

EQUILIBRIUM EXCHANGE RATE MODELS AND MISALIGNMENTS

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BY T. ASHBY MCCOWN, PATRICIA POLLARD AND JOHN WEEKS

DEPARTMENT OF THE TREASURY • OFFICE OF INTERNATIONAL AFFAIRS

Equilibrium Exchange Rate Models and Misalignments

T. Ashby McCown, Patricia Pollard and John Weeks

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Many approaches have been developed to estimate "proper" or "equilibrium" or "long-run" exchange rate values. These approaches have been based on different views about how economies and financial markets work. The results have been used to draw conclusions about deviations of actual exchange rates from their "proper" or "equilibrium" level and thus whether they are "misaligned". It is difficult for any model to describe adequately all features of modern economies that are relevant to determining exchange rate movements, especially of economies fully integrated into the international economic and financial system. Some economists argue that misalignment cannot be measured at all because empirical techniques are unable to capture the continuous evolution of structural economic relationships that drive exchange rates. Thus, there is no "fail safe" method in estimating the proper value of an economy's foreign exchange rate or in establishing a precise measure of over- or under-valuation. The purpose of this Occasional Paper is to review various approaches to estimating equilibrium exchange rates and to compare their respective properties.

A key conclusion of this paper is that, although each of the approaches may provide useful information and insights into the operation of an economy, it is necessarily based on special methodologies and assumptions that limit the scope of behavior it can explain. One problem is the difficulty of modeling all the relevant features of an economy, particularly the behavior of financial markets. In fact, many exchange rate models focus heavily on trade-based relations and give relatively little attention to more dominant financial market influences. This can be a serious modeling weakness since the influence of trade on exchange rates is likely to be indirect, first through its impact on overall economic activity and then through the impact of overall activity on financial markets. The direct influence, say through conversion of the proceeds of trade, are small compared to activity in international financial markets.

A second key conclusion is that the result of any exchange rate model should be interpreted with a full understanding of the model's key assumptions and mathematical structure, and the limitations that these imply. The value of an exchange rate can differ from the equilibrium value implied by a model because the model takes inadequate account of cyclical, temporary or random influences, or simply because the model fails to account for some important features of the economy, including the functioning of global capital markets.

This paper is divided into four sections. Section 1 discusses the function of exchange rates in the modern economy. Section 2 describes economists' attempts to determine equilibrium exchange rate values, which form the basis of developing measures of over- or under-valuation.



Section 3 lists some practical models in use and compares their estimated results. Section 4 discusses the practical problems of assessing exchange rate “misalignment” and describes some methodological and conceptual considerations that might prove useful in evaluating currency misalignment.

SECTION 1: FOREIGN EXCHANGE RATES

A foreign exchange rate is the price of one currency in terms of another, of which is typically set in financial markets by supply and demand for currencies.¹ Supply and demand for currencies are strongly influenced by conditions in the market for other financial assets, as well as market perceptions of underlying real macroeconomic conditions. Exchange rate levels, like the prices of other financial instruments, have an influence that extends considerably beyond financial markets, being a significant factor, in particular, in determining the terms of trade between internationally tradable goods and services and internationally non-tradable goods and services.

- **There are many different exchange rates.**

For example, there are spot rates, the rates quoted at which two currencies trade for immediate settlement.² There also are forward or futures rates, which are rates at which currencies trade today but settle in the future (i.e., 90 days in the future, 180 days in the future, etc.). As a general rule, most exchange rates are some extension of the spot rate.³ That is, they specify the terms of delivery, or contingent delivery, of one currency at a given time and place against the delivery, or contingent delivery, of another currency at a given time and place.

- **The volume of money exchanged each day in foreign exchange markets is large.**

Data on foreign exchange markets indicate that *daily turnover* in foreign exchange markets averaged \$1.9 trillion in 2004.⁴ Over half of all daily activity occurs in London (\$763 billion) and New York (\$461 billion). In addition, daily activity in over-the-counter currency-related derivative trades totaled another \$1.3 trillion – for a combined daily volume of foreign exchange trading activity of \$3.2 trillion. The value of transactions that flow through foreign exchange markets in one week is greater than the value of the flow through all international goods and

¹ This includes supply and demand by governments. It is possible, of course, for a government to impose such strict capital controls and payments restrictions that there is no real market in the currency and an official exchange rate is more of an accounting convention than a price.

² Settlement is typically two business days after the transaction occurs.

³ In addition to spot and forward or futures exchange rates, there also are options rates, which allow a prospective purchaser of a currency to pay for another currency for settlement in the future *provided* the purchaser exercises the trade in the future (the prospective purchaser pays a fee for the right or option of future purchase at a given rate, but is not obliged to execute the transaction). There are many other derivative currency markets and contracts, such as options on futures and foreign exchange interest rate swaps. For analysis, derivatives contracts can usually be decomposed into underlying futures and options contracts.

⁴ Bank for International Settlements, *Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2004*, March 2005.



services markets in one year.⁵

- **The choice of exchange rate regime importantly affects the setting of an economy's exchange rate.**

Under the Gold Standard system that operated prior to World War I, participating currencies were convertible into gold at a fixed price and the exchange rate between two currencies was set by the relative rates at which each currency converted into gold. Under the Bretton Woods system that operated from 1946 to 1971, currencies were fixed to gold, but only the U.S. dollar was convertible into gold at a fixed price, and only for official holders of dollars (primarily foreign central banks). Since 1973, the international currency system has been a complex mixture of fixed and flexible exchange rate regimes. Where predominately flexible exchange rate regimes are in operation (as those for the major currencies: the dollar, yen and euro), it is the continuous trading on organized exchanges and over-the-counter markets that determines the exchange rate that will equalize market demand for a currency with market supply.

The Articles of Agreement of the International Monetary Fund, which is tasked with the surveillance of exchange rate policies, provide that each country may choose its own exchange rate regime. The IMF groups exchange rate regimes in eight broad categories. According to the IMF's most recent *Exchange Arrangements and Exchange Restrictions (2006)*, managed floats and fully independent floats account for the largest share of arrangements, as well as the largest share of economic activity.

