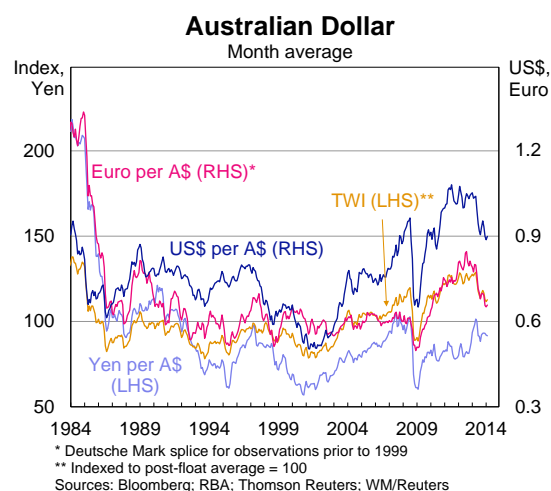


Update on the Australian dollar

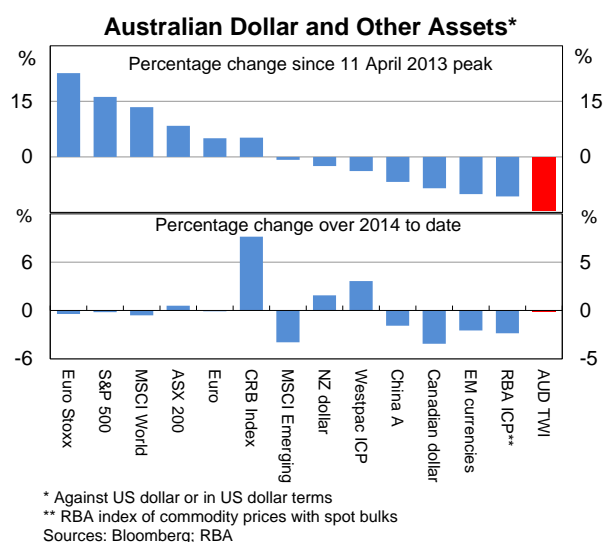
Since the last Testimony, the A\$ has been little changed on a **nominal trade-weighted basis**. In a longer-run context, the nominal TWI has depreciated by 14 per cent since its peak in April 2013, but remains 12 per cent above its post-float average.

- **Against the US\$,** the A\$ is 15 per cent below its April 2013 peak, but 17 per cent higher than its post-float average.
- **Against the JPY,** the A\$ is 14 per cent below its April 2013 peak, but remains around its end-2012 level.
- **Against the euro,** the A\$ is 24 per cent below its historical peak (reached in August 2012), but 3 per cent higher than its average since the introduction of the single currency in 1999.



Since the peak in mid-April 2013, the A\$ has generally underperformed other asset classes, including global equity and commodity prices. The depreciation has coincided with:

- a softening in the domestic economic outlook and associated cuts to the cash rate;
- some uncertainty over the outlook for the Chinese economy;
- a reassessment by market participants of the outlook for US monetary policy; and, relatedly,
- concerns about actual and/or perceived vulnerabilities in some emerging market economies (which have, at times, led to a broader deterioration in risk sentiment).



In real terms, the TWI is estimated to have depreciated by a little more than 10 per cent since its peak in the March quarter of 2013, and **our preferred internal model** suggests that it is currently close to the level consistent with its medium-term 'fundamentals'. Even though the current value of the A\$ can be largely explained by our preferred internal model, it could still be considered to be 'overvalued' to the extent that it is judged to be too high to achieve desired domestic economic outcomes.

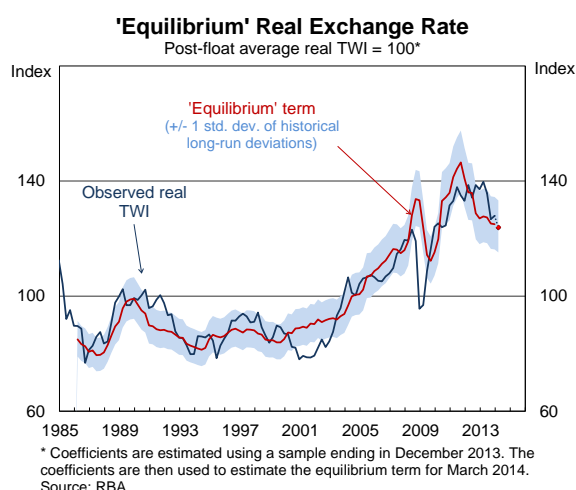
MA's preferred model of the real TWI is estimated from January 1986 to December 2013, and is based on its medium-term relationship with Australia's goods terms of trade and the real policy rate differential with the G3 (and some short-run variables). The model suggests that, in quarter-average terms, the real TWI:

- was 2 per cent above the level consistent with its medium-term fundamentals in the December quarter of 2013 (which is well within a ± 1 standard deviation band); and

- is almost exactly in line with the level consistent with its medium-term fundamentals in the March quarter of 2014 to date.¹

It should be noted that these estimates are sensitive to the estimation period:

- if the model is estimated using data since 1974 it suggests the A\$ was 8 per cent *below* the level consistent with medium-term fundamentals in the December quarter of 2013; whereas
- if the model is estimated since 2002 it suggests the A\$ was 5 per cent *above* the level consistent with its medium-term fundamentals in December.



External assessments provide a mixed view of the Australian dollar's valuation:

- The IMF's most recent assessment (February) suggests the A\$ real TWI is overvalued by 5-10 per cent;
- Investment bank models generally point to overvaluation of 5 per cent or less on a trade-weighted basis, but a somewhat greater degree of overvaluation with respect to the US dollar;
- In contrast, The Economist's Big Mac Index suggests *undervaluation* of 3 per cent against the US\$ (based on price data for January 2014).

Table 1: Models of the Australian Dollar – Summary

RBA Models (Real TWI) – December 2013	Estimated exchange rate valuation		
	Under/over-valuation	Per cent deviation	Standard deviations
From 1974	Under	8	0.6
From 1986 (preferred)	Over	3	0.2
From 2002	Over	5	0.5
External Assessments			
IMF (Real TWI)	Over	5-10	-
Big Mac Index (PPP Measure; against the US\$)	Under	3	-
JP Morgan (Real TWI)	Over	4	-
Goldman Sachs (Nominal TWI)	Over	3	-

According to a Bloomberg survey of foreign exchange market analysts, the median forecast is for the Australian dollar to depreciate by around 5 per cent against the US dollar by end-2015. Nevertheless, the range of forecasts is fairly wide (US\$0.75-US\$0.95).

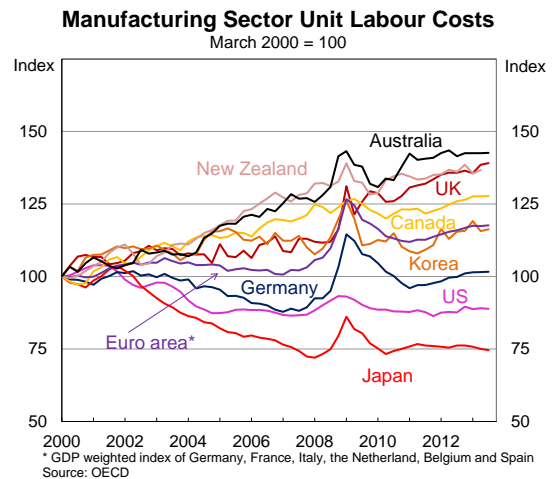
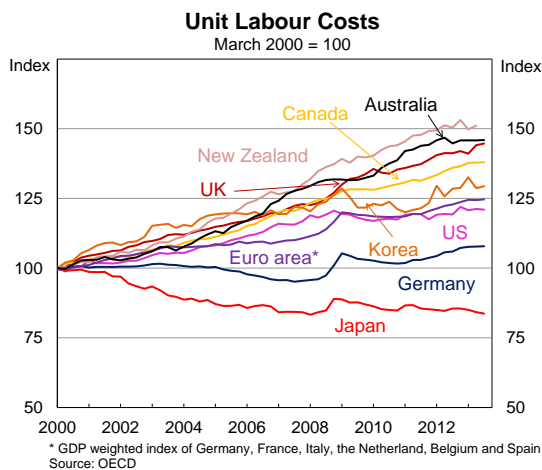
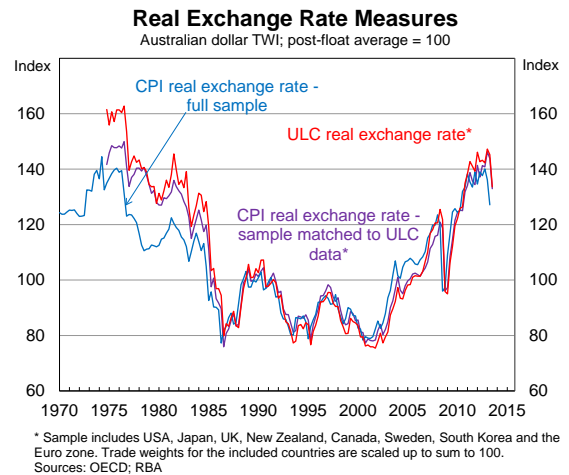
¹ The estimate for March 2014 is based on the assumptions that the nominal TWI remains at the current level for the rest of the quarter, and that inflation will be unchanged from the previous quarter.

The Australian dollar and unit labour costs (as included in the December briefing)

Although the level of the real TWI can be largely 'explained' by its medium-term determinants, it nevertheless remains at a high level. This observation is robust to the choice of deflator, with a unit labour cost (ULC) based measure presenting a very similar picture to the standard CPI-based measure. This is particularly evident when using a matched sample of countries (the ULC data are available for a relatively narrow sample of countries and, in particular, are not available for China).

ULCs are a commonly used – albeit partial – measure of cost competitiveness. The OECD publishes these data for a number of member nations, calculated as the ratio of total labour costs to real output. These data show an increase in Australia's ULC measure (in domestic currency terms) relative to most of Australia's OECD trading partners over the past decade or so. This has exacerbated the effect of the appreciation of Australia's nominal effective exchange rate on Australia's overall international competitiveness.

