Developments in the Australian Dollar and the Terms of Trade

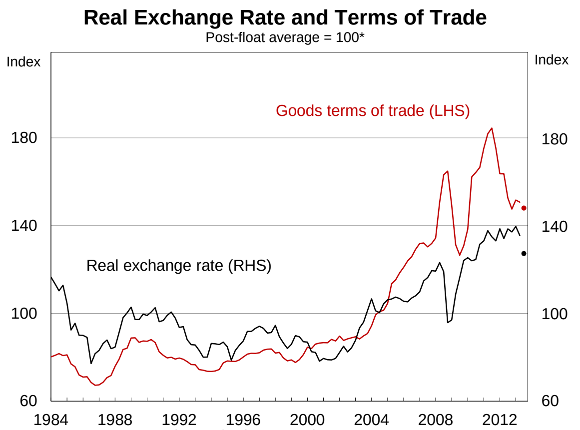
Up to the June quarter 2013, Australia's goods terms of trade had declined by around 18 per cent from its peak in the September quarter 2011 (based on EC's current estimate of the June quarter terms of trade), while the Australian dollar real trade-weighted index (RTWI) had, in quarter-average terms, remained little changed over the same period (around a historically high level). However, the RTWI also increased by less than the terms of trade during the preceding boom. As such, our sense is that the RTWI 'looked through' part of the increase and subsequent decline in the terms of trade.[1] The RTWI has since depreciated further in the September quarter to date, with estimates suggesting that the depreciation has been more pronounced than EC's forecasted decline in the terms of trade over the quarter.

Market Analysis' error correction model of the RTWI indicates that this behaviour has not been especially unusual relative to historical experience, with the long-run coefficient on the terms of trade remaining broadly stable at around 0.6 and little evidence of significant changes in the short-run dynamics. Using estimates of the RTWI and the terms of trade (from EC), the ECM currently suggests that the RTWI is at a level which is broadly consistent with its medium-term fundamentals.

Overview

Historically, there has been a fairly close long-term relationship between the goods terms of trade and the RTWI (Graph 1).[2] However, it is worth considering whether the recent terms of trade boom, which was associated with relatively large movements in the terms of trade compared with the RTWI, provides evidence of a change in that relationship.

Graph 1



* Dots represent estimates for the September quarter
Sources: ABS; RBA; Thomson Reuters; WM/Reuters

This question can be evaluated within the context of Market Analysis' (MA's) preferred error correction model (ECM), which estimates an 'equilibrium' co-integrating relationship between the RTWI, the goods terms of trade and the real interest rate differential (between Australia and the G3). The 'equilibrium' RTWI is the value justified by these medium-term fundamentals (in practice, the terms of trade is the most important determinant of this 'equilibrium' by some margin). The model also includes a number of short-run variables which attempt to account for short-term financial market influences. These include the CRB index (a widely-followed market-based commodity price measure), and two factors that 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).

$$\Delta RTWI_t = \mu + \gamma RTWI_{t-1} + \alpha_1 TOT_{t-1} + \alpha_2 RIRD_{t-1} + \beta_1 \Delta CRB_t + \beta_2 \Delta CRB_{t-1} + \beta_3 \Delta SPX_t + \beta_4 \Delta VIX_t + \varepsilon_t$$

Reflecting the dominance of the terms of trade as an explanatory variable, the model's estimated 'equilibrium' value for the RTWI has followed a similar profile to that of the terms of trade, increasing more sharply than the actual RTWI between September 2009 and September 2011 before falling back below the RTWI as the terms of trade subsequently retreated (Graph 2). As a

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[1] Such behaviour is not unexpected in a market with rational forward-looking participants. While Gruen and Kortian (1996) found some evidence of a lack of rational forward-looking participants in the Australian dollar market in the mid 1990s, the market has developed since then. More broadly theory does not suggest that the real exchange rate and the terms of trade should necessarily move together on a one-for-one basis.

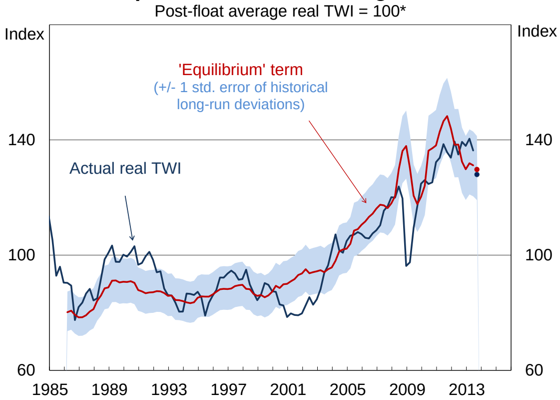
[2] The goods terms of trade is used due the possibility of endogeneity between changes in the goods and services terms of trade and the RTWI. For more information see Stone *et al* (2005).

result, the model implies that the RTWI was as much as 6 per cent lower than its medium-term ‘equilibrium’ in the June quarter 2010 and as much as 9 per cent higher than its medium-term ‘equilibrium’ in the March quarter 2013 (although throughout this episode the RTWI has remained within a +/- one, albeit large, standard error band around the model-implied ‘equilibrium’).[3] Having depreciated by an estimated 9 per cent in quarter-average terms since the March quarter 2013 (assuming the real exchange rate remains constant at its current level for the remainder of the September quarter), MA’s ECM now indicates that the RTWI is at a level which is broadly consistent with its medium-term fundamentals (it is estimated to be marginally below the ‘equilibrium’).

Graph 2

'Equilibrium' Real Exchange Rate

Post-float average real TWI = 100*



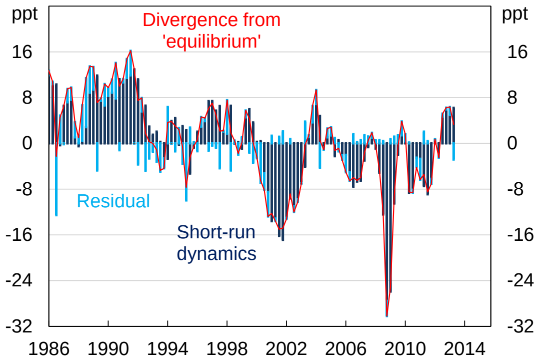
* Dots represent estimates for the September quarter

Source: RBA

Graph 3

Real TWI

Decomposition of the divergence from 'equilibrium'



Source: RBA

Importantly, since September 2009, the residuals from the ECM (the difference between the fitted values and the actual RTWI as opposed to the divergence of the actual RTWI from the model-implied ‘equilibrium’) have not been especially large by historical standards (Graph 3). Instead, most of the divergences between the actual and equilibrium RTWI have been ‘explained’ by the model’s short-run dynamics. Nevertheless, given the unprecedented nature of the recent mining investment boom and more recently, the extraordinary monetary policy settings in some major economies, additional work has been undertaken to establish whether these factors have altered the ECM’s long-run coefficients and/or the short-term dynamics.

Stability of the Long-term Relationship with the Terms of Trade

In order to test the stability of the relationship between the RTWI and the goods terms of trade, the ECM was estimated over the full sample (from March 1986 to June 2013) and over a shorter sample (from March 1986 to December 2004). This exercise yields a slightly higher estimate of the coefficient on the goods terms of trade for the pre-2005 sample, but the difference is not statistically significant (Table 1).[4] Relatedly, out-of-sample forecasts of the RTWI from the ECM estimated up to the December quarter 2004 are quite similar to, but slightly higher than, the in-sample estimates using data from the entire sample period. This suggests that the coefficients on the other variables in the model are also little changed

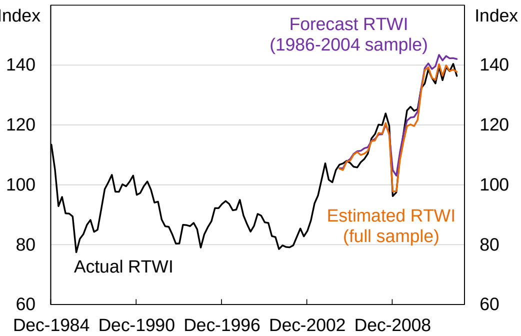
Table 1

Coefficients on the Goods Terms of Trade*	
Model estimated to the end of 2004	0.631
Model estimated over the full sample	0.604

Graph 3

Forecast and Actual RTWI

Using model estimated to different points



Source: RBA

[3] The standard error is calculated based on the deviation of the actual RTWI from the estimated ‘equilibrium’ RTWI.
[4] Based on a Wald test.

(Graph 3).[5]

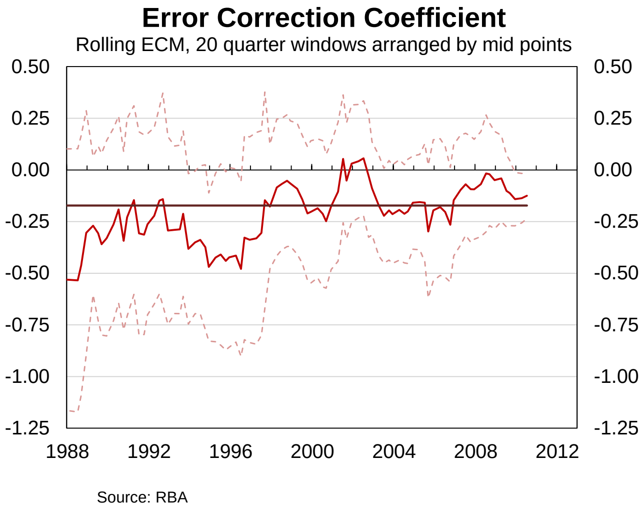
Stability of Short-term Dynamics

While the co-integrating relationship appears to have been fairly stable over recent years, it is also worth investigating whether this is true of the ECM's short-term dynamics. To assess this, we examined the stability of the error correction coefficient (as well as the coefficients on the short-run variables).[6] Any instability in the error correction coefficient would be of particular interest as it directly enters into the calculation of the 'equilibrium', and affects the expected half-life of any deviations from this equilibrium.

To test the stability of the short-run dynamics, we estimated the ECM in a two-step procedure, holding the coefficients on the co-integrating relationship (from the first stage) stable, while estimating the coefficients on the short-run dynamics on a rolling basis (in the second stage).

While the error correction mechanism does appear to weaken during the early part of the terms of trade boom, this has since been largely reversed (Graph 4). The strongest suggestion of a weakening in the error correction mechanism can be found for the early 2000s, during which the RTWI remained below the medium-term equilibrium for an extended period of time, consistent with the negative sentiment towards 'old economy' industries around the time of the 'tech boom'.

Graph 4



This rolling ECM analysis is presented in more detail in Weltewitz and Smith (forthcoming), along with a Markov switching ECM, which was developed to more formally investigate evidence of regime changes in the short-run dynamics of the ECM. However, consistent with the evidence presented above, this more complex regime switching model does not appear to provide strong evidence of a change in the relationship between the RTWI and the terms of trade during the most recent episode, nor does it improve on the estimates provided by the basic ECM.

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Market Analysis
International Department

24 July 2013

[5] The coefficient on the terms of trade also appears stable since 1994 when using a rolling regression. However, estimates are somewhat less stable when the pre-inflation targeting period is included in the sample. We intend to investigate this finding further.

[6] Results for the short-run coefficients are not reported here but are available on request.

REGIME CHANGES IN THE AUSTRALIAN DOLLAR MODEL

One of the outputs of MA's error correction model (ECM) of the Australian dollar real trade-weighted index (RTWI) is an estimated long-run 'equilibrium' time series, which is consistent with economic fundamentals – most notably, the terms of trade. While estimated divergences from this 'equilibrium' are largely explained by the model's short-run dynamics, this note investigates whether these short-run dynamics have changed over time. We do so by estimating rolling and Markov switching specifications of the model. Neither approach generates strong evidence of parameter instability, suggesting that the observed behaviour of the RTWI relative to the estimated long-run 'equilibrium' in the baseline ECM has been relatively stable over time, including during the most recent peak and subsequent decline in the terms of trade.

