MEASURING THE REAL EXCHANGE RATE: PITFALLS AND PRACTICALITIES

Luci Ellis

Research Discussion Paper
2001-04

August 2001

Economic Research Department
Reserve Bank of Australia

This paper has benefited from helpful discussions with Mardi Dungey and RBA staff. I would like to thank Ellis Connolly, Chris Thompson, Stephen McCalman and Chris Stewart for their exceptionally careful data assistance. Any remaining errors are the responsibility of the author, not of the Reserve Bank. The views expressed in this paper are those of the author and do not necessarily reflect those of the Reserve Bank of Australia.

Abstract

The real exchange rate is an important concept in economic theory, but it is not directly observable and must be constructed, usually as an index. The construction of such indices requires a number of decisions – which currencies to include, the appropriate weighting scheme and the price measures to use – which materially alter the results. Unfortunately, theory often gives very little guidance on the appropriate assumptions to make when constructing an exchange rate index. This paper discusses the various choices, highlighting their differing implications. Some of the practical issues of calculation are also reviewed. Several exchange rate indices that have been used in analytical work in the Reserve Bank are presented. These will be updated quarterly on the Reserve Bank website at <http://www.rba.gov.au/statistics/>.

JEL Classification Numbers: C82, F31, G15
Keywords: effective exchange rate, index numbers, real exchange rate index

Table of Contents

MEASURING THE REAL EXCHANGE RATE: PITFALLS AND PRACTICALITIES

Luci Ellis

1. Introduction

The real exchange rate is an important concept in international macroeconomics, used in most textbook models (for example, Turnovsky (1997)). It is usually defined as the product of the nominal exchange rate, expressed as the number of foreign currency units per home currency unit, and the relative price level, expressed as the ratio of the price level in the home country to the price level in the foreign country. There are only two countries in this definition; the exchange rate used is a *bilateral* rate.

However, in the real world, there are more than two currencies. Therefore every country is affected by the movements of more than one bilateral exchange rate. To assess the net effect of movements in a number of bilateral (real) exchange rates, some sort of weighted average of them is needed.

This complication is analogous to the issues faced when measuring the price level; except in the one-good world of many theoretical economic models, measures of the price level must combine the prices of many goods. This boils down to a choice of *components* and their *weights*. For the price level, a common choice of components is those goods and services most commonly purchased by (some subset of) consumers, and the weights corresponding to their shares of those consumers' total expenditure. These choices are on occasion controversial, but they make little difference over the medium term (Australian Bureau of Statistics 1992).

For the exchange rate, however, the choices of which bilateral exchange rates to include and the appropriate weights to use are less clear-cut. In large part, the choice of index depends on the issue being investigated. For example, an index weighted by import shares might be most appropriate when investigating the effects of exchange rate movements on the domestic prices of imported goods. The effect of nominal exchange rate movements on a nation's foreign debt must be measured by an index weighted by the currencies' shares of foreign borrowings. There is no single 'right' measure of the exchange rate.

Selection of the best available exchange rate index is particularly important if bilateral rates are moving in opposite directions. In those circumstances, exchange rate indices constructed on different bases can give quite different results. An example of this was the divergent movements in 1997 and early 1998 of the exchange rates between the Australian dollar and the currencies of countries initially affected by the Asian crisis (Thailand, Indonesia and Korea), compared with the exchange rates between the Australian dollar and the currencies of major industrialised nations (RBA 1998).

In short, the translation from the real exchange rate of theory to real-world data is not straightforward; judgement is required when selecting or constructing an exchange rate measure for empirical research. This paper explains some of the issues faced in constructing both real and nominal exchange rate measures, and highlights the implications of choosing particular components or calculation methods. Although there are some approaches that are strictly preferable to others, there remain a large number of possible indices to choose from. The aim of this paper is to guide users in making choices that are appropriate to their needs, rather than to dictate one – or even a few – 'right' measure of the real exchange rate.

The paper is structured as follows. The next section explains the mechanics of calculating a real exchange rate index correctly. Section 3 discusses the advantages and disadvantages of different weighting schemes. Section 4 presents a set of alternative real exchange rate indices, and explores their differing implications for two econometric equations that have been used in a number of previous RBA studies. After a brief conclusion, the data sources and methodology are set out in the appendix. A selection of real exchange rate indices are now being published on the RBA website and will be updated quarterly.

2. Calculating a Real Exchange Rate Index

As mentioned above, a real exchange rate index is generally calculated as a weighted average of bilateral exchange rates that have been adjusted for relative price levels.[1] These real bilateral rates are calculated as:

$$rer = e \times \frac{p}{p^*} \text{ or in logarithms as: } \ln(rer) = \ln(e) + \ln(p) - \ln(p^*) \qquad (1)$$

where e is the nominal bilateral rate, expressed as the number of foreign currency units per home currency unit, p is the price level of the home country, and p^* is the price level in the foreign country. In this presentation, an appreciation is recorded as an increase in the exchange rate index. Some literature uses the alternative presentation of the exchange rate as the number of home currency units per foreign currency units, where an appreciation is recorded as a fall in the index. It should be noted that standard market quotations for currencies may be in either format. Therefore in some cases it will be necessary to invert the published bilateral series to be compatible with the other bilateral rates comprising the index.[2]

2.1 The Averaging Process

There are two ways to calculate the weighted average. Suppose there are N components e_n to be averaged, with weights w_n, $\sum_{n=1}^{N} w_n = 1$. Then the *arithmetic* average of the e's is calculated as:

$$\sum_{n=1}^{N} e_n \times w_n \qquad (2)$$

---

1 Another way of looking at real exchange rates is as relative price levels adjusted for exchange rate movements (Rosensweig 1987).

2 For the Pound sterling, New Zealand dollar, Australian dollar, PNG kina, the euro and the currencies of most Pacific nations, market quotations are generally for number of US dollars per home currency unit (denoted, for example, AUD/USD). For all other currencies, the quotation is usually in the form of home currency units per US dollar (eg USD/JPY).

while the *geometric* average is calculated as:

$$\prod_{n=1}^{N} e_n^{\,w_n} \tag{3}$$

The arithmetic average is probably more familiar, but there are strong theoretical and statistical reasons to prefer the geometric average. Percentage movements in an arithmetic index will differ in magnitude depending on whether the bilateral rates are expressed as units of home currency per foreign currency unit, or the other way around. Exchange rate indices based on arithmetic averages can also be distorted when the base period is changed. Because geometrically averaged indices treat movements in exchange rates symmetrically, they do not have these undesirable properties (see Rosensweig (1987) for a more detailed discussion). In addition, the logarithm of a geometric average is the arithmetic average of the logs of the bilateral rates. This is a useful feature, as a linear representation in logarithms greatly simplifies many econometric models.

Although the geometric averaging process is theoretically preferable, it can complicate the process of calculating average exchange rate indices for particular periods (month, quarter). To derive the average value of the index over a quarter, for example, one could take daily readings of the index (calculated as a geometric average across all the bilateral exchange-rate pairs) and form the (arithmetic) average of these readings over the quarter. Alternatively, one could form the (arithmetic) average over the quarter of each bilateral real exchange rate, and then generate the geometric average across these quarterly average bilateral pairs. These two approaches do not, however, produce the same outcome in general. In research papers and for the Bank's other published material, the Reserve Bank staff use the second method, because inflation data are only published at monthly or quarterly frequency and it is therefore not possible to derive the daily real bilateral exchange rates that comprise a *daily* real exchange rate index.

For the same reason, real exchange rate indices cannot be constructed by deflating the nominal exchange rate index by the ratio of the domestic price level to the weighted arithmetic-average world price level. Instead, they must be constructed by averaging bilateral real exchange rates using the geometric averaging procedure described above.

2.2 Dealing with Changing Weights

Fixed-weight indices of the real exchange rate are frequently used because they are easy to calculate. There are, however, a number of reasons why it might be preferable to allow the weights to change. For example, if some countries have become more important trading partners over time, a trade-weighted exchange rate index should reflect this. Otherwise, if actual trade shares move too far away from the shares embodied in the weights used, the exchange rate index will give a misleading picture of the net effect of movements in particular bilateral exchange rates.