Exchange Rate Regimes		
Exchange Rate Regime	Number of Countries	Pct of Global GDP 2005
No separate legal tender ⁶	41	15.3
Currency board	7	0.7
Conventional pegs	52	20.2
Pegs within horizontal bands	6	0.8
Crawling pegs	6	1.1
Crawling bands	0	0.0
Managed floating	51	17.2
Independently floating	24	43.8

Source: International Monetary Fund

- **Exchange rates, and particularly their ability to change over time, have an important role to play in adjusting external imbalances and in ensuring the overall smooth and efficient functioning of the international economic and financial systems.**

Investment portfolios often include assets and liabilities denominated in different currencies. Private enterprises that operate in more than one currency or engage in international trade also must manage assets in different currencies in light of current and anticipated flows of foreign

⁵ The IMF estimates that the total dollar value of world exports in 2005 was \$12.7 trillion, about \$3 trillion less than the typical weekly volume of foreign exchange transactions.

⁶ Includes countries of the Euro Area. The euro itself floats independently.



exchange and use exchange rates to evaluate the relative profitability of different management decisions. Flexible exchange rates move quickly to rebalance markets when there are sudden changes in the relative supply or demand of assets denominated in different currencies, avoiding the need for official institutions to offset changing excess demand and compromise monetary objectives.⁷

SECTION 2: CONCEPTS OF EQUILIBRIUM VALUE

Making a judgment about the proper value of an exchange rate and rendering a view on whether an observed level of the exchange rate is misaligned depends first on establishing some notion about what constitutes an equilibrium value of the exchange rate. And even this is only a necessary but not a sufficient condition for determining misalignment.⁸ It also should be noted that economists have not adopted a single concept of equilibrium when it comes to exchange rates. For example, one could say that the foreign exchange rates, where determined by markets, are always in “equilibrium” in that the market is equating supply and demand for a currency at each instant. Others focus, however, on much longer-term conditions, such as consistency with underlying fundamentals.

Most practitioners of exchange rate models employ more abstract, long-term definitions of equilibrium. Typically, the “equilibrium exchange rate” in these models is the rate implied by the presumed equilibrium conditions of the model. In other words, different modeling assumptions and approaches generate different conditions of equilibrium and thus different estimates of the equilibrium exchange rate – often for the same economy. Indeed there is no model that can successfully predict exchange rates over a wide selection of countries and time horizons. The wide range of estimates reflects the fundamental difficulty of getting a good representation of the operation of international real and financial sectors that is valid over a long period of time. One of the most difficult tasks in economics is to model the foreign exchange market in a fashion that is both theoretically and empirically acceptable. There are significant differences in modeling and estimating the day-to-day behavior in the spot market for foreign exchange where the influence of fundamentals can often be ignored and in modeling and estimating medium- and long-term exchange rates where changes in asset ownership and valuation can be large. Economists’ understanding of what drives investors’ desired allocation of their global portfolios is not as well developed as we would like.

• Purchasing Power Parity

Purchasing power parity theory (PPP) is perhaps the earliest approach to thinking about equilibrium exchange rates. PPP holds that, in the long-run, exchange rates will adjust to ensure

⁷ See Annex 2 of the Department of the Treasury’s *Report to Congress on International Economic and Exchange Rate Policies*, May 2006. Although a fixed nominal exchange rate may be appropriate in certain limited circumstances, for example as a monetary anchor for a central bank, the U.S. Treasury has emphasized that the global economy functions best when goods and capital markets are open and when exchange rates are flexible and thus reflect underlying market conditions.

⁸ Section 4 discusses various additional considerations that must be part of the analytical process of evaluating whether a currency is likely to be misaligned.



the equal relative purchasing power of currencies. PPP follows from the early insight of the ‘law of one price,’ which states that a commodity that sells in free and deep markets in two different economies will, in the absence of differences in such factors as transaction costs, taxes, and transportation costs, sell for the same price when expressed in a common currency. If not, arbitrageurs will buy in the cheaper market and sell in the dearer market until the two prices adjust to eliminate the profitability of arbitrage. If true for every good in an economy, then the price of every good in one country would be equal to the price of every good in another country multiplied by the exchange rate. If price indices were constructed for the two countries, using the same weights and bases, then the ratio of the price indices would be the exchange rate.

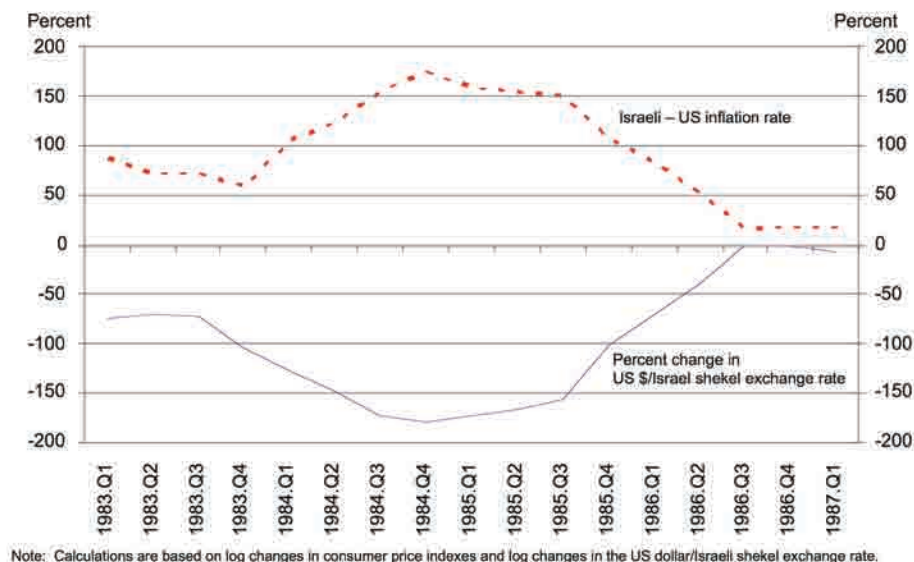
There are many reasons why PPP fails to hold, including the existence in all economies of many non-tradable goods and services. In addition, transportation takes time and information on comparative prices is neither universally available nor free. Other factors, such as trade restrictions, also tend to drive a wedge between domestic and foreign prices for the same good or service. Even if prices were the same across all goods and services in two countries, differences in income levels and preferences would cause the weights given to each item in the consumer price index to vary. Thus, for example, an increase in the price of rice will have a greater effect on the consumer price index in Japan than it will on the price index of the United States.⁹ The best one can expect is that PPP holds over the medium or longer run.