Overview

Modelling exchange rates is notoriously difficult and most forecasting approaches have historically failed to outperform random walks (see for example Meese and Rogoff, 1983 and Cheung, Chinn and Pascual, 2005). However, so-called 'commodity currencies' are something of an exception, as models based on the terms of trade have tended to yield better results (Cashin, Céspedes and Sahay, 2004).[1] Consistent with this, MA's preferred model of the Australian dollar real trade-weighted index (RTWI), which is an error correction model (ECM) based on the long-run relationship between the RTWI and the terms of trade (TOT), has typically performed reasonably well. Nevertheless, there have been episodes during which the RTWI has deviated from the model-implied equilibrium for a sustained period. This note investigates whether these episodes are symptomatic of historical 'regime changes'; that is, whether there is evidence that the relationship between the RTWI and the explanatory variables has varied systematically over time.

We use two approaches to answer this question. First, we estimate a rolling version of the ECM, which holds the long-run relationship between the RTWI and the TOT constant but allows the error correction term and the coefficients on the short-term variables to change over time. Second, we estimate a Markov switching ECM to more formally allow for the presence of two distinct 'regimes' governing the RTWI's behaviour around a stable long-run equilibrium (within the ECM framework it would not make sense to allow for changes in the long-run cointegrating relationship).

Overview of MA's ECM

Our analysis builds on Market Analysis' (MA's) preferred ECM, which draws on Beechey et al (2000) and Stone et al (2005).[2] This model specifies a long-run cointegrating relationship between the RTWI, the goods terms of trade (TOT) and the real policy rate differential (RIRD) between Australia and a GDP(PPP)-weighted average of the G3 economies.[3]

The model also incorporates short-run variables that are intended to capture near-term financial market influences on the behaviour of the RTWI. These variables include: the change in the CRB commodity price index (a widely-followed market-based commodity price measure), and two factors that capture 'risk sentiment' in financial markets – the change in

[1] The question of causality is another issue. A more recent reference is Chen, Rogoff and Rossi (2010), who find that exchange rate changes Granger-cause commodity price changes in-sample, though not out-of-sample.

[2] The current specification of the model is also informed by internal MA work by Cockerell, De Silva and Potter.

[3] The goods terms of trade is used due the possibility of endogeneity between changes in the goods and services terms of trade and the RTWI. For more information see Stone *et al* (2005).

the real S&P500 total return index (SPX) and the change in the VIX index of US large-cap equity price volatility[4]

$$\Delta RTWI_t = \beta_0 + \alpha RTWI_{t-1} + \beta_1 TOT_{t-1} + \beta_2 RIRD_{t-1} + \phi_1 \Delta CRB_t + \phi_2 \Delta CRB_{t-1} + \phi_3 \Delta SPX_t + \phi_4 \Delta VIX_t + \varepsilon_t \,. \quad (1)$$

The error correction term, α, is of particular interest, as it describes the speed at which deviations from the long-run 'equilibrium' are corrected, all else equal.[5] For analytical purposes, we are generally interested in the value of the RTWI relative to the model's implied long-run equilibrium value, which is given by[6]

$$-\frac{1}{\alpha}\left[c + \beta_1 TOT_t + \beta_2 RIRD_t\right] \quad (2)$$

where

$$c = \beta_0 + \overline{\Delta RTWI_t} - \phi_1 \overline{\Delta CRB_t} - \phi_2 \overline{\Delta CRB_{t-1}} - \phi_3 \overline{\Delta SPX_t} - \phi_4 \overline{\Delta VIX_t} \,.$$

Although, the results are somewhat sample-dependent, our preferred model is estimated from Q1 1986.[7] While the cointegrating relationship between the RTWI and the goods terms of trade has shown remarkable stability since the mid 1990s, the large rise in the terms of trade in the last few years has reduced the magnitude of the estimated coefficient on the real interest rate differential. Nevertheless, as theory justifies its inclusion, the real interest rate differential remains in the model.[8] The estimated long-run equilibrium series is shown in Graph 1.

It should be emphasised that divergences from the estimated long-run 'equilibrium' are accounted for by 'explained' variation in the short-run variables and the 'unexplained' residual ε_t. The residual – that is, the difference between the observed RTWI and the fitted value from the model *including* the short-run dynamics – is fairly small and does not have a systematic effect (Graph 2). Instead, most of the divergences from the model-implied long-run equilibrium are explained by the model's short-run dynamics (although we cannot clearly distinguish between the effects of the short-run variables and the error correction term analytically).

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[4] Various alternative measures of equity and commodity prices have previously been tried, but the results of alternative specifications are generally consistent with those presented here.

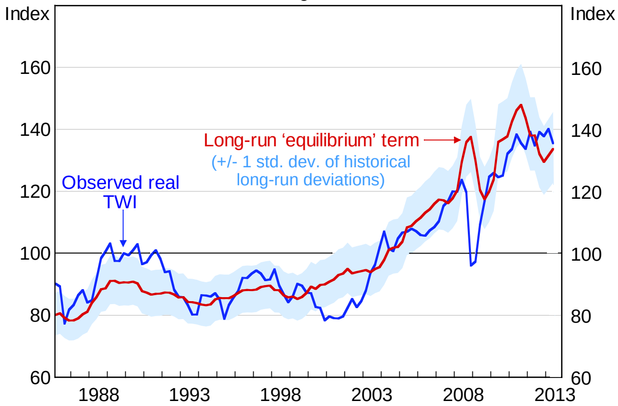
[5] We would expect α to fall between 0 (none of the divergence from equilibrium is corrected in the subsequent period) and -1 (all of the divergence from equilibrium is corrected).

[6] The intercept estimated in equation (1), β_0, reflects both the long-run and short-run variables. To get an intercept for our estimated long-run 'equilibrium' that is not affected by the short-run variables, c, we adjust β_0. In practice, the adjustment is very close to zero.

[7] This is the longest sample for which data are available for all explanatory variables, and covers most of the post-float period.

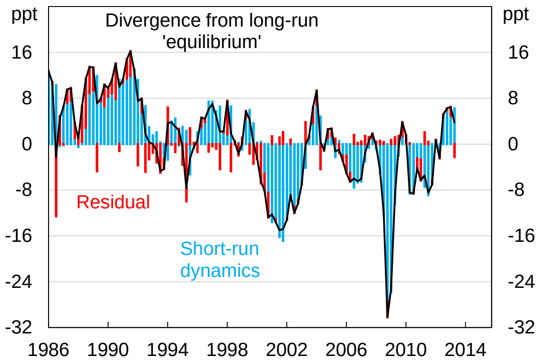
[8] Further work is planned to re-examine the relationship between the terms of trade and the RTWI in the early part of the sample. We also aim to establish whether the real interest rate differential variable can be improved upon and/or respecified as part of the model's short-run dynamics.

Graph 1
Long-run 'Equilibrium' Real Exchange Rate*
Post-float average real TWI = 100



* Forecasts used for June quarter
Source: RBA

Graph 2
Real TWI
Decomposition of the divergence from long-run 'equilibrium'



Source: RBA

Several periods of reasonably persistent deviations from the implied long-run equilibrium have been observed in the post 1985 period, and these are the focus of this note. The first occurred in the late 1980s and early 1990s, when the observed real TWI was noticeably higher than the estimated long-run 'equilibrium'. Commodity prices increased sharply in the second half of the 1980s, bringing about a 26 per cent increase in the terms of trade between late 1986 and early 1989 as well as a sharp appreciation of the RTWI. However, as the terms of trade subsequently declined in the early 1990s, the depreciation of the RTWI was noticeably delayed and it remained above the implied equilibrium for several years. Previous research identified several factors as having played a role in this episode, including strong demand for Australian bonds and the dissipation of concerns about foreign debt sustainability, which had been more prevalent in earlier years (Blundell-Wignall, Fahrer and Heath, 1993).

The second period occurred between 2000 and 2003, when the observed real TWI was noticeably lower than the model-implied 'equilibrium'. One explanation is that even after the collapse of the technology 'bubble' in 2000, there remained a persistent view in foreign exchange markets that Australia's economy – with its relatively small reliance on 'new economy' industries, and relatively heavy reliance on primary industries – had poor growth prospects relative to other developed economies. This view may have taken several years to change, as the increase in the terms of trade continued to surprise on the upside (Kearns and Lowe, 2011).

The third period coincided with the global financial crisis, which precipitated a rapid depreciation of the RTWI. However, the effect on the terms of trade was delayed, as new bulk commodity export contracts specifying higher prices had been signed just prior to the crisis, creating a significant, but short-lived, deviation from the implied equilibrium in early 2009.[9]

More recently, the goods terms of trade have declined by around 18 per cent between the peak in the September quarter 2011 and the June quarter 2013, while the RTWI has remained broadly unchanged over the same period. This might suggest that the relationship between the terms of trade and the exchange rate has changed, or been outweighed by some other factor (De Voss, 2012). Several possible explanations for this have been advanced, including Australia's relatively strong economic performance compared to most other developed economies, the extraordinary monetary policy measures adopted by major central banks, and a decline in the global availability of highly-rated fixed income assets.

Some of these factors are likely to be at least partly captured in the ECM through their correlation with the long-run or short-run variables (for example, all three explanations

[9] See for example the Commodity Prices section in the August 2008 *Statement of Monetary Policy*.

mentioned above could be captured, in part, by the real interest rate differential). However, other factors that may have been supportive of the RTWI – particularly latent shocks to sentiment or asset availability – are not captured explicitly. While it may be possible to address this by adding explanatory variables (including dummy variables) to the model *ex post*, such an exercise is less useful in explaining developments in the Australian dollar on an ongoing basis.[10] Furthermore, selection bias would render the interpretation of their statistical significance questionable.

The error correction coefficient in the ECM framework allows us to make some judgments about changes in the RTWI's behaviour around the implied equilibrium without requiring any exogenous information or additional data to identify the nature of these changes. If this coefficient becomes less negative, it suggests that departures from the estimated equilibrium will take longer to be reversed – in other words, persistent, but not directly observable, shocks to the RTWI can be represented as a change in the regime governing the error correction term. Some shocks may also be expressed as changes in the coefficients on the short-run variables already included in the model. In the remainder of this note, we look for evidence of regime changes by investigating the stability of the error correction term and the short-run coefficients.

Rolling Error Correction Model

Rolling regressions are a simple method for detecting structural change in the parameters of a model. Given that a key requirement of any ECM is a stable cointegrating relationship between the long-run variables, we focus on changes in the short-run dynamics of the model while keeping the cointegrating relationship stable. To do so, a rolling ECM can be estimated using a two-step procedure which holds the long-run relationship constant while allowing the short-run dynamics to vary over time.[11, 12]

More specifically, we first estimate the long-run cointegrating relationship over the entire sample period:

$$RTWI_t = \beta_0 + \beta_1 TOT_t + \beta_2 RIRD_t + z_t \tag{3}$$

We then use the lagged residuals from this regression (z_t) to estimate a short-run model in differences:

$$\Delta RTWI_t = \phi_0 + \alpha z_{t-1} + \varphi_1 \Delta TOT_t + \varphi_2 \Delta RIRD_t + \phi_1 \Delta CRB_t + \phi_2 \Delta CRB_{t-1} + \phi_3 \Delta SPX_t + \phi_4 \Delta VIX_t + \varepsilon_t \tag{4}$$

Although we include an intercept in the short-run equation (4), implying a trend in the RTWI's behaviour around the estimated equilibrium, in practice the estimated coefficient is around zero. We chose window lengths of 20 quarters, generating 89 separate regressions between 1986Q1 and 2013Q1.[13]

[10] For example, Stone et al introduce a dummy variable, known as the 'tech dummy', for the early 2000s intended to capture the aforementioned apparent undervaluation of the RTWI.