The decline in Australia's ULC-based measure of cost competitiveness has been even more pronounced for the manufacturing sector. However, it should be noted that the Australian manufacturing sector accounts for around 7 per cent of GDP, compared to an average of around 15 per cent for Australia's OECD trading partners.



The Mining Boom and the Australian Dollar Real TWI Model

Historically, the real trade-weighted index of the Australian dollar (RTWI) has displayed a close relationship with Australia's goods terms of trade (ToT). However, in recent years there have been periods when movements in the RTWI have diverged from movements in the ToT. Moreover, these divergences have tended to coincide with particularly large movements in bulk commodity prices (as measured in the ToT). These observations raise two questions: (i) is the relationship between the RTWI and bulk commodity prices different to the relationship between the RTWI and other export prices?; and, if so, (ii) does Market Analysis's (MA) existing RTWI model adequately capture the dynamics of the recent ToT boom, insofar as it was driven largely by increases in bulk commodity prices?

This note provides a brief overview of MA's existing RTWI model and presents a number of augmented versions that attempt to answer these questions, namely: a model that incorporates a ToT that is decomposed into its bulks and non-bulks components; a model that incorporates a forward-looking measure of the ToT; and a model that incorporates an investment-to-GDP ratio. The latter two appear to provide additional insight into movements in the RTWI, particularly over recent years. Consequently, they will be used on an ongoing basis to complement the existing model.

1. Background

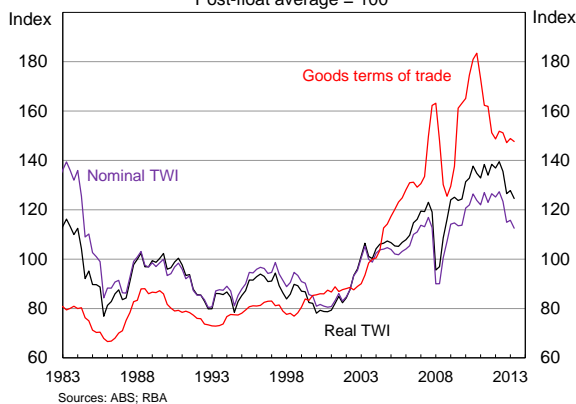
As is well known, the Australian dollar has been at a historically high level in recent years, with the RTWI reaching a post-float high in the March quarter of 2013. Although the RTWI has since depreciated by around 8 per cent, it remains around 30 per cent higher than its post-float average.

Historically, the ToT has been a key determinant of Australia's RTWI (e.g. [Tarditi 1996](#); [Beechey et al. 2000](#); [Stone, Wheatley and Wilkinson 2005](#)).¹ Consistent with this, the appreciation of the Australian dollar since the early 2000s coincided with a significant increase in Australia's ToT, which almost doubled between the end of 2003 and September 2011 (Graph 1).² The increase in the ToT has largely been attributed to a significant increase in demand for bulk commodities from emerging market economies, which saw prices for these commodities almost quadruple over the same period (while prices of other, non-bulk, exports rose by around 40 per cent). At the same time, bulk commodities' collective share of Australia's exports rose from around 25 per cent to around 50 per cent.³

Graph 1

Terms of Trade and the Australian Dollar TWI

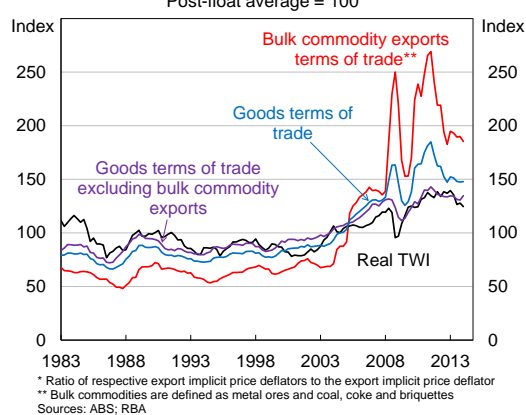
Post-float average = 100



Graph 2

Terms of Trade and the Real TWI

Post-float average = 100*



¹ This relationship has also been documented for other 'commodity currencies'. See for example Chen and Rogoff (2003), and Cashin, Céspedes and Sahay (2004).

² For more information on the boom and its implications for the Australian economy see for example [Connolly and Orsmond 2011](#), [Plumb, Kent and Bishop 2013](#), and [Atkin, Caputo, Robinson and Wang 2014](#).

³ Bulks include metal ores, most importantly iron ore, and coal. Mineral fuels, such as LNG, are also often classified as bulks.

Interestingly, while bulks prices have garnered most of the attention in recent years, the RTWI appears to have had a stronger relationship with a measure of the ToT that *excludes* bulk commodity export prices (Graph 2, above). This reflects the fact that periods when movements in the RTWI and in the ToT have diverged have tended to coincide with particularly large movements in bulks prices, such as during the onset of the global financial crisis in 2008 and following the Queensland floods in 2010/11. This observation raises two key questions:

- (i) *Is the relationship between the RTWI and bulks prices (as measured in the ToT) different to the relationship between the RTWI and other export prices?; and, if so*
- (ii) *Does MA's existing model of the RTWI adequately capture the dynamics of the recent ToT boom, insofar as it was driven largely by increases in bulks prices?*

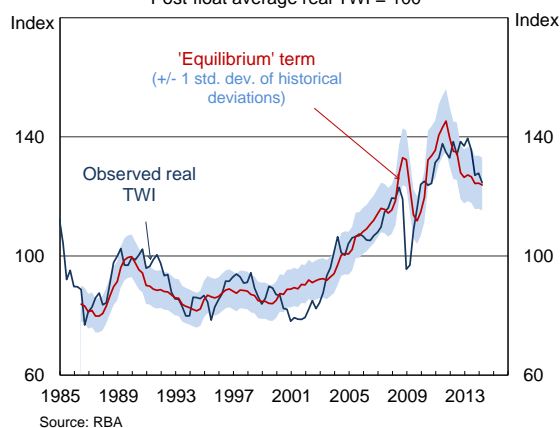
This note begins with a brief review of MA's 'existing' RTWI model, which incorporates the ToT as a key explanatory variable, before attempting to answer these questions using three augmented versions of the model. The first augmented version incorporates the 'bulks ToT' and the 'ex-bulks ToT' as separate explanatory variables, in place of the aggregate goods ToT. The second version replaces the aggregate goods ToT with a forward-looking measure of the ToT. This is motivated by the nature of bulks prices, which could be argued to be less reflective of market participants' current expectations than other export prices given, for example, the use of 'sticky' long-term contracts. Finally, the third version incorporates measures of investment alongside the aggregate goods ToT. This is motivated by the observation that investment could be the main channel through which higher bulks prices affect the RTWI, given the relatively low level of domestic inputs used in the production of bulk commodities and the high level of foreign ownership in the industry both suggest that increased production and profits could have relatively little effect on the domestic economy (see [Box A](#) for more information).

2. A Brief Review of MA's Existing RTWI Model

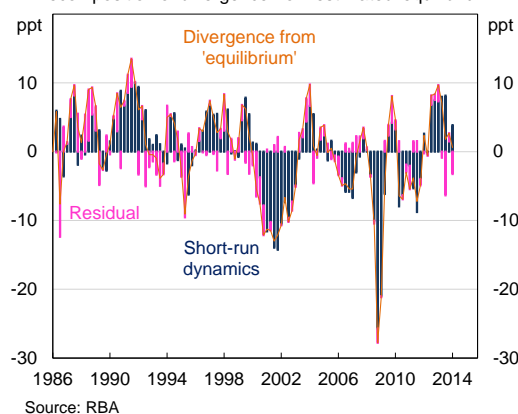
MA's existing model of the RTWI is an error correction model (ECM), which estimates an 'equilibrium' co-integrating relationship between the (log) RTWI, the (log) goods ToT and the real policy rate differential between Australia and the G3. The estimated 'equilibrium' RTWI is the level which is estimated to be justified by these medium-term determinants and which should exert itself over time (Graph 3, below).⁴ The model also includes a number of short-run variables which are incorporated to account for shorter-term financial market influences (though these are not the focus of this note). These include the CRB index (a widely-followed market-based commodity price measure and a proxy for shorter-term developments in the ToT), and two factors that are intended to capture 'risk sentiment' in financial markets: the (real) US S&P500 equity index and the VIX (an index of option-implied expectations of volatility in the S&P500). All of the short-run variables enter in first differences (Equation 1).

$$\begin{aligned} \Delta RTWI_t = & \mu + \gamma RTWI_{t-1} + \alpha_1 TOT_{t-1} + \alpha_2 RIRD_{t-1} \\ & + \beta_1 \Delta CRB_t + \beta_2 \Delta CRB_{t-1} + \beta_3 \Delta SPX_t + \beta_4 \Delta VIX_t + \varepsilon_t \end{aligned} \quad (1)$$

⁴ It is important to note that this type of model does not attempt to directly estimate the level of the exchange rate that is consistent with desired economic outcomes. Rather, it indicates the level that would be expected based on the RTWI's historical relationships with variables which have, and theoretically should, determine the exchange rate over the medium-term.

Graph 3**'Equilibrium' Real TWI**
Post-float average real TWI = 100**Graph 4****Real TWI**

Decomposition of divergence from estimated 'equilibrium'



The model is estimated over a sample beginning in 1986 and displays reasonable and consistent explanatory power over this period (with an R-squared of around 0.50).⁵ Although there have been periods of unusually large or sustained divergences between the observed RTWI and the estimated equilibrium level, in most cases these can be explained mainly by the short-run dynamics of the model, rather than the model residuals (Graph 4; [Weltewitz and Smith 2013](#)). Consequently, attempts to find variables other than the ToT (and the real interest rate differential) that consistently explain medium-term movements in the RTWI have been largely unsuccessful.

