

China's Equilibrium Exchange Rate and Trade Balance: A Tale of Apples and Pirates

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Abstract

China has been widely accused of deliberately maintaining an undervalued currency to fuel its exports. In this paper we argue that one of the most popular measures of equilibrium exchange rates, the Big Mac index, should make way for an Apple index; a theoretically more appealing index where purchasing power parity exchange rates are calculated based on the prices of globally available Apple Inc. products such as the iMac and iPod. Our Apple index also embodies a technique that can account for the value share of non-tradeable inputs, a bias that has plagued the Big Mac index. In contrast to the Big Mac index, the Apple index concludes that the RMB is not undervalued. An alternative explanation for the rapid growth in China's exports is offered and we note that after accounting for intellectual property right (IPR) piracy, there is nothing in China's overall trade balance to suggest an undervalued exchange rate. Piracy means that China may well be unfairly benefiting from trade, but the salient policy implication is better IPR enforcement, not distorting the exchange rate in a bid to compensate.

JEL classifications: F31, F36

Keywords: Big Mac Index, Purchasing Power Parity, Renminbi, intellectual property rights

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1. INTRODUCTION

Since Japan pioneered the export-led industrialization strategy in the 1950s, debates over equilibrium exchange rates have long provided a hotbed for economic and political antagonism between trading nations. In the latest example, China has been accused of pursuing a mercantilist development strategy by deliberately maintaining an undervalued Renminbi (RMB) to fuel its exports. In response, some of its major trading partners are erecting retaliatory trade barriers. Less than 6 months after the expiration of the Multifibre Agreement at the end of 2004, China has already been forced by the US and EU to accept new “voluntary” restraints on its textile exports. Pressure for revaluation and greater exchange rate flexibility has come not only from foreign governments but also from the International Monetary Fund (Rajan and Subramania 2004; Prasad and Wei 2005), the Asian Development Bank (IHT 2005) and other national central banks, as well as from academics such as Eichengreen (2004), Goldstein and Lardy (2003), Bernanke (2005), Roubini and Setser (2005) and Frankel (2005).

In searching for equilibrium exchange rates, the main theoretical point of reference for economists is purchasing power parity (PPP)¹. According to PPP theory, the equilibrium exchange rate is the exchange rate that equalizes the price of goods across countries. This law of one price will hold as long as commodities are subject to arbitrage, and accordingly, PPP theory assumes that commodities are tradeable, transportation costs are zero and that there are no other barriers to trade such as tariffs. While there have been previous estimates of China’s equilibrium exchange rate using PPP as the theoretical framework (e.g., Chou and Shih 1998), a problem for these studies is that China has historically had high trade barriers. However, leading up to World Trade Organization (WTO) entry at the end of 2001 and since this time, China sharply reduced its trade barriers vis-a-vis to the rest of the world (Lardy 2002). Its simple average tariff rate fell from 42.9 percent in 1992 to just 10.4 percent at the beginning of 2004 (Panitchpakdi 2004). As a result, PPP theory has become increasingly relevant as a framework for estimating China’s equilibrium exchange rate and it is in this environment that *The Economist* magazine’s Big Mac index has

¹ This might be considered an unfortunate state of affairs given the mixed empirical performance of PPP theory in explaining observed exchange rate movements (Makin 1994).

received revived attention. In 1986 the magazine first suggested that because of the Big Mac's homogeneity and widespread availability across countries, it could serve as a convenient basis upon which to test the law of one price and provide rough and ready estimates of PPP exchange rates. According to the Big Mac index, the equilibrium RMB/US\$ exchange rate can simply be calculated as the price of a Big Mac in China divided by the price of a Big Mac in the US. The latest edition of the index, which appeared in June 2005, showed that a Big Mac sold for RMB10.50 in China as compared with \$3.06 in the US. Thus, the PPP exchange rate arrived at by the Big Mac Index was RMB3.43:US\$1, which implied the actual spot rate of RMB8.28:US\$1 was undervalued by a massive 59 percent. This was in step with the estimates of 57 percent undervaluation in May 2004 and 56 percent in April 2003, respectively. The Big Mac index has thus served to fuel complaints from lobby groups abroad, such as the China Currency Coalition in the US, that China's rapid export growth is the result of an undervalued exchange rate.

The Economist readily admits that its index is a flawed (but fun and easy) measure of PPP. Perhaps the most serious limitation of the index is that the majority of a Big Mac's value is made up of non-tradeable inputs that are not subject to arbitrage (e.g., labor, rent and utilities). As Yang (2004) as demonstrated because these non-traded goods tend to be cheaper in lower income countries by virtue of the Balassa-Samuelson effect, the Big Mac index will be biased toward concluding that the currencies of lower income countries are undervalued. Yang (2004) regresses the valuation implied by the Big Mac index against per capita income (as a share of US per capita income) in 28 countries and reports that the coefficient to per capita income is positive (0.5248) and statistically significant at the 1 percent level. In an attempt to account for the impact of non-tradeable inputs, efforts have been put into measuring the share of non-tradeable inputs in the total value of a Big Mac. These estimates have ranged from 55 percent (Parsley and Wei 2003) to 75 percent (Yang 2004) to 97 percent (Ong 1997), with such a range of estimates illustrating the difficulties in imputing the cost of non-tradeable inputs. A large part of the difficulty is that the costs of non-tradeable inputs are shared between Big Macs and all other products sold in the same fast food restaurant. How to ascribe the appropriate share of those non-tradeable inputs to a particular product, in this case the Big Mac, is problematic. The

problem of non-tradeable inputs also cannot be solved simply by choosing a broader basket of goods upon which to base PPP calculations on. Funke and Rahn (2005) show that even when PPP exchange rates are calculated using the World Bank's International Comparison Program there continues to be a strong correlation between the implied valuation and income per capita.