[11] In MA's model, Engle-Granger and Johansen cointegration tests confirm the presence of cointegration between the RTWI and the terms of trade over the entire sample period. As discussed above, the role of the RIRD in the model has been subject to some change and will be the subject of future work. For more detail on the theory behind the variables chosen, please see for example Beechey et al (2000) and Stone et al (2005).

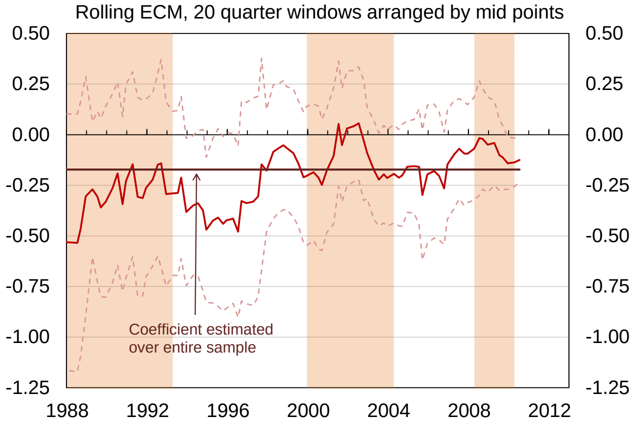
[12] There are several disadvantages to using the 2-step procedure, which is why we normally use an ADL specification. However, in this case it provides an intuitive way to separately estimate the stable long-run relationship and the rolling short-run equation. Furthermore, the long-run coefficient for the terms of trade is close to that derived from the ADL model.

[13] Different window lengths were tested with similar results.

The rolling point estimates of error correction coefficient $\hat{\alpha}_t$ have drifted up over time (Graph 3). In particular, the error correction mechanism appears to have been weaker ($\hat{\alpha}_t$ is higher) in the early 2000s episode and in the aftermath of the financial crisis. More recently, however, the error correction mechanism has strengthened ($\hat{\alpha}_t$ has fallen) towards its long-run average. However, on the basis of the 20-quarter sub-samples, the estimates of the error correction coefficient are not significantly different from zero throughout most of the sample.

Graph 3

Error Correction Coefficient

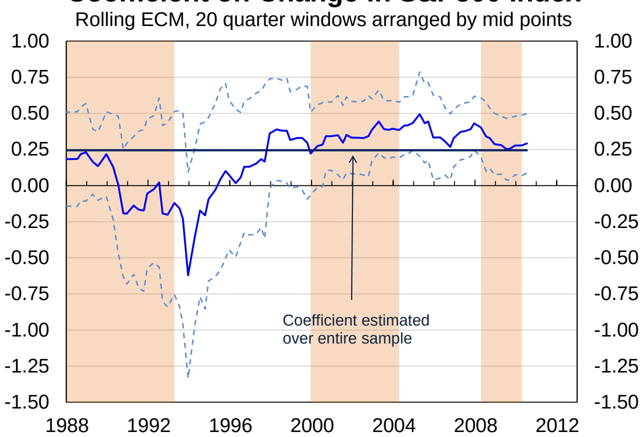


Source: RBA

Estimates of the model's short-term variables increased in the early 2000s (Graphs 4 and 5 show coefficients on the S&P500 and the CRB variables, respectively). Nevertheless, in regressions run over the most recent 20-quarter sub-samples, the coefficients are very close to those that result when the model is estimated over the entire sample.

Graph 4

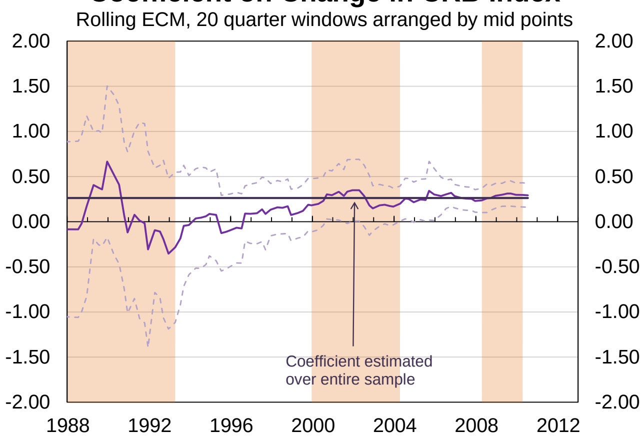
Coefficient on Change in S&P500 Index



Source: RBA

Graph 5

Coefficient on Change in CRB Index



Source: RBA

Overall, while the rolling ECM does not yield strong evidence of parameter instability, this is not conclusive. Given the loss of information associated with estimation over a 20-quarter sub-sample, further evidence is needed.

Markov Switching ECM

A more formal way of investigating whether the Australian dollar has undergone regime changes is by estimating a Markov switching model.[14] This technique is suited to modelling relationships that are hypothesised to be subject to recurring, but unobservable, change and have found a wide range of applications in the literature. For example, Engel (1994) investigated whether Markov switching models could improve forecasts of exchange rates relative to a random walk with drift, though he found little evidence of this. Hall, Psadarakis and Sola (1997) and Psadarakis, Sola and Spagnolo (2004) used Markov switching error

14 Markov switching models derive their name from the Markov process that is assumed to determine the switching from one state to another. In a Markov process the current state depends on the previous state, and not on any events preceding this.

correction models (MS-ECMs) to investigate periods of significant deviations of UK housing prices and US equity prices from their long-term fundamentals.

In this note, we estimate a two-state Markov switching model based on MA's baseline ECM, using Bayesian estimation techniques outlined in Kim and Nelson (1999).[15]

As in the case of the rolling ECM, our MS-ECM holds the long-run cointegrating relationship constant and focuses instead on whether the behaviour of the error correction term and the coefficients on the short-run variables switch according to the value of a binary state variable $S_t = \{0,1\}$. In particular

$$RTWI_t = \beta_0 + \beta_1 TOT_t + \beta_2 RIRD_t + z_t$$
$$\Delta RTWI_t = \phi_{0S_t} + \alpha_{S_t} z_{t-1} + \phi_{1S_t}\Delta CRB_t + \phi_{2S_t}\Delta CRB_{t-1} + \phi_{3S_t}\Delta SPX_t + \phi_{4S_t}\Delta VIX_t + e_t$$

where

$$\alpha_{S_t} = \alpha_0(1-S_t) + \alpha_1 S_t$$
$$\phi_{jS_t} = \phi_{j,0}(1-S_t) + \phi_{j,1} S_t$$

for $j = 0,\ldots,4$.

The residuals of the process are assumed to be normally distributed with a mean of zero and constant variance[16]

$$e_t \sim N(0,\sigma^2).$$

The unobserved state variable S_t evolves according to a Markov process with transition probabilities

$$P(S_t = 1 \mid S_{t-1} = 1) = p$$
$$P(S_t = 0 \mid S_{t-1} = 1) = (1-p)$$
$$P(S_t = 0 \mid S_{t-1} = 0) = q$$
$$P(S_t = 1 \mid S_{t-1} = 0) = (1-q)$$

The states S_t are identified via parameter constraints. In this note, we focus on the model identified by the error correction coefficient ($\alpha_0 < \alpha_1$), although we also considered other identification schemes ($\phi_{j,0} < \phi_{j,1}$ for $j = 0,\ldots,4$) with results reported in the Appendix.

When there are different regimes governing the speed of reversion to equilibrium there should be a significant difference between the α_0 and α_1. Specifically, state 1 will be associated with the larger (i.e. less negative) error correction coefficient and slower reversion to equilibrium

[15] We adopt a Bayesian approach to inference for a number of reasons. First, Markov switching models tend to have irregular likelihood surfaces in small samples - maximum likelihood estimators are often attracted to local rather than global maxima and asymptotic inference on the significance of the parameters is unreliable. Secondly, the Bayesian approach treats the model parameters (i.e. the estimated coefficients and estimated probabilities of 'switching' between states, known as 'transition probabilities') and the unobserved state variable (i.e. the 'actual' regime at any point in time) as random variables. The inference on the latter is therefore drawn from a joint distribution, allowing us to reflect uncertainty not only about the unobserved states and transition probabilities, but also about the coefficients themselves. In contrast, using the classical approach one would first estimate the coefficients and then draw inferences on the unobserved state variables based on this, as in other state-space models. This implies the use of a conditional rather than a joint distribution, and in effect assumes in the second step that the coefficients estimated in the first step are 'true'.

[16] We also estimated a model that allowed for switching in the residual variance. However, the results were not materially different from those of the simpler specifications and are not reported here.

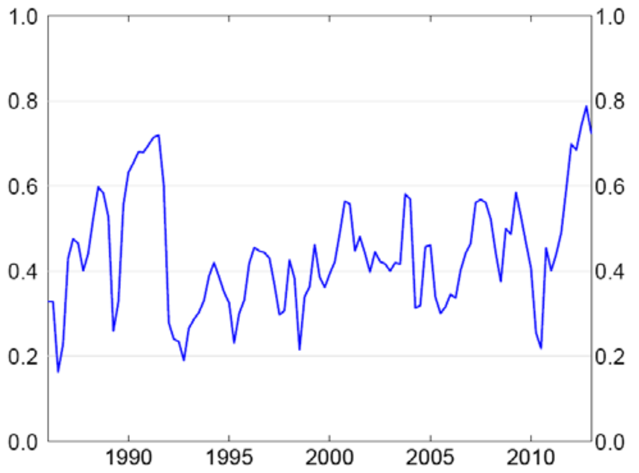
than state 2. Since we are looking to detect evidence of switching from the data, we use uninformative priors to avoid imposing any particular behaviour on the model.

The posterior distributions of the long-run coefficients are consistent with the estimated coefficients obtained from our standard ECM. There are two ways to treat these long-run coefficients: we could directly reflect the uncertainty about the equilibrium parameters, or we could estimate them first and use the mean of the resulting posterior distributions as point estimates in the subsequent estimation of the model's short-run dynamics. We follow the latter approach, as is common in the literature.[17]

Results

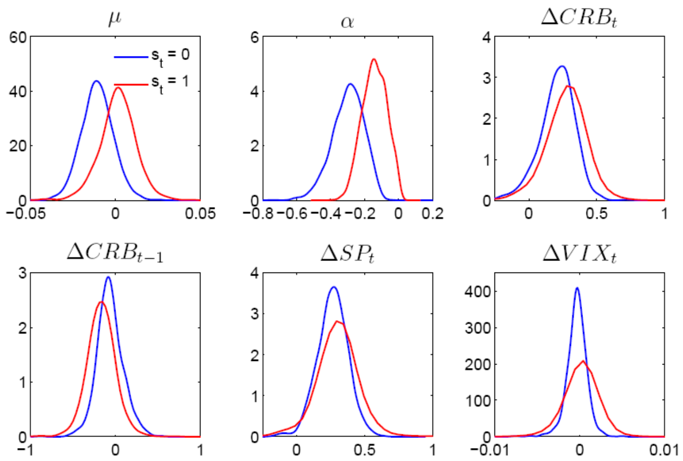
Overall, the model fails to provide conclusive evidence of switching in the error correction mechanism. The likelihood of being in the slow-reversion state does vary somewhat over the sample, and has been relatively high since around 2011 (Graph 6). However, the difference between the estimated state-specific error correction coefficients α_0 and α_1 is small and their posterior distributions overlap (Graph 7 and Table 1). Thus, even if there have been 'switches' in regime, the difference in the speed of error correction in each regime does not appear to be significant. Furthermore, we could find no meaningful difference in the estimates of the other coefficients in the short-run relationship.

Graph 6
Probability of Slow Reversion State – Pr(St=1)



Source: RBA

Graph 7
Coefficient Posterior Densities



Source: RBA

[17] See for example Krolzig, Marcellino and Mizon (2002), Hall, Psadarakis and Sola (1997) and Psadarakis, Sola and Spagnolo (2004). We also attempted to allow for parameter uncertainty in the long-run relationship, but found that this resulted in a high degree of autocorrelation between the draws in the Markov chain. In either case, when estimating the model we discarded all draws that were inconsistent with the presence of a cointegrating relationship.