Still, there have been some periods when the residuals have explained a greater proportion of the divergence between the RTWI and the estimated equilibrium, and other variables have, at times, been found to be significant determinants of the RTWI. These observations suggest that the exchange rate can be affected by different factors and dynamics at different times. This is not entirely unexpected and could reflect the varying focus of financial market participants ([Debelle and Plumb 2006](#)). For example, during the technology boom in the early 2000s, the RTWI remained consistently below the estimated equilibrium term, apparently reflecting investors' preference for currencies that were aligned with so-called 'new' economies. Similarly, during the early stages of the global financial crisis in the latter part of 2008, the RTWI depreciated sharply while the estimated equilibrium term (and the ToT) remained at a high level. More recently, in 2010/11, the RTWI was somewhat below its estimated equilibrium level, while in 2012 and early 2013 the RTWI remained high relative to its estimated equilibrium level. The latter three examples appear, at least in part, to reflect movements in bulk commodity prices which were not also reflected in the RTWI. Some possible reasons for this are discussed in [Box A](#) below.⁶

⁵ If a longer sample is used (e.g. starting in 1974) the current estimated equilibrium level is somewhat higher, while if a shorter sample is used (e.g. beginning in 2002) the current estimated equilibrium level is somewhat lower.

⁶ Other factors that are also reported to have contributed to the high level of the dollar in recent years include increased demand for AAA-rated CGS, which can be partly attributed to the introduction of quantitative easing by major foreign central banks. However, as MA's existing model use a policy rate differential variable, the effect of quantitative easing is unlikely to be fully captured. Forthcoming work will examine this issue further.

Box A: Why might the RTWI be less responsive to movements in bulks prices?

There are two key reasons why the relationship between bulk commodity export prices (as measured in the ToT) and the RTWI could differ to that of other export prices.

Price Setting

Foreign exchange markets are forward-looking and so should 'price in' *expected* changes (and to some extent, 'look through' *transitory* changes) in the ToT and its constituent import and export prices (e.g. Chen, Rogoff and Rossi 2010). However, until relatively recently, prices for bulk commodities were predominantly set using 'sticky' **long-term contracts** ([Jacobs 2011](#); [Caputo 2012](#)). Consequently, bulks prices (as measured in the ToT) would not react immediately to changes in the outlook for prices (unlike the exchange rate), and this could contribute to divergences between the ToT and the RTWI. This dynamic was particularly evident in late 2008, when a number of contracts for bulk commodity exports were signed just before the onset of the (unanticipated) global financial crisis. While the RTWI reacted immediately to the crisis (falling by around 25 per cent), bulk export prices, and therefore the ToT, could not immediately reflect the implications of the crisis for global demand.

More recently, the shift towards the use of shorter-term contracts and spot pricing for bulk commodities has reduced some of this price 'stickiness' ([Connolly and Orsmond 2011](#), [Caputo 2012](#)). Nevertheless, bulks prices are still likely to be somewhat less reflective of expectations than some other prices – at least at certain points in time. This is because bulk commodities markets can be **prone to transitory price shocks**, reflecting relatively inelastic supply, as well as the tendency for natural disasters to cause supply disruptions. Market participants and, consequently, the exchange rate are likely to 'look through' price spikes that are believed to be transitory, which would contribute to temporary divergences between the ToT and the RTWI. One prominent example of this dynamic occurred in 2010/2011, when floods in Queensland pushed coal prices and the ToT higher, while the RTWI remained relatively unchanged.

Interaction with the rest of the economy

The reaction of the RTWI to movements in the ToT could differ based on which constituent export price(s) caused the change in the ToT (Amano and van Norden, 1995). This reflects the fact that individual industries could interact differently with the rest of the economy in terms of their use of domestic inputs, their use as an input into other industries and their overall effect on national income. Relative to other export sectors, the bulks sector uses fewer domestic inputs, exports most of its output and has a high level of foreign ownership ([Plumb, Kent and Bishop 2013](#); [Rayner and Bishop 2013](#)). Consequently, the increased *production* and *profits* associated with higher bulks prices could have a more limited effect on the domestic economy and the RTWI (than increased production and profits in some other export sector).

Nevertheless, the *investment* in the bulks sector that has accompanied higher prices would still be expected to affect the economy, and consequently the RTWI, through increased employment, income and capital inflows. If this is the case, even if the ToT were to remain elevated, the exchange rate could still be expected to depreciate as the mining boom moves from its 'investment' phase to its (less labour intensive) 'production' phase, due to the associated easing in labour demand and reduction in real wages ([Hall and Rees 2013](#)).⁷

⁷ [Debelle \(2014\)](#) suggests a similar dynamic. As the investment phase ends, foreign firms will require fewer Australian dollars to pay for Australian inputs. While this could be offset somewhat by higher dividends and taxes associated with increased production in the production phase, net demand for Australian dollar is likely to be reduced.

3. Augmented Versions of MA's Existing Model

Below, three augmented versions of MA's existing model of the RTWI are presented. The models incorporate, respectively:

- a decomposed ToT measure (incorporating 'bulks' and 'ex-bulks' ToT measures separately)
- a forward-looking measure of the ToT
- an investment-to-GDP ratio

3.1 Incorporating a decomposed ToT measure

3.1.1 Overview

There are a number of reasons to suspect that the relationships between the RTWI and bulks export prices, and between the RTWI and other export prices, could differ. These include the pricing mechanisms used for bulk commodity exports, and the fact the bulks industry is somewhat less integrated with the rest of the economy than other export industries (see [Box A](#)).

To the extent that these relationships differ, more disaggregated measures of the ToT could provide additional insight into the behaviour of the RTWI. To examine these relationships, the aggregate goods ToT was decomposed into a 'bulks ToT' and an 'ex-bulks ToT' (see [Appendix A](#) for details on the construction of the series).⁸ These are included in the medium-run portion of the ECM separately, in place of the aggregate ToT (Equation 2).

$$\begin{aligned} \Delta RTWI_t = & \mu + \gamma RTWI_{t-1} + \alpha_1 TOTBulks_{t-1} + \alpha_2 TOTExBulks_{t-1} + \alpha_3 RIRD_{t-1} \\ & + \beta_1 \Delta CRB_t + \beta_2 \Delta CRB_{t-1} + \beta_3 \Delta SPX_t + \beta_4 \Delta VIX_t + \varepsilon_t \end{aligned} \quad (2)$$

Four different specifications are considered, which vary along two dimensions:

- **Weighting scheme:** the bulks and ex-bulks ToT measures are calculated as both 'unweighted' and 'weighted' measures. The unweighted measures are simply the decomposed ToT series (see [Appendix A](#)), while the weighted measures are constructed by multiplying the unweighted bulks and ex-bulks ToT measures by the (time-varying) bulks and ex-bulks nominal export shares, respectively. The weighted measures account for the increasing share of bulk commodities in Australia's export basket over the past decade.⁹
- **Definition of 'bulks':** the bulks and ex-bulks measures are calculated using two definitions of bulk commodities. The 'narrow' bulks measure includes 'metal ores', and 'coal, coke and briquettes', while the 'broad' bulks measure also includes 'other mineral fuels' (i.e. LNG).

3.1.2 Key Findings

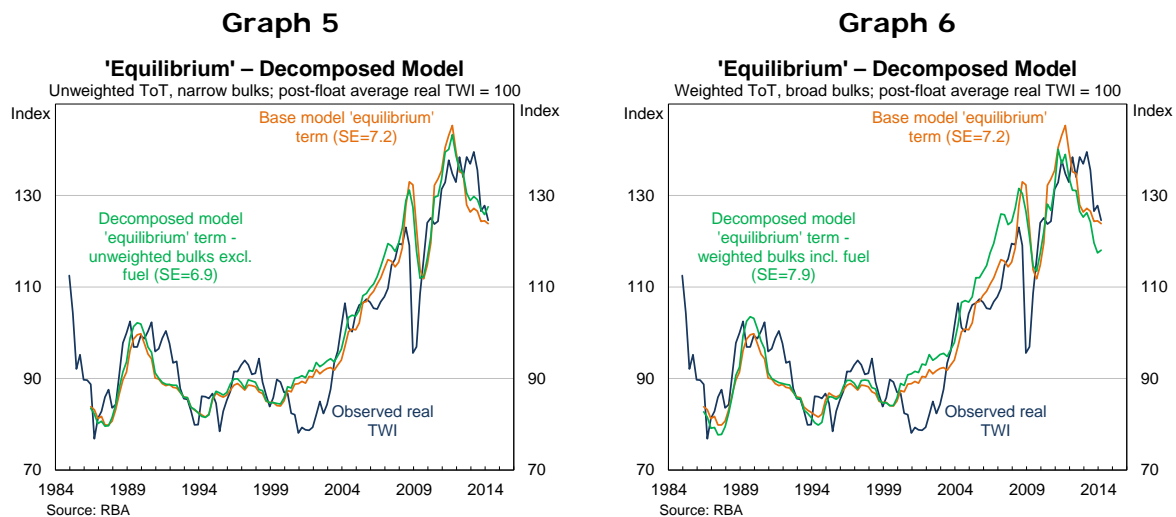
The results of these models are reported in full in [Appendix B](#) (Table B1). Consistent with the observation that the RTWI appears to have been less responsive to movements in bulks prices, the coefficient on the bulks ToT is smaller than the coefficient on the ex-bulks ToT in all four specifications (weighted/unweighted; broad/narrow). Further, the coefficient on the bulks ToT is only significant in the two specifications that use the weighted ToT measures. Nevertheless, the coefficients on the bulks and ex-bulks ToT are only statistically different from each other in the *unweighted broad* specification.¹⁰

⁸ Unit root tests indicate that the decomposed ToT series are non-stationary over the sample. Co-integration between the medium-run variables is evident in all specifications.

⁹ A similar approach was used to model the Canadian dollar in Maier and DePratto (2008).

¹⁰ Based on a Wald test, the coefficients are significantly different at the 5 per cent level.

The estimated equilibriums from all four specifications follow fairly similar paths to each other, and to the existing model, for most of the sample, though they have diverged somewhat since 2003. The estimated equilibrium from the *unweighted narrow* and *weighted broad* specifications are shown below as they reflect the two extremes, both in terms of the ToT measures used and in terms of estimated equilibriums (Graph 5 shows the *unweighted narrow* specification and Graph 6 shows the *weighted broad* specification).¹¹



The estimated equilibrium from the *unweighted narrow* specification follows the observed RTWI slightly more closely over the full sample than the estimated equilibrium from MA's existing model, as evidenced by the lower standard error (SE; 6.9 compared to 7.2 for MA's existing model) – a standardised measure of the deviations of the observed RTWI from the estimated equilibrium. In particular, it tracks the RTWI more closely in 2008, and since 2013. This specification suggests that the RTWI was 2 per cent below its estimated equilibrium, on average, in the March quarter of 2014, while MA's existing model suggests the RTWI was in line with its estimated equilibrium.

