Weighted Average Relative Price (WARP): A Supplement to Standard Real Effective Exchange Rates (REERs)

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Abstract

This paper describes a weighted average relative price (WARP) for the United States. The staff at the Federal Reserve Board has found it to be a useful supplement to the Board's standard real effective exchange rate (REER) measures. The WARP attempts to measure the level of US prices relative to the prices of those countries that either trade directly with the United States or compete against US exporters in third markets. We review how REERs and the WARP are constructed and discuss why the WARP will reflect an interaction between differences in price levels and changing trade shares that REERs cannot capture. For the United States there is a significant difference between the secular movement in the REER and the WARP.

Kewords: Competitiveness, International Comparison Project, PPP.

1. Introduction and Summary

This paper describes our weighted average relative price (WARP).[1] The staff in the International Finance Division of the Federal Reserve Board has found it to be a useful supplement to the Board's standard real effective exchange rate (REER) measures. The idea behind the WARP is very simple: It attempts to measure the level of US prices relative to the prices of those countries that either trade directly with the United States or compete against US exporters in third markets.[2] Later we describe in detail how this measure differs from standard real effective exchange rates (REERs), but first a little motivation is useful.

As shown in Figure 1, between 1970 and 1985, the share of US trade that was with emerging market economies (EMEs) stayed fairly steady at about 25 per cent. Starting in the mid-eighties, as these economies became more integrated in the global trade network, their share in US trade grew and is now over 50 per cent.

Since many EMEs had lower cost structures than the developed economies, this meant that a larger share of US and world trade was with relatively low-cost producers. We could see the effects of this on import prices and the pattern of trade, and it clearly had implications for US external balances and employment. However, the standard REERs, were not signalling any secular change in real exchange rates. There was no signal because the REERs are not designed to pick up this kind of secular change. The world was seeing a shift in the location of productive capacity. As a first order event, this was a change in quantities, not prices, and the REERs are designed to pick up only price changes. The point of the WARP is to capture the way shifting quantities (or productive capacities) interact with established differences in price levels to affect competitiveness.

In the next section we review how REERs are constructed and contrast them with the WARP. We then compare the WARP to standard REERs and show that indeed it has

[1] This paper is an abridged version of Thomas and Marquez (2013) with updated series. The longer paper contains citations to applications and the earlier development of the measure.

[2] We are by no means the first to think of this or to implement it. Early and excellent work on this was done at the BIS by Turner and Van't dack (1993).

a secular trend that the REERs do not. The note closes with a few examples of where we have used the WARP and discusses how it relates to notions of competitiveness.

2. REERs vs. WARP: Their construction

2.1. REERs

All REERs for the United States start with a set of bilateral market exchange rates against the dollar E(j/$,t). As given in equation (1), these are then adjusted for relative price movements in the two economies, typically using the ratio of a US price index to a price index for country *j*:

$$(1) \quad q_{j,t} = \frac{PI_{us,t}}{PI_{j,t}} \cdot E_{\frac{j}{\$},t}$$

These $q_{j,t}$ are bilateral real exchange rates against the dollar and an increase represents a real appreciation of the US dollar.

Of course, the price indexes (the PIs) are just that, price indexes, so their ratio in a given time period has no intrinsic meaning. The information content in the ratio is in how it moves over time.

From these bilateral measures, the REER is usually constructed as a chain index with time-varying trade weights, as follows:

$$(2) \quad \frac{Q_t^{CR}}{Q_{t-1}^{CR}} = \prod_{j=1}^{J} \left(\frac{q_{j,t}}{q_{j,t-1}} \right)^{\omega_{j,t}}$$

where $\omega_{j,t}$ is a simple trade weight or some other measure of the relative importance of country *j* in our trade at time *t* and *J* is the number of countries. The level of Q_t^{CR} is set equal to 100 in some arbitrary period and the other periods are solved for recursively.

By using period-to-period ratio changes in the $q_{j,t}$, we get around the fact that the levels of the price indexes, and hence the *q*'s, have no intrinsic meaning. We only use the information content in their changes over a given period—say a month or a quarter. Of course there are many price indexes one can choose from—CPIs, PPIs, unit labour costs, etc., and there are many ways to construct the trade weights. Given these choices there are many ways to construct chained REERs.