Table 1

Markov Switching ECM

Parameter	Regime	Prior Mean	Prior Std. Dev.	Posterior Mean	Posterior 95% HPD*	
Model identified by switching in error correction term						
Intercept	0	0	100	-0.01	-0.03	0.01
	1	0	100	0.00	-0.02	0.02
Error correction	0	-1	1	-0.30	-0.52	-0.14
	1	-1	1	-0.14	-0.28	-0.02
S&P 500	0	0	100	0.26	0.03	0.49
	1	0	100	0.27	-0.04	0.57
CRB	0	0	100	0.21	-0.05	0.43
	1	0	100	0.25	-0.06	0.53
CRB_{t-1}	0	0	100	-0.08	-0.37	0.24
	1	0	100	-0.20	-0.57	0.15
VIX	0	0	100	-0.08	-0.37	0.24
	1	0	100	-0.20	-0.57	0.15
Residual Variance**	0	-	-	0.04	0.03	0.04
	1	-	-	0.04	0.03	0.04

* 'Highest Posterior Density' (95 per cent of the posterior distribution fell within this interval)

** The prior distribution of σ^2 is improper.

Source: RBA

We also tested models identified by switching in the coefficients on the short-run variables. These also did not result in clearly delineated regimes, with the posterior distributions overlapping to a significant degree (see more results in Appendix). In addition, the probability of being in each state oscillates within a relatively tight band, with no discernible relationship to the observed episodes of deviation from the model–implied equilibrium discussed above.

Bayes Factors also provide little evidence that switching improves on the basic ECM. Bayes factors are the ratios of the probability of the switching model being 'true' relative to those of the model without switching and can be interpreted as a weighted likelihood ratio test. Values greater than one support the Markov switching specification. Kass and Raftery (1995) offer bounds for the interpretation of these ratios, with values between 1 and 3 "not worth more than a bare mention", Bayes factors between 3 and 20 suggesting "positive" evidence, factors between 20 and 150 equivalent to "strong evidence", and values above this being "very strong" evidence in favour of the model in the numerator. In our case, all the ratios are very close to one, implying an even-money bet on the Markov switching model relative to the simpler model without switching (Table 2).

Table 2

Odds of Switching in MS-ECM

Regimes identified by	Bayes Factor*
Error Correction Term	1.02
S&P500	1.00
CRB	0.98
Intercept	0.98

* Relative to model without switching

Source: RBA

Discussion and Future Research

Neither the rolling ECM nor the Markov switching approach provide conclusive evidence of changes in the speed with which the RTWI has reverted to the equilibrium implied by MA's standard ECM over time. This suggests that even sustained deviations from the implied equilibrium are generally well explained by the short-run variables included in the model. Furthermore, the coefficients on the short-run variables themselves also do not appear to have been subject to regime changes. Moreover, the method used in the Markov switching approach is sufficiently flexible to give us confidence that we have rejected the presence of a wide variety of non-linear dynamics in the model.

This supports the view that the ECM has performed reasonably well in modelling the RTWI over the post-float period to date, including over the course of the recent unprecedented terms of trade boom, and during its subsequent decline thus far. It also implies that the changes in the global economic and policy environment since the 2008/09 financial crisis have been largely captured by the model without the need to explicitly cater for latent behavioural or systemic changes. While the RTWI was elevated relative to its long-run fundamentals between March 2012 and June 2013, this was nevertheless broadly consistent with the short-run dynamics of the model.

Future research may further improve the model. In particular, the role of interest rate differentials could be reinvestigated in light of some apparent changes in the magnitude of the coefficient on this variable over time. And given that the RTWI appears to have 'looked through' part of the recent peak and subsequent decline in the terms of trade, it may also be interesting to consider using *forecast profiles* of the terms of trade as an explanatory variable, rather than the realised outcomes.

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Penny Smith
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International Department[18]

2 August 2013

[18] Some of this work was completed while in Economic Research Department.

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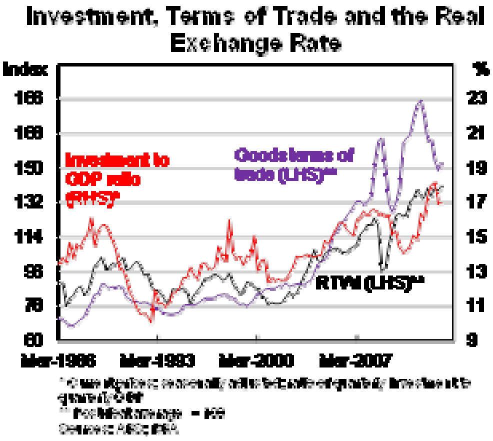
LOMAS, Phil

From: HAMBUR, Jonathan
Sent: Thursday, 8 August 2013 1:45 PM
To: RYAN, Chris; HOLLOWAY, James
Cc: WRIGHT, Michelle; WYRZYKOWSKI, Mark; WATSON, Benjamin
Subject: Investment to GDP ratio and the RTWI [SEC=UNCLASSIFIED]

Hi Chris and James,

We have taken a look at the relationship between the investment to GDP (I/GDP) ratio and the real trade-weighted index (RTWI).

The below graph does appear to show some relationship between the nominal I/GDP ratio and the RTWI (note that we have adjusted the scales a bit to deliberately present the relationship in the most favourable light).



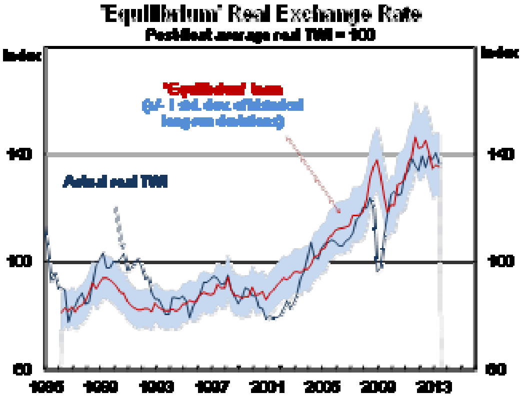
Abstracting from any theoretical justification for doing so, the empirical relationship between the two series could be analysed more formally by including the nominal I/GDP ratio as a long-run variable in MA's preferred error correction model (ECM) of the RTWI.

The nominal I/GDP ratio cannot be used *in place* of the goods terms of trade variable (ToT) as it is not cointegrated with the RTWI (this is true even when the last few years are excluded from the sample). However, it can be included *in addition to* the other long-run variables (the ToT and the real interest rate differential) as they are jointly cointegrated. While this is still questionable without a clear theoretical justification for doing so (and given the possibility of multicollinearity between the I/GDP ratio and the other long-run variables), this expanded model has a slightly higher adjusted R^2 and a somewhat lower coefficient on the ToT than MA's baseline ECM (table below). Meanwhile, the coefficient on the nominal I/GDP ratio is significant at the 10 per cent level and is positively signed.

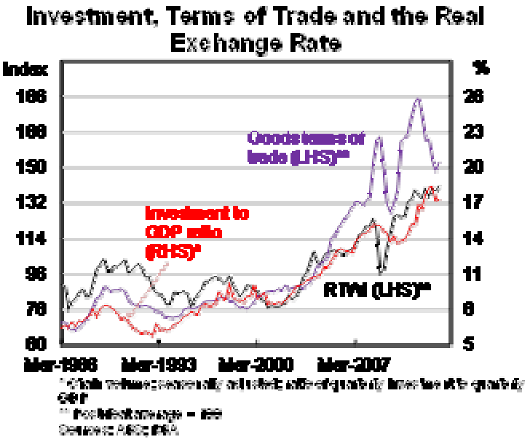
	Baseline	Terms of trade and Investment (nominal)
Adj. R^2	0.460	0.471
Adjustment coefficient	-0.169***	-0.180***
Goods terms of trade (Bewley)	0.603***	0.463***
Investment to GDP ratio	N/A	0.025*

*,**,*** represent significance at 10, 5 and 1 per cent significance levels respectively

Assuming that the nominal I/GDP ratio remained constant over the June quarter, the expanded model indicates that in the June quarter the RTWI was at a level that was broadly consistent with its medium-term fundamentals (graph below). However, this conclusion is somewhat dependent on the assumption used for the nominal I/GDP ratio. For example, if the nominal I/GDP ratio was assumed to have fallen by about 1 percentage point over the June quarter to 16 per cent, the model would indicate that the RTWI was around 3 per cent higher than the model-implied 'equilibrium'.



The real I/GDP ratio can also be considered, although as James has previously noted there are several conceptual problems with using the real ratio.



While graphically there does appear to be some relationship between the RTWI and the real I/GDP ratio, when it is included in MA's ECM as an additional long-run variable the coefficient on the real I/GDP ratio is not significant. As with the nominal ratio, the real I/GDP ratio cannot be used in place of the ToT as it is not cointegrated with the RTWI.

Jonathan

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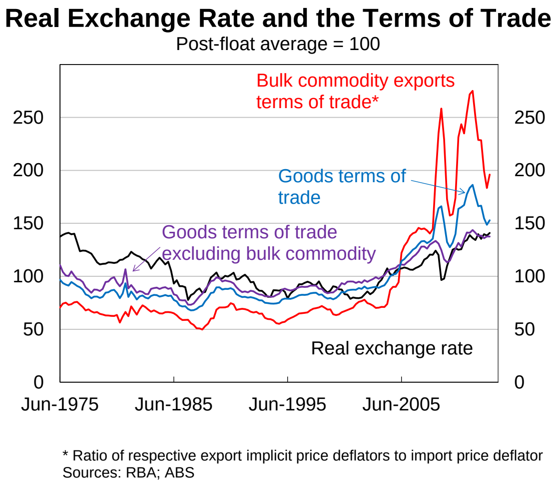
Australia's Experience with a Floating Exchange Rate – Terms of Trade Decomposition

As part of the Research Discussion Paper (RDP) on "Australia's Experience with a Floating Exchange Rate" the relationship between the bulks terms of trade (ToT), the ToT ex-bulks and the real trade weighted exchange rate index (RTWI) has been examined. This note outlines the initial findings.

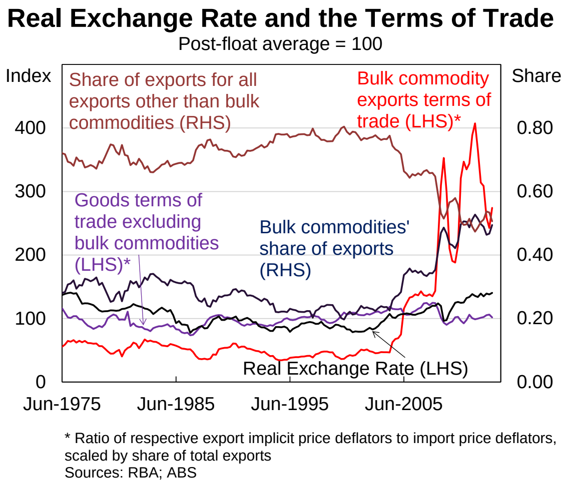
Bulks and ex-bulks terms of trade

- Over recent years, a higher bulks ToT has led to a clear divergence between the levels of the ToT and the RTWI (Graph 1).