In contrast, the *weighted broad* specification suggests the RTWI was 6 per cent above its estimated equilibrium in the March quarter of 2014. However, as this specification has a fairly poor fit over the entire sample (with an SE of 7.9), the estimated deviation in the March quarter was still within one standard error. While the higher SE indicates a poorer fit, the SE only provides a simple benchmark for assessing the models, and other factors – most crucially, the theoretical soundness of the model – should also be considered in evaluating their usefulness. In particular, this specification arguably provides the purest decomposition of the ToT into bulks and ex-bulks (in that it encompasses the full range of bulk commodities and accounts for changing export shares).

Finally, it should be noted that the coefficients in all four decomposed models are less stable than those from MA's existing model ([Appendix B](#), Graphs B3 to B16).¹² In particular, in early 2009 there is a discrete downwards shift in the coefficient on the ex-bulks ToT and a discrete upwards shift in the coefficient on the bulks ToT. This broadly coincides with the introduction of more flexible (less sticky) price-setting mechanisms for bulk commodity exports (discussed above in [Box A](#)).¹³ Break-point tests were unable to identify a statistically significant break; however, this could reflect the relatively short sample during

¹¹ The estimated equilibriums from the other two models are shown in [Appendix B](#) (Graphs B1 and B2).

¹² Recursive regressions were used to assess the stability of the model coefficients over time.

¹³ While the shift is somewhat less pronounced in the models incorporate weighted ToT, suggesting that part of the increased responsiveness of the RTWI to changes in bulks prices relates to bulk commodities exports' increasing share of the export basket, it is still evident.

which more flexible price-setting mechanisms have been in effect, as well as the fact that these mechanisms are likely to have continued to evolve gradually over time.

3.1.3 Assessment

Overall, these models provide some evidence that the RTWI has been less responsive to movements in bulk commodity prices (though the differences in the estimated coefficients on the various bulks and ex-bulks variables are generally not statistically significant). Consistent with this, incorporating separate bulks and ex-bulks ToT measures into the model does result in smaller divergences between the RTWI and the estimated equilibrium level in the 2008 and 2010/11 episodes. Nevertheless, this approach also produces less stable coefficients. Further, the estimated equilibriums are fairly sensitive to the precise methodology used to calculate the bulks and ex-bulks ToT measures, and there is no strong theoretical or empirical evidence to support one specification over another. Consequently, we do not propose to add these models to a suite of RTWI models for ongoing monitoring, although they could be examined occasionally as a cross-check.

3.2 Incorporating a forward-looking measure of the ToT

3.2.1 Overview

Foreign exchange markets are generally considered to be forward-looking. If this is true, they should 'price in' expected changes in the ToT and should respond more to changes in the ToT that are expected to be sustained.¹⁴ Consequently, a forward-looking terms of trade (FToT) measure could display a stronger and more consistent relationship with the RTWI than the backward-looking observed ToT (as used in MA's existing ECM). While this is a general point, in the Australian context the significance of using an FToT measure is likely to have increased in recent years because bulks prices, which may be less reflective of current expectations (see [Box A](#) above), have underpinned much of the recent ToT boom.

To investigate the relationship between the RTWI and the FToT, past vintages of Business and Trade section's (BAT) goods and services ToT forecasts were used to construct a number of FToT measures.¹⁵ The measures were constructed using forecast horizons of 4-8 quarters ahead for a sample beginning in 2003.^{16,17} The exercise assumes that BAT's forecasts provide a reasonable proxy for the market's forecasts, with the market's expectations the relevant determinant of the exchange rate.¹⁸

¹⁴ Chen et al (2010) note that, so long as there are costs in moving factors of production between sectors, the exchange rate should contain a forward-looking component that incorporates future expected commodity prices.

¹⁵ The *goods* ToT is used in MA's existing ECM due to concerns over endogeneity between the RTWI and the *services* ToT (see [Stone et al. \(2005\)](#) for details). However, this is unlikely to be an issue when using forecasts, as current movements in the RTWI should have little to no effect on expectations for the future ToT.

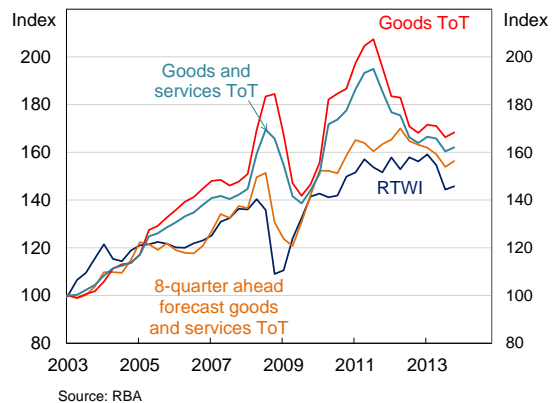
¹⁶ The *average* of the forecasts for the next *t* quarters (as well as the current quarter) was also considered. The results were broadly similar, though the fit was slightly worse. As such, the results are not reported.

¹⁷ A maximum of 8 quarters was used as longer term forecasts are not available for older vintages. While forecasts are available from the December quarter of 2001 onwards, the forward-looking measures were only constructed from the March quarter of 2003 onwards. This was done to avoid including the technology boom and bust period in the sample. Nevertheless, including this period does not materially affect the results.

¹⁸ A time-series of market forecasts of the ToT is not readily available.

These ToT forecasts have consistently underestimated the persistence of increases in the ToT during the recent boom (Graph 7). This finding is consistent with [Rees \(2013\)](#), which finds that a large portion of the rise in the ToT during the 2000s was considered, at the time, to be transitory. Further, consistent with the notion that the exchange rate should be more aligned with expectations for the *future* ToT, the FToT measure appears to track the RTWI somewhat more closely than the observed ToT. This is particularly evident in 2008, when both the FToT and the RTWI

Graph 7
ToT, Forecasts of the ToT and the RTWI
 March 2003 = 100



appear to have declined more quickly in response to the onset of the global financial crisis than the observed ToT. Similarly, both the FToT and the RTWI appear to have 'looked through' the Queensland flood-induced spike in the observed ToT in 2010/11.

In order to formally test the relationship between the FToT and the RTWI, various FToT measures are included in the medium-run portion of MA's existing ECM in place of the observed ToT. The change in the FToT is also included in the short-run portion of the model to examine whether changes in expectations about the ToT exert an influence on the RTWI's path back to its estimated equilibrium.¹⁹

3.2.2 Key Findings

The results from the model that includes an 8-quarter ahead ToT forecast are reported in [Appendix B](#) (Table B2).²⁰ As expected, when the models are estimated over the post-2003 sample, the coefficient on the FToT variable (0.7) is larger than the coefficient on the observed ToT variable (0.5), as is the associated adjustment coefficient (in absolute terms).²¹ In addition, the coefficient on the change in the FToT variable is positive and significant, indicating that changes in expectations about the future ToT exert an influence on the RTWI's path back to its estimated equilibrium.

¹⁹ The change in the observed ToT is not included in the short-run portion in MA's existing model as its coefficient is not significant.
²⁰ The results from the other specifications are very similar and so are not reported.
²¹ To an extent, the higher coefficient on the FToT measures could simply reflect the fact that movements in the ToT have been larger. However, the somewhat different profiles of the two series suggest that this does not account for the entire difference.

The estimated equilibrium from the FToT model also tends to track the observed RTWI more closely than the estimated equilibrium from MA's existing model, as evidenced by a much smaller SE (Graph 8). This is particularly evident in 2008 and also in the past two years. Meanwhile, the FToT model suggests that the RTWI was slightly below its estimated equilibrium level, on average, in the March quarter of 2014, while the existing model suggests that it was around 2½ per cent above its estimated equilibrium (when estimated over the shorter sample).

3.2.3 Assessment

Over the post-2003 sample period, the estimated equilibrium from the FToT model has tracked the level of the RTWI more closely than the estimated equilibrium from MA's existing model (which instead uses the observed ToT as the explanatory variable).²² This suggests that the FToT model could be a useful complement to MA's existing model.

Nevertheless, there are two major limitations associated with using FToT measures. Firstly, FToT measures can only be constructed for a fairly short sample, compared with observed ToT measures. Secondly, it is difficult to use the model to 'forecast' the RTWI, even one-quarter ahead, as this would require assumptions to be made regarding future forecasts.

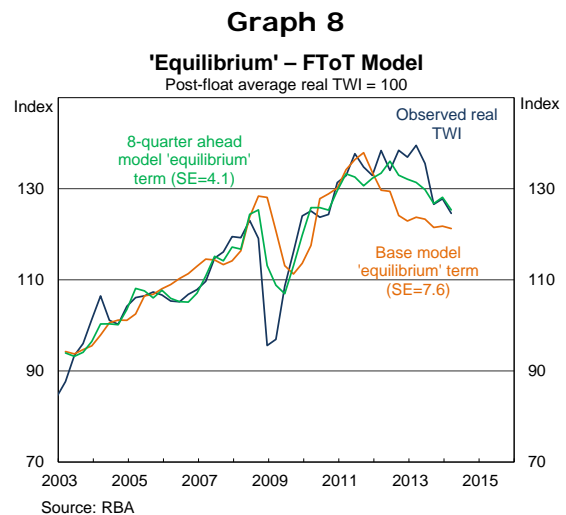
3.3 Incorporating an Investment/GDP variable

3.3.1 Overview

Investment in the Australian mining sector has increased markedly over recent years, as firms have responded to the sizeable increase in demand for bulk commodities. This investment is one of the main channels through which higher prices for bulk commodities (and the consequent increase in Australia's ToT) are likely to have affected the domestic economy and the RTWI. However, developments in bulk commodity prices and in the level of investment in the sector can diverge, in part reflecting the 'lumpy' nature of investment in the mining sector. For example, the ToT has declined somewhat over recent quarters, but the RTWI has remained elevated, possibly reflecting the continuing high levels of mining investment.