In section two of this paper we propose that the McDonald's Big Mac should make way for a very different class of product – high tech consumer products such as computers, MP3 players and the like. Specifically, we suggest using the highly standardized products from Apple Inc. such as the iMac, eMac and iPod. Like the Big Mac, these products also satisfy the criteria of homogeneity and widespread availability across countries. In contrast to the Big Mac however, most of their value is made up of tradeable inputs and other price distortions such as tariffs and taxes can readily be accounted for. To be sure, even Apple products have some non-tradeable component. To that end, another novelty of this paper is a new method to control is proposed in section three to control for non-tradeable inputs in order to avoid bias in our results. In section four our Apple Index is presented and a test of the index's performance is undertaken by considering whether the implied PPP exchange rates amongst European Monetary Union (EMU) members are close to one as would be expected. We also test for any evidence in our results of bias due to the Balassa-Samuelson effect. The results of both robustness tests are extremely encouraging. In contrast to the Big Mac index, the Apple index concludes that the RMB is not undervalued. The challenge then is to provide an alternative explanation for the rapid growth in China's exports (and not so large trade surpluses) and this is undertaken in section five. One issue we believe to be important but that has been overlooked in the existing literature is the connection between intellectual property right (IPR) violations and the trade balance. The widespread practice of IPR piracy means that China has been able to avoid paying the full cost associated with it imports of capital intensive goods and services. If the value of piracy is accounted for, China's modest trade surplus disappears almost entirely. Piracy means that China is indeed unfairly benefiting from trade but the salient policy implication lies in better IPR enforcement, not in distorting the exchange rate in a bid to compensate. Section six concludes.

2. WHY AN APPLE INDEX?

There are numerous theoretical reasons why high tech consumer products are superior to the Big Mac in providing a basis for estimating PPP exchange rates. There are also good reasons why Apple products might exhibit distinct advantages over the high tech consumer products of other brands.

Firstly, Apple products are highly homogenous, perhaps even more so than Big Macs. The Big Mac sold in Islamic countries use halal beef, while that sold in Israel has no cheese (Pakko and Pollard 2003). Similarly, we found that the range of Dell computer products sold in China and in the US is quite different; and even if the same model is available in both countries, the specifications may not be the same. On the contrary, Apple computers have identical specifications wherever they are sold.²

Secondly, tradeable inputs make up the bulk of a high tech consumer product's value and while the supply of such inputs may come from many countries, the production of each input and the assembly work is highly concentrated due to economies of scale. For instance, Apple purchased all the flash memory chips for iPod Shuffle and iPod Mini from South Korea's Samsung and it has been reported that \$144 out of a \$250 iPod Nano is spent on memory, the remaining inputs costing just \$30 (Business Week 2005). As a result, the cost structure of these types of products sold in different countries should be largely identical, with the residual difference coming from differences in transportation costs, tariffs and taxes on the final products, and non-tradeable inputs such as local sales and services staff and advertisement costs. By comparison, the ingredients that go into producing a Big Mac may be purchased domestically or imported from other countries, and more importantly, the situation varies from country to country.

Thirdly, in contrast to agricultural products, computer products are rarely subject to protection. This is presumably because most governments consider them as essential capital goods for either production or education and their use is thought to produce positive productivity spillovers throughout the economy (Hearn and Mandeville

² For a given model, say the iMac, consumers can choose different screen sizes, memory chip size, and hard drive. However, the choices are identical and available in all countries.

2005). And even when a tariff is applied to imported high tech consumer products, the amount is readily known³ and so can be accounted for. The problem in working out the amount of tariff embodied in a Big Mac is not only that different countries import different ingredients, but also that the tariffs are likely to vary across ingredients and across countries.

Fourthly, the size of domestic taxes is clearly indicated on the product website of Apple Inc. and so these factors can easily be easily controlled for.

Fifthly, because high tech consumer products are widely available across the internet, there is limited opportunity for a producer to practice price discrimination within a country. In comparison, the same Big Mac can be sold for different prices at different cities within the same country.