A more commonly used version of PPP is called “**relative purchasing power parity**,” which focuses on *changes* in prices and *changes* in exchange rates. This approach is closely tied to more complete macroeconomic models of economies, particularly monetary models, and studies of inflation. In practical terms, it would not be surprising for a country with a relatively high rate of inflation, for example, hyper-inflation, to see its currency depreciate at roughly the same rate as inflation. This was the case for the value of the Israeli shekel relative to the dollar in the mid-1980s, as shown in Figure 1. Israeli inflation peaked at 175 percent above U.S. inflation in the fourth quarter of 1984. In that quarter the Israeli shekel fell by 180 percent against the dollar. At modest levels of inflation, however, it is difficult to validate even this relationship empirically, particularly in the short term. The validation is complicated by the relatively rapid adjustment of financial markets relative to adjustments of the real economy, potentially resulting in short-term over- or under-shooting of long-term exchange rates.

⁹ Researchers have created common baskets of goods and services across countries to study purchasing power parity. These vary from the very simple Big Mac Index created by *The Economist* to the Penn World Tables [Heston, Summers and Aten (2002)] constructed by the UN International Comparison Program (ICP). The ICP makes detailed price comparisons between the goods and services of a wide selection of countries and calculates the level of each country’s national product and national income valuing goods and services at common dollar prices across countries. The term “purchasing power parity”, as used in this project, means the rate of exchange between two currencies that would allow the same volume of goods and services to be purchased with a given amount of one country’s currency in either of the two countries. If the law of one price held, PPP would equal the exchange rate.



Figure 1
 Inflation Differential and the Exchange Rate
 1983.q3 to 1987.q1



• Nominal and Real Effective Exchange Rates

A still different approach is to focus on either nominal or real effective exchange rates when attempting to establish equilibrium exchange rate values.

- Interest in what a currency can buy domestically compared to what it can buy in another country, when converted into that country's currency, has led to measures of the **“real exchange rate,”** which is the nominal exchange rate, adjusted by the ratio of domestic to foreign prices.
- In addition, real life reflects international financial and trading patterns interacting in a multinational, multicurrency world. The value of a currency in terms of its ‘overall’ or global foreign exchange value is measured by an index that is called an **“effective exchange rate.”** The weights of these indices are often derived from a country's international trading pattern and in these cases are frequently called “trade weighted” indices.
- Indices of effective exchange rates can be constructed for nominal or real exchange rates, with the latter denoted as “REERs” for the **real effective exchange rates**. The REER, which is sometimes regarded as a measure of competitiveness, is the key variable in most studies of equilibrium exchange rates.

Different techniques for constructing REER indices are aimed at capturing different aspects of competitiveness. These different techniques, as will be shown, often result in sharply different, and even contradictory estimated outcomes with respect to over- or under-valuation. The choice of nominal price measure, for example, can yield surprisingly different results. To calculate

REERs the Federal Reserve Board uses consumer price indices, JPMorgan uses producer prices, and the IMF calculates several indices using different measures, including one based on unit labor costs.

Weighting systems can vary significantly. For example, the indexes of JPMorgan use fixed weights based on bilateral trade. The indexes of the Federal Reserve Board and the CTERI indices of Citigroup use trade weights that evolve through time and take into account competition in third markets – a currency is given more weight in the index if the country is a significant competitor in a third market.¹⁰ It is important to note that adjustments of the REER can come through either exchange rate or price adjustments. A REER is a calculated result of many exchange rates set in foreign exchange markets and many prices of goods and services set in their own markets.

A working hypothesis is that the REER is stable over time.¹¹ It may rise in some years and fall in others but the REER generally moves around some fixed level. Some would consider this is an appropriate way to look at the equilibrium exchange rate, particularly in a static world experiencing predominately monetary shocks. A simple measure of disequilibrium would then be to compare the current rate of the REER to its average over a long, presumably normal period of time.

Adjustments of the REER to this simple form of equilibrium appear to be empirically very slow. In fact the REER looks, over shorter periods of time, like a random walk.¹² Studies examining longer periods have typically found that the half-life of a deviation from equilibrium to be on the order of three to five years.¹³ Different statistical approaches can, however, give substantially slower adjustment speeds.¹⁴ More generally, one should not expect to see significant deviations from equilibrium REERs, even from complex models, dissipate quickly.

There are a number of reasons, based on shifts in fundamental economic quantities, to expect that the equilibrium REER will change over time. The most celebrated of these is probably the observation of Balassa, Samuelson and others¹⁵ that the equilibrium REER should appreciate if productivity grows more rapidly in the tradable goods sector than in the non-tradable goods sector. This is because real wages in the tradable goods sector will rise in line with productivity

¹⁰ A good explanation the Federal Reserve Board indices is in Leahy, M. (1998) “New Summary Measures of the Foreign Exchange Value of the Dollar”, *Federal Reserve Bulletin* October.

¹¹ If relative purchasing power parity holds, the real effective exchange rate is a constant.

¹² That is, whenever the REER changes it is expected to remain at its new level.

¹³ A classical review is Froot, K.A. and K. Rogoff (1995) “Perspectives on PPP and Long-Run Exchange Rates” in the *Handbook of International Economics*, Volume 3, (ed.) Grossman, G. M. and K. Rogoff, North-Holland.

¹⁴ For example Cashin, P. and C. J. McDermott (2006) “Parity Reversion in Real Exchange Rates: Fast, Slow, or Not at All?”, *IMF Staff Papers* Vol. 53, No. 1.

¹⁵ Balassa, B. (1964), “The purchasing power parity doctrine: A reappraisal”, *The Journal of Political Economy* 72:584-596; and Samuelson, P.A. (1964) “Theoretical notes on trade problems”, *Review of Economics and Statistics* 46: 145-164.



and, if labor is mobile, will rise competitively in the rest of the economy, putting upward pressure on relative prices in the non-tradable goods sector.

Several advances to comparing simply an economy's REER to a long period average have been devised. A common modification is to compare statistically how REERs vary with specific fundamental factors, using this comparison to estimate an equilibrium exchange rate for each economy. Productivity is, of course, a typical fundamental factor. Other factors, some of which are used in lieu of productivity when appropriate data are not available, include per capita income, ratio of consumer to producer prices, terms of trade, and net foreign asset position.