Indeed, we should expect that weights would change over time as trade patterns adapt to exchange rate movements. If the home currency appreciates relative to another currency, imports coming from that country will become cheaper relative to domestic production or imports from elsewhere. Therefore it is likely that the share of total imports sourced from that country would increase, which will directly change weights based on import shares. The converse will be true for exports.[3] Similar arguments apply to other bases for weighting schemes, such as shares of world GDP or capital flows.

If weights are allowed to vary, the index must be spliced together at every period that the weights are changed. Otherwise, movements in the index will be misleading; in the periods in which the weights change, it would not be clear if the movement in the index reflected changes in the underlying exchange rates, or changes in the weights.[4] We can see this using a simple numerical example. Suppose that the home country trades with two other countries, A and B. The bilateral exchange rates and weights are shown in Table 1.

---

3 Since an appreciation will tend to result in a fall in exports from the home country to the foreign country, the effect on weights based on *total* trade (exports plus imports) is ambiguous. The response of total trade shares to a movement in one bilateral exchange rate (keeping all other bilateral exchange rates involving the home currency unchanged) depends in part on the bilateral trade balance with that country, the types of goods and services traded, and the price responsiveness of demand for imports in both countries.

4 Rosensweig (1987) identifies this problem. The splicing procedure described in this paper eliminates the bias Rosensweig describes.

If the exchange rate index has not been spliced together, it gives the erroneous impression that the home country's exchange rate has appreciated between periods 2 and 3, even though neither bilateral exchange rate has changed. If the weights are updated on a regular basis, these small errors will tend to compound rather than offset each other. This is because trade shares (and other bases for weights) tend to move in the same direction for a number of years.

Table 1: Exchange Rate Index for a Country with Two Trading Partners

Period	Bilateral exchange rate		Weight on exchange rate		Exchange rate index	
	Country A	Country B	Country A	Country B	Not spliced	Spliced
1	100	100	0.5	0.5	100.00	100.00
2	110	90	0.5	0.5	99.50	99.50
3	110	90	0.6	0.4	101.50	99.50

In the case of weights based on import or export shares alone, the bias will naturally compound. As mentioned above, import shares tend to rise if the home currency has appreciated against that trading partner's currency, and conversely currency depreciation tends to expand the share of home country exports to that destination. Therefore, unless the index is properly spliced, changing weights can impart an appreciation bias to an import-weighted exchange rate index, or a depreciation bias to an export-weighted index.

The conceptually correct method for calculating an index with changing weights can now be described. Assume that at time $t=\tau$, weights change from their previous values $w(i,\tau-B)$, which had been set at time $\tau-B$, to new values $w(i,\tau)$. Then for $t \geq \tau$,

$$rer_t = \prod_i brer_{i,t}^{w(i,\tau)} \times Q_\tau \tag{4}$$

where rer_t is the index, $brer_{i,t}$ is the bilateral real exchange rate with country i at time t, as defined in Equation (1) above, and $w(i,\tau)$ is the weight for the ith exchange rate at time τ. Q_τ is a splicing adjustment calculated as:

$$\frac{rer_{\tau-B}}{\prod_i brer_{i,\tau-B}^{w(i,\tau)}} \tag{5}$$

Therefore, this method of calculation can be characterised as a spliced Laspeyres index.

With some rearrangement, we can see that the real exchange rate is the product of the real exchange rate's level prior to the introduction of new weights, and a Paasche index of bilateral real exchange rates in that base period and in the current period. These are weighted according to the weights that apply in the *current* period:

$$rer_t = rer_{\tau-B} \times \frac{\prod_i brer_{i,t}^{w(i,\tau)}}{\prod_i brer_{i,\tau-B}^{w(i,\tau)}} \tag{6}$$

That is, the real exchange rate is calculated as the ratio of geometrically weighted bilateral real exchange rates in the base period and the current period, using *current* weights, spliced onto the base period level of the real exchange rate. If the composition of countries in the basket has changed for the new set of weights, the set of bilateral exchange rates used for both parts of the second term in this expression are those included in the current-period set of weights.

By splicing together the series in this way, weighting schemes can be updated to reflect changing trade patterns. Although this method complicates the calculations, it avoids biasing the results.[5]

[5] Omitting the splicing adjustment creates only a fairly small bias in the short run. Cox (1986) calculates both fixed-weight and (unspliced) moving-weight nominal exchange rate indices for the US dollar, and finds estimates of the depreciation between March 1985 and September 1986 only ranging between 4½ and 6 per cent. This indicates that the bias in the moving-weight index must have been small, despite the divergence in bilateral exchange rates affecting the US dollar at the time. On the other hand, the rationale for using moving weights is to ensure weights remain consistent over the longer term. Therefore, if the moving-weight method is justified, the index should also be properly spliced.

This spliced Laspeyres index results in a measure of the effective exchange rate that gives similar results to the Törnqvist index, which like the Fisher index, is a superlative index. In the current context, where the weights are trade shares, the Törnqvist index can be calculated as the geometric average of a Paasche index and a Laspeyres index constructed with trade (expenditure) weights (Diewert 1976; Caves, Christensen and Diewert 1982).

There are practical reasons for preferring the spliced Laspeyres to the Törnqvist index in policy work. The first is that the Törnqvist index requires next-period weights, for example trade shares for the following year. These data will not be available for the latest period since the next year has not happened yet; the latest period's index will therefore inevitably be revised when the data become available. Therefore although a Törnqvist index is suitable for econometric estimation using historical data, it induces some uncertainty into real-time analysis.[6]

Secondly, the Törnqvist index still requires that the weights are updated at least as frequently as typically occurs for a spliced Laspeyres index – it is not sufficient to choose two base periods a long way apart. Otherwise, if trends in the weights used are not monotonic, the level of the exchange rate in the intervening period between the base and end periods can be distorted.

For a simple numerical example of this second point, consider again the case of a country with two trading partners, A and B. Its trade share with A rises then falls, while the share with B falls then rises. The home country's currency is appreciating against A's currency and depreciating against B's currency, both by 5 per cent per period. As Table 2 shows, if the weights in the beginning and end period are the same, the Törnqvist index will give the same result as its

6 The trade shares or other sources for weights for the current period may not be available in real time, let alone for the future period. For its own purposes, the Reserve Bank of Australia uses trade shares for the *previous year* in calculating current-period exchange rate indices. Although this introduces some measurement error compared with the conceptually correct contemporaneous weights, trade shares move sufficiently slowly that the distortion is small, and arguably the disadvantages of this approach are more than offset by the advantage of enabling real-time analysis. Moreover, current-dated weights may not be appropriate for some purposes. Estimation of trade equations could be distorted if the right-hand side variable (the exchange rate) is constructed using current trade shares, as these incorporate the endogenous response to exchange rate movements that is being estimated. The right-hand side variable would therefore be correlated with the equation's error term.

components, the Laspeyres and Paasche indices. These fixed-weight indices all imply that the home country's effective exchange rate has not changed. In fact, the increased importance of country A in the intermediate periods should be reflected in the effective exchange rate, and some appreciation should occur over those periods. A spliced Laspeyres index captures this effect, provided the splicing occurs sufficiently frequently. On the other hand, it does not then return to the original index level once weights have returned to theirs. A Törnqvist index comprised of *spliced* Laspeyres and *spliced* Paasche indices (not shown) will also capture this effect. However, it is not clear that it is necessarily an improvement on the spliced Laspeyres index, given that the next-period weights required for the spliced Paasche component are not available in real time.