One can also construct a REER by aggregating levels, that is, without chaining. For example, we could set all price indexes, $PI_{j,t}$, including those for the United States, to equal one in some base period, call it *z*; index the exchange rates to one in the same period; and then construct the REER as an arithmetic or geometric average of the ratios of the normalized US index to the normalized foreign indexes. The geometric one is more common and is constructed via (3)-(5):

$$(3) \quad PI'_{j,t} = \frac{PI_{j,t}}{PI_{j,z}}, \qquad E'_{\frac{j}{\$},t} = \frac{E_{\frac{j}{\$},t}}{E_{\frac{j}{\$},z}}$$

$$(4) \quad q'_{j,t} = \frac{PI'_{US,t}}{PI'_{j,z}} \cdot E'_{\frac{j}{\$},t}$$

$$(5) \quad Q_t^{LR} = \prod_{j=1}^{J} \left(q'_{j,t} \right)^{\omega_{j,t}}$$

These measures give the weighted change in the bilateral real rates since the base period.

There are two problems with these: First, the value of Q_t^{LR} depends on what base period, *z*, you choose. So you need a good reason to pick one base period over

another. Second, it still does not fully capture the quantity effects discussed earlier, unless the low-cost producers became low-cost sometime after the base period.

To see why none of these REERs address the quantity effect, we run the following thought experiment: Suppose the United States trades with many countries, some with relatively high prices and some with relatively low prices. To keep things simple we suppose inflation rates are the same everywhere and nominal exchange rates are fixed. So all the $q_{j,t}$ are constant during our experiment. Now, as happened in the 1980s, we suppose the low-price economies grow faster than the rest, greatly expand their productive capacities, and start producing more goods for international trade.

What happens to the REERs? The chained REERs do not move. The weights change, but because there is no period-to-period change in the bilateral price ratios, the aggregate measure does not change. What about the REERs constructed in levels via equations (3)-(5)? These aggregates may move as the weights move because the ratios that we are aggregating need not all be equal to one over this period. But the amount and direction by which the aggregates move will depend entirely on what happened between the base period, *z*, (when all the $q'_{j,t}$ ratios were set to one) and the starting date of our thought experiment.

2.2. WARP

As do the REERs, the WARP starts with market exchange rates and measures of US prices and foreign prices. The difference in the WARP is that it uses measures of the US price *level* relative to the foreign price *level* and not relative price *indexes*. These measures of relative price levels come from the purchasing power parity (PPP) exchange rates constructed by the International Comparison Project (ICP). A discussion of how the PPPs are constructed is given in Thomas and Marquez (2013). Here we simply note that $E_{j/\$}$ /PPP_j is a measure of the general US price level relative to country j's price level when both countries' prices are expressed in a common currency.

The WARP is a geometric average of these price ratios where the weights are changing with trade shares.

$$(6) \quad q''_{j,t} = \frac{1}{PPP_{j,t}} \cdot E_{\frac{j}{\$},t},$$

$$(7) \quad Q_t^W = \prod_{j=1}^{J} \left(q''_{j,t}\right)^{\omega_{j,t}}$$

We note that the level of Q_t^W has a very natural interpretation as the ratio of US prices to foreign prices. Thus a value of 1.5 implies that US prices are 50 per cent higher than the average of our trading partners' prices.

3. REERs vs. WARP: Their behaviour over time

This section compares the movement of the WARP to several REERs over the past several decades. To begin it is useful to look at the movements of what goes into them. As noted earlier, and shown in Figure 1, the share of US trade done with emerging market economies (EMEs) has increased dramatically since the early 1980s.[3] This is one key requirement for there to be a difference between the WARP and the REERs. The other key requirement is that there be a significant difference in the price levels across our trading partners. Figure 2 illustrates that this second requirement is also fulfilled. The dashed blue line plots the ratio of US prices to the prices of our advanced foreign economy (AFE) trading partners. This ratio was near 1.3 in early 1985 when the dollar was at its peak, but has since been in the range of

[3] Construction of the FRB trade weights is described in Leahy (1998).

1.1 to 0.9. That is, by this measure US prices were roughly 30 percent above our AFE trading partners' prices in 1985, but have since been roughly equal to theirs plus or minus 10 per cent. The solid green line shows the ratio of US prices to those of our emerging market economy (EME) trading partners. It has also moved with the large swings in the dollar, but it has generally been in the neighbourhood of 1.7, implying that US prices have been roughly 70 per cent higher than EME prices.

Figure 3 shows what happens when we put these pieces together. The solid green line is the WARP when it includes the prices of all our major trading partners. The other lines plot three standard REERs—the Federal Reserve Board's Broad Real Dollar (solid black), the IMF's REER for the US dollar (dashed red) and the BIS's REER for the dollar (boxed blue). The three REERs have been re-indexed so they all equal the value of the WARP in 1994Q1—the first quarter for which we have an observation for the BIS measure.

There are two points to take away from this figure. The first is how closely the three REERs track each other over the period. Compared to the FRB's REER, the IMF's measure shows somewhat more appreciation of the dollar in the early 1980s, but since 1985 these two REERs have moved nearly in lock step. The same is true for the BIS measure. Since its start in 1994, it has moved almost exactly with other two REERs.