To test whether investment is a better indicator of the effect of higher bulks prices on the economy (and therefore on the RTWI) than the prices themselves, an investment-to-GDP ratio (I/GDP) variable is added to the model's co-integrating relationship.

Two measures of I/GDP are considered. One is constructed using private business investment from the National Accounts (Graph 9).²³ The other uses a forward-looking measure of non-residential construction work yet to be done (WYTBD), which is constructed using data from the ABS's Building Activity and Engineering Construction Activity releases (Graph 10).

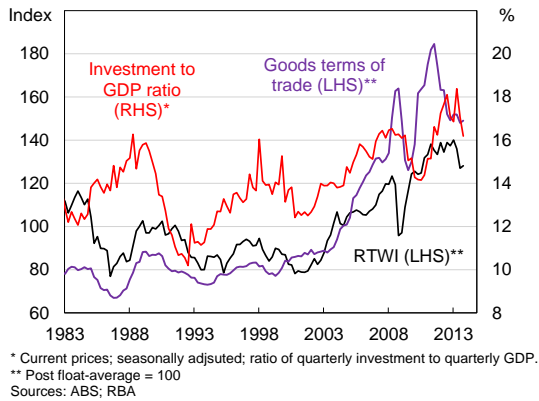


²² By using forecast vintages, the model also avoids issues related to data revisions, as discussed in Faust, Rogers and Wright (2003).

²³ Two measures of mining investment were also considered, but the estimated coefficients had counterintuitive negative signs. It is possible that this reflects collinearity between the ToT and mining investment.

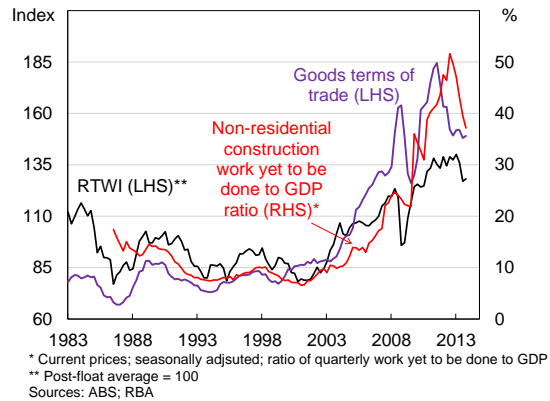
Graph 9

Investment, Terms of Trade and the Real TWI



Graph 10

Work Yet to be Done, Terms of Trade and the Real TWI



3.3.2 Key Findings

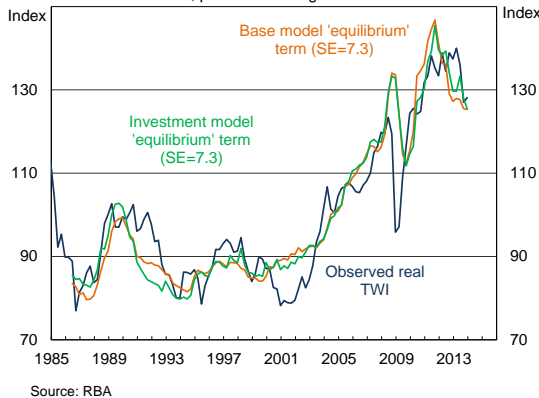
The results from incorporating the I/GDP variables into MA's existing ECM are reported in [Appendix B](#) (Table B3).²⁴ The coefficients on both of the investment variables have the expected positive sign, but only the coefficient on the forward-looking WYTBD variable is statistically significant. At the same time, the coefficient on the ToT is lower in both models, possibly reflecting the separation of the direct effect of higher bulks prices (and a higher ToT) on the RTWI from the effect via the investment channel (though there is some evidence of collinearity, which makes it difficult to interpret the individual coefficients).²⁵

The estimated equilibrium terms from these models are fairly similar to the estimated equilibrium term from MA's existing model (Graphs 11 and 12). Nevertheless, there has been some divergence in recent years. In particular, the estimated equilibrium from the models that include I/GDP have tended to be higher than the estimated equilibrium from MA's existing model, reflecting the continuing high levels of investment even after the ToT declined from its peak in 2011. This also means that they have tracked the observed RTWI somewhat more closely during this period. Still, both the existing model and the models that include investment variables suggest that the RTWI was around 2 per cent above the estimated equilibrium, on average, in the December quarter of 2013.²⁶

Graph 11

'Equilibrium' – I/GDP Model

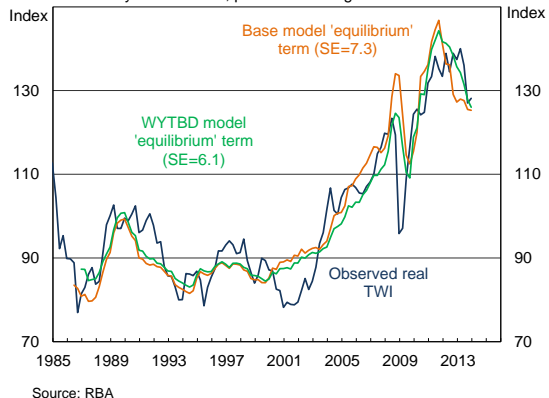
Investment; post-float average real TWI = 100



Graph 12

'Equilibrium' – I/GDP Model

Work yet to be done; post-float average real TWI = 100



²⁴ Unit root tests suggested that both I/GDP measures were non-stationary over the sample and that co-integration was evident in both specifications. Over a longer sample (i.e. since 1970) the total investment measure appears to be stationary, which is more in line with the notion that investment should fluctuate over the business cycle. However, given it was non-stationary over the estimated sample, it was treated as non-stationary in this exercise.

²⁵ Results are similar if the I/GDP variables are incorporated into a model with separate bulks and ex-bulks ToT variables.

²⁶ The underlying data used to construct the WYTBD variable are not yet available for the March quarter of 2014.

3.3.3 Assessment

There is some evidence that including a WYTBD/GDP variable in MA's existing model of the RTWI provides some additional explanatory power, particularly over recent years. This suggests that the model could be a useful complement to the existing model, particularly as mining investment is expected to decline in coming years as the economy reaches the so-called 'capex cliff'.

4. Conclusion

There is evidence to suggest that the relationship between the RTWI and bulks prices is different to the relationship between the RTWI and other export prices. This is consistent both with the nature of price-setting mechanisms for bulk commodity exports – and recent changes in these mechanisms – as well as the fact that the bulks industry is less integrated with the rest of the economy than other export industries. There is also evidence to suggest that the use of the aggregate goods ToT in MA's existing model of the RTWI has contributed to relatively large and sustained divergences between the observed RTWI and the model's estimated equilibrium term.

This note shows that extensions to MA's existing model that attempt to account for the differences in these relationships can provide some additional insight into movements in the RTWI, particularly over recent years. Consequently, we propose to use variants of these models to complement the existing model on an ongoing basis. Specifically:

- Various specifications of the **decomposed ToT** model will be considered occasionally as a cross-check for the existing model. Issues with parameter stability, the sensitivity of the estimated equilibrium to the specification of the decomposed ToT, as well as the lack of clear theoretical or empirical guidance as to which specification is 'best', makes it difficult to use this model as a more regular complement to the existing model.
- The model that incorporates a **forward-looking ToT** measure will be added to MA's suite of models. The model is tractable, has strong theoretical underpinnings, and has robust and intuitive results, despite the relatively short sample period available.
- The model that incorporates the WYTBD measure of **I/GDP** will also be added to the suite. Again, the model has reasonable theoretical underpinnings, and robust and intuitive results. Further, it is intended to capture dynamics that will continue to play out over the coming years (i.e. the 'capex cliff').

Nevertheless, none of the augmented models provide a particularly different estimate of the current deviation of the RTWI from its estimated equilibrium level, compared to MA's existing model. All models indicate that the RTWI was within one standard error of the estimated equilibrium during the March quarter of 2014 (or, in the case of the model that incorporates I/GDP, in the December quarter of 2013).

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20 June 2014

Appendix A and B can be found [here](#)

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Appendices – The Mining Boom and the Australian Dollar Real TWI Model

Appendix A

The ToT is the ratio of the export implicit price deflator (IPD) to the import IPD. Similarly, the bulks and ex-bulks ToT were constructed as the ratios of relevant export IPD, to the *aggregate* import IPD. While the import IPD was available, the relevant export IPDs needed to be constructed. This was done using chain-volume data on bulk commodity and non-bulk exports, constructed using chain linking techniques.¹

Note that non-seasonally adjusted data were used for chain linking. Nevertheless, no residual seasonality was evident in the final series and so the series were not adjusted. However, the findings are largely consistent if the series are seasonally adjusted, or if seasonally adjusted data are used for chain linking.

¹ For more information on chain linking see [Cagliarini \(2003\)](#).

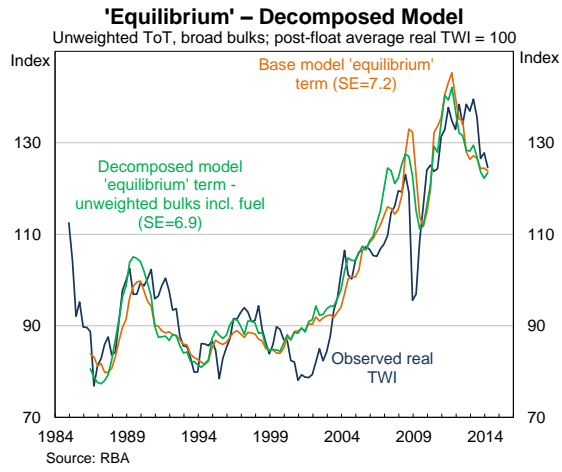
Appendix B

Table B1: Model results incorporating decomposed ToT measures

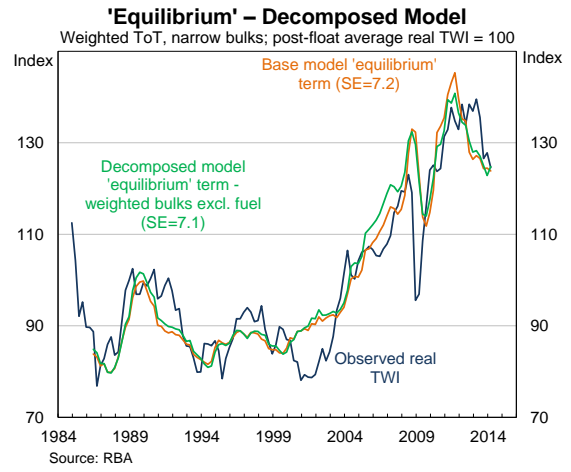
	Base ²	Unweighted (narrow)	Weighted (narrow)	Unweighted (broad)	Weighted (broad)
	1986:2	1986:2	1986:2	1986:2	1986:2
	2014:1	2014:1	2014:1	2014:1	2014:1
<i>Variables</i>					
Constant	0.36***	0.28	0.36*	0.03	0.16
(s.e.)	(0.11)	(0.18)	(0.19)	(0.20)	(0.20)
Real exchange rate (t-1)	-0.20***	-0.21***	-0.21***	-0.21***	-0.17***
(s.e.)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Terms of trade (t-1)	0.12***	--	--	--	--
(s.e.)	(0.03)				
Bulks terms of trade (t-1)	--	0.03	0.04***	0.02	0.04***
(s.e.)		(0.02)	(0.01)	(0.02)	(0.01)
Terms of trade ex-bulks (t-1)	--	0.12**	0.09**	0.19***	0.09***
(s.e.)		(0.06)	(0.04)	(0.06)	(0.03)
<i>Equilibrium relationships</i>					
Terms of trade	0.59***	--	--	--	--
(s.e.)	(0.06)				
Bulks terms of trade	--	0.13	0.20***	0.09	0.26***
(s.e.)		(0.09)	(0.02)	(0.07)	(0.03)
Terms of trade ex-bulks	--	0.57**	0.43***	0.87***	0.54***
(s.e.)		0.25	0.15	0.26	0.21
Real interest rate differential	1.46	1.55	1.47	1.26	1.62
(s.e.)	(1.03)	(0.97)	(0.97)	(0.96)	(1.17)

² Results reported using seasonally-adjusted data. The results are similar if non-seasonally-adjusted data are used.

Graph B1

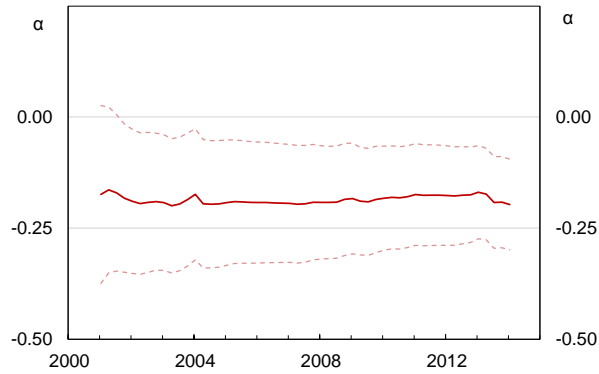


Graph B2



Graph B3

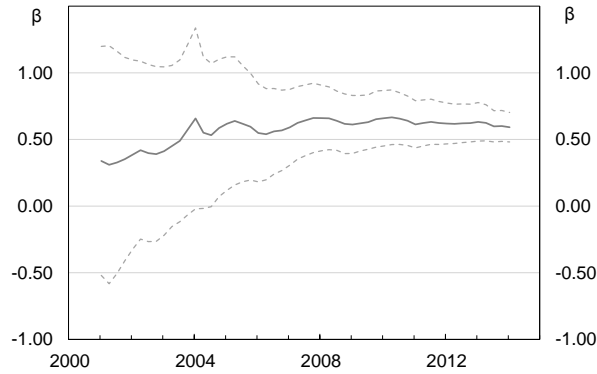
Error Correction Coefficient - Base Model
Rolling coefficients, windows arranged by endpoints



Source: RBA

Graph B4

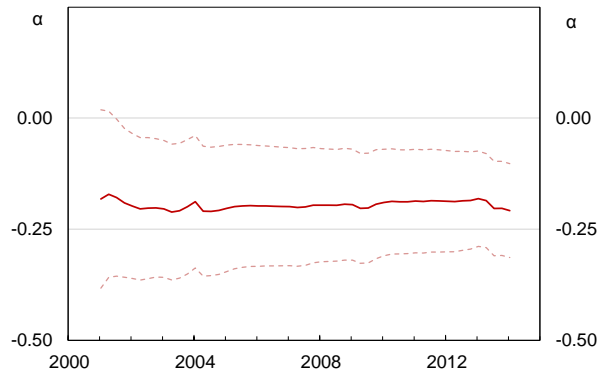
Coefficient on Terms of Trade - Base Model
Rolling coefficients, windows arranged by endpoints



Source: RBA

Graph B5

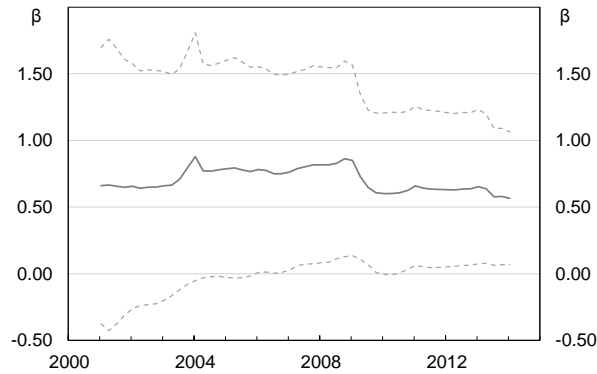
Error Correction Coefficient - Unweighted
Rolling coefficients, windows arranged by end points



* Bulks excludes other mineral fuels.
Source: RBA

Graph B6

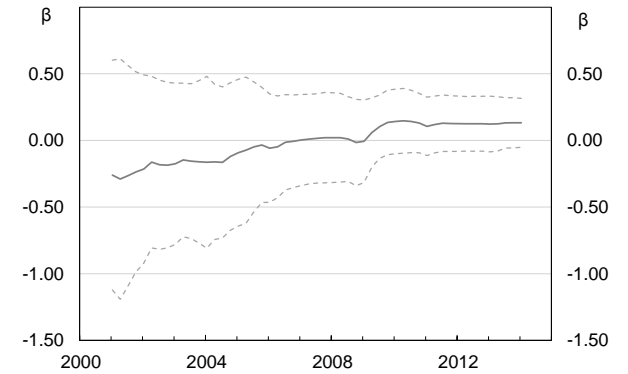
Coefficient on Terms of Trade Ex-Bulks - Unweighted
Rolling coefficients, windows arranged by end points*



* Bulks excludes other mineral fuels.
Source: RBA

Graph B7

Coefficient on Bulks Terms of Trade - Unweighted
Rolling coefficients, windows arranged by endpoints*

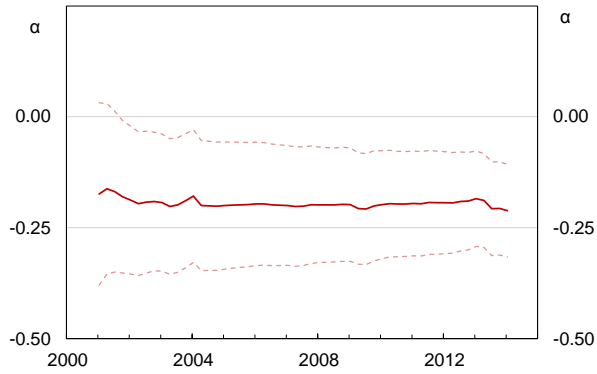


* Bulks excludes other mineral fuels
Source: RBA

Graph B8

Error Correction Coefficient – Weighted

Rolling coefficients, windows arranged by mid points*

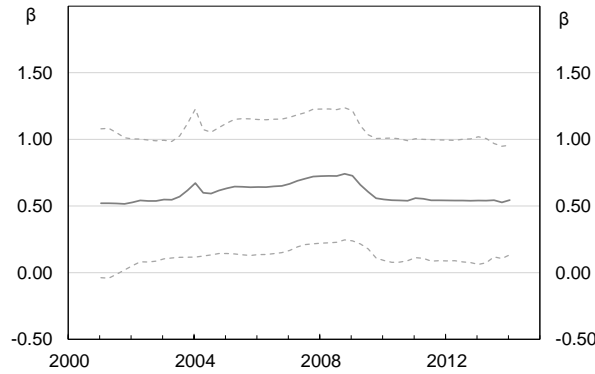


* Bults excludes other mineral fuels
Source: RBA

Graph B9

Coefficient on Terms of Trade Ex-Bults - Weighted

Rolling coefficient, windows arranged by end points*

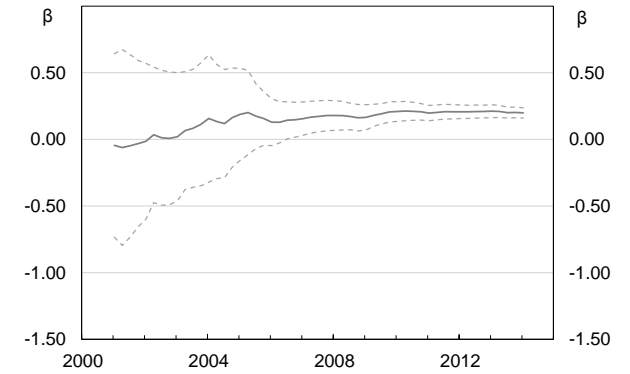


* Bults excludes other mineral fuels
Source: RBA

Graph B10

Coefficient on Bults Terms of Trade - Weighted

Rolling coefficients, windows arranged by end points*

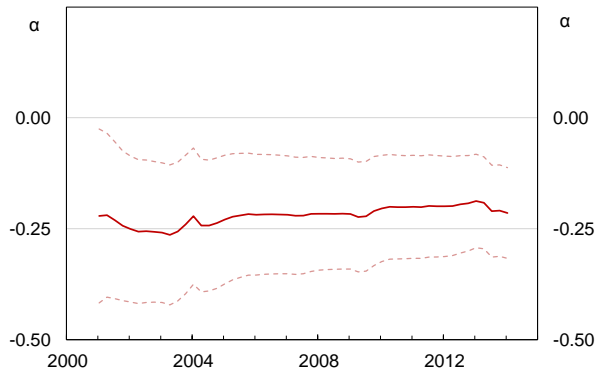


* Bults excludes other mineral fuels
Source: RBA

Graph B11

Error Correction Coefficient - Unweighted

Rolling coefficients, windows arranged by end points

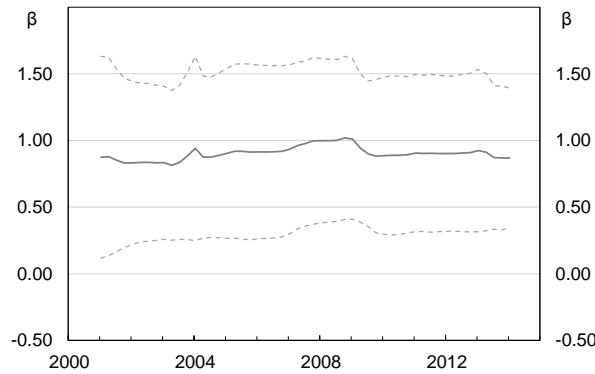


* Bults includes other mineral fuels
Source: RBA

Graph B12

Coefficient on Terms of Trade Ex-Bults - Unweighted

Rolling coefficient, windows arranged by end points*

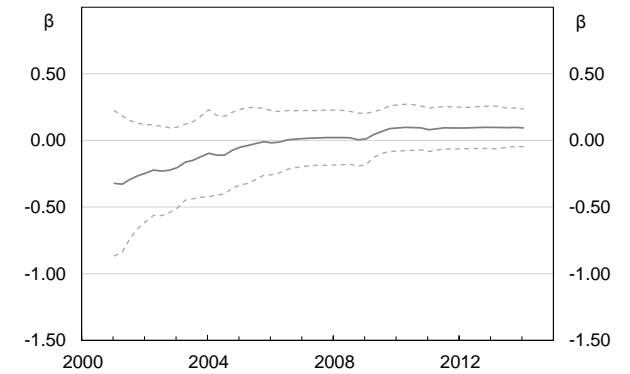


* Bults includes other mineral fuels
Source: RBA

Graph B13

Coefficient on Bults Terms of Trade - Unweighted

Rolling coefficients, windows arranged by endpoints*

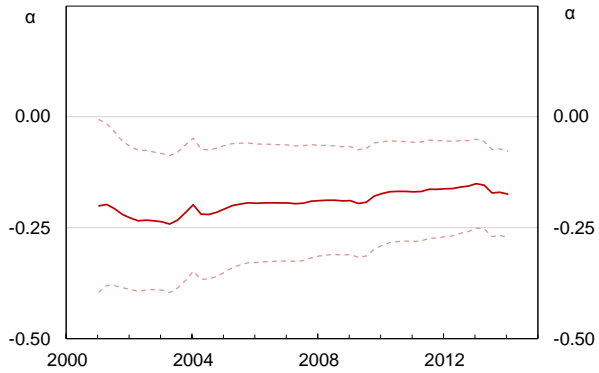


* Bults includes other mineral fuels.
Source: RBA

Graph B14

Error Correction Coefficient – Weighted

Rolling coefficients, windows arranged by mid points

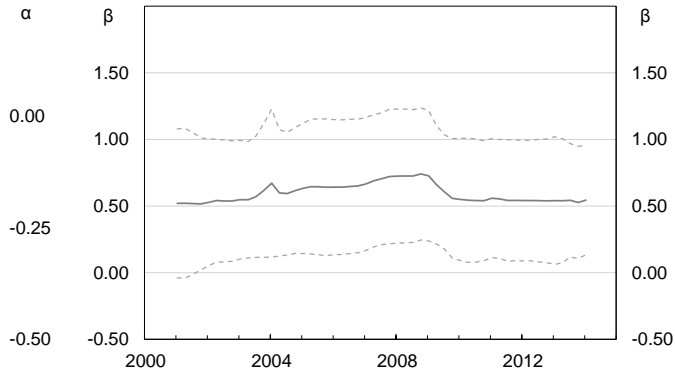


* Bulks includes other mineral fuels
Source: RBA

Graph B15

Coefficient on Terms of Trade Ex-Bulks - Weighted

Rolling coefficient, windows arranged by end points*

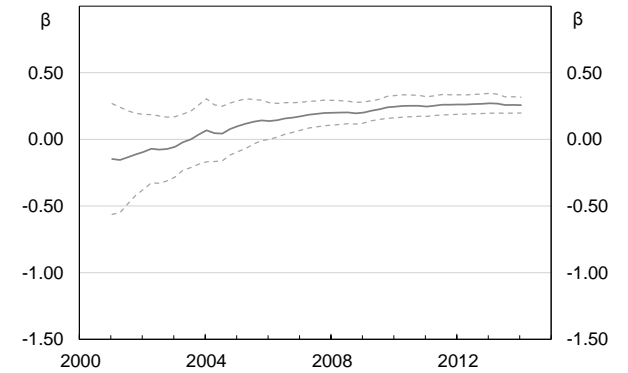


* Bulks includes other mineral fuels.
Source: RBA

Graph B16

Coefficient on Bulks Terms of Trade - Weighted

Rolling coefficients, windows arranged by end points*



* Bulks includes other mineral fuels.
Source: RBA

Table B2: Model result incorporating an FToT measure

	Base	Eight-quarter ahead
	2003:1	2003:1
	2014:1	2014:1
<i>Variables</i>		
Constant	0.56***	0.58***
(s.e.)	(0.14)	(0.14)
Real exchange rate (t-1)	-0.25***	-0.46***
(s.e.)	(0.06)	(0.11)
Terms of trade (t-1)	0.12***	0.32***
(s.e.)	(0.04)	(0.09)
d(Terms of trade)	--	0.37***
(s.e.)		(0.11)
<i>Equilibrium relationships</i>		
Terms of trade	0.50***	0.70***
(s.e.)	(0.07)	(0.05)
Real interest rate differential	0.90	0.09
(s.e.)	(1.80)	(0.93)

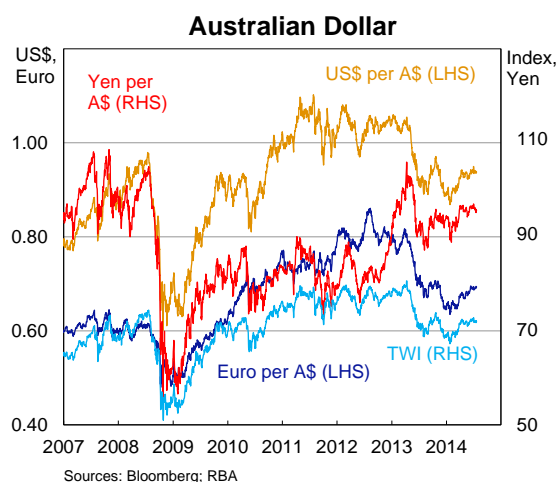
Table B3: Model results incorporating I/GDP

	Base	Total Investment	WYTBD
	1986:2	1986:2	1986:4
	2013:4	2013:4	2013:4
<i>Variables</i>			
Constant	0.34***	0.38***	0.53***
(s.e.)	(0.12)	(0.12)	(0.17)
Real exchange rate (t-1)	-0.19***	-0.20***	-0.20***
(s.e.)	(0.05)	(0.05)	(0.05)
d(Total Investment/GDP)	--	0.73*	--
(s.e.)		(0.44)	
d(Work yet-to-be-done/GDP)	--	--	0.26
(s.e.)			(0.15)
<i>Equilibrium relationships</i>			
Terms of trade	0.60***	0.51***	0.39***
(s.e.)	(0.06)	(0.07)	(0.11)
Real interest rate differential	1.37	1.37	1.40
(s.e.)	(1.07)	(1.01)	(1.01)
Total Investment/GDP	--	2.03	--
(s.e.)		(1.26)	
Work yet-to-be-done/GDP	--		0.47*
(s.e.)			(0.25)

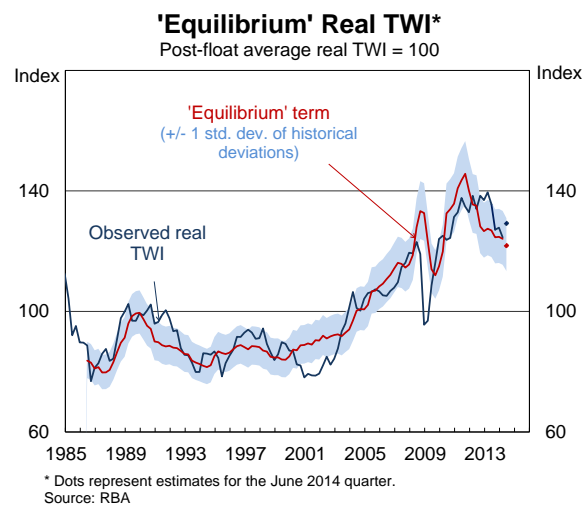
INTERNATIONAL DEPARTMENT MONTHLY REVIEW JULY 2014

Summary

- The Australian dollar has depreciated by 1 per cent on a trade-weighted basis over the month though remains around 7 per cent higher than its late-January level.



Consistent with the fact that the Australian dollar's appreciation over 2014 has coincided with declining commodity prices, Market Analysis's baseline model of the Australian dollar estimates that the Australian dollar was 6 per cent above the level justified by its medium-term determinants, on average, in the June quarter (in real trade-weighted terms).²



Australian Dollar

The Australian dollar has been little changed against the US dollar over the month but has depreciated by 1 per cent on a trade-weighted basis. The Australian dollar remains 7-8 per cent above its low in late January on both measures.

