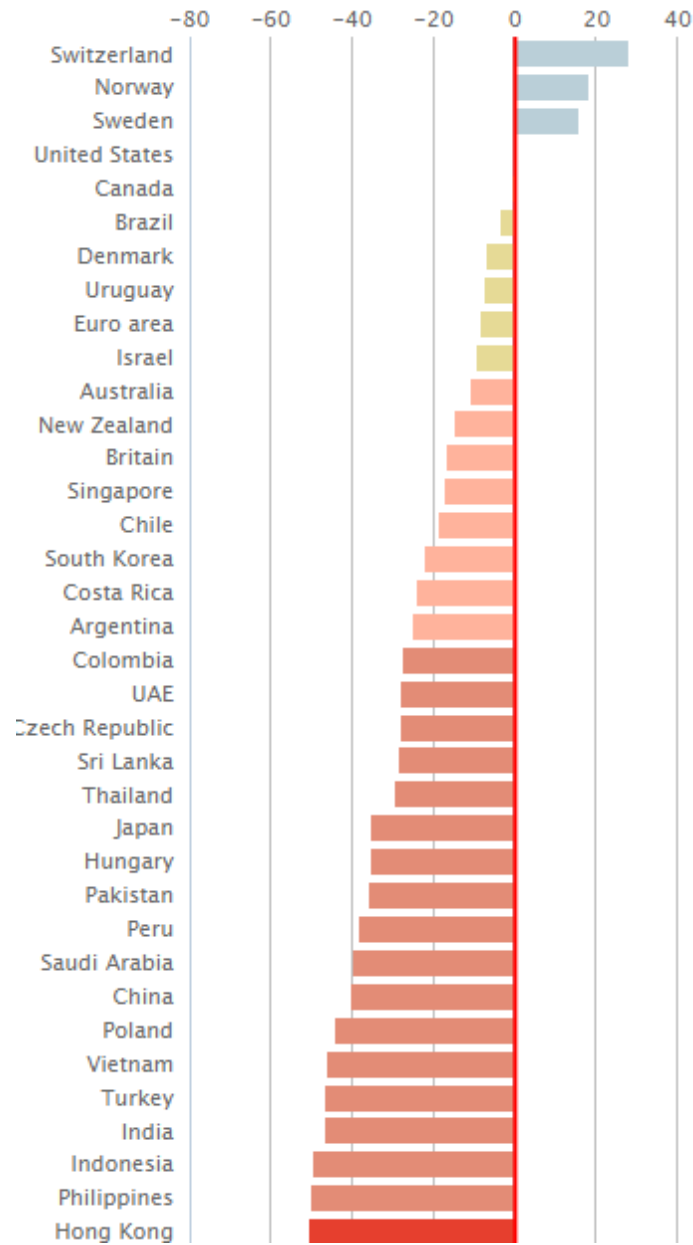[5]You can play around with the data visualization here: `https://www.economist.com/content/big-mac-index`