Lastly, even if tradeable inputs make up the bulk of a product's value and we could perfectly account for the non-tradeable component (see section 3), and if we could also account for price distortions that result from tariffs and taxes, one wildcard would remain. In a monopolistically competitive market, whether it is in the business of producing hamburgers or high tech consumer products, a profit maximising firm will set the final mark-up of a differentiated product according to the price elasticity of demand. The price elasticity of demand will in turn depend upon consumer preferences (i.e., the perceived availability of substitutes) and income levels, and these may differ from country to country. Here we believe that basing equilibrium exchange rate calculations on Apple products may be preferable to other brands in that Apple's consumers are well known, albeit primarily anecdotally, for their brand loyalty (Business Week 2004) and this loyalty appears to extend to China (Liu 2005). To the extent that this is true, an implication of this brand loyalty is that demand for Apple products would be relatively less price sensitive, and so while their mark ups might still vary somewhat country to country, they will be relatively stable compared with other brands. With respect to the impact that cross country differences in income levels would have on the price elasticity of demand, a couple observations are

³ See the international tariff database of the Office of Technology and Electronic Commerce, USA at: <http://www.export.gov/>.

relevant. For one, the difference in income levels of high tech product consumers across countries is likely to be much smaller than the difference in average per capita income levels. Therefore, the tendency to charge a lower mark-up in a lower income country such as China compared with the US may not be as great as first thought. Secondly, as we will later show, relaxing the assumption on uniform cross-country mark-up rates, only serves to reinforce our conclusion regarding the RMB's valuation.

3. ACCOUNTING FOR NON-TRADEABLE INPUTS

A distinct advantage of using Apple products to calculate PPP exchange rates is that the bulk of their value is made up of tradeable components. However, even Apple products have a non-tradeable component that should be accounted for in order to derive unbiased PPP estimates. In this section we outline the methodology we use to account for the non-tradeable share.

It is customary to consider the production cost of a good as a sum of the costs of tradeable and non-tradeable inputs, respectively. However, in many cases, the non-tradeable input is a fixed input (in the short run) in the production of a whole range of outputs. For instance, the cost of renting a shop is fixed regardless how many Big Mac's or iMac's are sold; workers in McDonald restaurants need to serve Big Macs as well as coffee to customers, and sale persons in Apple Centres need to answer enquiries regarding the iMac as well as the iPod. 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 through making some simple and plausible assumptions.

Consider a number of product models, each with a few very similar varieties, and all of which are sold around the world. For instance, a product model could be an iPod or eMac; for an iPod, the two varieties are 20GB and 60GB, and for an eMac, the two varieties are Combo drive and Super drive. For each product model, suppose the local currency price of variety j ($j=1,2\dots J$) sold in country k ($k=1,2\dots K$) is presented by P_k^j , and it can be expressed as a combination of a number of factors:

$$P_k^j = (T_k X^j + N_k Y^j) \phi_k^j \quad (1)$$

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, respectively; 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

$$e_{k,k+1} = \frac{T_k}{T_{k+1}} \quad (2)$$

However, only P_k^j is directly observable and the system is under-identified. To identify $e_{k,k+1}$, we need to impose a number of assumptions, which we consider to be realistic with respect to the market situation for Apple products.

Firstly, as we are considering very similar product varieties, we assume the mark-up rates to be the same across them (i.e. $\phi_k^j = \phi_k$). As an example, we assume the mark-up rate on an iPod 20GB will be the same as that on an iPod 60GB in a country.

Secondly, if all product varieties sold in a country share the fixed local operational cost, Y^j will be equal to Y^{j+1} for all j , and we can further normalize it to one without losing any generality. Here what we are assuming is that the cost share of non-tradeable inputs is constant for all varieties of a product model. Again, as an example, we are assuming that the share of non-tradeable inputs will be the same for an iPod 20GB as an iPod 60GB. This assumption, while not necessarily holding for different products, is reasonable for products of only small variations.

Incorporating these two assumptions into equation (1) for two products, j and $j+1$, we can write

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

Substituting this into equation (2), we obtain

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

The exchange rate is identifiable only if we impose the third, and perhaps the most controversial assumption; that the mark-up rates are the same across countries, i.e. $\phi_k = \phi_{k+1}$. As discussed in the preceding section, here is where we believe that choosing Apple products might have certain advantages. In any case, the empirical implication of Apple Inc. possibly varying the mark-up according to a country's income level will be shown in the following section.

With the third assumption in place, the PPP exchange rate can then be identified as:

$$e_{k,k+1} = \frac{T_k}{T_{k+1}} = \frac{P_k^j - P_k^{j+1}}{P_{k+1}^j - P_{k+1}^{j+1}} \quad (5)$$

By using the price difference of two varieties of the same product model, essentially we extract the price information of the *additional tradeable input* of the more expensive variety of the model, such as the price of the additional 40GB memory inside a 60GB iPod, and use the price of this additional tradeable input to calculate the PPP exchange rate.

One may query that if the above procedure can handle non-tradeable inputs, why we do not apply it to the Big Mac and other McDonalds' hamburgers? The reason is that with products that have a large non-tradeable input, a small violation of the assumptions underlining the method could lead to substantial errors in the imputed equilibrium exchange rate. Therefore, applying the procedure to products with a relatively small proportion of non-tradeable input will reduce the potential effects of such errors.

In this study, we include five Apple product models, with two to three varieties for each: iPod nano (2GB and 4GB), iPod (20GB and 60GB), eMac (Combo drive and Super drive), iMac (17-inch, 1.8GHz; 17-inch, 2 GHz; and 20-inch, 2GHz), and

PowerMac (2GHz, 2.3GHz, and 2.7 GHz). We use multiple product models so that we can average out the effect of any peculiar pricing elements associated with a particular product that are not captured by our model. Data were downloaded from the Apple Inc. website in November, 2005. There are 24 countries in our sample, including nine Euro zone members. Besides China, there is only one other developing country in our sample, India.

