Measuring long-run equilibrium exchange rates using standardized products with different specifications

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Abstract
Purchasing Power Parity (PPP) is an appealing theory of the determination of long-run equilibrium exchange rates as it is founded on the intuitive proposition that opportunities for arbitrage will not go unexploited. However, in practice, measuring PPP exchange rates is hindered by difficulties in isolating the cost of tradeable inputs in the price of a reference product basket. This paper proposes a method that can extract this component using price information embodied in slightly different specifications of otherwise identical, standardized products. The method is illustrated using two well-known information and telecommunication (ICT) products, and could readily be applied to a broader, more representative product basket.

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1. Introduction

Purchasing power parity (PPP) is an appealing theory of the determination of long run equilibrium exchange rates as it is founded on the intuitive proposition that opportunities for arbitrage will not go unexploited. In an absence of trade barriers and transportation costs, arbitrage should equalize the prices of the same product in different markets when they are expressed in a common currency – the law of one price. Yet, in practice, measuring PPP exchange rates is made difficult by the presence of non-tradeable inputs in the reference product basket such as labour, rent and utilities. The well-known Big Mac index is a case in point. Yang (2004) shows that there exists a strong positive correlation between the valuation implied by the Big Max index and a country's income per capita due to the fact that non-tradeable inputs tend to be cheaper in lower income countries. Rather than being abandoned, its novelty has meant that the Big Mac index has received several resuscitation attempts from academics that have sought to control for the non-tradeable input component. Unfortunately, these attempts have been less than successful with proffered estimates ranging from 55 per cent (Parsley and Wei 2003) to 75 per cent (Yang 2004) to 97 per cent (Ong 2004).

This paper proposes a method that can extract the cost of tradeable inputs in a single product, or more appropriately if one is seeking to measure PPP exchange rates, a broader and more representative product basket. It does so by utilizing the price information embodied in slightly different specifications of otherwise identical, standardized products. This method is outlined in section two. Section three provides an illustration of the method using two well-known information and telecommunication (ICT) products – the Apple iPod and iMac. Section 4 concludes the paper.

2. Methodology

It is customary to consider the production cost of a good as a sum of the costs of tradeable and non-tradeable inputs. However, in many cases, the non-tradeable input is a fixed input, at least in the short run, and is used in the production of a whole range of outputs. For example, the rental cost for a shop is largely fixed regardless of how many products are sold, and workers are typically paid to serve customers buying any type of products in the shop. Therefore, it is not easy to ascribe the appropriate share of the fixed cost to a particular product. However, the cost associated with non-tradeable inputs can be controlled for and the tradeable component can be extracted by making some simplifying, yet plausible assumptions.

Consider a number of identical, standardized products, each of which has several slightly different specifications. An example might be an iPod, which comes in 30GB and 80GB specifications. For each such product, suppose the local currency price of specification *j* sold in country *k* is presented by P_k^j, which can be broken down into tradable and non-tradeable components:

$$P_k^j = \left(T_k X^j + N_k Y^j\right)\phi_k^j;\ j = 1, 2...J;\ k = 1, 2...K \quad (1)$$

where T_k and N_k are the unit costs of tradeable and non-tradeable inputs, respectively, expressed in the domestic currency; X^j and Y^j are the amounts of tradeable and non-tradeable inputs used in the product's manufacture; and ϕ_j^k is the rate of mark-up on the product. If the law of one price is applied to the tradeable input, the PPP exchange rate between two countries, k and $k+1$, will be given by

$$e_{k,k+1} = \frac{T_k}{T_{k+1}} \tag{2}$$

However, only P_k^j is directly observable and the system is under-identified. To identify $e_{k,k+1}$, a number of assumptions are required. Firstly, as what is being considered here are standardized products with only small differences in specification, it can be assumed that the mark-up rates amongst them are the same, i.e., $\phi_k^j = \phi_k$. In the iPod example, this means that in a given country the mark-up rate on a 30GB model is assumed to the same as that on an 80GB model. Secondly, if all product specifications sold in a country share the fixed local operational cost, Y^j will be equal to Y^{j+1} for all *j*, and can be further normalized to one without losing any generality. This assumption, while not necessarily holding true for vastly different products, is reasonable for products with only small differences in specification such an iPod 30GB and an iPod 80GB. Incorporating these two assumptions into equation (1) for a standardized product with two specifications, *j* and *j* + 1, yields

$$P_k^j - P_k^{j+1} = T_k \left(X^j - X^{j+1} \right) \phi_k \tag{3}$$

Substituting (3) into (2), gives

$$e_{k,k+1} = \frac{T_k}{T_{k+1}} = \left(\frac{P_k^j - P_k^{j+1}}{P_{k+1}^j - P_{k+1}^{j+1}} \right) \left(\frac{\phi_{k+1}}{\phi_k} \right) \tag{4}$$

The exchange rate then becomes identifiable if a third assumption is imposed that the mark-ups rates are the same across countries, i.e., $\phi_k = \phi_{k+1}$. If product markets across countries are equally competitive, then ϕ_k and ϕ_{k+1} will be driven toward the same value. In this respect, measuring PPP exchange rates using products that trade in highly competitive markets in most countries is desirable. An example is the ICT products that feature in the following section.