Figure 2: The over-/ undervaluation of the Big Mac relative to USD in Jan 2018. Raw index. Source: *Economist*
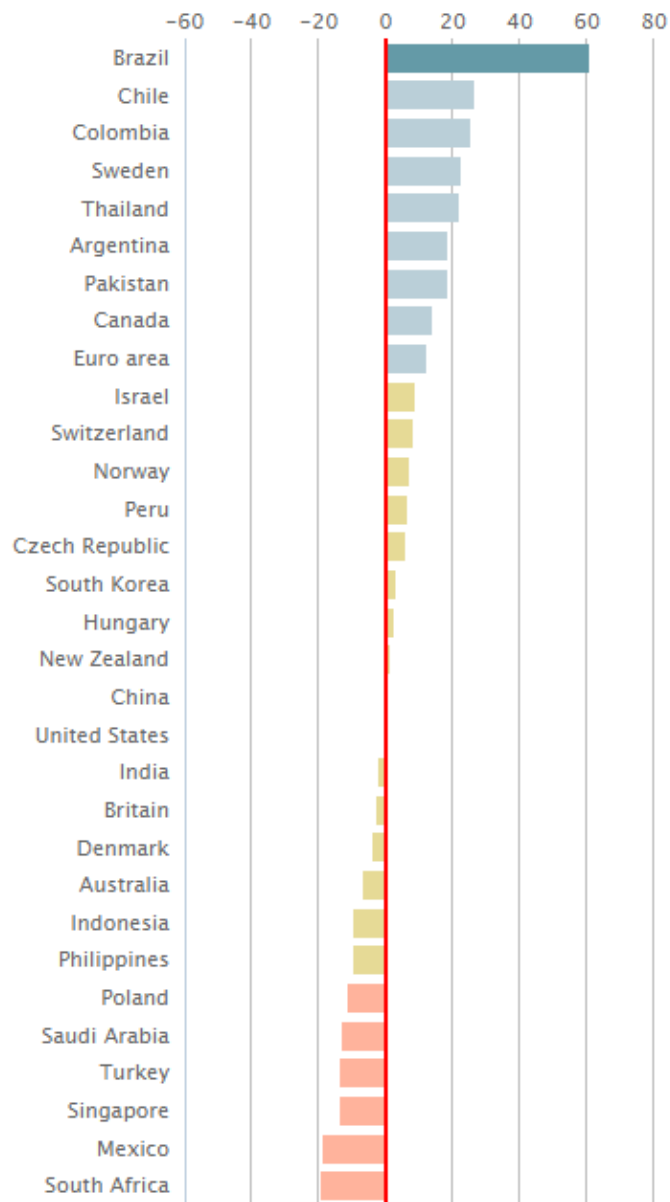
Figure 3: The over-/ undervaluation of the Big Mac relative to USD in Jan 2018. Adjusted index. Source: *Economist*
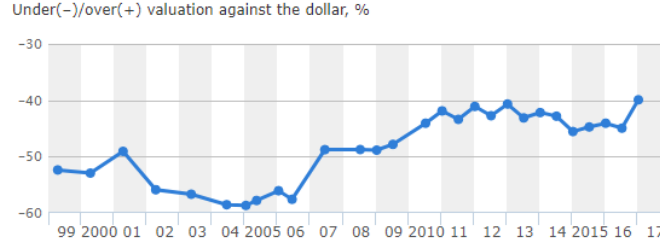
Figure 4: The undervaluation of the Big Mac in RMB relative to USD in Jan 2018. Raw index. Source: *Economist*
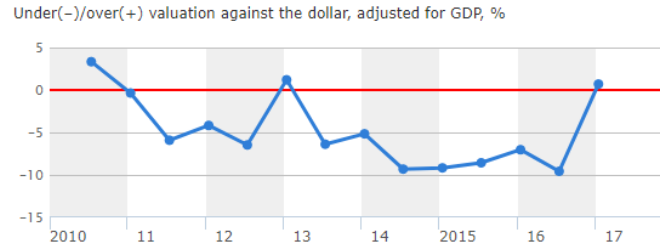

Figure 5: The valuation of the Big Mac in RMB relative to USD adjusted for GDP in Jan 2018. Adjusted index. Source: *Economist*

Here, $E_{implied}$ is the exchange rate (USD to RMB) that we expect to get based on PPP. However, the actual exchange rate is $E_{actual} = 0.16$. Clearly, PPP does not properly predict the actual exchange rate, and the Chinese RMB is undervalued relative to the USD. Looking at Figure 4, the Chinese currency has been undervalued relative to the equilibrium exchange rate for years before 2018 as well. When we adjust for GDP, the price of the Big Mac in China is not as dramatically undervalued relative to the US dollar.

Both the adjusted and unadjusted Big Mac indicies do a good job in explaining a country's exchange rate policies. Turning back to China and the US, it should be no surprise that China undervalues its currency relative to the USD, since China is export-oriented. Undervalued currency implies that Chinese exports are cheaper, so China will export more at the cost of more expensive imports. Similarly, the Big Mac index shows that the Asian "Tigers", such as Hong Kong and Singapore, also undervalue their currencies relative to the USD to promote exports and drive growth. In 1986, the hamburger in the US cost 64% more than that in Hong Kong and 23% more than that in Singapore.

3 Violations of Absolute PPP: Non-traded goods and Relative PPP

What accounts for the violations of the PPP theory when looking at the Big Mac index? What are the shortcomings to the Big Mac index? The *Economist* notes many factors that contribute to the shortcomings of PPP: transport costs, government regulations, product differentiation, and non-traded goods[6].

Non-traded good can only be consumed domestically and cannot be imported nor exported. Since non-traded goods are priced based on domestic supply and demand, prices of non-traded goods, such as rent or electricity, vary from country to country. The pricing of non-traded goods play a large role in pricing the traded good and change the real exchange rate even though the terms of trade do not change.

To show this, consider the small country case, where the country is a price-taker. Let P_{TG} be the world price of traded goods, so the price of traded goods in within the price-taking country is $P_{TG} = P_{TG}^*$ (i.e. set by the world price).[7] Although P_{TG} is exogenous and is independent of the exchange rate, exchange rate policy can still affect the relative price of the traded good to the non-traded good, $\frac{P_{TG}}{P_{NTG}}$, where P_{NTG} is the price of the non-traded goods. Consider the domestic currency depreciates against the foreign currency (increase in E). Relating the relative price of traded-goods to non-traded goods domestically to that of the world, we get the following equation

$$\frac{P_{TG}}{P_{NTG}} = \frac{EP_{TG}^*}{P_{NTG}} \tag{1}$$

Using (1), an increase in E will cause an increase in P_{TG}. The quantity consumed of the traded good will decrease while the quantity produced of the traded good will increase, which increases $\frac{P_{TG}}{P_{NTG}}$. Consider the real exchange rate

$$q = \frac{EP^*}{P} \tag{2}$$

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[6]Non-traded goods here are synonymous with nonfood inputs. These include rent and electricity.