Graph 1

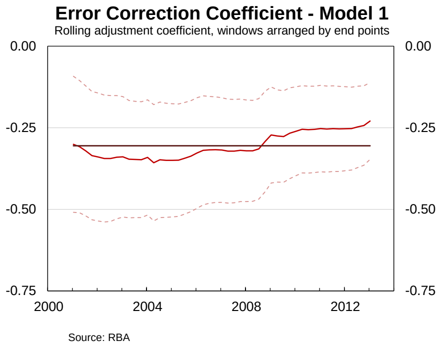


Graph 2

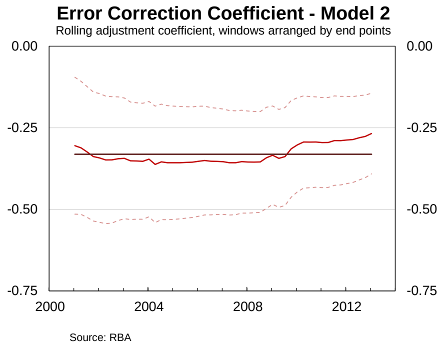


- When the bulks and ex-bulks ToT are weighted by their nominal export shares (to account for changes in their relative importance), the rise in the bulks ToT is even more pronounced (Graph 2).
- To examine the relationship between the RTWI, the bulks ToT and the ToT ex-bulks, three specifications of the RDP's RTWI model were estimated:
  - Model 1 uses the aggregate ToT in the long-run equation;
  - Model 2 allows the unweighted bulks ToT and the ToT ex-bulks to enter the long-run equation separately;
  - Model 3 does the same, but using ToT series that are weighted by their nominal export shares.
- To examine the evolution of the coefficients over time rolling regressions were used where the starting point was kept the same, while the sample was extended with each estimation
- Graphs 3 to 10 show the Bewley transformed coefficients estimated using these rolling regressions.

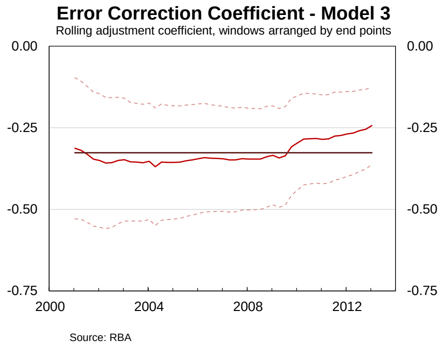
Graph 3



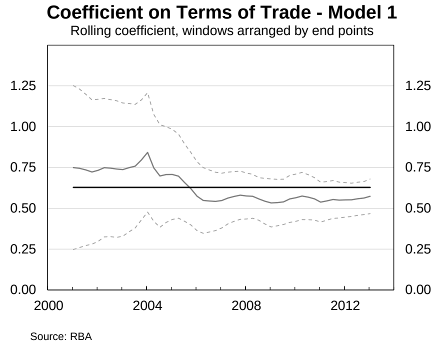
Graph 4



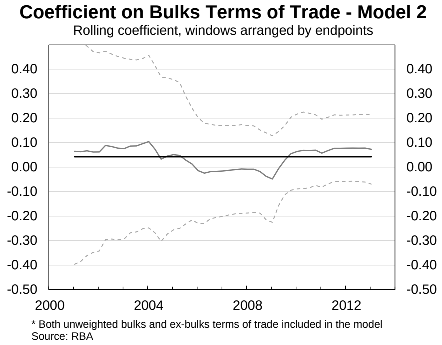
Graph 5



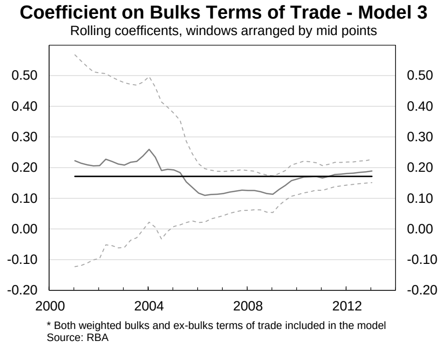
Graph 6



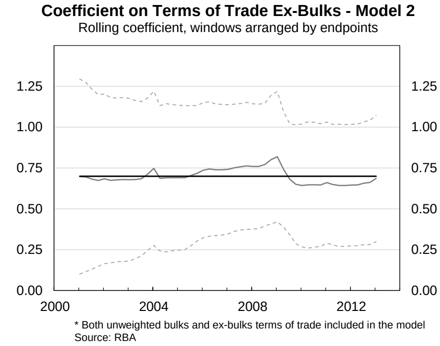
Graph 7



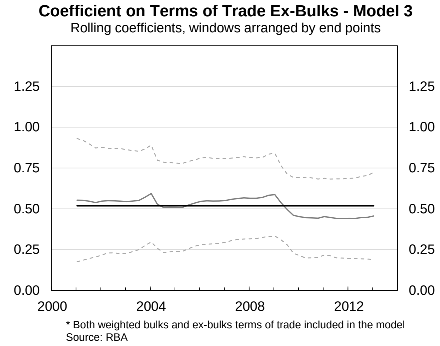
Graph 8



Graph 9



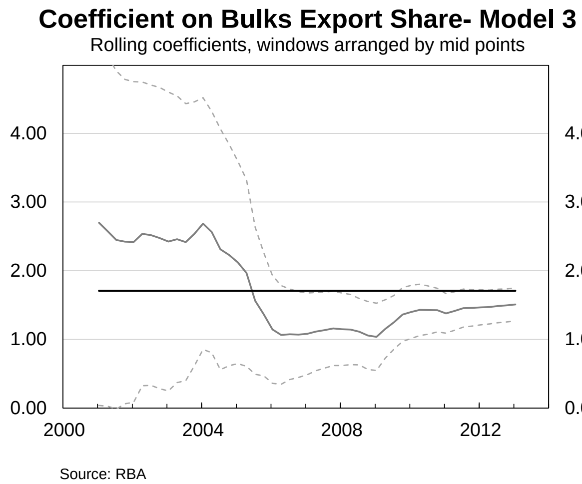
Graph 10



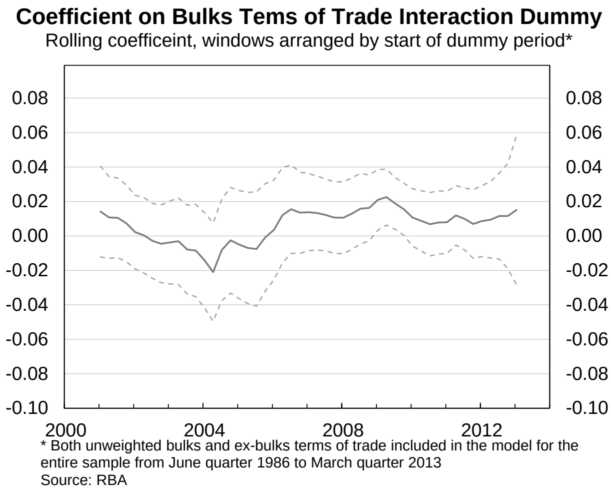
Coefficients and significance

- In both Models 2 and 3, the coefficient on the bulks ToT is lower than the coefficient on the ToT ex-bulks; however, the former is only significant in Model 3.
- In Model 3, the estimated coefficients on the long-run variables evolve in a similar pattern if the weighted bulks ToT variable is replaced with the bulks' nominal export share (Graph 11). Further, the adjusted-R^2 is slightly higher when the export share is used in place of the weighted bulks ToT.
- This suggests that the explanatory power in Model 3 comes from the bulks' export share rather than their ToT.[1]
- One explanation for this may be that bulks prices, which have tended to be based on backwards looking contracts that were prone to discrete changes, do not adequately capture the impact of the mining boom on the RTWI.

Graph 11



Graph 12



Structural change in the relationship between RTWI and the bulks ToT

- From late-2008 the relationship between the bulks ToT and the RTWI appears to become stronger.[2]
- This coincides with a shift in iron ore pricing from annual contract prices to shorter-term contracts and spot pricing (Caputo 2012).
- Two rolling regressions were estimated: one that allowed the coefficient on the bulks ToT to change discretely (using a dummy variable interacted with the bulks ToT), and one that only includes the bulks ToT variable for some of the sample.
- Both indicate that there is a significant change the relationship between the RTWI and the bulks ToT from early-2009, with the bulks ToT becoming significant if included from then onwards (Graph 12).[3]
- The second rolling regression was run again using a bulks ToT measure based on iron ore spot prices.
- As with the bulks ToT, this measure is also only significant if included only from early-2009 onwards.
- This supports the notion that the change in the relationship between RTWI and the bulks ToT reflects a shift in bulks' price setting arrangements.

Equilibriums

- The equilibriums from Models 2 and 3 are fairly similar to the equilibrium from Model 1 (Graph 13).

---

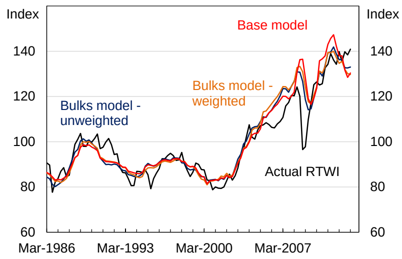
1 There is no evidence of correlation between the bulks export share and the weighted ToT ex-bulks.

2 The RDP includes a tech dummy in the long-run equation from the September quarter 1999 to the June quarter 2003. If the tech dummy is removed the level of the coefficients, as well as their evolutions, are somewhat different. Nonetheless, the bulks ToT still seems to become more important from 2009 onwards. For more details see Appendix A.

3 If the dummy variable is included, the coefficient on the unweighted bulks ToT is insignificant but has a negative sign. This is of some concern; especially given the coefficient on the bulks ToT is larger than the positive coefficient on the dummy variable in absolute terms, implying that the bulks ToT has a negative relationship with the RTWI for the entire sample.

Graph 13

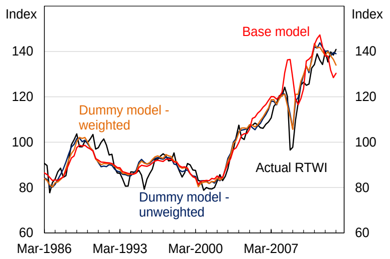
Actual and 'Equilibirum' Real Exchange Rates



Sources: RBA

Graph 14

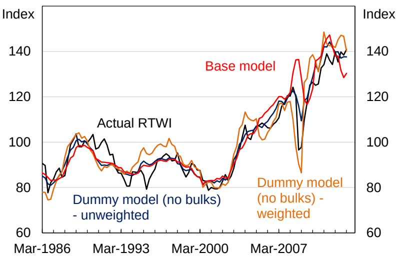
Actual and 'Equilibirum' Real Exchange Rates



Sources: RBA

Graph 15

Actual and 'Equilibirum' Real Exchange Rates



Sources:

- If the coefficient on the bulks ToT is allowed to change discretely in early-2009, the equilibriums track the observed RTWI more closely (Graph 14).
- When using the unweighted ToT series, a similar pattern is observed when the bulks ToT is only included from early-2009 onwards; however, if the weighted series are used, only including the bulks ToT from early-2009 onwards leads to a more volatile equilibrium (Graph 15).

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20 August 2013

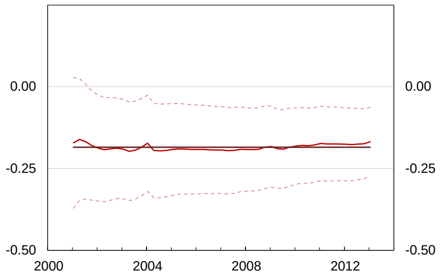
Appendix A

If the tech dummy is not included in the model, the adjustment coefficients are somewhat more stable and are smaller in absolute terms (Graphs 16 to 18). Nonetheless, as with the models that included the tech dummy, the adjustment coefficient becomes less negative from early 2009 (though this is less pronounced).

Graph 16

Error Correction Coefficient - Model 1

Rolling adjustment coefficient, 60 quarter windows arranged by endpoints

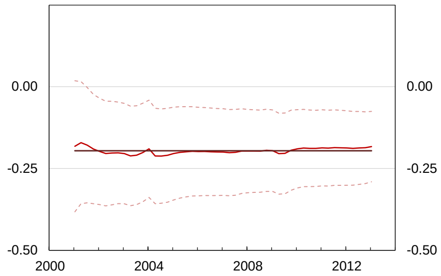


Source: RBA

Graph 17

Error Correction Coefficient - Model 2

Rolling adjustment coefficient, 60 quarter windows arranged by end points

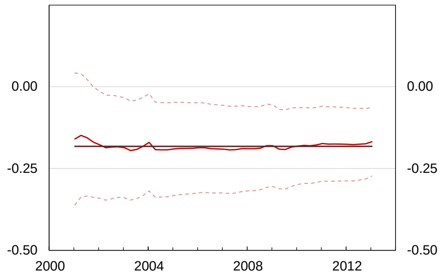


Source: RBA

Graph 18

Error Correction Coefficient

Rolling adjustment coefficient, 60 quarter windows arranged by mid points



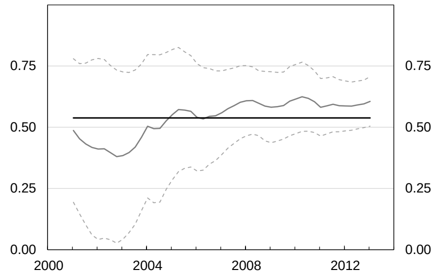
Source: RBA

Similarly, the coefficients on the bulks ToT become somewhat larger from early-2009, though this is less pronounced in Model 3 (Graphs 19 to 21).