² Using forward-looking measures for the terms of trade implies that the Australian dollar is 3-5 per cent above the level suggested by its medium-term determinants. For more information on these models see [Hambur \(2014\)](#)

Australian Dollar against Selected TWI Currencies

Percentage change

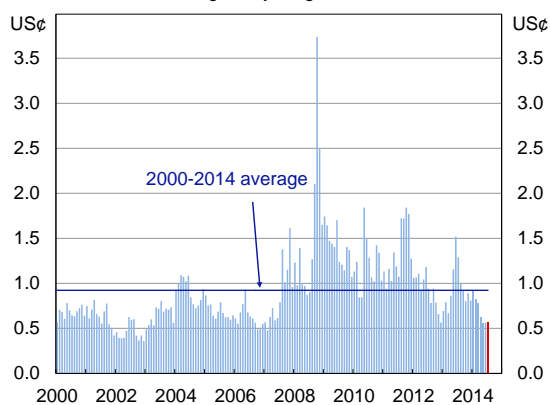
	Past Year	Since previous Board
European euro	-1	0
South Korean won	-6	0
Swiss franc	-2	0
New Zealand dollar	-7	0
Indian rupee	4	0
Canadian dollar	6	0
South African rand	10	0
US dollar	2	0
Chinese renminbi	3	-1
Japanese yen	3	-1
UK pound sterling	-9	-1
Singapore dollar	0	-1
Malaysian ringgit	1	-2
Thai baht	5	-2
Indonesian rupiah	17	-5
TWI	1	-1

Sources: Bloomberg; RBA

Consistent with developments in most other currencies, volatility in the Australian dollar also remains subdued, with the average intraday trading range in the AUD/USD exchange rate remaining around multi-year lows.

Intraday Range in AUD/USD

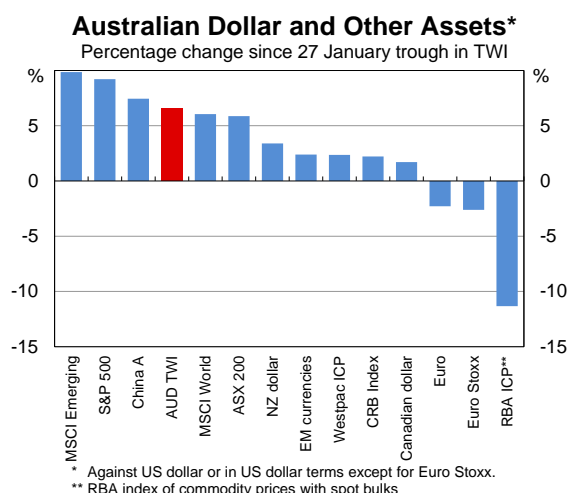
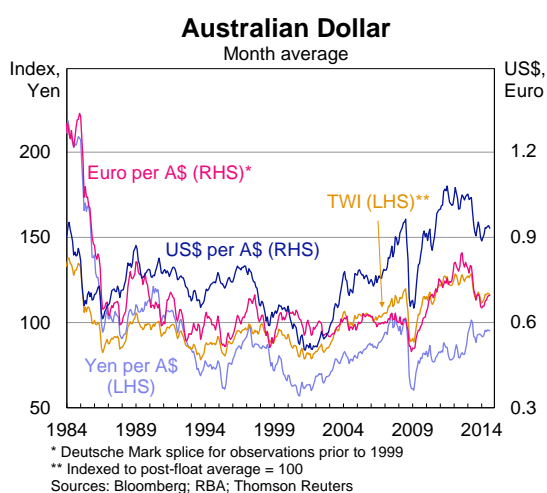
Average daily range in month


International Department
22 July 2014

UPDATE ON THE AUSTRALIAN DOLLAR

Since the previous testimony in March, the A\$ has appreciated by around 3% on a **nominal trade-weighted basis** to be 7% above its January 2014 low. In a longer-run context, the nominal TWI has depreciated by 11% since its peak in April 2013, but remains 16% above its post-float average.

- **Against the US\$**, the A\$ has appreciated by 7% since its January low, though remains 12% below its April 2013 peak; it is 22% higher than its post-float average.
- **Against the JPY**, the A\$ has appreciated by 7% since its January low, though remains 9% below its April 2013 peak; it is 3% higher than its post-float average.
- **Against the euro**, the A\$ has appreciated by 10% since its January low, though remains 19% below its historical peak (reached in August 2012); it is 10% higher than its average since the introduction of the single currency in 1999.

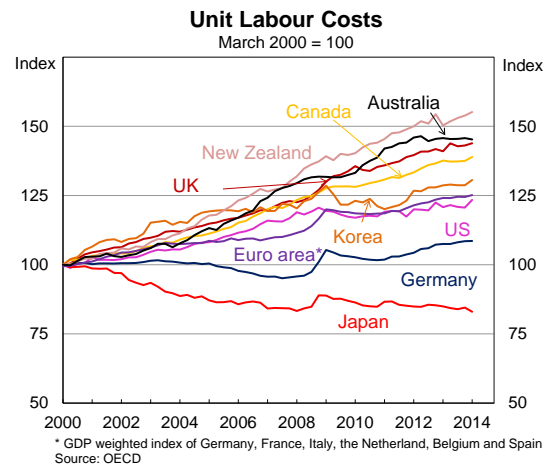
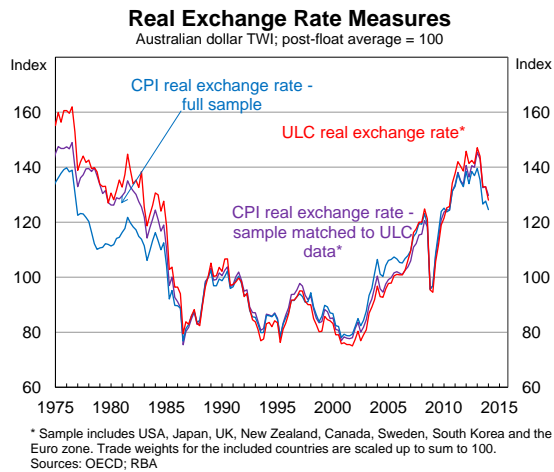


The appreciation in the Australian dollar since late January has occurred even though key commodity prices have declined, and interest rate differentials between Australia and a number of other advanced economies have narrowed. In broad terms, it has coincided with:

- an improvement in risk sentiment – and further declines in volatility across a number of asset markets – which has underpinned gains in most global equity markets and higher-yielding assets;
- broadly stronger domestic economic data and diminished expectations of a lower cash rate, though, there has been a partial reversal in both of these in recent weeks;
- reduced market concerns over the outlook for China; and
- weaker US economic data in the MQ14 – against expectations of better US growth, higher US yields and a stronger US\$ over 2014 – though more recent US data has been broadly stronger.

In real terms, the TWI has depreciated by around 7% since its peak in the MQ13, but it remains around 30% above its post-float average.

The real TWI remains high by historical standards with a unit labour cost (ULC) based measure presenting a very similar picture to the standard CPI-based measure (though the ULC-based measure excludes a number of countries, including China). That said, the ULC-based measure has experienced a slightly larger depreciation over the past year, reflecting some improvement in Australia's relative ULC.



MA's base model of the (CPI-deflated) real TWI is estimated from JQ86 to JQ14, and is based on its medium-term relationship with Australia's goods ToT and the real policy rate differential with the G3 (and also some short-run variables). The model suggests that, in quarter-average terms, the real TWI was 8% *above* the level consistent with its medium-term determinants in the JQ14 (which is slightly outside the +/- 1 standard deviation band). Estimates for the SQ14 to date suggest a slightly larger deviation.¹

It should be noted that these estimates are sensitive to the estimation period:

- if the model is estimated using data since 1974, it suggests the A\$ was 2% *below* the level consistent with its medium-term determinants in the JQ14; whereas
- if the model is estimated using data since MQ03, it suggests the A\$ was 9% *above* the level consistent with its medium-term determinants in the JQ14.

MA's models of the real TWI that incorporate forward-looking measures of the ToT – based on the Bank's internal ToT forecasts – are estimated from MQ03 to JQ14. They suggest that, in quarter-average terms, the real TWI was 3-5% *above* the level consistent with its medium-term determinants in the JQ14. Estimates suggest a slightly smaller deviation in the SQ14 to date.

External assessments also suggest that the A\$ is overvalued:

- The IMF's most recent assessment suggests the A\$ real TWI was *overvalued* by 5-15% as of May 2014;
- A small sample of investment bank models generally point to *overvaluation* of around 10% on a TWI basis.

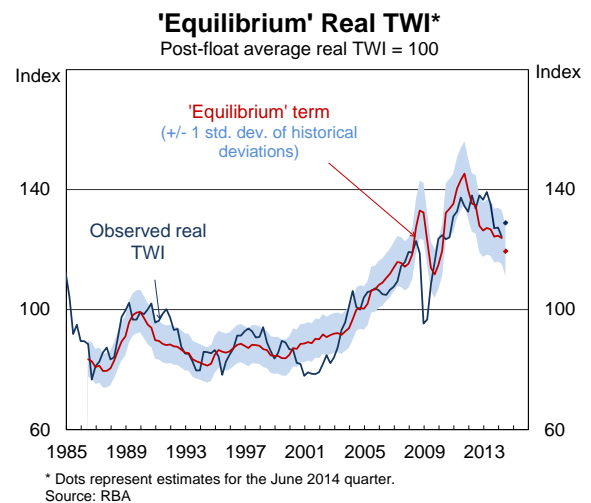


Table 1: Models of the Australian Dollar – Summary

¹ The SQ14 estimates assume that: the nominal TWI remains unchanged for the rest of the SQ14; domestic and foreign inflation remains unchanged; domestic and foreign policy rates remain unchanged; and the terms of trade grows in line with BAT's forecasts (which are for a 1½% decline in the SQ14).

RBA Models (Real TWI) – June Quarter 2014	Estimated exchange rate valuation		
	Under/over-valuation	% deviation	Standard deviations
Base, from 1974	Under	2	0.1
Base, from 1986 (preferred base model)	Over	8	1.1
Base, from 2003	Over	9	1.2
Forward-looking terms of trade, from 2003	Over	3-5	0.7-1.0
External Assessments			
IMF (Real TWI; May 2014)	Over	5-15	-
Big Mac Index (PPP Measure; against US\$; July 2014)	-	0.4	-
JP Morgan (Real TWI; August 2014)	Over	13	-
Goldman Sachs (Nominal TWI; July 2014)	Over	7	-
Barclays (Real TWI; July 2014)	Over	12	-

According to a Bloomberg survey of foreign exchange market analysts, the median forecast is for the A\$ to depreciate by 6% against the US\$ by end 2015. However, the range of forecasts is fairly wide (US\$0.78-US\$0.99).

Market Analysis
International Department
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