Table 1 lists the prices of all the product models and their varieties at domestic currencies. The prices include import tariffs and domestic taxes, and these rates are shown in the table as well. The amount of tariffs and taxes will be taken out in the exchange rate computation process. Before moving on to discuss the results it can be seen from Table 1 that in the Euro area prices can sometimes vary substantially across countries, even after accounting for differences in tax rates. This may well be due to differences in mark-ups across countries. In other words, despite all the arguments in favour of using Apple products, we still need to be aware of the possible errors arising from a violation of the assumption of a uniform mark-up across countries.

Table 1 Products price in domestic currency and the domestic tax rate

Country	Domestic tax (%) ^a	iPod nano		iPod		eMac		iMac			PowerMac		
		2GB	4GB	20GB	60GB	Combo drive	Super drive	17-inch, 1.8GHz	17-inch, 2GHz	20-inch, 2GHz	Dual 2 GHz	Dual 2.3 GHz	Dual 2.7 GHz
US	0	199	249	299	399	799	999	1299	1499	1799	1999	2488	2999
Australia	10	299	359	449	598	1299	1499	1999	2299	2795	3199	3999	4899
China	0	1900	2400	2900	3900	8620	10620	13900	15900	18900	20900	25900	30900
Canada	0	249	299	379	519	999	1249	1599	1849	2199	2499	3149	3799
Denmark	25	1599	1999	2399	3449	6199	7799	9999	11499	13999	15499	18999	22999
Hong Kong	0	1550	1900	2400	3200	6200	7800	10300	11900	14200	15900	19900	23900
India	0	n.a.	n.a.	20700	29000	53200	62600	78400	87100	105500	136200	162500	189600
Japan	5	21800	27800	32800	45800	94290	115290	152040	173040	209790	236040	293790	351540
Norway	25	1790	2190	2790	3690	6990	8790	11290	12990	15790	17490	21490	25990
Singapore	0	348	438	528	728	1488	1788	2388	2688	3288	3688	4588	5488
South Korea	10	230000	290000	350000	470000	950000	1190000	1490000	1790000	2090000	2490000	3090000	3690000
Sweden	25	1995	2495	2995	4295	7495	9295	11995	13995	16995	18495	22995	27495
Switzerland	7.5	289	369	439	599	1099	1399	1799	2049.01	2499	2699	3399	4049
Taiwan	5	6900	8600	10500	13900	28900	35900	45900	53900	62900	74900	92900	108900
UK	17	139	179	209	299	549	679	899	999	1199.01	1349.01	1699	1999
Euro													
Austria	20	209	259	309	449	799	999	1299	1499	1799	1979	2479	2969
Belgium	21	209	259	319	448.99	799	1019	1319	1519	1829	1999	2499	2999
Finland	22	209	269	319.01	449	819	1019.01	1328.99	1529	1849	2019	2519	3019
France	20	239	319	329	469	799	998.99	1299	1498.99	1799	1979	2469	2959
Germany	16	199	249.01	299	429	779	979.01	1269.01	1469	1759	1919	2399	2879
R. Ireland	20	209	259	319	448.99	799	999	1319	1529	1829	1999	2499	2999
Italy	20	209	269	319	459	799	999	1299	1499	1799	1979	2479	2969
Netherlands	20	209	259	309	439	789.01	999.01	1299	1499	1798.99	1969	2459	2949
Spain	16	199	249.01	299	429	769	968.99	1269.01	1459	1749	1919	2389	2869

Notes: (a) Domestic taxes include goods and services tax (GST) or value-added tax (VAT). The tax rates are obtained from Apple Inc.'s product website, except that the tax rates of South Korea and Taiwan are obtained from the US Office of Technology and Electronic Commerce.

4. RESULTS

In Table 2, we present two different versions of the Apple index. The main Apple index is the one described above that contains an adjustment for non-tradeable inputs. For this index we first calculate PPP exchange rates based on the price differential (after accounting for tariffs and taxes) between different varieties of the same product model (column 3 – 9). We then take an average across the product models to arrive at our final index in column 10. Column 11 shows the actual spot exchange rate drawn from Reuters on September 26 and October 12, 2005. The figures for both days are very close, eliminating the chance of obtaining data from a particular volatile trading day. The valuation implied by comparing the main Apple index with the spot rate is found in column 12. Take Canada as an example; the main Apple index indicates that one US\$ should buy 1.24 Canadian dollars, while the spot rate on the foreign exchange market is only 1.17 Canadian dollars per US\$. Therefore, the Canadian dollar is overvalued by $100 * (1.24 - 1.17) / 1.24 = 5.36$ percent. We then supplement the main Apple index with a more basic version that does not include the adjustment for non-tradeable inputs. This basic Apple index is included for a couple of reasons. For one, the basic index is the technical equivalent of the Big Mac index in that it calculates PPP exchange rates simply by comparing the local currency prices (also after accounting for tariffs and taxes) of the various product varieties and taking an average across the products. In this way it is interesting to compare the Big Mac index with the Apple equivalent. Also, because Apple products only have a relatively small non-tradeable component to begin with, it may be that going through the procedure for adjusting for non-tradeable inputs does not materially change the results anyway. The valuation implied by comparing the basic Apple index with the spot rate is presented in column 13. Finally, for comparison purposes, the valuation implied by the latest Big Mac index is presented in column 14.