- **Model Based Equilibrium Exchange Rates**

Other models envision the equilibrium exchange rate as the rate that reconciles an economy's internal and external balance. For example, John Williamson¹⁶ and others have developed the concept of the "fundamental equilibrium exchange rate" (or FEER)¹⁷. The conditions of FEER that are consistent with internal and external balance are often taken to be low inflation and full employment with a sustainable current account balance. In this approach, the "sustainable current account balance" is set judgmentally as the size of the current account that the modelers believe can be financed. This procedure has been called the "macroeconomic balance" approach. Examination of the current account over the medium- or long-run inherently implies interaction with financial markets since protracted surpluses or deficits imply the transfer of net assets between domestic and foreign portfolios. These models do not typically describe explicitly or estimate financial market equilibrium, the determination of exchange rates, or the interaction between financial and real markets. A typical application involves calculating how much the exchange rate must change in order to bring the current account to a level deemed (pretty much judgmentally) to be sustainable and is thus typically based on a current account, or basically a trade, model.

The IMF uses a macroeconomic balance approach to determine equilibrium exchange rates for most advanced economies. The IMF approach takes its name from the interdepartmental Coordinating Group on Exchange Rates (CGER) that developed the methodology. The CGER approach determines the REER that is consistent with the "appropriate" current account position in an economy at potential output.¹⁸ This requires both an estimate of the underlying current account position and the equilibrium saving-investment position. The underlying current account position is the current account balance at prevailing exchange rates if all countries were producing at potential and the lagged effects of exchange rates on the current account had been realized. Estimates are based on current account projections from the IMF's *World Economic Outlook*. The equilibrium saving-investment position is determined through an econometric

¹⁶ Williamson, John (1985), *The Exchange Rate System*, Institute for International Economics, Revised Version.

¹⁷ There are several other acronyms include DEER (desirable equilibrium exchange rate), BEER (behavioral equilibrium exchange rate) and NATREX (natural equilibrium exchange rate model) applied to broadly similar models.

¹⁸ This approach is described in Isard, P., H. Faruquee, G. R. Kincaid and M. Fetherston (2001) "Methodology for Current Account and Exchange Rate Assessments", International Monetary Fund Occasional Paper # 209.

model that relates the current account balance to various factors such as per capita income, fiscal balance, interest rates, output gap and demographic factors. This model produces an estimate for the “normal” current account balance under potential output and the REER consistent with this balance. The difference between the REER based on the underlying current account balance and the “normal” current account balance provides an estimate of the overvaluation or undervaluation of the REER. Using the CGER methodology the IMF estimates that the REER of the U.S. dollar was overvalued by 15 to 35 percent in mid 2006.¹⁹

Extensions of this approach to equilibrium modeling introduce behavioral components, such as real interest rate and productivity differences, that might be relevant to saving-investment balances. This is explicitly a medium- or long-term concept that allows for short-term deviations from the equilibrium rate. FEER can evolve over time, meaning equilibrium values are in a state of continuous change.

Still another behavioral approach to exchange rate models is to abandon the judgmental determination of sustainable current account balances and explain the behavior of a REER through consideration of transitory, cyclical, and long-run influences. Some approaches are derived from models that include structural models of exchange rate determination e.g., real interest rate parity conditions.²⁰ The long-run equilibrium exchange rate depends on the value of sets of fundamental variables such as relative productivity growth in traded goods sectors, net foreign assets, terms of trade, and openness of an economy. These models can allow some view of the adjustment of exchange rates when disturbed from an equilibrium level.

A weakness of these models is that they typically concentrate on the medium term but assume arbitrary capital flows. A full understanding of a medium-term economy requires consideration of international financial markets and capital flows. Equilibrium in the real economy, in particular, should be consistent with equilibrium in international financial markets.

SECTION 3: ESTIMATES OF EQUILIBRIUM EXCHANGE RATES

As noted, numerous approaches have been suggested for estimating equilibrium exchange rates. The various approaches entail different model specifications, use different price deflators, assign different weights, and thus generate different measures of “equilibrium” and different “misalignment” outcomes. What follows are some practical examples in current use.

¹⁹ “Staff Report on the 2006 Article IV Consultation” at www.imf.org/external/pubs/ft/scr/2006/cr06279.pdf

²⁰ The “uncovered interest rate parity” relationship states that the expected appreciation of one currency in terms of a second currency is equal to the difference between interest rates in the two economies. The theory arises from an arbitrage argument to the effect that one should not be able, on the average, to make a profit by borrowing in one currency, converting the proceeds through the foreign exchange market to lend in the second currency, then converting the principal and interest of the loan through the foreign exchange market again to the home currency. Although theoretically appealing, the empirical support for this theory, even using various forms of risk premia, is not very good in the short-run. The “carry trade” is, in fact, built on the assumption that uncovered interest rate parity does not hold over an investment period. Real interest rate parity substitutes price-adjusted exchange rates and inflation adjusted interest rates for nominal exchange and interest rates.



• PPP Computations

The World Bank maintains a databank of “purchasing power parity conversion factors”²¹ to make international comparisons of Gross National Product (GNP), in which each country’s national product or national income are valued at common dollar prices across countries. To illustrate, the conversion factors used by the World Bank for the years 2000 and 2003, for a select group of countries, are shown below, alongside the actual average exchange rates for the same two years.