Table 2: Exchange Rate Index for a Country with Two Trading Partners

Period	**Bilateral exchange rate**		**Weight on exchange rate**		**Exchange rate index**	
	Country A	Country B	Country A	Country B	Törnqvist	Laspeyres spliced each period
1	100	100	0.5	0.5	100	100.00
2	105	100/(1.05)	0.6	0.4	100	100.98
3	$100*(1.05)^2$	$100/(1.05)^2$	0.7	0.3	100	102.97
4	$100*(1.05)^3$	$100/(1.05)^3$	0.6	0.4	100	103.98
5	$100*(1.05)^4$	$100/(1.05)^4$	0.5	0.5	100	103.98

Non-monotonic movements in trade shares will distort the index in intermediate periods between re-weightings for any index, including the spliced Laspeyres. Therefore if the weights used move significantly, they should be updated frequently. A Törnqvist index is not a means of avoiding the requirement for regular updating of weights. Ideally, weights should be updated for every period – quarterly in the case of a real exchange index, since this is the highest frequency at which price data are available for Australia. However, the slow speed at which trade shares move mean that quarterly updating provides little advantage over the annual updating approach pursued by the Reserve Bank. Since quarterly trade data by country are only available on a non-seasonally adjusted basis, any such measurement advantage would furthermore be outweighed by the seasonal volatility introduced by using a quarterly weighting scheme.[7] If the weights were updated less frequently, such as at three to five-year intervals, some distortions could potentially arise.

2.3 Choice of Which Bilateral Rates to Include

As long as the bilateral exchange rates are not wildly divergent, it seems reasonable to include all currencies with 'significant' weights in the index. For example, in constructing the (nominal) trade-weighted index of the Australian dollar, the Reserve Bank includes enough countries to account for at least 90 per cent of Australia's total international merchandise trade. However, there are occasions when large exchange rate movements specific to a single currency may result in the index giving a misleading indication of overall competitiveness. For example, the dramatic depreciation of some east Asian currencies, particularly the Indonesian rupiah, in 1997 and 1998 resulted in the published TWI remaining at roughly the same level in June 1998 as it had been a year earlier, despite the A$'s depreciation against other currencies (RBA 1998).

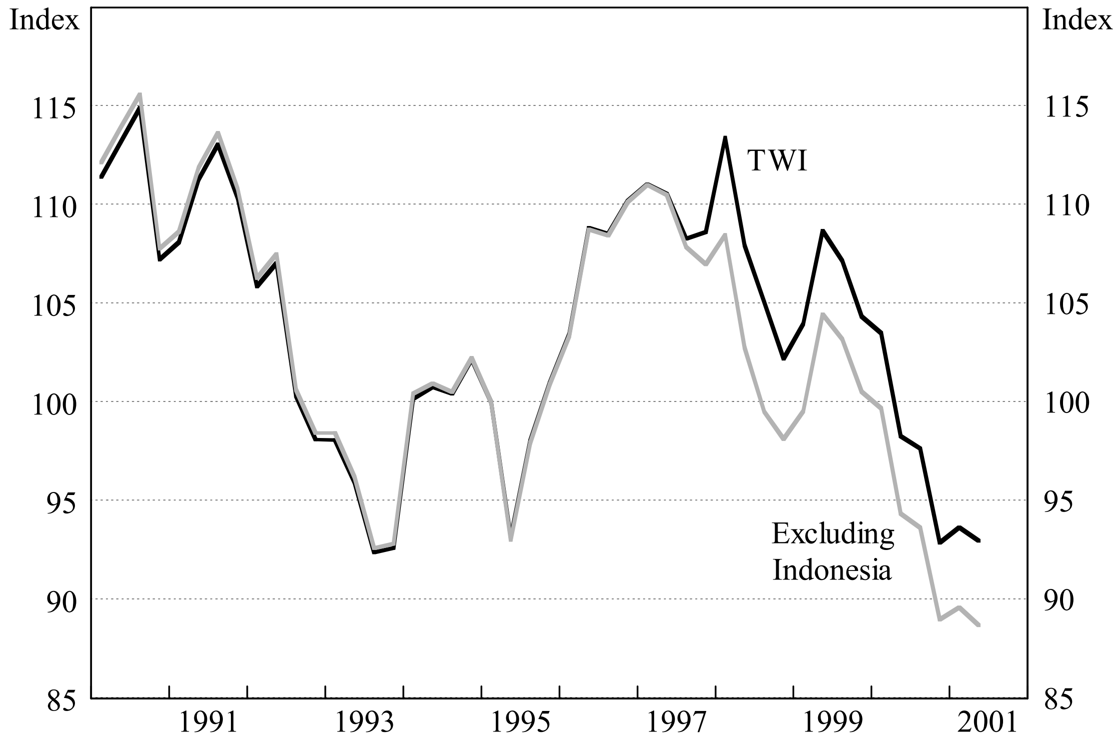
One possible response to an exceptionally large depreciation in a single currency would be to exclude the currency from the index entirely. The difference between the published TWI and a trade-weighted index for the A$ excluding the rupiah is shown in Figure 1. This response could be justified on the grounds that any country experiencing such a massive depreciation would no longer be a potential export market, and so further movements in its exchange rate do not impinge on other countries' competitiveness. However, it has the disadvantage of being possible only after the fact. Nonetheless, as a general rule, exclusion of a minor trading partner from the index should not affect the end result much. If it does, it indicates that this exchange rate is biasing the results, and should be excluded (Rosensweig 1987). Since its weight in the TWI was around 3.5 per cent at the time, this suggests that the *ex post* exclusion of Indonesia is justifiable for some purposes.

---

[7] In addition, the RBA uses merchandise trade by country to determine weights in the TWI, thereby excluding the effects of trade in services. For some applications, total (goods and services) trade weights might be preferable. These data are available disaggregated by country on an annual basis, and so a total-trade weighted exchange rate index with weights updated annually could be constructed.

Figure 1: Nominal Trade-weighted Index

March 1995=100



2.4 Choice of Price Level

Most of the issues discussed up until now apply to the construction of both nominal and real exchange rate indices. When constructing real indices, however, there are additional issues relating to the price series used to deflate the bilateral nominal exchange rates.

The most commonly used price series for this purpose are consumer price indices (CPIs). Although there are theoretical reasons to prefer other types of price index when measuring competitiveness (Rosensweig 1987), CPIs have the advantage of being timely and available for a wide array of countries over a long time period. Other classes of price or cost index, such as producer price or unit labour cost indices, are often difficult to obtain on a comparable basis across more than a few countries.

Ideally, the price series used should be comparable across countries, representative of price conditions in those countries, and relatively free from measurement error.

Although CPIs are not perfect on these criteria, they come closer than other candidate series, especially for indices covering many currencies. In its own work, the Reserve Bank uses 'core' or underlying price measures where available. These measures generally abstract from food and energy prices, which can impart unnecessary volatility into relative price measures. Even so, data availability may still prevent the inclusion of some currencies in a real exchange rate index. For example, the Soviet Union and Russian roubles have been included in the RBA's published nominal TWI from time to time, but are excluded from the real TWI used in this paper because of the difficulties in obtaining price data for the Soviet Union and its successors. Similarly, the United Arab Emirates does not currently publish domestic consumer price data; the RBA uses the IMF's Middle East CPI series as a proxy in calculation of real exchange rate indices.

Inclusion in the index of countries experiencing hyperinflation can also create problems. Since these countries' currencies generally depreciate rapidly, other countries' nominal exchange rate indices can be distorted. For real exchange rate indices, some of this distortion is offset because most of the nominal depreciation captures relative inflation rates rather than a real depreciation. However, the measurement error in measures of domestic price levels for countries experiencing hyperinflation can be large relative to that in other countries. Therefore, although real exchange rate indices abstract from the large nominal depreciations of hyperinflating currencies, some measurement error may remain when these currencies are included.[8]

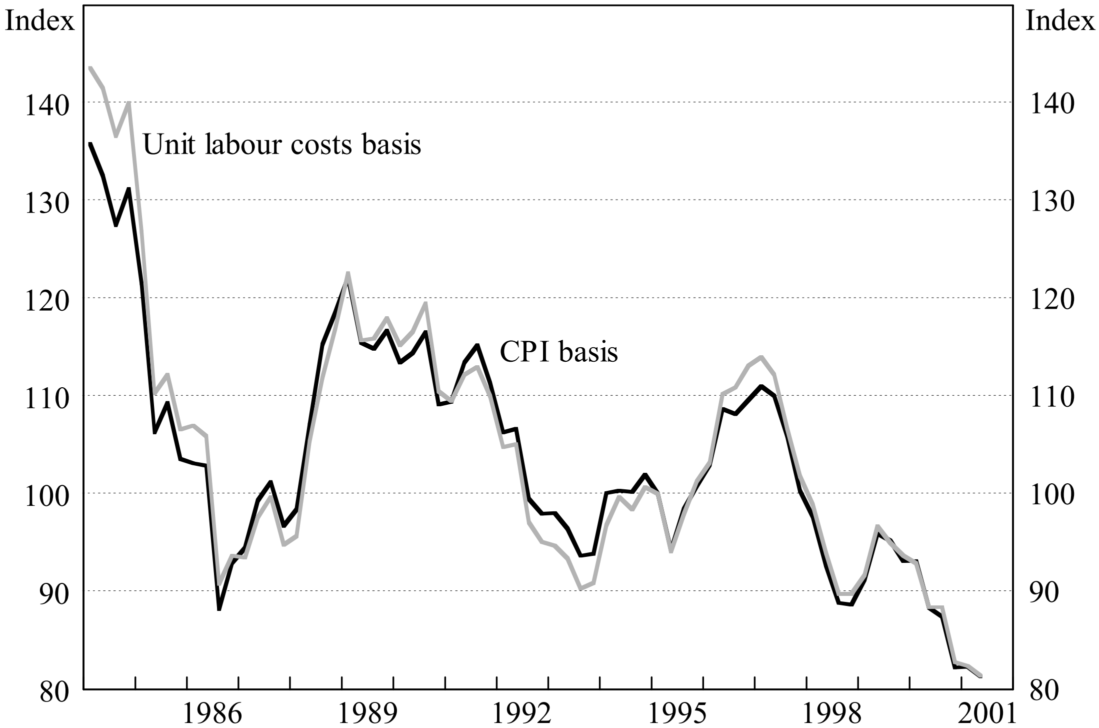
Since real exchange rates are intended to capture movements in competitiveness, it would be conceptually preferable to deflate the nominal exchange rates with some measure of *producer* prices or costs rather than consumer prices. Therefore, if data series of sufficient quality are available, it makes sense to use them instead of CPIs when assessing movements in competitiveness. An index constructed on this basis is shown in Figure 2, along with a consumer-price-based real exchange rate index calculated on the same basis. As the figure shows, the quarterly profile of real exchange rate measures is not greatly affected by the choice of deflator. However, wedges between the *levels* can persist for some time.

---

8 Similar considerations apply to countries with multiple exchange rates for different purposes or market participants. See Rosensweig (1987) for a discussion.

Figure 2: Australian Real Exchange Rate against the G7

GDP-weighted, March 1995=100



Note: The unit labour cost measures are derived as the ratio of nominal employee compensation to real GDP from the national accounts in each country. GDP weights are converted to a common currency using OECD Purchasing Power Parities (PPP).

A final consideration in the selection of a price index is the treatment of changes in indirect taxation. A Goods and Services Tax (GST) was introduced in Australia on 1 July 2000, which increased the price level by a few percentage points. For a given nominal exchange rate, this resulted in an increase in the relative price level and thus an apparent real appreciation of the A$ relative to other currencies. However, this does not represent a genuine deterioration in competitiveness. Imports into Australia attract GST on the same basis as domestically produced goods at the retail level; Australian exports are zero-rated – that is, they do not attract GST. Therefore the introduction of the GST should not have had a deleterious effect on the relative competitiveness of Australian goods and services in either domestic or overseas markets.[9]

This suggests that there is a case for excluding the effects of changes in indirect taxes on measured consumer prices when constructing real exchange rate indices. Accordingly, the real exchange rate measures presented in this paper incorporate an approximate adjustment for the introduction of the GST in Australia. However, similar adjustments were not made to allow for the price effects of indirect tax changes in other countries, as the effects of these on a A$ exchange rate are likely to be small, once they are weighted by those countries' weights in the various exchange rate measures.

3. Weighting Choices

The choice of weighting scheme depends on the purpose. For example, import-weighted indices are generally the most appropriate when assessing the effect of exchange rate movements on import prices. But assessing the effect of exchange rate movements on competitiveness more generally is never simple (Rhomberg 1976). In some cases, trade shares might seem a reasonable basis of comparison, but they do not reflect the 'third-country' effects; that is, the competition that home-country exports experience in foreign markets from other sources of these exports (see RBA (1998)). Nor do they capture the effect of exchange rate movements on components of the capital account or foreign liabilities. This section examines each of the main candidate weighting schemes, and sets out some of the measurement issues encountered when using them. The data sources for the weights used by the RBA are set out in the appendix.

---

[9] On the other hand, it could be argued that imposition of a GST does affect tourism flows and therefore should be included. These adjustments result from the difference between CPIs and the theoretically preferable producer price indices for tradables, and are not straightforward. The Commonwealth Treasury (2000) argued that the tax changes would result in a nominal exchange rate appreciation of 3–3½ per cent relative to what it would otherwise have been. This would have offset the effect of the GST on the relative price of imports to exports.

3.1 Trade, Import and Export Weights

The relative importance of a nation's trading partners seems a natural basis for assessing changes in competitiveness. This is the approach used by the RBA in its published trade-weighted index (TWI) and numerous other published series; for example, those published by the Bank of England, Bank of Canada and JP Morgan; see also Anderson, Karamouzis and Skaperdas (1987). The weights are derived as the share of total trade (exports plus imports) with each country, as measured in balance of payments statistics. In the RBA's TWI, the weights are based on annual data and revised annually in most cases. An alternative approach could be to use weights that change more or less frequently, or that are based on rolling averages of trade shares. The methodology for deriving import or export-based weights is essentially identical.

For some purposes, however, these weighting schemes may be inappropriate, because they only capture the bilateral trade between the home country and its trading partners. This is unlikely to be a good proxy for the importance of those countries in determining world price and demand conditions. To the extent that traded goods are sold on world markets, the composition of the home country's current trading partners is less important, as other trading partners could easily be found. Moreover, bilateral weights do not allow for third-country effects, as already mentioned.

An alternative approach would be to measure countries' shares of *world* trade, rather than bilateral trade with the home country. This is the approach taken by the FRB Index (Anderson *et al* 1987). These weights, known as multilateral trade weights, should better capture the importance of other countries in determining the competitive pressures faced by home-country exporters on world markets. On the other hand, this weighting scheme ignores the competitive effects of the importing country's domestic producers, which are implicitly incorporated into measures based on bilateral trade. This scheme also has the major practical disadvantage of enlarging the problem of collecting timely and accurate trade data by including countries that are neither trading partners nor competitors of the home country, and that might not necessarily publish high-quality data.

An extension of the multilateral trade weight approach derives weights from a general equilibrium model of world trade. This is the approach taken by the IMF's MERM exchange rate indices (Artus and McGuirk 1982). Rather than using weights implied by countries' actual trade patterns, these models derive weights that incorporate the estimated responses of trade patterns to movements in exchange rates. This approach explicitly accommodates the determinants of trade flows, namely the price elasticities of countries' demand for traded goods, and the changes in traded-goods prices induced by the exchange rate movements.

3.2 Third-country Export Weights

As mentioned above, bilateral trade weights of the type used in the RBA TWI do not necessarily capture the changes in the home country's competitiveness relative to alternative suppliers of its exports (RBA 1998). That is, there may be countries with which the home country trades little, but with which it competes intensely for export markets.

In contrast to a standard bilateral trade-weighted or export-weighted index, third-country export-weighted exchange rate indices tend to weight more highly countries with export compositions similar to that of the home country. For example, a third-country export-weighted index for Australia weights countries such as the United States, Canada and Brazil more highly than does the standard TWI. Like multilateral trade weights, however, calculating third-country trade weights could potentially be hampered by the difficulty in obtaining comparable timely data. This is because the calculation then relies on trade statistics published in other countries, whereas bilateral trade weights can be calculated from the home country's trade statistics. The third-country weighted index presented in this paper is a fixed-weight index based on 1994 trade data from the United Nations.

3.3 GDP Weights

One problem with trade weights – even multilateral trade weights – is that they only cover goods and services that are actually traded. This does not necessarily correspond to countries' shares of world *production*, and hence their influence on world prices. Bilateral trade weights exclude countries with a large influence on world prices, but with which the home country does not trade much. Multilateral (world) trade-share weights overweight small open economies that only trade with a small set of other open economies and thus have little influence on world prices (the smaller EU nations being obvious examples).

For this reason, it is sometimes preferable to use weights based on countries' shares of world GDP. However, calculating GDP on a comparable basis requires conversion to a common currency – usually the US$. This means that, unless some smoothing or other adjustment is applied, the weights in the exchange rate index will be subject to the same fluctuations as the exchange rates they are intended to weight. This is clearly undesirable, as it weights countries against which the home currency has recently depreciated more highly, thereby creating a depreciation bias into the results. One way to avoid this problem is to use purchasing power parities (PPP) to convert the GDP figures. The PPP conversion rates are calculated by the OECD and used by the IMF for the GDP comparisons in its *World Economic Outlook* publication (IMF 2001); these are the basis for the GDP weights used in this paper. Another way of reducing this bias is by taking a moving average of exchange rates to convert the GDP shares. This is the approach taken in the *World Bank Atlas* measures of GDP, which are converted using 3-year moving averages of bilateral exchange rates with the US$. Using this method gives fairly similar results to the PPP-based approach.

3.4 Capital Account Weights

The weighting schemes discussed so far focus on nations' trading behaviour. For some purposes, it may be preferable to use weights based on capital market quantities. For example, a trade-weighted index does not capture the effects of exchange rate movements on the domestic-currency value of (unhedged) foreign debt or holdings of foreign equity assets. Therefore, for some purposes, an exchange rate index using weights based on quantities from a country's international investment position will be more appropriate than one based on its trade accounts (Robson and Makin 1997).

There are several issues to be aware of when constructing such an index. Firstly, it should be constructed from information on the *currency denomination* of the assets and liabilities, not the identity of the counterparty country. For debt assets and liabilities, the currency and counterparty can differ. For example, if Australian investors were borrowing from Japanese investors by issuing US$-denominated securities, this should add to the weight of the US$ in such an exchange rate index, not to that of the yen. For weighting schemes based on the composition of equity assets or liabilities, it is reasonable to assume that the liability-side counterparty corresponds to the currency. That is, Australia's equity liabilities are in A$, while its equity assets are in the currency of the other country.

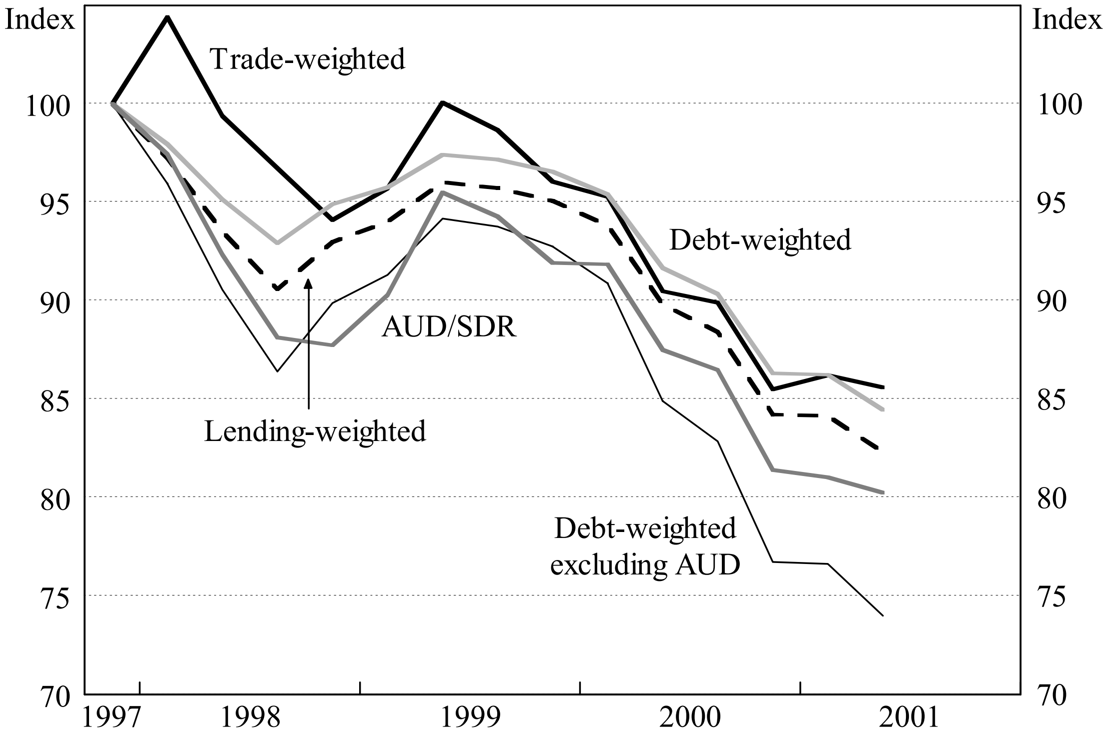
Secondly, a large proportion of Australia's foreign liabilities – all of the equity liabilities and around 40 per cent of debt liabilities – are denominated in A$. The appropriate treatment of domestic-currency denominated stocks in calculating weights for exchange rate indices is to include them as the weight for an 'exchange rate' that never moves relative to the home country currency. If only foreign-currency denominated assets and liabilities are included in its weights, the resulting exchange rate index will be more volatile than the actual valuation effects of exchange rate movements on these asset and liability stocks. Therefore the exchange rate index would over-predict the effects of exchange rate movements on the value of foreign assets and liabilities. Since the usual purpose of an exchange rate index weighted by asset and liability stocks is to help predict valuation effects in those stocks, this over-prediction is clearly undesirable.

Thirdly, under the standard treatment of foreign assets and liabilities, the values of foreign-currency denominated assets and liabilities are recorded separately from any associated hedging through derivative contracts. Therefore calculation of an exchange rate index based on the currency composition of foreign assets and liabilities will be a good predictor of reported valuation effects due to exchange rate movements, but will not properly represent the vulnerability or indebtedness of the home country. This effect cannot be offset using information on derivatives from the balance of payments; these statistics record the market value of the derivative contract, not the notional value hedged, which could be much larger.

In Australia, foreign debt and lending by currency are only available on a comparable basis since 1997; accordingly, it is not currently feasible to use exchange rate indices based on these weighting schemes in econometric work. Figure 3 shows a range of measures of the real exchange rate using weights based on foreign assets and foreign liabilities and debt. Because of the particular composition of Australia's foreign liabilities, the nominal AUD/SRD rate moves in the same direction as exchange rate indices based on capital account and international investment position quantities, and could therefore be used as a proxy. It is more volatile than the debt-weighted index shown in Figure 3 because of the presence of A$-denominated foreign debt. Of course, for reasons described in Section 2, a real AUD/SRD exchange rate index still has to be calculated from the component real bilateral rates.

Figure 3: Nominal Exchange Rate Indices

December 1997=100



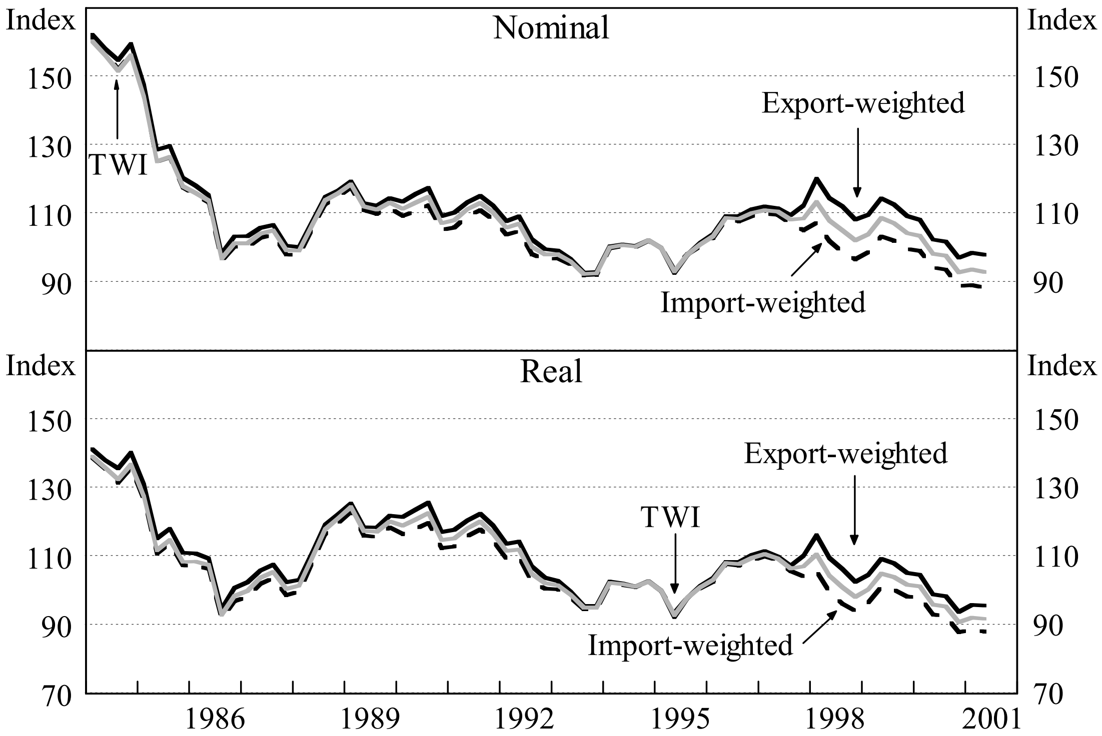
If the weight on the A$ is excluded and the other components rescaled, the debt-weighted exchange rate index displays somewhat greater volatility than the bilateral exchange rate against the SDR (Figure 3). This is due to the greater relative weight of the US$ in this index. A debt or lending-weighted index excluding the A$ shows the effect of exchange rate movements on the foreign-currency denominated component of the relevant parts of Australia's international investment position, but beyond this its economic interpretation is not obvious.

4. The Implications of Different Exchange Rate Indices

Figures 4 and 5 show a set of quarterly nominal and real exchange rate indices. The data for the trade-weighted, import-weighted, export-weighted and G7 GDP-weighted indices are available at <http://www.rba.gov.au/Statistics/>. Data sources are detailed in Appendix A.

Figure 4: Exchange Rate Indices

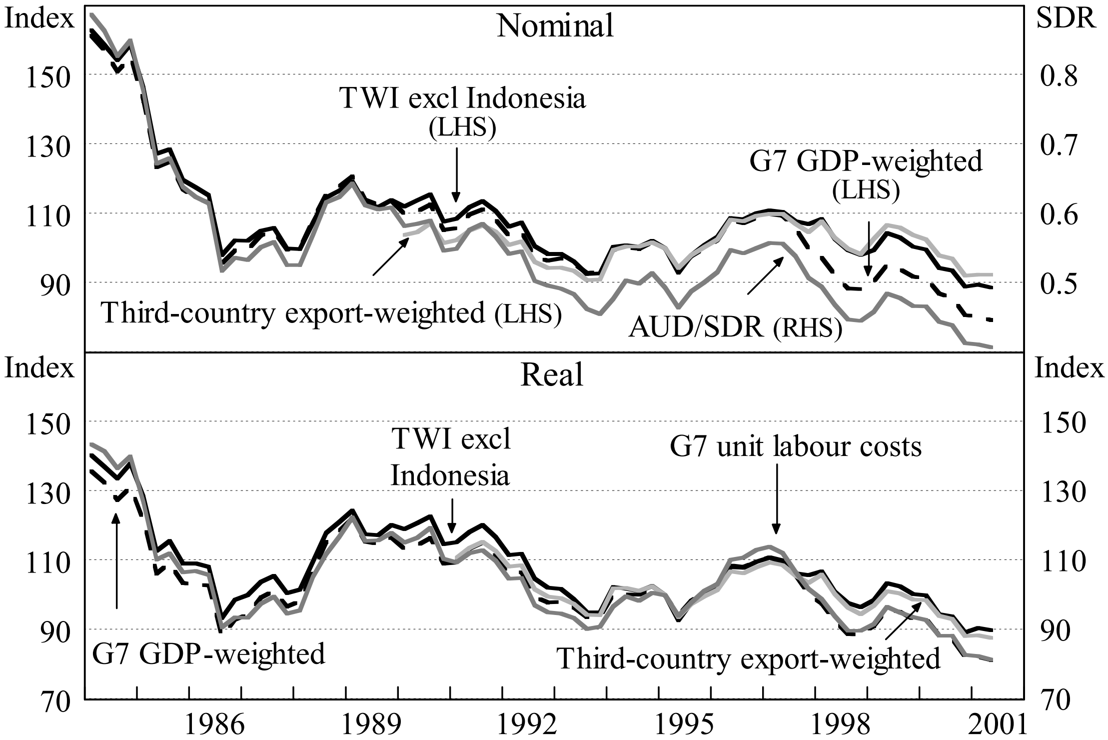
March 1995 = 100



It is apparent that different weighting schemes can sometimes result in markedly different results, particularly in the short run. In a few cases, different series do not even agree on the *direction* of exchange rate movements, let alone the magnitude. This is particularly the case when the home currency is appreciating against some currencies and depreciating against others, as occurred for Australia in 1997 and 1998, and for the major industrialised economies on several occasions.

Figure 5: Exchange Rate Indices

March 1995 = 100



Similarly, these divergences can affect assessments of the position of the real exchange rate relative to 'fundamentals'. For example, it has previously been found that the A$ real exchange rate tends to be partly explained over the medium term by fundamental determinants such as the terms of trade (or commodity prices) and real interest differentials (Gruen and Wilkinson 1991; Blundell-Wignall, Fahrer and Heath 1993; Tarditi 1996). We estimate Equation (7) for different measures of the real exchange rate:

$$\Delta rer_t = \beta_1 + \beta_2 rer_{t-1} + \beta_3 tot + \beta_4 \left(r_{t-1} - r^*_{t-1} \right) + \beta_5 \Delta tot_t + \varepsilon_t \tag{7}$$

where *rer* is the relevant real exchange rate index, *tot* is the terms of trade, *r* is the real cash rate in Australia, and *r** is a proxy for the world real interest rate, the weighted average of the real short-term policy rates in the G3 economies.[10] Table 3 shows the results. The differences in the estimated coefficients are not very large in

[10] This is the equation presented in Beechey *et al* (2000). Variants on this equation have been used in de Brouwer and O'Regan (1997) and Lowe and Ellis (1997).

an absolute sense, and the fit of the model is broadly similar regardless of the exchange rate index used. As would be expected, indices with similar weighting schemes – such as the TWI and the TWI excluding Indonesia – give similar results, while the differences between these indices and the export-weighted or GDP-weighted indices are more substantial. By contrast, the price indices used seems less important; the G7 GDP-weighted index deflated by consumer price indices gives very similar results to the index with the same weights deflated by unit labour costs.

Table 3: Estimation Results for Real Exchange Rate Equation

Exchange rate	Coefficient					$\bar{R}^2$
	β_1	β_2	β_3	β_4	β_5	
Trade-weighted	0.2874 (0.883)	–0.3201 (–4.011)	0.2543 (2.396)	0.0087 (3.682)	1.2236 (6.736)	0.5487
TWI (excl Indonesia)	0.3526 (1.098)	–0.2959 (–3.986)	0.2152 (2.152)	0.0095 (3.937)	1.2570 (7.040)	0.5592
Import-weighted	0.3850 (1.219)	–0.3037 (–4.010)	0.2152 (2.153)	0.0092 (3.906)	1.2702 (7.247)	0.5700
Export-weighted	0.1808 (0.520)	–0.2904 (–3.734)	0.2492 (2.306)	0.0078 (3.151)	1.1709 (5.972)	0.5044
G7 GDP-weighted	0.5237 (1.613)	–0.2448 (–3.409)	0.1245 (1.217)	0.0095 (3.871)	1.4176 (7.955)	0.5687
Unit-labour-cost basis	0.2709 (0.797)	–0.2461 (–3.660)	0.1805 (1.727)	0.0092 (3.606)	1.4110 (7.552)	0.5672

Notes: Estimation period: 1985:Q1–2000:Q2. Numbers in parentheses are *t*-statistics.

A similar divergence occurs when using different measures of the exchange rate as explanators in other econometric equations. For example, movements in the nominal exchange rate explain much of the variability in import prices (Beechey *et al* 2000). Table 4 compares the results from an import-price equation with the same structure as that in Beechey *et al* (2000), using different measures of the exchange rate.[11] The equation takes the form:

$$\Delta pm_t = \phi_1 + \phi_2 pm_{t-1} + \phi_3 p_{t-1}^{*x} + \phi_4 e_{t-1} + \sum_{i=0}^{1} \phi_5^i \Delta p_t^{*x} + \sum_{i=0}^{1} \phi_6^i \Delta e_{t-i} + \phi_7 D_t^1 + \phi_8 t + v_t \quad (8)$$

[11] See Anderson *et al* (1987) for a similar exercise using a model of US merchandise trade.

where pm is import prices, p^{*x} is a measure of world export prices, and e is the nominal exchange rate. The equation also includes a time trend to proxy for the shift towards lower-priced imports from non-G7 countries, and a dummy since June quarter 1998 to capture the effects of discounting by exporters from countries in financial crisis. Data limitations prevent construction of an export price index covering a wide range of countries. The world export price series used in this equation (p^{*x}) is based on the export price indices of the G7 nations. Therefore, at least some of the divergence in the results presented in Table 4 reflects the mismatch between the nominal exchange rates used and the export price index. This simply underlines the importance of using exchange rate indices that are appropriate to the task at hand, rather than relying on a single index for all purposes.

As would be expected, the equation that fits best is the one containing the exchange rate most closely matching the construction of the export price index, that is, the G7 GDP-weighted exchange rate index. The posited long-run relationship is not significant for the trade-weighted index, the export-weighted index and the third-country export-weighted index; this indicates the unsuitability of these indices to explaining *import* price movements.[12] The trend and dummy terms become less significant when the exchange rate measure incorporates more information from non-G7 trading partners. The dummy for the Asian crisis becomes completely insignificant when the export-weighted and third-country export-weighted indices are used. This is because these indices incorporate large enough weights on countries affected by financial crisis in 1997–1998 – Thailand, Indonesia, Korea and Brazil – so that the exchange rate measure captures the effects of discounting by crisis-country exporters on the world price level, and therefore the dummy is not needed.

---

[12] Although theory would suggest we impose static homogeneity in the effects of exchange rates and foreign prices on Australian import prices, we have not done so for this exercise, so that we can demonstrate the effects of the different exchange rate measures on the estimated long-run relationship.

Table 4: Estimation Results for Import-price Equation

Exchange rate measure	Coefficient ϕ_1	ϕ_2	ϕ_3	ϕ_4	$\sum_{i=0}^{1}\phi_5^i$	$\sum_{i=0}^{1}\phi_6^i$	ϕ_7	ϕ_8	$\overline{R}^2$
Trade-weighted	1.3070 (1.679)	–0.2766 (–2.191)	0.1563 (0.647)	–0.1528 (–1.192)	0.9120 (*)	–0.8154 (***)	–0.0119 (–0.913)	–0.0004 (–0.595)	0.7344
TWI (excl Indonesia)	1.4496 (2.082)	–0.3820 (–3.195)	0.3786 (1.709)	–0.2839 (–2.351)	0.8048 (*)	–0.8101 (***)	–0.0107 (–1.154)	–0.0011 (–1.816)	0.7980
Import-weighted	1.6064 (2.272)	–0.3977 (–3.280)	0.3944 (1.784)	–0.3190 (–2.549)	0.7912 (*)	–0.8126 (***)	–0.0116 (–1.282)	–0.0010 (–1.869)	0.7973
Export-weighted	1.0188 (1.168)	–0.1508 (–1.186)	–0.0913 (–0.367)	0.0138 (0.111)	1.0887 (**)	–0.7979 (***)	–0.0267 (–1.479)	0.0004 (0.592)	0.6550
G7 GDP-weighted	1.6080 (2.809)	–0.5126 (–4.860)	0.6950 (3.429)	–0.4796 (–4.543)	1.0005 (**)	–0.7206 (***)	–0.0332 (–3.670)	–0.0022 (–4.082)	0.8564
Third-country export weighted	1.4109 (1.497)	–0.1819 (–1.304)	–0.0177 (–0.056)	–0.1377 (–0.888)	0.8271 ()	–0.7207 (***)	–0.0114 (–1.194)	–0.0001 (–0.276)	0.7320

Notes: Numbers in parentheses are t-statistics. For ϕ_5^i and ϕ_6^i, the table shows whether at least one of the parameters is significant at the 10 per cent (*), 5 per cent (**) or 1 per cent (***) level. Estimation period is 1985:Q1–2000:Q2, except for third-country export weighted (1990:Q1–2000:Q2).

5. Conclusion

This paper sets out some issues that must be considered when constructing real exchange rate indices for analytical or econometric work. We point out that there is no one single measure of the real exchange rate (or the nominal exchange rate, for that matter) that is ideal for all purposes. There are many feasible choices of weighting schemes and frequencies, price deflators, index number formulae and sets of countries to include. The appropriate choices depend on the task at hand.

Beyond these choices, there are some basic issues for which there is a preferred approach. Some of these are arithmetic considerations: geometric averages are preferable to arithmetic averages; period-average exchange rate indices should be constructed from period-average bilateral rates. Other issues relate to index number theory: if the quantities underlying the weights used in the index's construction are moving, it makes sense to allow the weights to change. If the weights change, however, it is essential that the index be spliced together as described in Section 2.

It may sometimes be necessary to make compromises between what is theoretically most appropriate and what is feasible given data availability and quality. In some cases, measurement issues might indicate one approach for econometric work, but this will be infeasible for day-to-day analysis and policy work. Accordingly, there is no guarantee that the appropriate exchange rate index for one task will be a good match for the data needs of another.

Appendix A: Data Sources

Import, export and total trade weights

From 1988, trade weights match those used in the measure of the TWI published three times a day by the Reserve Bank. These are derived as the shares of total trade (exports plus imports) by country published in the ABS release *International Merchandise Trade,* Cat No 5422.0. The countries in the import and export-weighted indices are the same as those in the TWI, even though a 90-per-cent rule based on import or export weights alone might yield a different list of countries.

Third-country export weights

Weights for this series are calculated from United Nations *Commodity Trade Statistics* for 1994. Data limitations have restricted the available data sample to 1990 for nominal and 1991 for the real third-country weighted exchange rate index. Poland is excluded from the real third-country weighted index.

Debt and lending weights

Weights for the debt and lending-weighted exchange rate indices presented in Graph 3 are (financial-year) annual averages of foreign borrowing and lending disaggregated by major currency, from Table 37 of ABS Cat No 5302.0 (*Balance of Payments and International Investment Position*). Derivatives and other securities that are unable to be allocated by currency are omitted.

GDP weights

GDP weights are from the IMF *World Economic Outlook* (IMF 2001), constructed as annual national nominal GDP converted to US$ using OECD PPP exchange rates, then rescaled so that the sum of the weights in the exchange rate index sum to one. See also Gulde and Schulze-Ghattas (1993).

Bilateral exchange rates

From 1984, quarterly bilateral exchange rates are quarterly averages of daily 4pm (Sydney) close exchange rates against the USD, sourced from the internal database of the RBA's International Department, except for the Spanish peseta, which is sourced from the IMF's *International Financial Statistics* (IFS). Exchange rates for earlier periods are sourced from the IMF's IFS as reproduced on the Datastream service. These are quarterly averages of daily exchange rates, recorded at noon New York time. Small differences can arise between the noon New York rates from Datastream and the 4pm Sydney rates used internally by the Bank. Table A1 shows the relevant Datastream codes, including for currencies such as the Vietnamese dong, which did not trade sufficiently with Australia in the pre-1984 period.

Table A1: Datastream Codes for Bilateral Exchange Rates

Country	Exchange rate	Datastream code
Australia (dollar)	AUD/USD	AUI..RF.
Belgium (B franc)	USD/BEF	BGI..RF.
Canada (dollar)	USD/CAD	CNI..RF.
Chile (peso)	USD/CLP	CLI..RF.
China (renminbi)	USD/CNY	CHI..RF.
Denmark (krone)	USD/DKK	DKI..RF.
Fiji (dollar)	USD/FJD (inverted)	FJI..RF.
France (franc)	USD/FRF	FRI..RF.
Germany (mark)	USD/DEM	BDI..RF.
Hong Kong (dollar)	USD/HKD	HKI..RF.
India (rupee)	USD/INR	INI..RF.
Indonesia (rupiah)	USD/IDR	IDI..RF.
Ireland (punt)	USD/IEP	IRI..RF.
Italy (lira)	USD/ITL	ITI..RF.
Japan (yen)	USD/JPY	JPI..RF.
Malaysia (ringgit)	USD/MYR	MYI..RF.
Netherlands (guilder)	USD/NLG	NLI..RF.
New Zealand (dollar)	USD/NZD	NZI..RF.
Norway (krone)	USD/NOK	NWI..RF.
Philipines (peso)	USD/PHP	PHI..RF.
PNG (kina)	USD/PGK	NGI..RF.
Poland (zloty)	USD/PLN	POI..RF.
Saudi Arabia (riyal)	USD/SAR	SII..RF.
Singapore (dollar)	USD/SGD	SPI..RF.
South Africa (rand)	USD/ZAR	SAI..RF.
South Korea (won)	USD/SKW	KOI..RF.
Spain (peseta)	USD/ESP	ESI..RF.
Sweden (krona)	USD/SEK	SDI..RF.
Switzerland (franc)	USD/CHF	SWI..RF.
Thailand (baht)	USD/THB	THI..RF.
Turkey (lira)	USD/TRL	TKI..RF.
UAE (dirham)	USD/AED	UAI..RF.
United Kingdom (pound)	USD/GBP	UKI..RF.
Vietnam (dong)	USD/VND	VICPUSD.F

Table A2: Consumer Price Indices

Country	**Description**	**Datastream / CEIC code** where relevant
Australia	Prior to September quarter 1976, headline (all groups) CPI published by ABS (Cat No 6401.0). From that date, weighted median CPI calculated by RBA. Series are spliced and rebased to March 1995=100.	
Belgium	CPI excl food (nsa)	**BGCPNONFF**
Canada	CPI excl food, energy & indirect taxes (nsa)	**CNB3321.**
China	CPI: from **CHI64…F** to March 1988, from **CHCPI…F** thereafter	**CHI64…F** **CHCPI…F**
Euro	CPI excl food, energy, alcohol & tobacco (harmonised measure – nsa)	**EMESCPIG%**
France	CPI excl energy (nsa)	**FRCPXENGF**
Germany	Quarterly average of monthly CPI excl energy (sa)	**WGUS0057E**
Hong Kong	CPI	HIAA
India	CPI – urban non-manual employees (nsa): from Datastream to January 1988, from CEIC thereafter	**INCPUINDF** (to January 1988); IICA
Indonesia	CPI: from Datastream prior to August 1983, from CEIC thereafter. Excludes East Timor from 1996.	**IDI64…F** DIXAA DIHA
Italy	CPI excl food (nsa)	**ITOCCPXFF**
Japan	Quarterly average of monthly CPI excl fresh food (nsa)	**JPCPXFFDF**
Korea	CPI	KIAA
Malaysia	CPI: from Datastream prior to 1994, from CEIC thereafter	**MYI64….F** MIAA
Netherlands	CPI excl food (nsa)	**NLOCCPXFF**
New Zealand	CPI excl credit services (nsa)	**NZCPIX..F**
Papua New Guinea	CPI	**PGI64…F**
Philippines	CPI: from PIAA prior to 1997, from PIFA thereafter	PIAA PIFA
Saudi Arabia	CPI (nsa)	**SII64…F**
Singapore	CPI	SISA SIAA
South Africa	CPI	**SACP….E**

Country	Description	Datastream / CEIC code where relevant
Spain	CPI excl food & energy (nsa)	**ESCPEXFEF**
Sweden	CPI excl indirect taxes (nsa)	**SDCPNET.F**
Switzerland	CPI excl food (nsa)	**SWOCCPXFF**
Taiwan	CPI	WIAA
Thailand	CPI: from Datastream prior to 1990, from CEIC thereafter	**THI64…F** TIAA
United Arab Emirates	No national data available. IMF Middle East CPI series used as a proxy.	**MEI64…F**
United Kingdom	Prior to 1975: headline CPI. Since 1975, quarterly average of monthly CPI excl mortgage interest (nsa)	**UKRP….F** **UKRPAXMIF**
United States	Quarterly average of monthly core CPI (CPI excl food and energy, nsa).	**USCPXFDEF**
Vietnam	CPI: from VIAAA prior to 1998, from VIBA thereafter	VIAAA VIBA

Note: Datastream codes in bold type; CEIC codes in plain type.

References

Anderson GH, NV Karamouzis and PD Skaperdas (1987), ‘A New Effective Exchange Rate for the Dollar and Its Implications for U.S. Merchandise Trade’, *Federal Reserve Bank of Cleveland Economic Review*, Quarter 2, pp 2–23.

Artus JR and AK McGuirk (1982), ‘Multilateral Exchange Rate Model (MERM) Estimates Effects of Currency Changes on Trade Flows’, *IMF Survey*, 11(3), pp 37–39.

Australian Bureau of Statistics (1992), ‘Australian Consumer Price Index: Feasibility of Constructing Price Indexes for Special Population Groups’, ABS Information Paper Cat No 6445.0.

Beechey M, N Bharucha, A Cagliarini, DWR Gruen and C Thompson (2000), ‘A Small Model of the Australian Economy’, Reserve Bank of Australia Research Discussion Paper No 2000-05.

Blundell-Wignall A, JG Fahrer and A Heath (1993), ‘Major Influences on the Australian Dollar Exchange Rate’, in A Blundell-Wignall (ed), *The Exchange Rate, International Trade and the Balance of Payments*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 30–78.

Caves DW, LR Christensen and WE Diewert (1982), ‘Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers’, *Economic Journal*, 92, pp 73–86.

Commonwealth Treasury (2000), ‘Economic Outlook’, Commonwealth Budget 2000/01 Statement No 2.

Cox WM (1986), ‘A New Alternative Trade-weighted Dollar Exchange Rate Index’, *Federal Reserve Bank of Dallas Economic Review*, September, pp 20–28.

de Brouwer G and J O'Regan (1997), 'Evaluating Simple Monetary-policy Rules for Australia', in P Lowe (ed), *Monetary Policy and Inflation Targeting*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 244–276.

Diewert WE (1976), 'Exact and Superlative Index Numbers', *Journal of Econometrics*, 4, pp 115–145.

Gruen DWR and J Wilkinson (1991), 'Australia's Real Exchange Rate: Is it Explained by the Terms of Trade or by Real Interest Differentials?', Reserve Bank of Australia Research Discussion Paper No 9108.

Gulde AM and M Schulze-Ghattas (1993), 'Revised Weights for the "World Economic Outlook"', *World Economic Outlook*, May, Annex IV, IMF, pp 116–119.

International Monetary Fund (2001), *World Economic Outlook*, April.

Lowe P and L Ellis (1997), 'The Smoothing of Official Interest Rates', in P Lowe (ed), *Monetary Policy and Inflation Targeting*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 286–312.

Reserve Bank of Australia (RBA) (1998), 'Alternative Measures of the Effects of Exchange Rate Movements on Competitiveness', Reserve Bank of Australia *Bulletin*, January, pp 1–7.

Rhomberg RR (1976), 'Indices of Effective Exchange Rates', *IMF Staff Papers*, 23(1), pp 88–112.

Robson ARW and AJ Makin (1997), 'Comparing Capital and Trade Weighted Measures of Australia's Effective Exchange Rates', University of Queensland Department of Economics Discussion Paper No 220.

Rosensweig JA (1987), 'Exchange Rate Index Construction: With a US Dollar Application', *Journal of Foreign Exchange and International Finance*, 1(3), pp 293–301.

Tarditi A (1996), 'Modelling the Australian Exchange Rate, Long Bond Yield and Inflationary Expectations', Reserve Bank of Australia Research Discussion Paper No 9608.

Turnovsky SJ (1997), *Macroeconomic Dynamics*, MIT Press, Cambridge.