Table 2. PPP exchange rates implied by the Apple index

Countries	Currency	PPP exchange rate (domestic currency per US\$)							Main Apple Index	Spot rate (Sept 26; Oct 12, 2005)	Overvalue (+) / Undervalue (-)		
		iPod nano	iPod	eMac	iMac		PowerMac				Main Apple index (Oct 2005)	Basic Apple index (Oct 2005)	Big Mac index (June 2005)
		4GB - 2GB	60GB - 20 GB	Super drive - Combo drive	17-inch, 2GHz - 17-inch, 1.8GHz	20-inch, 2GHz - 17-inch, 2GHz	Dural 2.3 GHz -Dual 2 GHz	Dual 2.7 GHz - Dural 2.3 GHz					
US	US dollar	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0
Australia	Australian dollar	1.08	1.34	0.90	1.35	1.49	1.47	1.59	1.32	1.32	-0.52	5.77	-18
China	RMB	10.00	10.00	10.00	10.00	10.00	10.22	9.78	10.00	8.09	19.12	21.12	-59
Canada	Canadian dollar	1.00	1.40	1.25	1.25	1.17	1.33	1.27	1.24	1.17	5.36	6.19	-14
Denmark	Danish Krone	6.00	7.88	6.00	5.63	6.25	5.37	5.87	6.14	6.21	-1.12	1.43	50
Hong Kong	HK dollar	7.00	8.00	8.00	8.00	7.67	8.18	7.83	7.81	7.76	0.67	1.71	-50
India	India rupee	n.a.	67.23	38.07	35.24	49.68	43.56	42.96	46.12	44.35	3.85	15.11	n.a.
Japan	yen	114.00	123.50	99.75	99.75	116.38	112.19	107.36	110.42	113.44	-2.73	-3.45	-23
Norway	Norwegian Krone	6.00	6.75	6.75	6.38	7.00	6.13	6.60	6.52	6.51	0.17	8.03	98
Singapore	Singapore dollar	1.80	2.00	1.50	1.50	2.00	1.84	1.76	1.77	1.69	4.59	6.65	-29
South Korea	Won	1080.00	1080.00	1080.00	1350.00	900.00	1104.29	1056.75	1093.01	1038.60	4.98	3.93	-19
Sweden	Swedish Krona	7.50	9.75	6.75	7.50	7.50	6.90	6.60	7.50	7.78	-3.75	-1.34	36
Switzerland	Swiss Franc	1.48	1.48	1.39	1.16	1.39	1.32	1.18	1.34	1.29	3.65	1.25	65
Taiwan	NT dollar	32.30	32.30	33.25	38.00	28.50	34.97	29.75	32.72	33.31	-1.78	2.09	-21
UK	Pound	0.66	0.75	0.54	0.42	0.55	0.59	0.49	0.57	0.57	0.61	3.72	12
Austria	Euro	0.80	1.12	0.80	0.80	0.80	0.82	0.77	0.84	0.83	1.35	1.98	n.a.
Belgium	Euro	0.79	1.03	0.87	0.79	0.82	0.81	0.77	0.84	0.83	0.81	2.18	n.a.
Finland	Euro	0.94	1.01	0.78	0.78	0.83	0.80	0.76	0.84	0.83	1.31	2.28	n.a.
France	Euro	1.28	1.12	0.80	0.80	0.80	0.80	0.77	0.91	0.83	8.53	5.84	n.a.
Germany	Euro	0.84	1.09	0.84	0.84	0.81	0.82	0.79	0.86	0.83	3.52	2.24	n.a.
Ireland	Euro	0.80	1.04	0.80	0.84	0.80	0.82	0.78	0.84	0.83	0.94	2.88	n.a.
Italy	Euro	0.96	1.12	0.80	0.80	0.80	0.82	0.77	0.87	0.83	3.95	2.76	n.a.
Netherlands	Euro	0.80	1.04	0.84	0.80	0.80	0.80	0.77	0.84	0.83	0.40	1.52	n.a.
Spain	Euro	0.84	1.09	0.84	0.80	0.81	0.81	0.79	0.85	0.83	2.56	1.89	n.a.
All Euro countries	Euro								0.85	0.83	2.66	2.63	17

Notes: The figures for “All Euro countries” are calculated as the arithmetic mean of the figures of the Euro countries in the sample.