In summary, by using the price information embodied in slightly different specifications of otherwise identical, standardized products, the cost of the additional tradeable input, such as the extra 50GB memory of an 80GB iPod over its 30GB counterpart, can be captured. The price of this additional tradeable input can then be used to measure PPP exchange rates.

3. An illustration

An illustration of the above method is performed using two well-known ICT products – the Apple iPod in 30GB and 80GB specifications, and the 17-inch iMac in 1.83GHz and 2.0GHz specifications. For each, a PPP exchange rate can be estimated; the average of the two exchange rates is taken as the final estimation, which is labelled the Apple index. While these two products are sufficient for the purposes of illustrating the above method and to provide a novel comparison with the Big Mac index, obviously a broader basket of products would be needed for a more serious attempt to measure PPP exchange rates.

Data were downloaded from the Apple Inc. website on March 1, 2007. Prices were adjusted to take into account any relevant import tariffs and domestic taxes. In Australia, for example, prices quoted are inclusive of a 10 per cent value-added tax and so this was extracted before calculations were performed. The extent of currency mis-valuation implied by the Apple index is presented in Table 1, column 3. According to the Apple index, amongst the included countries India has the most overvalued currency with the rupee trading at 33 per cent higher than the implied PPP valuation. Meanwhile, Australia has the most undervalued currency, although the extent of undervaluation is only very small at just six per cent. The exchange rate of the Chinese Renminbi, a hotly debated topic (see Laurenceson and Qin, 2006), is found to be only marginally undervalued.

For comparison purposes, the currency mis-valuation implied by the latest Big Mac index, which was published in early February 2007, is presented in column 4. A clear difference between the Apple index and the Big Mac index is that the former implies the extent of misalignment in currency markets is far smaller than does the latter. Even for a heavily traded currency like the Swiss franc, the Big Mac index suggests the market has it overvalued by 57 per cent, compared with just 11 per cent according to the Apple index. In this respect, the valuations implied by the Apple index are more conceivable.

To further evaluate its performance, the Apple index it is subjected to two tests of robustness. Firstly, the Euro zone offers an absolute benchmark to measure the performance of the Apple index as PPP exchange rates between Euro countries should be equal to one. As can be seen from Table 1, the nine Euro countries included in the analysis all have roughly the same implied mis-valuation and the coefficient of variation amongst them is just 0.14. Unfortunately, the Big Mac index is not published for individual Euro countries and so a direct comparison is not possible.

The second test makes use of the Balassa-Samuelson effect. If a product basket has non-tradeable inputs that are unaccounted for, then there will be a bias toward implying that the exchange rates of lower income countries are undervalued and those of higher income countries are overvalued. This effect will be smaller as the share of non-tradable inputs reduces. Therefore, if the Apple index is free of bias caused by non-tradeable inputs, no Balassa-Samuelson effect should be evident. To test this, the valuations implied by the Apple index and the Big Mac index are plotted in Figure 1 against per capita income, which is expressed as a share of US per capita income. Whereas there is a noticeable positive relationship between the Big Mac index's valuation and income per capita, there is no such correlation in the case of the Apple index.

4. Conclusion

A problem in measuring PPP exchange rates has been how to overcome the bias caused by non-tradeable inputs in the reference product basket. This paper proposed a method that can isolate the cost of tradeable inputs, which can then be used to measure PPP exchange rates. The method was illustrated using two standardized Apple Inc. products, each of which has several slightly different specifications. The resultant Apple index appears to perform well compared with others indices based on a simple product basket such as the Big Mac index. Of greater significance however, is that the method could easily be applied to a broader and more representative product basket.

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Table 1 Exchange Rate Valuation Based on the Apple and Big Mac Indexes, January, 2007

Country	Currency	Under (-)/over(+) valuation against US$ (%)	
		Apple Index	Big Mac Index
Australia	Australian dollar	– 6.16	– 17
Canada	Canadian dollar	– 4.66	– 4
China	Renminbi	– 1.19	– 56
Denmark	Danish Krone	11.50	50
Hong Kong	Hong Kong dollar	5.63	– 52
India	India rupee	33.03	--
Japan	Yen	0.36	– 28
Norway	Norwegian Krone	5.43	106
Singapore	Singapore dollar	14.12	– 27
South Korea	Won	9.87	– 4
Sweden	Swedish Krona	9.04	43
Switzerland	Swiss Franc	11.52	57
Taiwan	New Taiwan dollar	7.90	– 29
UK	Pound	8.48	21
Euro area[1]	Euro	12.88	19
Austria		14.94	--
Belgium		12.70	--
Finland		11.77	--
France		11.85	--
Germany		14.58	--
Ireland		12.70	--
Italy		13.64	--
Netherlands		14.58	--
Spain		9.15	--

Euro area here only includes the countries in Table 1. The misalignment for the Euro area based on the Apple Index is an unweighted average of the misalignment values of its members.

Figure 1 Apple and Big Mac Index Valuation against Income per capita (2005)