PPP Conversion Factors			Exchange rates			PPP Conversion Factors			Exchange rates		
Country Name	2000	2003	(Local Currency per Dollar)		Country Name	2000	2003	2000	2003	2000	2003
			2000	2003							
Argentina	0.6470	0.8445	0.9997	2.9472	Mexico	6.2906	7.2025	9.4590	10.7968		
Australia	1.3363	1.3672	1.7195	1.5330	Norway	9.3111	9.0991	8.8109	7.0791		
Brazil	0.8789	1.1012	1.8310	3.0793	Philippines	10.9876	12.3769	44.2614	54.1941		
Canada	1.2357	1.2368	1.4855	1.4012	Poland	1.8853	1.8751	4.3454	3.8891		
Chile	289.0	308.9	539.6	690.5	Russian Federation	6.9303	10.0354	28.1578	30.6812		
China	1.8544	1.8195	8.2784	8.2772	Saudi Arabia	2.7158	2.6991	3.7500	3.7500		
France	0.9524	0.9415	0.9234	1.1317	Singapore	1.6706	1.5295	1.7249	1.7427		
Germany	0.9470	0.9294	0.9234	1.1317	South Africa	2.1404	2.5509	6.9470	7.5569		
Hong Kong, China	7.4968	6.5858	7.7924	7.7875	Sweden	10.0910	10.1800	9.1751	8.0801		
India	8.5149	8.9669	45.0008	46.5950	Switzerland	2.0303	1.9198	1.6899	1.3452		
Indonesia	2011	2476	8402	8574	Turkey	0.2958	0.7512	0.6248	1.5016		
Japan	155.2	139.8	107.8	115.9	Ukraine	0.8362	0.9948	5.4402	5.3327		
Korea, Rep.	809.8	837.8	1138.5	1192.0	United Kingdom	0.6547	0.6826	0.6597	0.6117		
Malaysia	1.6475	1.6727	3.8000	3.8000	Venezuela, RB	602	1088	680	1614		

The comparisons illustrate how cautious one should be when interpreting the results. For example, the purchasing power parity conversion factor for the Japanese yen in 2003 is implied to be roughly 140 yen/dollar, whereas the actual exchange rate in 2003 was 116 yen/dollar, an implied over-valuation of the yen of 21 percent. The conversion factor for the Chinese renminbi, the Indian rupee and the Ukrainian hryvnia would have implied very large under-valuations of these currencies.

The difficulty of such measures lie in the prices of non-tradable goods being systematically lower in “lower income countries”, when converted to a common currency, than is the case for “higher income countries”. In other words, when exchanged for local currency it takes fewer dollars to buy the same basket of goods in a low income country than it does in a high income country, such as the United States. To the extent the World Bank’s measure is influenced by prices of non-tradable goods, deviations of market from purchasing power parity are limited as indicators of competitive trade advantage.

Perhaps the best known, and easiest to understand, measure of PPP is *The Economist* magazine’s Big Mac index. As in other PPP measures *The Economist* magazine calculates how much it costs to buy a standard basket in around 120 countries. The standard basket contains one hamburger, the Big Mac. The implied PPP measures are the fictitious exchange rates that would equalize the cost of buying a Big Mac in all of the markets. There are clearly reasons for Big Mac prices to differ across countries – transportation costs for inputs and final product relative to value can be

²¹ Based in ICP tables.

significant, and restrictions on imports of agricultural products, particularly beef, exist in many countries, while some inputs like the structure in which the hamburger is sold are not tradable internationally.²² It is nonetheless a useful, and very practical, idea.

Big Mac Indices

Country	Currency	Implied PPP of the dollar	Dollar FX Rate 22-May-06	Overvaluation(+) against dollar (%)
United States	\$	-	-	-
Argentina	peso	2.26	3.06	-26
Australia	A\$	1.05	1.33	-21
Brazil	real	2.06	2.3	-10
UK	£ ‡	1.60‡	1.88‡	18
Canada	C\$	1.14	1.12	1
China	yuan	3.39	8.03	-58
Egypt	pound	3.06	5.77	-47
Euro area	€ *	1.05	1.28	22
Hong Kong	HK\$	3.87	7.75	-50
Indonesia	rupiah	4,710	9,325	-49
Japan	yen	80.6	112	-28
Malaysia	ringgit	1.77	3.63	-51
Mexico	peso	9.35	11.3	-17
New Zealand	NZ\$	1.44	1.62	-11
Philippines	peso	27.4	52.6	-48
Poland	zloty	2.1	3.1	-32
Russia	ruble	15.5	27.1	-43
Singapore	S\$	1.16	1.59	-27
South Africa	rand	4.5	6.6	-32
South Korea	won	806	952	-15
Sweden	SKr	10.6	7.28	46
Switzerland	SF	2.03	1.21	68
Taiwan	NT\$	24.2	32.1	-25
Thailand	baht	19.4	38.4	-50
Turkey	lire	1.35	1.54	-12
Venezuela	bolivar	1,839	2,630	-30

* dollars per euro

‡ dollars per pound

Source: *The Economist*, May27-June 2, 2006

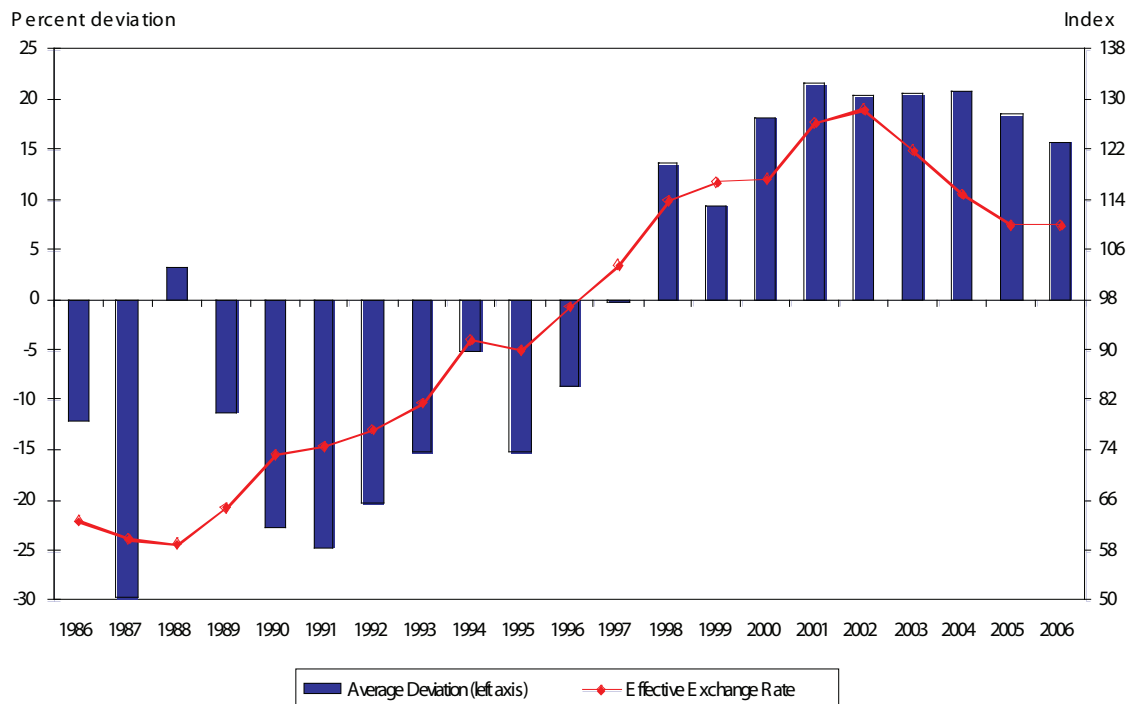
²² For an analysis of PPP and the Big Mac index see Pakko, M. R. and P. S. Pollard (2003) "Burgernomics: A Big Mac Guide to Purchasing Power Parity", *Federal Reserve Bank of St. Louis Review*, November/December.