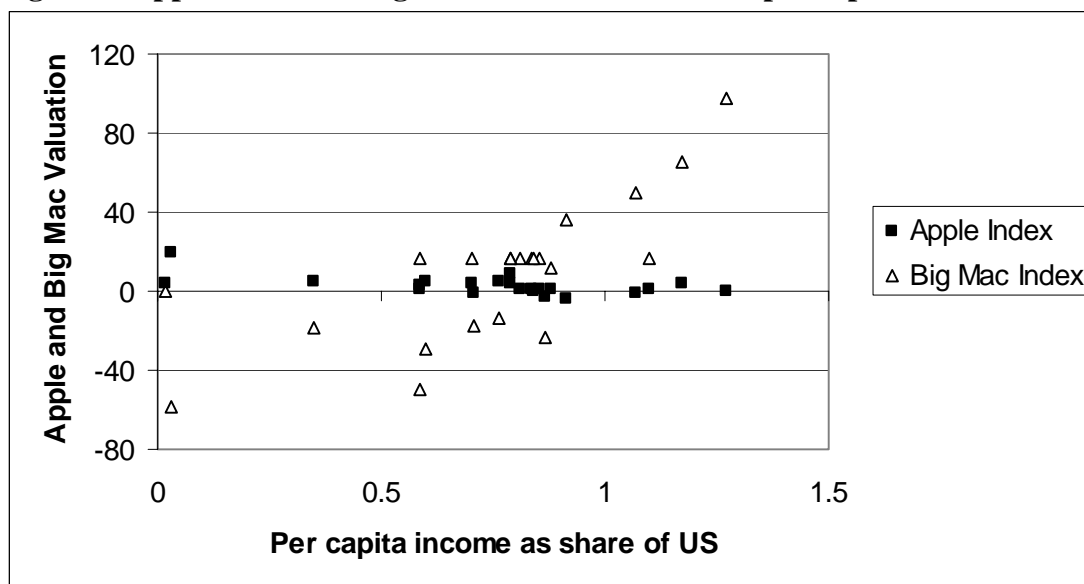
Columns 3 to 9 show that the PPP exchange rates implied by each product model can vary significantly for some countries. For instance, the PPP exchange rate implied by the iPod nano for the Australian dollar is A\$1.08:US\$1, and the PPP exchange rate implied by other product models varies from A\$0.90 to A\$1.59 per US\$. Such variations are the reason we take an average value to arrive at our final index. For some countries however the range is very small to begin with. For example, the range of PPP exchange rates calculated for China only varies between RMB9.78 and RMB10.22 per US\$.

It is clear from Table 2 that the level, and in many cases, even the direction of valuation implied by the Apple index and Big Mac index are in great contrast. In general, the amount of deviation from equilibrium implied by the Apple index is much smaller, mostly just a few percentage points. On the contrary, the amount of deviation implied by the Big Mac index is over 10 times larger. For instance, even for a heavily traded international currency like Swiss Franc, the Big Mac index suggests that foreign exchange markets have it overvalued by a massive 65 percent, compared to the 3.7 percent suggested by the Apple index. In this respect, we believe the Apple index to be more intuitively appealing. It is also interesting to note that there is little variation between the main Apple index and its more basic version. The largest difference is for India, where the main index implies the Rupee was overvalued by 3.85 percent while the basic index has it overvalued by 15.11 percent. The general agreement between the main and basic Apple Index is not surprising since we know that non-tradeable goods only account for a small value share of Apple products. In the rest of the discussion, we focus only on the main Apple index.

To further evaluate the robustness of the Apple index we perform two tests. Firstly, the Euro provides us with an absolute benchmark to measure the performance of the Apple index as the PPP exchange rates between any Euro countries should be equal to one. As it can be seen from Table 2, the PPP exchange rates implied by the Apple index for the nine Euro countries vary narrowly between 0.84 and 0.91. More specifically, the coefficient of variation (i.e. the standard deviation divided by the mean) is equal to only 0.027. Thus, the Apple index passes this first test convincingly. Since *The Economist* does not publish the Big Mac index for individual Euro

countries, a direct comparison of the two indexes using this measure of robustness cannot be performed. A second robustness test that makes use of the Balassa-Samuelson effect however can provide a platform for direct comparison between the two indexes. It was discussed earlier that if a product has a non-tradeable component that is not accounted for, the implied PPP exchange rate will tend to be biased toward concluding that the currencies of lower income countries are undervalued while the currencies of higher income countries are overvalued. This bias is smaller if the share of non-tradeables is small or is adjusted for. To test whether this bias is present in our Apple index, we plot in Figure 1 the valuations implied by the main Apple index and the Big Mac index against per capita income (expressed as a share of US per capita income).

Figure 1. Apple index and Big Mac index valuation and per capita income



Note: Source of GDP per capita is obtained from the IMF's World Economic Outlook Database.

As it can be seen from Figure 1, and as has already been pointed out by Yang (2004), for the Big Mac index there is a recognizable positive relation between valuation and income per capita. The pattern for the Apple index is strikingly different in that its implied valuation is entirely unrelated to income per capita. Thus, based on the theoretical arguments outlined in section two and the above robustness tests, we have considerable confidence in the results implied by the Apple index and certainly consider it superior to the Big Mac index.

Turning now to the Chinese currency debate, perhaps the most striking conclusion of the Apple index is that the equilibrium price of the Chinese currency is RMB10:US\$1. As mentioned previously, the PPP exchange rates implied by various Apple product models and varieties are very similar, with five out of seven PPP exchange rates being equal to this rate of exchange. Compared to the spot rate of RMB8.09:US\$1, the findings imply that the RMB is overvalued by 19 percent. This result is the opposite of the standard view, which considers that China has been deliberately maintaining an undervalued exchange rate to fuel export growth. Further recall that an assumption in constructing the Apple index is that for a product model, the mark-up is uniform across model varieties and across countries. One may argue that given the fact that income per capita in China is only a fraction that of the US,⁴ Apple Inc. might price their products at a lower mark-up in China than in the US. If the mark-up rate in China is lower, we know that the bias in the calculated exchange rate would be towards implying undervaluation. That is, if this type of market discrimination pricing policy did exist, then the 'true' PPP exchange rate of the RMB would be even higher, and the RMB would be overvalued by even more than 19 percent! Alternatively we could say that for the RMB spot rate to be undervalued, the rate of mark-up would have to be at least 20 percent higher in China than in the US. As this is a very unlikely scenario, the conclusion that the RMB is not undervalued is robust to relaxing the assumption of a uniform mark-up across countries.

5. THE TRADE BALANCE AND INTELLECTUAL PROPERTY RIGHTS

If the rapid growth in China's exports cannot be attributed to an undervalued exchange rate, how then might it be explained? Our view is that there are two primary reasons, quite apart from the value of the exchange rate, that have contributed to rapid export growth in China.

The first is simply that China began its export expansion from a very low and distorted base. In spite of having an unrivalled comparative advantage in the production of labor-intensive goods, China was a latecomer to export-orientated industrialization. Several decades of autarky meant that when the open-door policy

⁴ According to the IMF's World Economic Outlook database, in 2005, China's GDP per capita is equal to three percent that of the US if evaluated at current prices, and is equal to 14 percent if evaluated at PPP prices.

was adopted in 1979, the scope to increase its exports was massive. China's share of world exports in the late 1970s was just 1 percent, an absurdly low figure given the size of its economy and comparative advantage in producing labor-intensive manufactures. Even after two and half decades of rapid export growth, the level of China's exports is still less than what the size of its economy would imply. By 2004, China's share of world exports had risen to 6.7 percent. The combined trade share of Hong Kong, Korea, Malaysia, Singapore, Taiwan and Thailand meanwhile was 9.7 percent, despite the fact that their combined GDP was less than that of China's. Japan's export share, post-WW2, kept growing until it peaked at 10 percent in the early 1990s.

The second reason for the rapid growth in Chinese exports is that not only are domestic firms exploiting the country's comparative advantage, foreign firms are also recycling their comparative advantage through China. Neighbouring economies such as Japan, Hong Kong and Taiwan began their industrialization drives several decades before China also focusing on the export of labor-intensive manufactures. Over time, as labor costs in these countries have risen, their manufacturing firms have used foreign direct investment (FDI) in China as a means of maintaining their competitiveness. Firms in Hong Kong and Taiwan have been most aggressively pursuing this approach. This recycling of comparative advantage means that the majority of China's exports are in fact "foreign-owned". In 1981, exports from foreign-invested enterprises accounted for only 0.1 percent of China's total exports. By 2004, their share had reached nearly 60 percent. If we subtract the exports of foreign-invested enterprises, the growth rate of China's exports slows appreciably. We think that part of the problem here is one of perception in that China's FDI-led export growth is on a scale not previously seen. It is also in stark contrast to Japan's earlier growth spurt in which foreign investment played a negligible role⁵.

The view that an undervalued exchange rate has been driving China's export growth further loses currency when China's broader trade data is considered, such as the rate

⁵ It is true that in some sectors such as automobile production, Japanese firms were initially encouraged to form technical tie ups with foreign firms. This however was a temporary affair and Japanese firms were pushed to quickly acquire the necessary technology and increase the local content of their production.

of growth in imports and its overall trade balance. An undervalued exchange rate would promote exports while at the same time restrain imports, with the end result being large trade surpluses. In contrast, China's goods and services trade balance during 2000 – 2004 remained stable within the modest range of 2.39 - 2.95 percent of GDP. Enright (2005) points out that Japan, Russia, Germany, Canada, Ireland and Norway all run higher trade surpluses as a share of GDP than China. China continues to heavily import final goods and services and intermediate inputs that make intensive use of capital (physical and human). Foreign firms have primarily only been relocating labor intensive stages of production to China and because China's exports have a high imported component, the domestic value added input has been estimated to be only around 20 percent (Enright 2005). By way of comparison, Sung (2000) found that the rate of value-added in exports from Hong Kong was 100 percent higher than exports from the mainland.

Another important issue that has received little attention in the literature to date is the impact of intellectual property right (IPR) violations on China's trade balance. Based on comparative advantage, it is expected that China will be a net exporter of labor-intensive products and a net importer of capital-intensive products, and this, in the main, is what is observed. A distinct advantage that accrues to China based on this comparative advantage is that because the technology embodied in its imports of capital-intensive goods is sometimes easily misappropriated, it has effectively not been required to pay the full cost of these imports. In 2004, a senior US government trade official claimed that Chinese piracy of US products extended from DVDs to pharmaceuticals to golf clubs to car parts (Asia Times 2004). The total cost to US companies of such piracy was put at between \$US20-24 billion a year. If the losses incurred by European and Japanese companies are included, the figure jumps to in excess of US\$50 billion. In 2004, China's trade surplus was equal to US\$49 billion. In other words, if IPR violations were halted, China's modest trade surplus would disappear almost entirely. Piracy means that China may indeed be unfairly benefiting in trade but there is nothing in the overall balance of trade to suggest an undervalued exchange rate. Further, the salient policy implication is that more attention needs to be given to IPR enforcement, not distorting the exchange rate in an attempt to compensate.