Graph 19

Coefficient on Terms of Trade - Model 1

Rolling coefficeints, windows arranged by endpoints

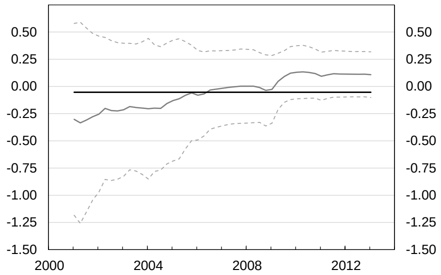


Source: RBA

Graph 20

Coefficient on Bulks Terms of Trade - Model 2

Rolling coefficients, windows arranged by endpoints*



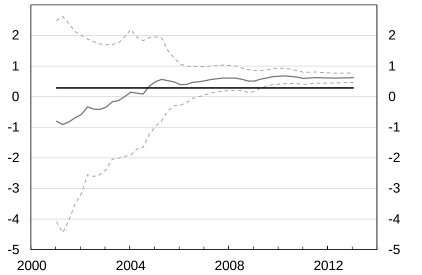
* Both unweighted bulks and ex-bulks terms of trade included in the model

Source: RBA

Graph 21

Coefficient on Bulks Terms of Trade - Model 3

Rolling coefficients, windows arranged by end points*



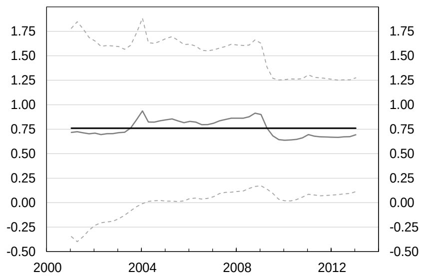
* Both weighted bulks and ex-bulks terms of trade included in the model

Source: RBA

Graph 22

Coefficient on Terms of Trade Ex-Bulks - Model 2

Rolling coefficient, windows arranged by end points*



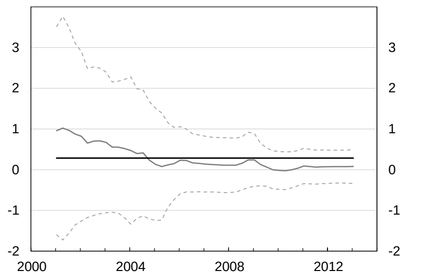
* Both unweighted bulks and ex-bulks terms of trade included in the model

Source: RBA

Graph 23

Coefficient on Terms of Trade Ex-Bulks - Model 3

Rolling coefficient, windows arranged by end points*



* Both weighted bulks and ex-bulks terms of trade included in the model

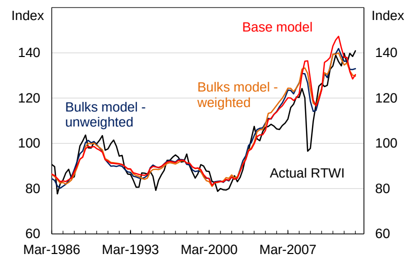
Source: RBA

Meanwhile, if the tech dummy is not included in the model there is still some evidence of a structural change in the relationship between the bulks ToT and the RTWI, but the evidence is weaker.

Finally, the equilibriums obtained when the tech dummy is excluded are similar to those obtained when the tech dummy is included. However, when the tech dummy is excluded the equilibriums tend to be slightly higher for recent years (Graphs 24 to 26).

Graph 24

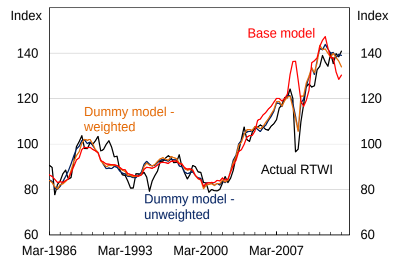
Actual and 'Equilibirum' Real Exchange Rates



Sources: RBA

Graph 25

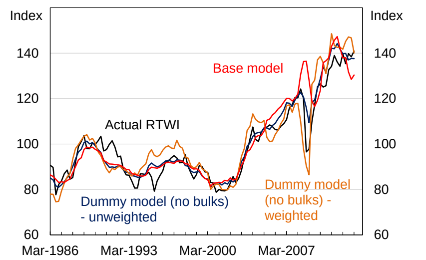
Actual and 'Equilibirum' Real Exchange Rates



Sources: RBA

Graph 26

Actual and 'Equilibirum' Real Exchange Rates

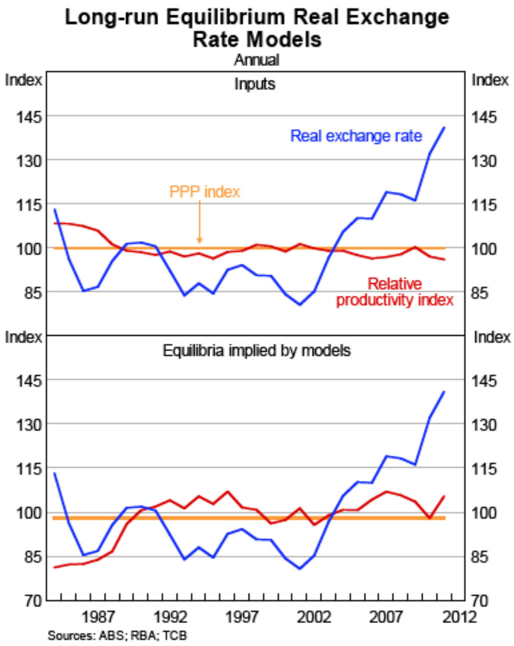


Sources:

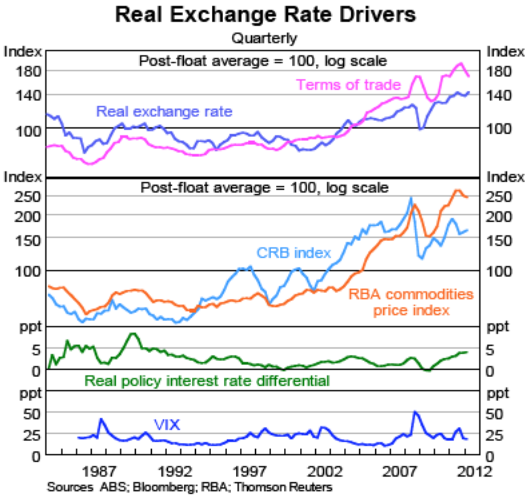
BRIEFING NOTE – THE AUSTRALIAN DOLLAR: THIRTY YEARS OF FLOATING

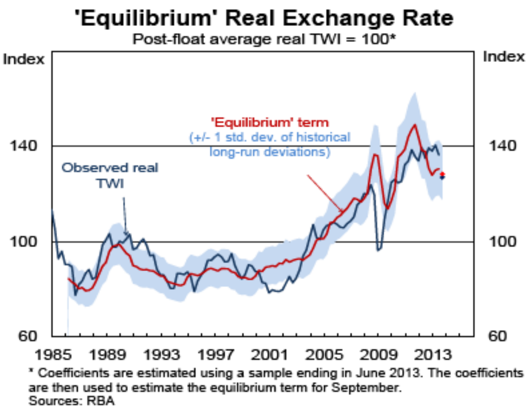
How has the e rate behaved? (Has it been 'misaligned' for long enough to do damage? If so why?)

In the long-run, the exchange rate should move such that purchasing power parity holds. However, exchange rates can diverge from PPP for extended periods of time and tend to be far more volatile than those implied by PPP, even once productivity differentials are incorporated in a Balassa-Samuelson framework.



For 'commodity currencies' such as Australia, the terms of trade, and to a lesser extent the real interest rate differential, have been shown to help explain medium-term fluctuations.

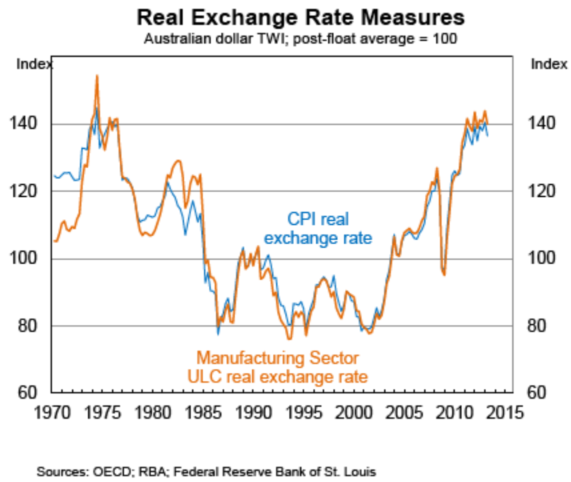


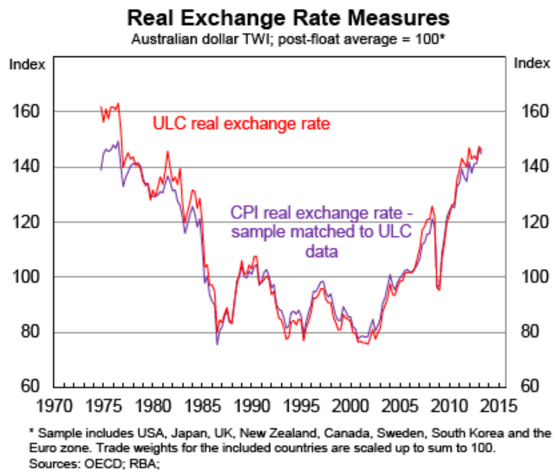


While the dollar has recently been somewhat above the level indicated by its medium-term fundamentals (according to Market Analysis' (MA) preferred ECM), much of this has been explained by shorter term market variables, such as market measures of risk aversion.

The preferred error correction model (ECM) estimates an 'equilibrium' co-integrating relationship between the RTWI, the goods terms of trade and the real interest rate differential (between Australia and the G3). The 'equilibrium' RTWI is the value justified by these medium-term fundamentals (in practice, the terms of trade is the most important determinant of this 'equilibrium' by some margin). The model also includes a number of short-run variables which attempt to account for short-term financial market influences. These include the CRB index (a widely-followed market-based commodity price measure), and two factors that 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).

The graphs below show the real exchange rate calculated using unit labour costs (ULC) as a deflator, rather than consumer price indices. The first measure is taken directly from the St. Louis Fed and is based on ULC in the manufacturing sector. The second measure uses data from the OECD, which is available for a relatively small subset of the countries included in our TWI and excludes most Asian countries.





Intervention – successful? Our views on it? (Why haven't we intervened much recently?)

Main Sources: Newman, Potter and Wright (2011), RBA Website (International Market Operations), and Macfarlane (1993)

The float was intended to be a largely free float, though intervention was not ruled out. The intellectual climate at the time has been described as 'very purist', to the extreme that some suggested exchange rates could be determined solely by the market and that international reserves would be no longer necessary.