The Big Mac index indicates that the currencies of most emerging markets are undervalued relative to the U.S. dollar. This undervaluation has been persistent. Balassa and Samuelson's analysis of productivity and REER may explain this pattern. Per capita income levels are generally reflective of productivity differences. Moreover, differences in productivity are greatest in the tradable goods sector. As noted above increasing productivity in the tradable goods sector will raise wages across all sectors in an economy. A Big Mac is thus likely to be more expensive in a high wage country than in a low wage country.

Although deviations of individual exchange rates from PPP are persistent in the Big Mac index, the average of the individual deviations tends to diminish over time. Moreover, the effective exchange rate of the dollar tends to move along with the average deviation from PPP of the currencies in the Big Mac index, as shown in Figure 2.

Figure 2
 Average Deviation of US Dollar from Purchasing Power Parity and
 the Nominal Effective Exchange Rate



• The Impact of Using Different Price Deflators and Other Practical Problems

The properties of a model are critical and have important implications for assessments of exchange rate levels. Even in the simplest of cases, for example, small changes can result in significant differences in the measurement of over- or under-valuation. To illustrate, the following table was prepared from two REERs calculated by the IMF. The first uses changes in unit labor costs as the price deflator to calculate the real exchange rate.

Deviation of 2004 REER from 1980-1999 Average (%)		
Industrial Countries	Relative Unit Labor Costs	Relative Consumer Prices
United States	-16.67	0.78
Canada	6.53	-5.20
Japan	-6.32	2.19
Euro Area	4.96	7.90
Austria	-17.93	5.69
Belgium	-1.83	1.63
Finland	-24.33	-9.90
France	-9.65	-1.12
Germany *	7.71	-4.25
Ireland	-53.33	7.05
Italy	14.69	3.52
Netherlands	4.26	7.35
Spain	14.54	6.20
Denmark	15.83	9.83
Norway	36.59	-0.80
Sweden	-15.09	-12.16
Switzerland	33.59	5.68
United Kingdom	22.13	16.73

The second uses changes in consumer prices. Other examples could include the use of producer or wholesale prices or other indices that capture price changes. In the example, the REERs are calculated using the two different price deflators, and then the calculated rates are compared to their 20-year average to detect deviations from the long-run trend.

The differences are again striking. The index based on relative labor costs shows the U.S. dollar, on a real effective basis, to have been undervalued by 17 percent in 2004.²³ Using consumer prices, the dollar was estimated to be close to its two-decade average. Similarly, the Japanese yen was estimated to be *undervalued* using unit labor costs and *overvalued* using consumer prices. The Canadian dollar had the reverse configuration: estimated to be *overvalued* using unit labor costs and *undervalued* using consumer prices. This simple example neatly shows how strategic choices of constructing an index, in this case in the choice of deflator, can result, without further analysis, in apparently conflicting results and potentially misleading judgments about proper exchange rate values.²⁴

²³ The Federal Reserve's broad index of the real value of the dollar had the dollar in 2004 at 2.4% above its average value for the years 1980-1999.

²⁴ Some analysts argue that consumer price indexes reflect the prices of more non-tradeable goods than producer price indexes and use changes in their ratios as a proxy for the growth of productivity in the tradable goods sector relative to growth of productivity in the non-tradable goods sector.



- **Private Sector Estimates**

Private sector financial institutions provide a broad spectrum of REER estimates using different model structures. Private sector estimates often focus on different issues than do academic estimates. For example, a private sector forecast may want to focus on nominal bilateral misalignments, however defined, as indicators of profitable trading opportunities. Academic economists are more likely to focus on misalignments of the REER since this is the measure of the exchange rate that is important in determining real macroeconomic activity levels. As a consequence, attempts to estimate such quantities as nominal bilateral misalignments require supplemental procedures and assumptions.

The Bank of America has developed several measures of misalignment of emerging market currencies, using different equilibrium concepts: one based on a CPI-based REER; another based on a cost-based REER; another based on a risk-adjusted REER – derived from a long-term currency crisis index (CCI-L), which summarizes the state of a country’s fundamental macroeconomic variables; and still another based on an income-adjusted PPP. The table below shows a sample of the various outcomes, for September 2005, based on each of the approaches.

Economy	% Overvaluation (+)			
	CPI Based REER	Cost Based REER	CCI Risk Adjusted REER	Income Adjusted PPP
Americas				
Mexico	7	6	16	40
Venezuela	-15	-18	13	87
Colombia	0	1	2	-17
Europe				
Russia	17	28	1	-15
Czech R	18	18	-24	-15
Turkey	32	18	19	38
Asia				
India	6	4	6	-34
China	-2	14	-44	-41
Hong Kong	-16	-19		-30
Taiwan	-6	-7		-43
South Korea	13	5	-8	2
Thailand	-7	-14	3	-29
Malaysia	-9	-6	-53	-5
Indonesia	-9	6	25	-10
Philippines	-12	-14	-2	-34
Singapore	-9	-7		-8
Africa				
South Africa	-15			13

The results are vastly different depending on the approach used. For example, estimates for the Mexican peso range from a 7 percent to a 40 percent overvaluation. Estimates for the Chinese renminbi range from 44 percent undervaluation to a 14 percent *overvaluation*. Estimates for the Venezuelan bolivar range from an 87 percent overvaluation to an 18 percent undervaluation.