[7]Assume P_{TG} consists of two goods A and B, such that

$$P_A = EP_A^*$$
$$P_B = EP_B^*$$

Therefore, $P_{TG} \equiv \frac{P_A}{P_B} = \frac{P_A^*}{P_B^*} \equiv P_{TG}^*$

The real exchange rate can be expressed in terms of traded goods and non-traded goods, so

$$q = \frac{E P_{TG}^*}{P_{NTG}} \tag{3}$$

Intuitively, the the price-taking country takes on the world price of the traded good, while non-traded goods are priced domestically. In conclusion, for a price-taking country, a depreciation of the domestic currency will cause price of the traded good to increase domestically to the world price. The depreciation also causes the real exchange rate q to increase without changing the terms of trade. Through this example, we see that P_{NTG} influences the pricing of domestic goods.[8] We now apply this analysis to the Big Mac index.

First, the Big Mac itself is a non-traded good. Because there are few close substitutes for the Big Mac, product differentiation gives McDonald's some power to adjust prices based on the local market. The Big Mac exists in an imperfectly competitive market, so arbitrage opportunities through buying and selling Big Macs are hard to capitalize on.

Second, even if the Big Mac were a traded good, it is made up of traded and non-traded inputs. The non-traded inputs will drive the Big Mac to deviate from the PPP price. The ingredients, such as beef, cheese, lettuce, and tomato, are all traded inputs that should obey law of one price, and thus also PPP.[9] Nonfood inputs such as electricity and rent are non-traded inputs that change the local price of the burger depending on a country's infrastructure and endowment.

Third, government interventions, like taxing unhealthy foods to incentivize people to eat healthier[10] or setting trade barriers, will influence the local price of the Big Mac. Therefore, these distortions will cause the price of the Big Mac to deviate from the Big Mac index.

Finally, while the adjusted Big Mac index is adjusted by GDP, we can also consider using relative PPP. Relative PPP is expressed mathematically

$$\frac{E^e - E}{E} = \pi^e - \pi^{e*} \tag{4}$$

where π^e is the expected percentage price change increase (inflation). Intuitively, relative PPP predicts the relationship between changes in prices and changes in exchange rates, so it holds more often than absolute PPP since we are measuring changes rather than measuring levels. Furthermore, since relative PPP is derived from absolute PPP, if absolute PPP holds, then relative PPP holds.[11] Assuming relative PPP holds, if the Big Mac price in the US goes

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[8] There are other cases to consider, such as the semi-small country case or rigid country case. These will not be described in this paper.

[9] Here, we assume that there are no tariffs imposed on the ingredients.

[10] This is a hypothetical example, which follows the thinking of having a soda tax.

[11] The converse does not need to be true. If relative PPP holds, it does not imply absolute PPP holds.

| | Regression in Levels | | Change Regression |
Ingredient	Coefficient Estimates[1]	Implied Cost Share (%)[2]	Coefficient Estimates[3]
Traded:			
Beef	3.010 (0.645)	9.0	2.257 (0.669)
Cheese	2.530 (0.592)	9.4	1.995 (0.625)
Lettuce	1.546 (3.645)	0.7	6.017 (3.476)
Onions	1.156 (3.610)	0.5	4.411 (3.239)
Bread	13.428 (3.053)	12.1	11.256 (3.200)
Nontraded:			
Labor	9.245 (0.832)	45.6	11.823 (1.069)
Rent	0.008 (0.003)	4.6	0.010 (0.004)
Electricity	0.085 (0.027)	5.1	0.078 (0.039)
		Total = 86.9%	
# of observations	318		284
Adjusted R-squared	.95		.66

Table 1: Regression of Big Mac prices on prices of eight factors. Source: Parsley and Wei (2003)

up by 5% and the Big Mac price in China goes up by 3%, it must be true that the exchange rate also goes up by 2%.

4 Further Studies on the Big Mac Index

In the previous section, I mentioned that the Big Mac index is far from perfect, particularly in the deviations from the PPP. In this section, I summarize two studies that addresses the shortcomings of the Big Mac index: Parsley and Wei (2003) and Cumby (1996).

In Parsley and Wei (2003), they matched prices of the Big Mac to the prices of the individual ingredients to study the movement of real exchage rates. They found that the Big Mac real exchange rates are highly correlated with the CPI-based exchange rates. Of the sample of 561 possible real exchange rates in the dataset, 61% of them had correlation coefficients greater than 0.65, with a median correlation coefficient of 0.889. This motivated the use of the Big Mac index compared to more traditional ways of measuring real exchange rates (i.e. using CPI-based exchange rates).

Next, Parsley and Wei regressed the price of the Big Mac on eight factors: five traded factors (beef, cheese, lettuce, onions, bread) and three nontraded factors (labor, rent, electricity). Table 1 summarizes the results of the regression. These eight factors account for 86.9% of the price of the Big Mac. Of these factors, the nontraded factors account for 55.3% of the Big Mac prices, which implies that nontraded factors are an important component of

Big Mac prices. Finally, Parsley and Wei showed that the deviations from the law of one price in tradeable goods do not add much to movements in real exchange rates.[12] Many government interventionist policies, such as pegging currencies, trade agreements, and tariffs, weakens the effect between real exchange rate and law of one price deviations. In conclusion, the results of Parsley and Wei (2003) suggest that the PPP "violations" mentioned earlier are largely affected by non-tradeable inputs such as labor, rent, and electricity. The regression of Big Mac prices on eight input factor prices is an important innovation to the Big Mac index model.[13]

Cumby (1996) studied the usefulness of the deviations from the Big Mac parity. Primarily, Cumby wanted to answer three questions:

1. Do the deviations from the Big Mac parity tend to return to the Big Mac parity?

2. Do deviations from the Big Mac parity forecast future exchange rates?

3. Do deviations from the Big Mac parity forecast changes in the local currency prices of the Big Mac?

Cumby's Big Mac parity adjusted for currency and time effects. First, Cumby found that a half-life of deviations from the Big Mac parity is 1 year, suggesting that these deviations are not permanent. Second, Cumby found that a 10% undervaluation in the Big Mac standard is associated with a 3.5% appreciation in the following year. Third, Cumby found that when U.S. dollar price of Big Macs is high in a country, local currency price of Big Macs in that country is likely to fall during the following year. In the first and third tests, Cumby regressed the Big Mac parity exchange rate (i.e. $\frac{P_{i,t}}{P_{US,t}}$) on itself in the previous period with shock and persistence variables.[14] In the second test, Cumby regressed the exchange rate on the lagged Big Mac parity exchange rate with shock and persistence variables.[15] The results from Cumby (1996) imply that the devations from the Big Mac index, and therefore PPP, are only temporary and are helpful in forecasting future exchange rates.

5   Conclusion

The Big Mac index is a reader-friendly way to explain whether the exchange rate is in equilibrium between two countries. In other words, it is easy to tell whether the currency

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[12]The movement of the real exchange rate are attributed to the deviations from the law of one price is called the Engel effect.

[13]All numbers from Parsley and Wei (2003). Read the paper for more in depth modeling.

[14]This is explained in Cumby (1996), p.3-7. The same technique. A variation of this technique is used to answer question 3.

[15]Explained on Cumby (1996), p. 9-10

in question is over- or undervalued relative to the base currency. While it is tempting to conclude that the PPP does not hold in real life and arbitrage opportunities arise from the Big Mac index, the raw index does not reflect the factors that contribute to the over- or undervaluation of currency. These factors include transport costs, government regulations, product differentiation, non-traded goods, and ingredient prices.

Economists have further studied the Big Mac index. Studies, such as Parsley and Wei (2003) and Cumby (1996), explained the deviations from the Big Mac index and further adjusted the Big Mac index through accounting input factors and fixed effects. On one hand, the deviations from law of one price of tradable inputs do not play a huge role in affecting the real exchange rates. On the other hand, the deviations from the Big Mac parity are helpful in predicting future exchange rates. As economists dig deeper into the Big Mac index question, there are more caveats to consider, and the Big Mac index becomes harder to digest.

6 References

"On the Origins of the Hamburger Standard." *The Economist*, 1986, `www.economist.com/news/business-and-finance/21639762-our-article-1986-introducing-big-mac-index-origins-hamburger-standard`.

Cumby, Robert. 1996. "Forecasting Exchange Rates and Relative Prices with the Hamburger Standard: Is What You Want What You Get With McParity?". *NBER Working Paper Series* #5675.

Golub, Stephen. 2018. "The Terms of Trade and the Real Exchange Rate: The Dependent Economy Model". Lecture notes.

H., D. "The Big Mac Index". *The Economist*, 2018. `https://www.economist.com/content/big-mac-index`.

Krugman, Paul R., et al. *International Economics Theory and Policy*. Pearson, 2017.

Parsley, David. 2003. "A Prism Into the PPP Puzzles: The Micro-foundations of Big Mac Real Exchange Rates". *NBER Working Paper Series* #10074.