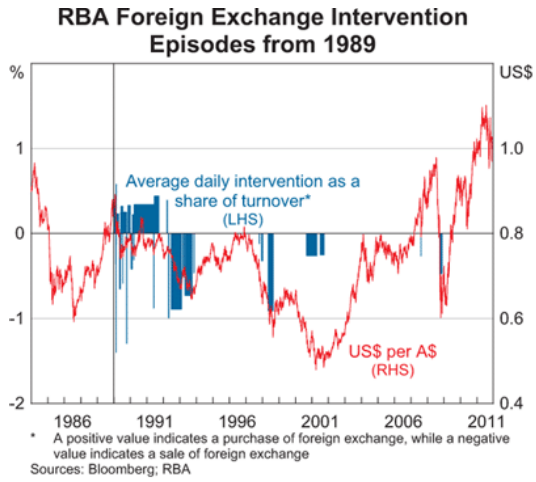
Immediately after the float the exchange rate was relatively volatile and market participants were not yet equipped to cope, so the RBA frequently made small interventions to reduce volatility. However, In keeping with the purist tenancies of the time, the term 'intervention' was avoided in favour of other expressions such as 'smoothing or testing movements'.

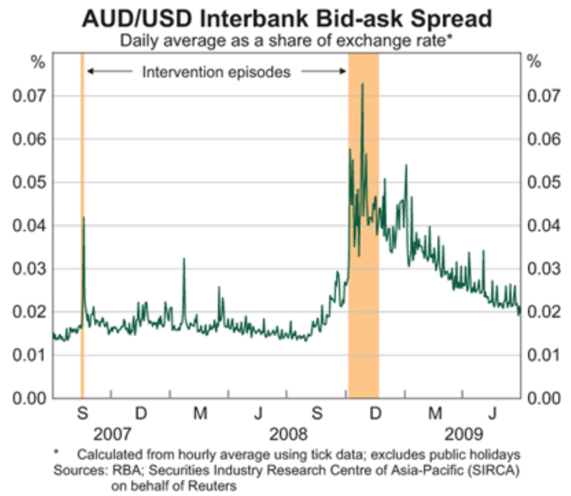
By the late 80s and early 90s volatility had decreased, so intervention was largely focused on occasions where the dollar overshot, or where speculators were dominating. As such, interventions were less frequent, but larger. During Asian crisis the RBA intervened during periods of significant volatility and during the tech bubble the RBA intervened to support the dollar, which was felt to be undervalued in one-sided market conditions. More recently, intervention has occurred only when there was significant market dysfunction, such as in 2007 and 2008.

It is hard to assess the effectiveness of intervention due to:

- Lack of single appropriate metric: intervention could be intended to lower volatility, to raise or lower the rate, or simply to avoid market disruption. Each would be assessed using a different metric.
- Endogeneity: Interventions often occur when the exchange rate is moving in the opposite direction. It is impossible to know what would have happened without the intervention.

Some studies have found that the RBA's interventions have been somewhat successful, though the above issues still apply. As noted in the Bulletin, the practical difficulties in assessing the 'fair value' of a currency make it difficult to improve market outcomes.





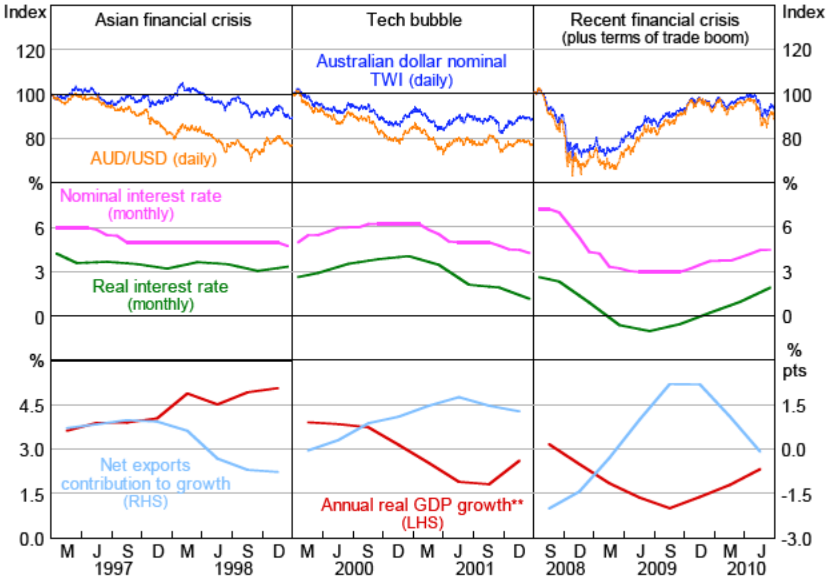
A speech by then Deputy Governor Macfarlane noted that interventions were to be used to avoid disorderly foreign exchange markets in the short-run, and overshooting of the exchange rate in the medium run. We can't really target a level because we don't know the appropriate level – "The main reason is that we do not know in advance what the fundamentals, such as world growth or commodity prices, are going to do."

In maintaining their cap, the SNB's reserves rose to 83 per cent of GDP and money base rose from 15 per cent of GDP to 60 per cent. In Australia, this would be the equivalent of accumulating reserves of $1.2 trillion (from around $50 billion). Further, turnover in the Australian dollar averages $460 billion per day (fifth most traded currency), compared to the Swiss franc's $275 billion per day (sixth most traded). Nevertheless, the Australian and Swiss foreign exchange markets are of similar sizes (around $200 billion)

How has the economy responded to the flexible exchange rate?

The floating exchange rate has worked as an automatic stabiliser for the economy and buffer against external shocks, leading to lower output volatility. For example, a terms of trade boom (like the current one), will be met with higher exchange rate and higher interest rate, helping macroeconomic stability. In contrast, under a fixed rate such booms often led to high inflation. Similarly, in response to the Asian financial crisis, the dollar depreciated sharply while monetary policy could continue to be set independently (in an expansionary manner).

Australia's Response to International Shocks



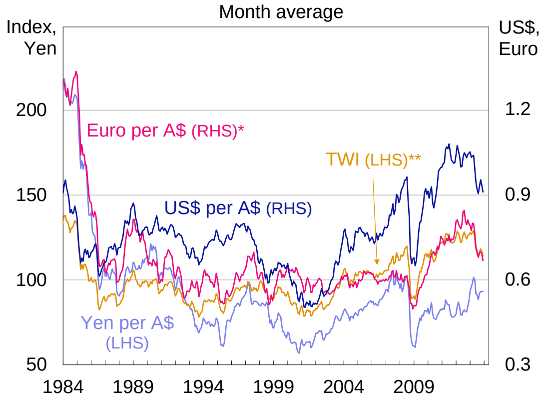
* Linear interpolation of the quarterly data
** Quarterly, seasonally adjusted
Sources: ABS; RBA

Update on the Australian dollar

The A$ has depreciated by 14 per cent on a nominal trade-weighted basis since its peak in April, but remains 12 per cent above its post-float average. In real terms, the TWI is estimated to have depreciated by around 8 per cent since its peak in the March quarter, and our preferred internal model suggests that it is close to the level consistent with its medium-term determinants. Even though the strength of the A$ can be largely explained by the model, it may still be considered to be 'overvalued' to the extent that it is judged to be too high to achieve desired domestic economic outcomes.[1]

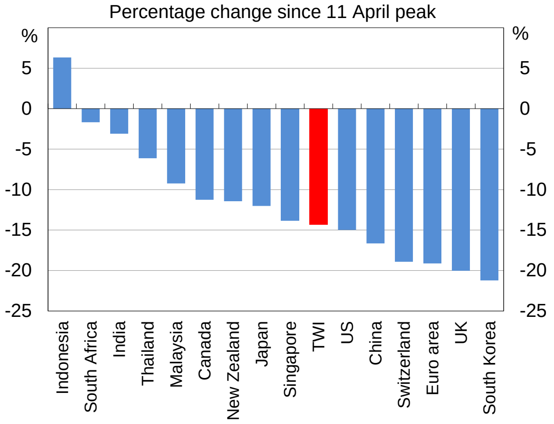
- Against the US$, the A$ is 15 per cent below its April 2013 peak, but around 20 per cent higher than its post-float average.
- Against the JPY, the A$ is 12 per cent below its April 2013 peak, but remains around 5 per cent higher than a year ago.
- Against the euro, the A$ is 24 per cent below its historical peak (reached in August 2012), but 3 per cent higher than its average since the introduction of the single currency in 1999.

Australian Dollar
Month average

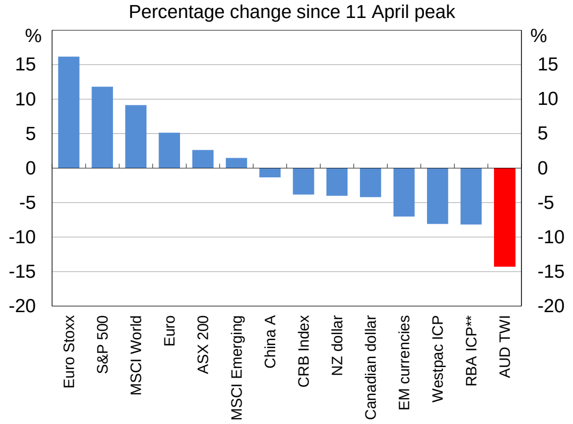


* Deutsche Mark splice for observations prior to 1999
** Indexed to post-float average = 100
Sources: Bloomberg; RBA; Thomson Reuters; WM/Reuters

Australian Dollar
Percentage change since 11 April peak



Australian Dollar and Other Assets*
Percentage change since 11 April peak



* Against US dollar or in US dollar terms except for Euro Stoxx.
** RBA index of commodity prices with spot bulks

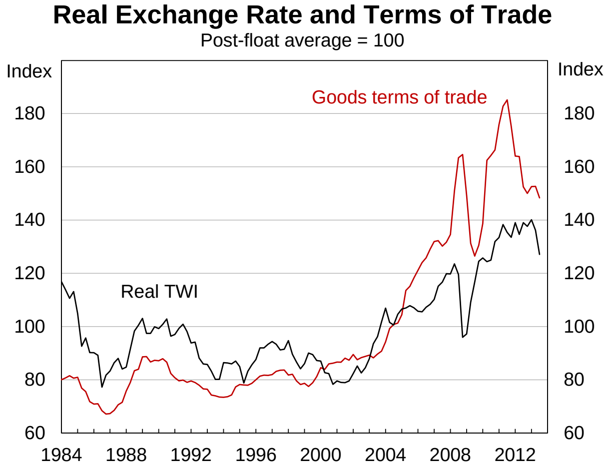
The A$ has underperformed most other currencies and assets since mid-April, including:

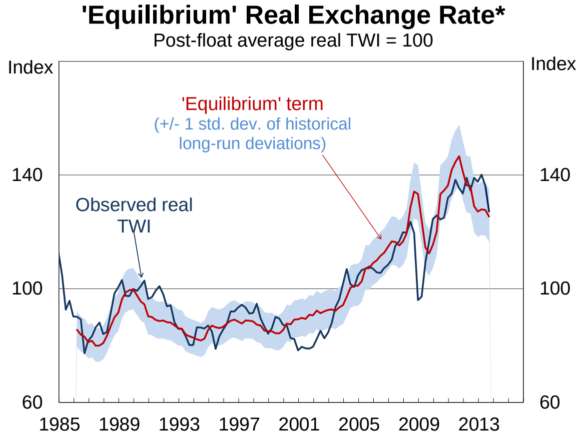
- global equity markets, which have rallied;
- most emerging market currencies, which have depreciated by less than the A$ (with the notable exception of the Indonesian rupiah); and
- commodity prices, which have declined more modestly than the A$.

The A$'s underperfomance has coincided with the softer domestic economic outlook and associated reductions in the cash rate, as well as a reassessment by market participants of the future path of US monetary policy. Over recent months, commentary from senior Bank officials has also weighed somewhat on the A$.

[1] John McDermott (Assistant Governor and Head of Economics, RBNZ) also made this point in a recent speech "Understanding the New Zealand exchange rate" delivered to Federated Farmers in Wellington, 22 November 2013.