Other financial institutions use still different approaches.

- The Hongkong and Shanghai Banking Corporation (HSBC), with some strong caveats,



estimates long-term, 5-8 year, bilateral exchange rates based on calculating a rate that would be consistent with long term external balance.

- J.P. Morgan Securities uses a behavioral equilibrium exchange rate model for emerging market countries, with fundamentals of productivity, terms of trade and trade openness to estimate real equilibrium exchange rates. The model provides a measure of currency over-valuation or under-valuation based on economic fundamentals. Short-term dynamics are described by an error correction form of the model. Morgan bases its estimates of the fair value of currencies, defined as the exchange rate consistent with the equilibrium in both domestic and foreign markets, more generally on the basis of fundamentals such as productivity differentials, external prices, country risk and interest rate differentials.
- GSDEEMER of Goldman Sachs is a behavioral equilibrium exchange rate model with long-run equilibrium exchange rates determined on the basis of relative productivity, the terms of trade, international investment position, trade openness and G-3 real interest rates. The equilibrium exchange rates in the initial part of the exercise are bilateral real exchange rates against the dollar. In a second stage, bilateral nominal rates are derived in an error correction model by assuming that the nominal rate carries all the burden of adjusting to a medium-term equilibrium.

	<u>HSBC</u>	<u>GS</u>	<u>JP Morgan</u>		<u>HSBC</u>	<u>GS</u>	<u>JP Morgan</u>
	End of 05	End of 05	14-Dec'05		End of 05	End of 05	14-Dec'05
	Overvalued	Overvalued	Deviation from Equilibrium		Overvalued	Overvalued	Deviation from Equilibrium
Americas				Asia			
Canada	7.2	3.8	5	Japan	1.8	-6.9	-14
Mexico	29.9	9.6	3	India	12.1	-14.7	
Brazil	50.0	3.7	14	Australia	22.4	3.5	8
Argentina	15.5	-13.6	-18	NZ	31.6	20.1	
Venezuela	58.5	-9.6	-4	China	-17.4	-10.8	
Colombia	9.3	8.3	-1	Hong Kong	0.6	-6.2	
Europe				Taiwan	-15.2	-18.6	
euro	7.7	-2.1	2	South Korea	8.1	-24.4	
sterling	9.5	6.1	1	Thailand	-11.7	-15.8	
Sweden			-3	Malaysia	-15.6	-26.2	
Norway			2	Indonesia	7.0	-28.7	
Russia	11.7	-25.5		Philippines	4.5	-26.4	
CHF/\$	0.3	-2.6	0	Singapore		-0.8	
Turkey			20	Africa			
				South Africa	14.0		0

Each approach generates a different set of results, which are not always consistent in the same direction. One shows the Korean won overvalued by 8 percent, while another shows it undervalued by 24 percent. One shows the Russian ruble overvalued by 12 percent while another shows it undervalued by 26 percent.



• The Chinese Renminbi: A Case Study

In an IMF working paper, Steven Dunaway and Xiangming Li²⁵ reviewed eight different estimates of undervaluation of the Chinese renminbi. They reviewed both modified purchasing power parity and macroeconomic balance approaches. It is clear from their work that estimates of misalignment depend critically on the approach chosen, the fundamental factors included in the analysis, and, in the case of macroeconomic balance approaches, the indicators of equilibrium in the balance of payments (or “norms”). The following table taken from Dunaway and Li’s paper illustrate the range of assumptions and outcomes in the estimates. Five modified PPP Approaches found undervaluation ranging from “small” to nearly 50 percent. The four macroeconomic balance approaches produced estimates between a 15-30 percent undervaluation range to a small overvaluation.

Macroeconomic Balance Approach

	Underlying Current Account	Balance of Payments Norm	Estimated Undervaluation
Goldstein (2004)	2.5 percent of GDP	-1.5 percent of GDP (based on "normal" capital inflows)	15-30 percent
Wang (2004)	2.1 percent of GDP (average 2000-02)	3.1 percent of GDP (savings-investment balance from panel data estimates)	Small overvaluation
Wang (2004)	2.1 percent of GDP (average 2000-02)	0.98 percent of GDP (stabilizes NFA/GDP at 2001 level)	Small undervaluation
Coudert and Couharde(2005)	2.5 percent of GDP (model based)	-1.5 percent of GDP (savings-investment balance from panel data estimates)	23 percent

²⁵ Dunaway, S. and X. Li (2005) “Estimating China’s ‘Equilibrium’ Real Exchange Rate”, IMF Working Paper WP/05/202, October.



Modified PPP Approach

	Samples	Dependent Variable	Independent Variable			Undervaluation
			Relative Productivity	Net Foreign Assets	Others	
Frankel (2004)	118 countries in 2000 Penn World Trade	Price level relative to the U.S.	PPP per capita income relative to the U.S.	36 percent
Coudert and Couharde (2005)	145 countries, with population over 1 million, for 2003	Bilateral real exchange rate against the U.S. dollar	PPP per capita income relative to the U.S.			49 percent
Coudert and Couharde (2005)	21 emerging market countries between 1980 Q1 to 2002 Q4	Bilateral real exchange rate against the U.S. dollar	Ratio of CPI to PPI			18 percent
Lee et al. (2005)	39 developed and developing countries, 1980-2003	CPI-based real effective exchange rate	Relative GDP per worker relative to trading partners	Cumulative current accounts scaled by GDP or exports	Terms of trade, imperfect product substitutability	Small undervaluation
Wang (2004)	China, 1980-2003	CPI-based real effective exchange rate	Ratio of CPI to PPI	Cumulative current accounts scaled by GDP	Trade openness, dummy variable for 1980-86	5 percent

SECTION 4: EVALUATING MISALIGNMENT

As noted at the beginning of this paper, one of the key goals of exchange rate models is to compare current exchange rate levels with the levels implied by the exchange rate models, the difference being termed “misalignment.” Given the divergent outcomes of econometric exchange rate models, it follows that a certain degree of care is necessary. There are a variety of factors to consider when using models to make judgments about misalignment, not the least of which is to focus only on the most egregious and most serious misalignments since one cannot rule out “false positives” in the case of estimated smaller misalignments.

- **Use as Many Models as Possible; Never Rely on One or a Few Models**

As we have seen, different models can produce different estimates of equilibrium. Different models may specify different sets of fundamental variables and produce different levels. One model might find a substantial under-valuation of a currency, while other models might find little or no under-valuation or might even find over-valuation. For example, cyclical or transitory factors may affect the level of an exchange rate so that models that account for these factors will yield different results from those of models that do not. Some would argue that it is reasonable that different models should be used for different economies, reflecting the idiosyncratic factors that influence each economy’s behavior. Since there is no broadly accepted “right model,” a range of models should be employed when attempting to discern misalignment. If many models and indicators provide similar information, then the basis for rendering a judgment is strengthened.

- **Currency Models Should Focus on Real Effective, and Not Bilateral, Rates**

Second, though all models suffer from methodological flaws, some flaws are of greater importance than others. For example, some models focus on nominal rather than real exchange rates. Some focus on bilateral exchange rates rather than on an index that captures



the multilateral, multi-currency world that exists in reality. Some use different base periods or starting points and others, as mentioned above, use different price deflators. Attempts to discern currency misalignment should focus on models that attempt to measure the real effective exchange rate.

- **Confidence Intervals Are Important**

Third, it needs to be recognized that most estimates of equilibrium exchange rates are point estimates and, though statistical estimates have error terms, confidence intervals for the estimates are generally not published. In other words, a model that estimates that a currency is 10 percent under-valued but has a confidence interval of +/- 15 percent might be saying the currency is as much as 25 percent under-valued, or it might be saying the currency is over-valued by 5 percent. Without knowing the confidence interval of the model, interpretation is significantly limited. If some parameters are set judgmentally, it will not be possible to provide accurate confidence intervals at all. John Williamson wrote, with respect to his model, that there was little reason to believe that the equilibrium rate could be judged with any precision and suggested that it might be prudent to operate with a margin of error of plus or minus 10 percent.²⁶

- **Is Misalignment Protracted or in the Process of Adjusting?**

Fourth, although some approaches can be framed in terms of an error correction model of real exchange rate movements and several studies have examined implied rates of adjustment (slow) to purchasing power parity conditions, these approaches do not attempt to describe formally the process by which exchange rates adjust when they are not at equilibrium levels. As a consequence, these approaches do not provide information on whether an economy whose exchange rate is out of equilibrium is adjusting to eliminate the misalignment or not. In fact, models typically have very little to say about whether the alleged misalignment is a temporary but self-correcting deviation, whether equilibrium is itself moving and the deviation simply reflects an observed rate chasing an ever-changing equilibrium exchange rate, or whether the misalignment is “protracted” and not self-correcting. Rendering a view on the latter will require supplemental information.

- **Are there Market-Based Reasons for Misalignment?**

If reasonably well specified models, that incorporate features of the real and financial economy and take into account fundamental, cyclical and transitory influences, were to point to significant misalignment *over a protracted period of time* then this would provide a compelling reason to look for factors that produce the apparent misalignment. It is necessary to examine a misalignment over a protracted period, since the equilibrium exchange rate that defines a misalignment is the rate judged, in one sense or another, to be appropriate in the medium term. The medium term is roughly a half dozen years.

In cases in which there is misalignment over a protracted period of time, the results need to

²⁶ Williamson, J. *op cit*, p. 66



be sifted carefully. There may be perfectly good market-based reasons that can explain the deviation from equilibrium. For example, a model may not account adequately for the risk of investing in a currency so that demand for assets denominated in that currency may increase, and the nominal exchange rate appreciate, only slowly in the face of significant productivity shifts. Alternatively, the deviation might reflect defective institutions that weaken adjustment processes, or it might be the result of a misguided exchange rate policy. Protracted misalignment of the currency of a major economy that is not market-based can seriously weaken the international adjustment process.

- **Look for Other Criteria that are Necessary to Sustain a Currency Misalignment**

In addition to the outcomes generated by multiple modeling efforts, the analysis should also be supplemented by analysis of other factors thought necessary to sustain a misaligned exchange rate. The list here is not exhaustive and is just meant to be illustrative, but persistent one-way intervention in currency markets, controls on capital movements, dependency on exports to generate economic growth, changes in reserves, size and changes in the size of the current account relative to GDP, and lack of currency flexibility are potential indicators, to name a few.

CONCLUSIONS

It is difficult for any model to describe adequately, and with a firm empirical basis, all features of modern economies that are relevant to determining exchange rate movements. This reflects in part the difficulty of modeling international financial markets and capital flows.

Economists have developed a variety of methods to estimate equilibrium exchange rates. The methods differ considerably in their construction and in their estimations of equilibrium values. In some sense, comparing the models is similar to comparing “apples and oranges” because they can radically differ in structure and can even use different measures of the real effective exchange rate. Often, they are attempting to measure entirely different kinds of equilibrium. That does not mean the models do not provide useful information. To the contrary, they provide valuable insights, but one must recognize that they are limited by the use of somewhat simplified structures, which are often necessary if they are to have a reasonable empirical underpinning.

Those shortcomings aside, practitioners have provided us with a variety of estimates of equilibrium values and measures of over- or under-valuation. Although the range of results can and often do vary considerably, it is possible to draw certain inferences about misalignment provided the results are drawn from a variety of models and the results are largely similar in magnitude and direction. This information should be supplemented with assessments of other reasons why the exchange rates, during relevant periods of time, might deviate from perceived equilibrium values.

However, the ability to draw inferences and make comparisons from different equilibrium exchange rate work could be substantially improved. Apart from the “apples and oranges” of bilateral vs. multilateral equilibrium exchange rate estimates, nominal vs. real estimates, use of

different deflator indexes, models are often run at different times and the structure and particular features of the models used are unclear.

The International Monetary Fund is the central global institution for exercising firm surveillance over members' exchange rate policies. With this in mind, the International Monetary Fund could make a valuable contribution to discussions of exchange rates and misalignment. The IMF has the considerable technical ability and staff resources required to help advance public understanding and debate about equilibrium exchange rates and misalignments to facilitate studies on these issues. It could, in particular, comprehensively collect descriptions of various private and public sector models and publish, as well as update, the model results on a consistent basis. This would allow analysts to sift through the data more closely and reach more informed judgments.