The second point, and the reason for writing this note, is that the WARP does not follow the other measures over the whole period. The WARP tracks the REERs fairly closely between 1986 and 1998, but starting in the late 1990s, the WARP shows much more real dollar appreciation. In fact, if we compare the latest value for the WARP with its value in the early 1990s, it shows a noticeable real appreciation. In contrast, the REERs show a noticeable depreciation over the same period.

We do not take the stand that the WARP is telling the 'true' story and the REERs are not. There is no reason to. Researchers have many measures to choose among and the choice of which one measure, or set of measures, to use will be determined by what is most useful for the question at hand. The WARP is designed to pick up a feature of the trade landscape that the REERs cannot, and it seems to do that.

4. Applications and a few words on "Competiveness"

The fact that the WARP behaves differently than REERs does not necessarily mean it is a useful construct. As discussed in Thomas and Marquez (2013) and the cites given there, we have run many horse races on trade volume and price equations where the WARP either replaces or augments standard relative price measures. In general we find it is useful, especially in explaining import prices. Assessing the usefulness of WARP in model equations is relatively straight forward as it is sufficient to evaluate the properties of the estimated equations. In contrast, the question of whether WARP can be used as an indicator of competitiveness is much harder, in large part because competitiveness is not a clearly defined concept.

Keynes noted almost a century ago that one cannot think of competitiveness in terms of differences in traded goods prices because trade—by its nature—tends to eliminate such differences.[4] Max Cordon concluded a reasonable definition of competitiveness is in terms of profitability of firms in the traded goods/services sectors.

[4] Using product-level PPP measures we find that cross-country differences in prices are much smaller for traded goods and when we compute a WARP-like measure for the US using only traded goods, it stays quite close to one, even when the overall measure is much higher.

Figure 1
Trade Shares

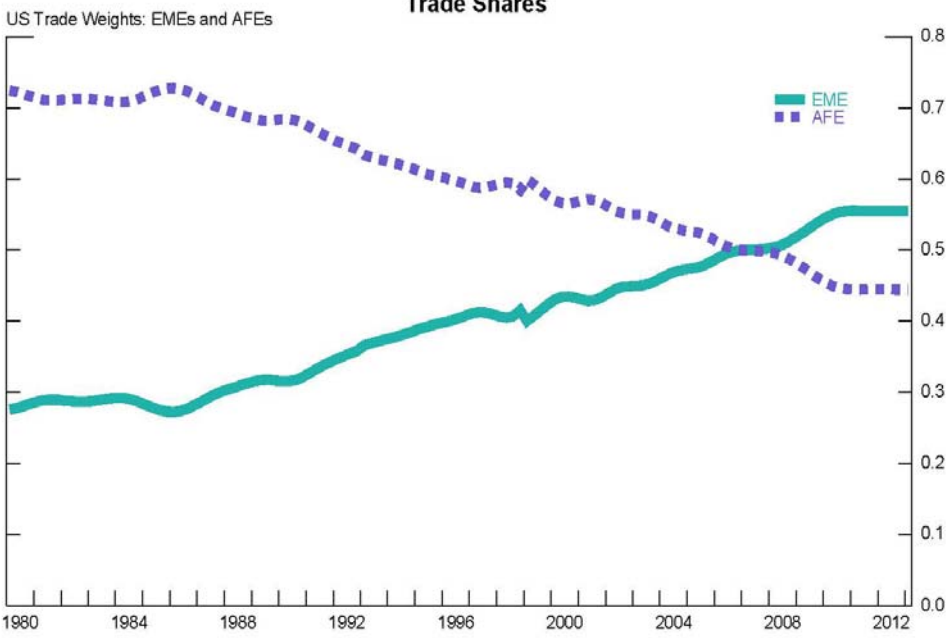


Figure 2
Relative Prices

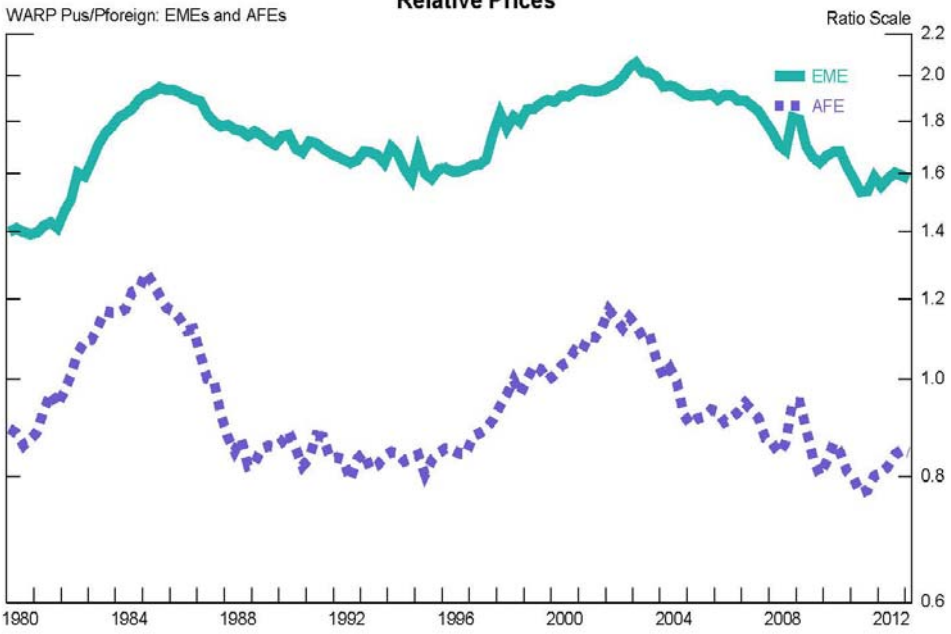
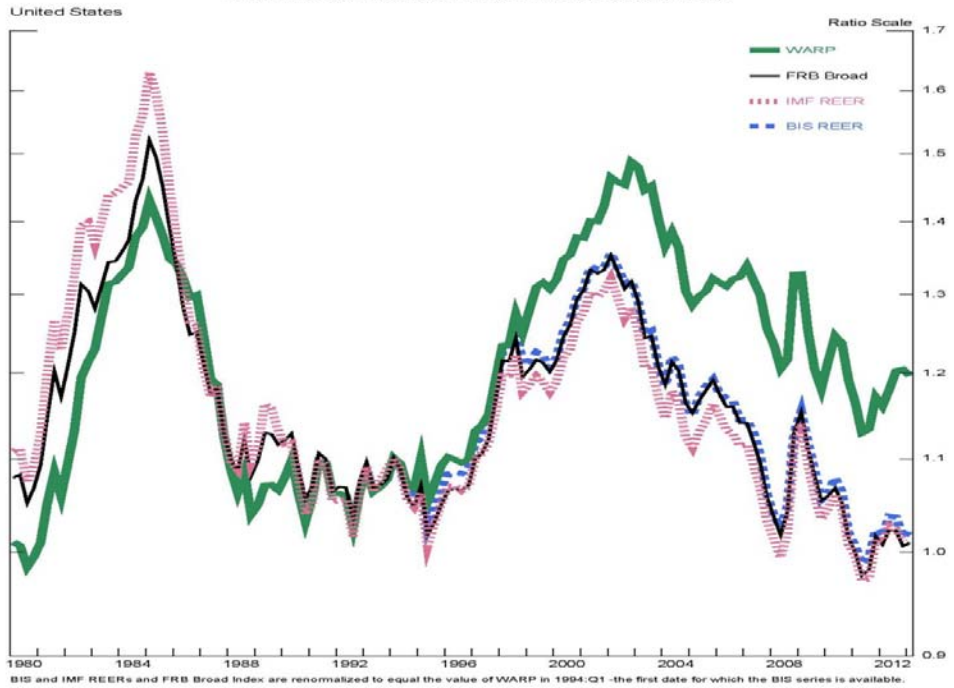


Figure 3
International Relative Prices: WARP and REERs



BIS and IMF REERs and FRB Broad Index are renormalized to equal the value of WARP in 1994:Q1 -the first date for which the BIS series is available.

Working with Cordon's notion of competitiveness as profitability, we are left with trying to map cross-country differences in general price structures (possibly with difference only in the non-traded sectors) into cross-country differences in the cost structures of traded goods and services. Such a mapping requires measures of relative labour and capital productivity in the traded sectors. The WARPs do not include such productivity measures. Put differently, the WARPs provide a summary measure of relative price structures across countries. To read them directly in terms of competitiveness or relative cost structures one would have to assume that labour and capital productivity are equalized across countries. This is clearly not the case, so the WARPs cannot capture all that is needed to measure competitiveness.

So where does that leave us? The discussion relating WARP to competitiveness is meant to be cautionary. The WARP seems to be related to competitiveness, but we caution against using it, or any single simple measure, to quantify such a complex aspect of the economy. On a more positive note, the WARP does capture some important phenomena that are not well reflected in other measures and we have found it to be helpful in explaining some important macroeconomic phenomena. As such we consider WARP to be a useful addition, or supplement, to the more standard, widely used, REERs.

References

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