MA's preferred model of the real TWI is estimated from January 1986 to September 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 goods terms of trade – which is the most important explanatory variable – has continued to decline over 2013 and is now around 20 per cent below its 2011 peak (although still around 50 per cent higher than its post-float average). The model suggests that, in quarter-average terms, the real TWI was 1 per cent above the level consistent with medium-term fundamentals in the September quarter (which is well within a +/–1 standard deviation band).





* The 'equilibrium' is based on the real TWI's medium-run relationship with the goods terms of trade and the real interest rate differential with major advanced economies.

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 7 per cent below the level consistent with medium-term fundamentals; whereas
- if the model is estimated since 2002 it suggests the A$ was 5 per cent above the level consistent with medium-term fundamentals.

External assessments of the Australian dollar provide a mixed view of the degree of overvaluation. The IMF suggests the A$ real TWI is overvalued by around 10 per cent, whereas The Economist's Big Mac Index suggests undervaluation of 2 per cent against the US$ (based on price data for July 2013). Meanwhile, the OECD's PPP measure, based on estimates for October 2013, suggests a larger degree of overvaluation of around 30 per cent against the US$. 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 of the bilateral exchange rate with the US dollar.

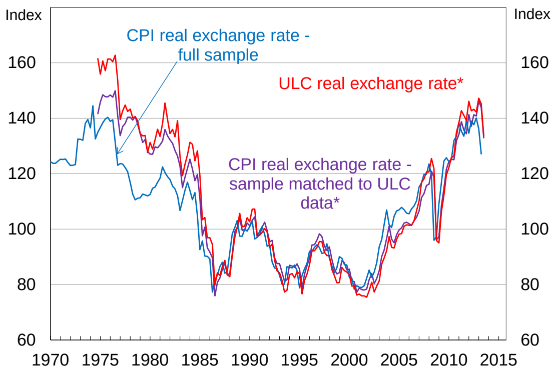
Table 1: Models of the Australian Dollar -- Summary

	Estimated exchange rate valuation		
RBA Models (Real TWI)	Under/over-valuation	Per cent deviation	Standard deviations
From 1974	Under	7	0.5
From 1986 (preferred)	Over	1	0.2
From 2002	Over	5	0.6
External Assessments			
IMF (Real TWI)	Over	10	-
Big Mac Index (PPP Measure; against the US$)	Under	2	-
OECD (PPP Measure; against the US$)	Over	30	-
JP Morgan (Real TWI)	Over	0-5	-
Goldman Sachs (Nominal TWI)	Over	5	-

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).

Real Exchange Rate Measures

Australian dollar TWI; post-float average = 100



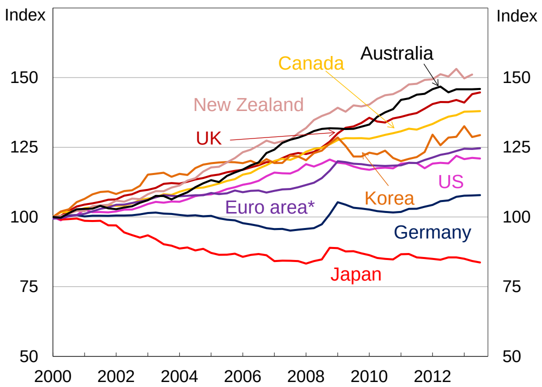
* Sample includes USA, Japan, UK, New Zealand, Canada, Sweden, South Korea and the Euro zone. Trade weights for the included countries are scaled up to sum to 100.
Sources: OECD; RBA

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.

Unit Labour Costs

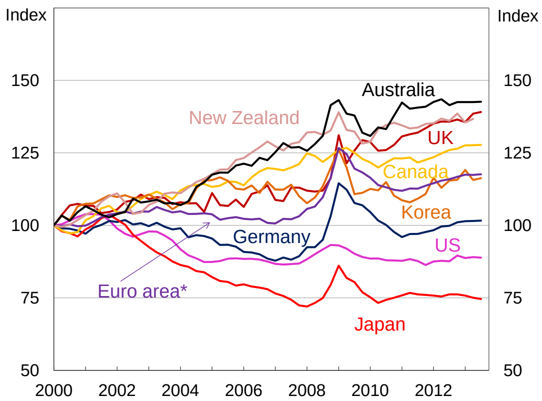
March 2000 = 100



* GDP weighted index of Germany, France, Italy, the Netherland, Belgium and Spain
Source: OECD

Manufacturing Sector Unit Labour Costs

March 2000 = 100

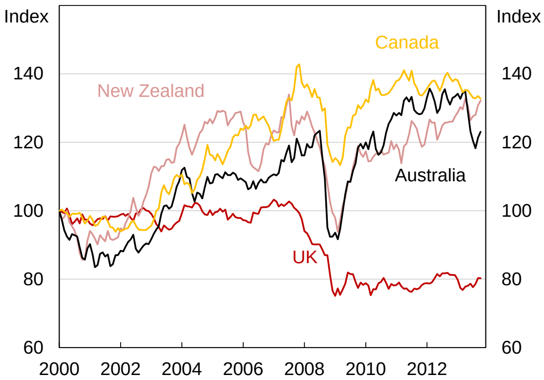


* GDP weighted index of Germany, France, Italy, the Netherland, Belgium and Spain
Source: OECD

New Zealand and Canada have also recorded relatively strong increases in their ULCs alongside marked appreciations of their nominal effective exchange rates over recent years. In contrast, the UK's strong increase in ULCs has coincided with a depreciation of their nominal exchange rate.

Nominal Effective Exchange Rates

January 2000 = 100



Source: BIS

Market Analysis
International Department
16 December 2013

Incorporating a forward looking measure of the terms of trade

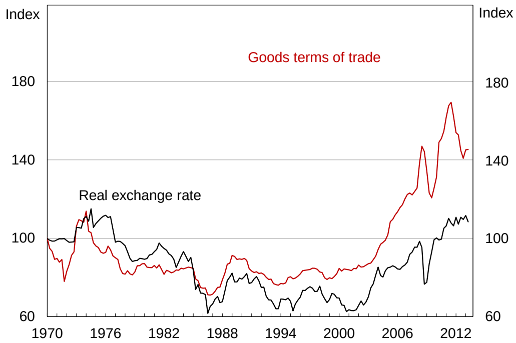
Historically, the ToT and the RTWI have exhibited a very strong relationship. However, in 2011 the ToT increased sharply – partly reflecting the effect of the Queensland floods on the supply of bulk commodities – but the RTWI did not appreciate significantly. Rather the RTWI appears to have largely looked through the transitory ToT shock (Graph x).

This behaviour is not altogether surprising because foreign exchange markets are generally considered to be forward-looking. Nevertheless, it does suggest that a forward-looking measure of the ToT may display a stronger and more consistent relationship with the RTWI than backwards looking measures of the ToT – as currently used in MA's preferred ECM.

Graph X

Real Exchange Rate and Goods Terms of Trade

March 1970 = 100



Sources: ABS; RBA; Thomson Reuters; WM/Reuters

Counter to this, Gruen and Kortian (1996) found evidence of a lack of rational forward-looking participants in the Australian dollar market in the mid-1990's. In particular, they found that the RTWI was forecastable over horizons of one to two years, reflecting both the strong relationship between the RTWI and the ToT, and the ability to characterise movements in the ToT as temporary fluctuations around a slowly declining trend. This forecastability led to predictable excess returns which would be arbitraged away if the market contained a sufficient number of forward-looking participants with investment horizons longer than one-year. Nevertheless, the Australian dollar market has developed somewhat since the mid-1990's, with the Australian dollar now the xth most traded currency globally. Consequently, it is worth investigating the relationship between a forward-looking measure of the ToT and the RTWI.

Comment [WIZ1]: Have to question if this still holds.

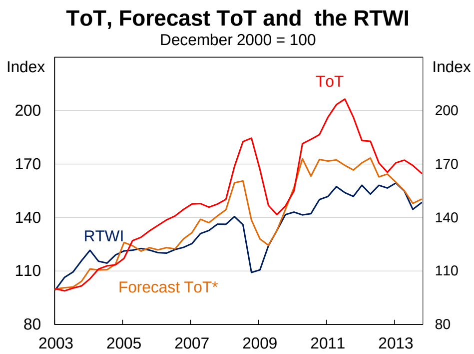
Forecast ToT

As a starting point, past vintages of Business and Trade section's (BAT) ToT forecasts were used to construct a number of forward-looking ToT measures. The measures were constructed using either the forecast t quarters ahead, or using the average of current quarter's forecast and the forecasts for the next t quarters. The measures were calculated using horizons of 4-8 quarters, for a sample beginning to 2001.

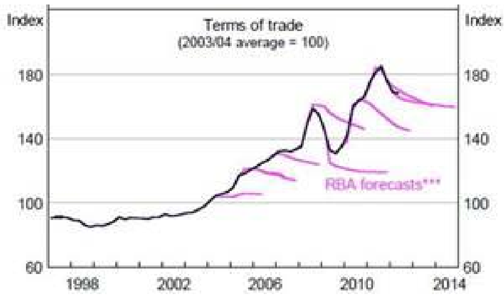
Graph X shows one of the forward-looking measures. The forward-looking measure has diverged somewhat from the observed ToT, reflecting the fact that BAT's ToT forecasts were consistently lower than the observed ToT during the sample (Graph X). The forward-looking measure appears to track the RTWI somewhat more closely than the observed ToT. This is particularly true in 2008, when the forward-looking measure appears to have reacted more quickly to the beginning of the financial crisis, and in 2010/2011, when both the forward-looking measure and the RTWI appear to look through the Queensland flood induced spike the observed ToT.

Graph X

Graph X



* Based on BAT's 7-quarter ahead terms of trade forecast
Sources: RBA

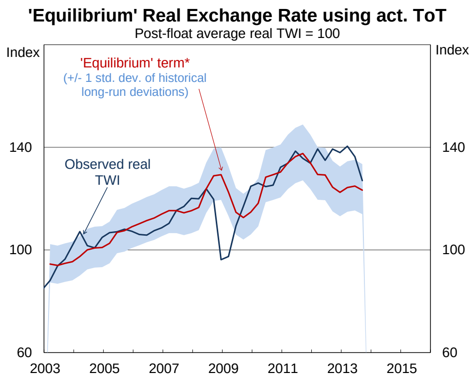


A measure of the ToT surprise was also calculated. This was constructed by calculating how much, on average, quarterly expectation for the future path of the ToT changed over the quarter. The surprise measure was included in the short-run portion of the ECM and is intended to measure whether sudden changes in the forecast ToT may influence the path of the RTWI back to equilibrium.

Tables 1 and 2 contain the results obtained when the forward-looking measures are included in MA's ECM.[1] The adjusted-R^2 are slightly higher in some of the models with the forward-looking measures; The adjustment coefficients and the Bewley transformed coefficients on the ToT variable are also larger in absolute terms. These results indicate that the RTWI is more responsive to changes in the expected ToT than the observed ToT. In addition, the coeffcients on the 'surprise' variable are significant and postive, though they are extremely small.

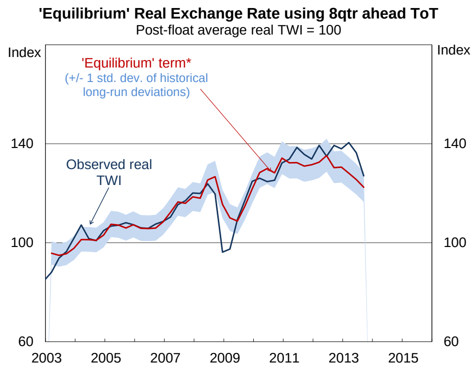
Further, when the model is estimated using forward-looking measures of the ToT the resulting equilibrium term tends to track the observed RTWI more closely than the equilibirum term from the base model.[2] As a result, the 'error bounds' for these models are smaller.

Graph X



Source: RBA

Graph X



Source: RBA

Market-based forward looking measures

Forward-looking measures of the ToT can also be constructed using either market forecasts or futures prices for certain exports. