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Law of one price: BigMac versus Fortnite - A Note

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Abstract

We analyze the law of one price (LoP) based on BigMac and Fortnite prices. We find a positive but less than perfect correlation between the over-/undervaluations of the two indices. While we cannot reject the LoP for the Fortnite data, we find that it does not hold for the BigMac data.

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1. Introduction

Fortnite is a so-called 'Player versus Player (PvP)' game where 100 participants compete online against each other. It is part of the 'Battle Royale' genre, a survival-based game. By using a kind of parachute, players land on an island, and they then collect weapons and other materials to eliminate each other. After a few minutes, a storm approaches, shrinking the playable map, so that the combat activities get more and more intense. The last person on the island wins an *'Epic Victory'* (Nicolaou 2019).

While the game is very successful, parents all over the world are scared of the excess gaming behavior of their children and would like to get them out of the 'Fortnite trap'. Kids do not only spend a lot of time, but also a lot of money on items from the in-game-shop.[1] The shop offers a large variety of uniforms ('skins'), parachutes ('gliders'), dance moves ('emotes'), which can be bought by using a Fortnite specific virtual currency called *V-Bucks*. In order to go shopping, the national currency has to be converted into V-Bucks. Our study is the first study that analyzes a virtual currency of a video game.[2]

Specifically, we use the fact that V-Buck prices are set in a large number of national currencies to study the law of one price (LoP). The LoP stipulates that that the prices of homogeneous goods, when expressed in a common currency, are the same in different countries provided free trade prevails, there are no transaction costs, and preferences are the same across borders (Krugman et al. 2012). When the LoP holds then players from different countries can buy Fortnite equipment at the same price when the latter is denominated in a common currency. The main idea of our research is that the LoP should hold to a stronger extent for Fortnite equipment than for conventional goods because of the absence of transportation costs and trade barriers.

[1] In the last two years, Fortnite was the best-selling video game which generated \$2.4 bn (2018) and \$1.8 bn. (2019) in revenues (SuperData 2019 and 2020).

[2] However, numerous studies deal with the virtual currency *Bitcoin* and examine, whether the law of one price holds across several Bitcoin market places (Pieters and Vivanco 2017 or Kroeger and Sarkar 2017).

In order to the LoP, we use the well-known BigMac index as a benchmark. Our first hypothesis is that there is a positive correlation between the under-/overvaluations measured by the BigMac and the Fortnite index. Because V-Bucks are virtual goods, our second hypothesis is that the degree of under-/overvaluation is smaller as compared to that of the BigMac. In fact, arbitrage in Fortnite V-Bucks should be much easier than in BigMacs, which contains several non-tradable components. A gamer could use a VPN client and mislead Fortnite to believe, that he or she is, for example, in Indonesia where 1,000 V-Bucks cost 100,000 Rupiah = \$7.04 instead of \$9.99 in the US (-29.5%).

Our empirical results for a sample of 26 countries support our hypotheses. The under-/overvaluation measured in mid-2019 using V-Bucks is significantly smaller (in absolute value) than the under-/overvaluation implied by the BigMac index. Moreover, the under-/overvaluation of V-Bucks is not significantly different from zero on average across countries. It, thus, appears that in the online world of video games, the border is much less wide than in the real-world (on the latter, see Engle and Rogers 1996).

The paper is structured as follows: In Section 2, we briefly review the literature. Section 3, we address methodological issues. In Section 4, we describe the data and the empirical results. In Section 5 ,we conclude.

2. Brief Literature Review

A popular way of studying the LoP is to use the BigMac index developed by the *The Economist* journal in the 1980s. The BigMac is a more or less homogeneous good (no differences in quality) and preferences can be assumed to be relatively homogeneous around the world. Of course, the BigMac is not a tradable good. However, several factors of production such as land, labor, capital, as well as several ingredients are necessary to create a BigMac (The Economist 2020). Therefore, the BigMac price can also be interpreted as a producer price index (PPI) or consumer price index (CPI). For example, Parsley and Wei (2007) show that there is a tight positive correlation between the BigMac index and the CPI index.[3]

Due to the positive correlation between the CPI index and the BigMac index, one might think that these indices could be regarded as substitutes. However, this intuition is misleading: Chen et al (2007) examine both indices in a study of purchasing power parity (PPP), where they employ methods of panel econometrics. They conclude that PPP has to be rejected when CPI price is used but based on BigMac index. As a consequence, their results show that the BigMac index is more supportive to the validity of PPP than CPI price indices.

One advantage of the BigMac index is that its *level* can be interpreted, which is not the case with a regular CPI index, where only changes of the CPI index can be interpreted as inflation. Another advantage is, that the composition of the BigMac itself is fixed: It is constant over time as well as in the cross-section between countries. This is also an important difference compared to a CPI index, because the underlying basket of goods is not identical in the cross-section. Furthermore, the quantity structure of the consumption basket changes over time due to, for example, product innovations. Using the BigMac index helps to avoid several aggregation biases (Parsley and Wei 2007, p. 1337).

Parsley and Wei (2007) also emphasize that it is important to disentangle a BigMac into its *tradable* and *non-tradable* components.[4] Their estimates point into the direction that the non-tradeable components have a higher share of the implied cost compared to the tradable components. In particular, labor is a very important non-traded component that influences overall cost by more than 45 % (Parsley and Wei 2007, p. 1342.) They find that the non-traded components display greater cross-country price dispersion than the traded components. Furthermore, they show that the speed of adjustment toward LoP for tradable inputs is faster than for the

[3] In an early study, Cumby (1996) reports that the BigMac helps to explain subsequent changes in the exchange rate.

[4] Similarly, Pakko and Pollard (2003, p. 22) argue that the BigMac price is a *"composite of tradable commodities and non-tradable service content"*.

non-tradable inputs. The estimated half life for tradables varies between 0.7 years (onions) and 2.4 years (bread). In contrast to his, the half life of non-tradables varies between 2.4 years (labor) and 4.1 years (rent). The convergence rate for the BigMac real exchange rate is estimated to be 1.8 years (Parsley and Wei 2007, p. 1344).

Froot et al. (2019) analyze the law of one price over a time period of 700 years. Their study is relevant for our research in so far as the subjects of their analysis are seven commodities (barley, butter, cheese, oats, peas, silver, and wheat), some of which can be regarded as input factors for a BigMac. Froot et al. (2019, p. 1) examine whether the magnitude, volatility, and persistence of deviations from the LoP have changed over time. Because they do not find a strong decrease of these measures over time, they conclude that their findings are in line with the *"growing evidence that goods-market arbitrage remains highly imperfect, even today."*

In a recent study, Clements et al. (2020) use retail prices from the International Comparisons Program (World Bank) in order to examine the LoP by running cross-country and cross-commodity regressions for a substantial number of food items and countries. They conclude that, while price disparities can be substantial and persistent in the short run, there seems to be mean-reversion towards the LoP over time.[5]

3. Hypotheses & Methodology

We test two hypotheses in our empirical research. H1: The correlation between the under-/overvaluations measured by the BigMac and the Fortnite index is positive. H2: The degree of under-/overvaluation is smaller for

[5] In order to meet the space restrictions of the journal, we had to keep our literature survey brief. For more information, we refer a reader to the following survey papers: Clements et al. (2012) for a survey on two decades of Burgernomics research. Bahmani-Oskooee and Nasir (2005) survey the literature on the relationship between the productivity bias (Balassa-Samuelson effect) and PPP. Drine and Rault(2008) summarize the PPP literature and differentiate between developing and developed countries, and Bahmani-Oskooee and Hegerty (2009) focus on less-developed and transition economies.

V-Bucks as compared to that of implied by the BigMac index.

We apply the following methodologies to test our two hypotheses:

1. We estimate a regression equation by the ordinary-least-squares technique for the misalignment based on the V-Bucks data on a constant and the misalignment based on the BigMac data: $\text{Misalignment Fortnite}_i = \alpha + \beta \cdot \text{Misalignment BigMac}_i + \epsilon_i$. In case the misalignments are positively correlated, the slope parameter of this regression equation should be significantly positive.

2. We apply t-tests to test whether the cross-country mean difference between the absolute misalignment implied by the BigMac index and the absolute misalignment implied by the Fortnite index is zero against the alternative that this difference is positive.

4. Data & Empirical Analysis

In order to set up our data set, we used a press release of the Fortnite developer *Epic* (2019). We then cross-checked the data by visiting the Internet pages of national *PlayStores*. By also visiting the Internet pages of the PlayStore shop, we were able to increase the list of countries in our sample data to include Brazil, Croatia, Indonesia, and Romania. We also realized that in the PlayStores of some countries – for example, Mexico – prices are set in U.S. dollars. We decided to include only countries where prices are set in local currency. In total, we analyzed data for 26 countries. The BigMac data (07/2019) were taken from the *Economist's* webpage, and exchange-rate data from PACIFIC Exchange Rate Service.

Figure 1 displays the degree of under-/overvaluation by country for the BigMac and the Fortnite data. The figure helps to illustrate the idea underlying the BigMac concept by means of a numerical example. A BigMac is sold for 13.99 TRY in Turkey and 5.74 USD in the United States, which gives an equilibrium exchange rate of $e^* = 13.99$ TRY / 5.74

USD = 2.44 TRY/USD. By computing the relative difference between the equilibrium and the current exchange rate, the degree of undervaluation is determined: $(e^* - e)/e = (2.44 - 5.72)/5.72 = -57.4\%$.

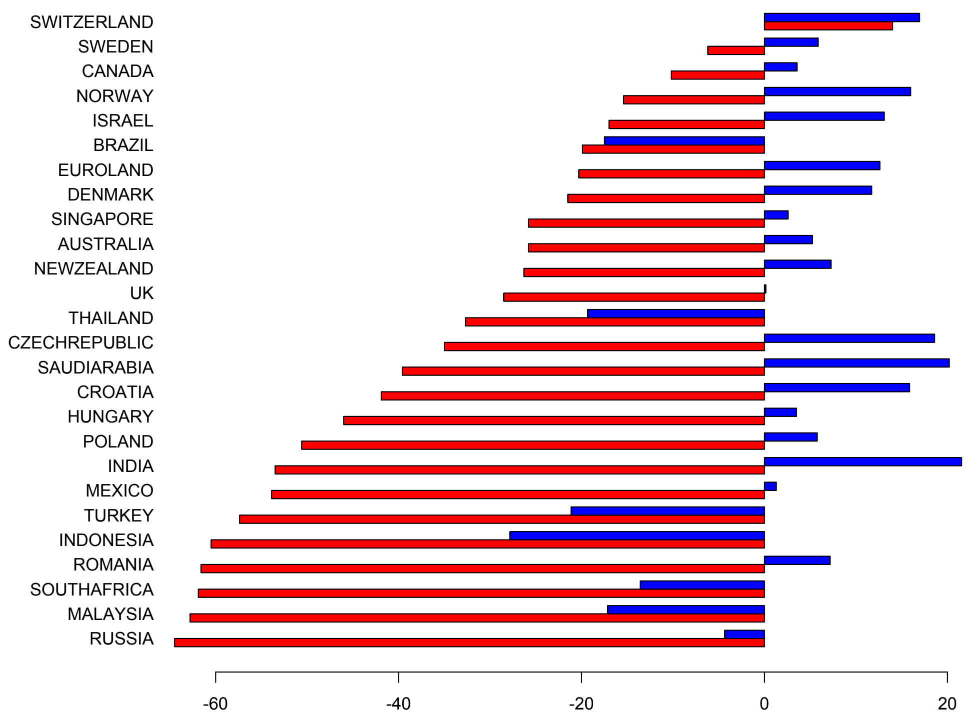
By the same approach, we compute the degree of over-/undervaluation using Fortnite prices. 1000 V-Bucks are sold for 44.99 TRY in Turkey and for 9.99 USD in the United States, leading to an equilibrium Fortnite-based exchange rate of $e_f^* = 44.99/9.99 = 4.50$. The resulting degree of undervaluation is $(e_f^* - e)/e = (4.50 - 5.89)/5.89 = -23.5\%$. In this example, the degree of undervaluation (in absolute value) is smaller using Fortnite prices as compared to BigMac prices.

The results in Figure 1 show that the BigMac prices imply strong undervaluations except in the case of Switzerland. In contrast, the results we obtain when using V-Bucks do not show a clear-cut pattern across countries. There are several overvaluations, but also several undervaluations. In absolute terms, the degree of misalignment based on V-Bucks is smaller than the one based on BigMac prices, supporting H2 that the extent of misalignment is smaller for the virtual good (V-Bucks) compared to the BigMac. In line with H1, the correlation between the over-/undervaluations implied by the BigMac index and the Fortnite index is positive (coefficient of correlation: 0.41; 95% confidence interval: 0.03; 0.69).

Table 1 depicts the summary statistics of the data. The summary statistics lend further support to our hypotheses. The median and mean of the misalignment based on the BigMac prices are negative and much larger (in absolute values) than the median and the mean of the misalignment based on V-Bucks data. A similar picture arises when we turn to the absolute values of the over-/undervaluations. Similarly, the minimum of the BigMac data is larger (in absolute value) than the minimum based on the V-Bucks data. The maximum based on the V-Bucks data, in turn, is larger than the maximum based on the BigMac data.

Applying t-tests shows that the null hypothesis that the difference in means is equal to zero can be rejected ($t = -7.17$, p-value < 0.01). When we

Figure 1: Under-/Overvaluations by Countries



Note: BigMac = red. Fortnite = blue. Undervaluation of currency against USD = negative number.

consider the absolute overvaluations, we can reject the null hypothesis that the difference in means (BigMac minus Fortnite) is smaller than zero ($t = 6.37$, p-value < 0.01), in line with H2. Moreover, we cannot reject the null hypothesis that the mean of the misalignment based on V-Bucks is zero ($t = -0.08$, p-value $= 0.93$). Hence, we cannot reject the LoP on average across countries for the Fortnite data. In contrast, we reject the null hypothesis of a zero mean misalignment for the BigMac data ($t = -8.72$, p-value < 0.01). Table 2 presents the results of estimating a regression equation by the ordinary-least-squares technique for the misalignment based on the V-Bucks data on a constant and the misalignment based on the BigMac data. In order to test the stability of the results based on a 1,000 V-Buck package, we also present evidence for other package sizes. The estimates for the slope parameter are around $\hat{\beta} = 0.3$ and significantly smaller than 1. Hence, there

Table 1: Summary Statistics

	minimum	1st quartile	median	mean	3rd quartile	maximum
BigMac	-64.50	-53.80	-33.85	-35.57	-20.60	14.00
abs(BigMac)	6.20	20.60	33.85	36.65	53.80	64.50
Fortnite	-29.53	-5.34	1.63	-0.23	9.99	20.09
abs(Fortnite)	0.17	1.88	9.76	10.72	17.67	29.53

Table 2: Regression Results

	Model 1	Model 2	Model 3	Model 4
	1,000 V-Bucks	2,500 V-Bucks	4,000 V-Bucks	10,000 V-Bucks
Intercept	.0968*	.1042*	.1008*	.1049*
	(.0516)	(.0530)	(.0509)	(.0547)
Slope	.2788**	.2945**	.2873**	.3243**
	(.1259)	(.1293)	(.1239)	(.1322)
R^2	.1697	0.1778	0.1771	0.1941
Obs.	26	26	26	26

Note: Standard errors in parentheses. ** (*) denote significance on a 5 % (10 %) level.

is a positive association in the data (in line with H1), but no one-to-one relationship. The R^2 statistic of the regression models varies between 0.17 and 0.19. Hence, the two price indices vary substantially.

5. Conclusions

We have compared misalignments (that is, over-/undervaluation) implied by BigMac data and Fortnite data and find a positive but less than a perfect association between the misalignments. We have rejected the LoP for the BigMac data, but not for the Fortnite data. One interpretation of our results is that, because Fortnite creates a virtual product, arbitrage possibilities are easier to exploit than for a BigMac.

Another interpretation is based on the observation that the variable cost of the game developer Epic to create V-Bucks (or the virtual good that can be bought for this amount) is relatively low. Variable costs are negligible when a standardized virtual good is created. Furthermore, the cost to create a virtual good is almost completely denominated in US-dollars and not in national currency. While the Balassa-Samuelson argument is convincing for misalignments in the BigMac, it does not hold for the Fortnite good.

Finally, it is worth emphasizing that Fortnite was firstly introduced in 2017. Hence, the time period since its introduction is much shorter than the time period during which the BigMac has been around. Because deviations from the LoP are to some extent due to exchange-rate fluctuations, a shorter time period since introduction implies a shorter time period for deviations from LoP to build up.

In case that one good is sold at the very same price internationally, it implies that the price – in developing economies – is relatively high in relation to the prevailing *GDP per capita* level. In these countries only the upper class will be able to buy this good. However, we should keep in mind that the Fortnite game itself is a Freemium game, the basic version can be played without any restrictions. All items sold in the in-game-shop are just cosmetic items which do not influence the playing skills or gamers' success. Hence, the fact that only the upper class is able to buy the good does not contradict the worldwide success (measured in terms of downloads). Poor gamers can still play the basic version free of charge (Schöber and Stadtmann 2020).

In future research, it is interesting to collect data for a longer time period and to estimate panel-data models in order to inspect in more detail the results we have reported in this research.

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