Only in the first quarter of 2005 did the growth rate of China's exports sharply outpace that of its imports. At the end of 2004, the year-on-year increase in exports and imports was 35.4 percent and 36 percent respectively. Whereas export growth held this rapid rate of increase (34.9 percent) through the first quarter of 2005, import growth slowed markedly (12.2 percent). By the third quarter, export growth has slowed somewhat (31.3 percent) and import growth had picked up (16.0 percent). Whether the differential pace of export and import growth in 2005 serves as evidence that China has begun moving up the value chain and that the trade balance will grow in the future is too early to say. Similar spikes have been observed in the past and proved to only be short run events. For example, at the end of 2002, the annualized rate of growth in exports and imports was 21.3 percent and 22.3 percent respectively. Yet in January 2003, import growth shot up to 63.4 percent, while exports also grew but far less dramatically to 37.3 percent. By the start of 2004, exports and imports were again growing at roughly the same rate. Whether the events of 2005 prove similarly momentary or are of a longer run in nature, some context needs to be brought to bear.

Firstly, to some extent, China experiencing a trade surplus is an expected outcome of a natural adjustment process as the world absorbs a massive amount of previously under-utilized labor. This under-utilized labor stock comes not only from China but to a lesser extent also from India, Eastern Europe and other emerging economies. There is an unavoidable lag that results from first having to mobilize this surplus labor through exports and other domestic sources of demand before they can become consumers with income levels sufficient to start demanding imports. Fu and Balasubramanyam (2005) advance a similar argument that exports provide a vent for the surplus productive capacity that occurs in developing countries such as China resulting from a disproportion between production and consumption capacities. Thus, in the short run, there is almost no other way out except to see the exports from these countries rise and this will have the effect of bringing world prices of labor-intensive products to a new and lower equilibrium level. To put it another way, if the RMB's value is pushed up in order to stem what some regard as excessive exports, it is in fact a manipulation of the exchange rate that intends to decelerate a necessary adjustment

process. Over time, average incomes in China will increase to the extent that more consumers can afford BMW cars from Germany, Harley Davidson motorcycles from the US and education services from Australia. Given the size of the future pool of consumers, the increase in imports will in some cases be dramatic. The Australian higher education market is a good example. In 2000, there were 4387 Chinese students, almost entirely full fee paying, studying in Australian universities. By 2004 that number had skyrocketed to 37106.⁶

Secondly, while the local sourcing of inputs and the transfer of higher-end stages of production to China would have the effect of increasing China's trade surplus, there are other mitigating factors that will come into play. Most obviously, as China itself increasingly produces goods and services that makes intensive use of physical and human capital, it can be expected that IPR enforcement in the country will receive a boost. This will have the flow on effect of raising the amount that China will have to spend in order to import capital-intensive goods and services from other countries.

Finally, as Enright (2005) points out, we should not lose sight of the fact that China's export profile is presently skewed towards those highly visible sectors in which it is prodigiously competitive such as the manufacture of garments and labor-intensive consumer goods. In many of its other industries meanwhile, it remains far from being internationally uncompetitive and there is little reason to expect this will change in the foreseeable future.

6. CONCLUSION

There are few topics in international economics that are presently more debated than the equilibrium value of China's exchange rate. One of the most popular measures of equilibrium exchange rates, the Big Mac index, has fuelled discontent abroad in suggesting that the RMB is a seriously undervalued currency. Yet previous studies have already pointed out the numerous limitations of the Big Max index; in particular, the bias resulting from failing to account for non-tradeable inputs. In this paper we extend the literature by offering a new and theoretically more appealing index of

⁶ The statistics are sourced from the Department of Education, Science and Training, Australia Commonwealth Government.

equilibrium exchange rates based on the high tech consumer products sold by Apple Inc. Our Apple index also embodies a technique that can account for the value share of non-tradeable inputs. While we only apply this method to Apple products in this paper, it can in principle also be applied to other products that satisfy the underlining assumptions. The Apple index performs strongly in tests of robustness. Perhaps the most striking finding of the Apple index is that the RMB is not undervalued. This then presents the challenge of explaining the rapid growth rate of China's exports without resorting to claims of currency undervaluation. We believe the answer lies primarily in the fact that China's exports are growing from an extremely low and highly distorted base and because other countries are also recycling their comparative advantage in the production and export of labor-intensive manufactures through China. We also note that there is nothing in China's overall trade balance to suggest an undervalued exchange rate. Firstly, while China's exports have grown rapidly, so to have its imports such that the country's overall balance of trade through 2004 was only moderately in surplus. Secondly, because of the nature of China's comparative advantage, it imports capital-intensive goods and services that are sometimes vulnerable to IPR piracy. This means that China does not have to pay the full cost associated with its imports and once an adjustment is made for the cost of piracy, China's modest trade surplus disappears almost entirely. In this way China does indeed unfairly benefit from trade but it has nothing to do with the value of its exchange rate. The salient policy implication lies in better IPR enforcement, not distorting the exchange rate in a bid to compensate.

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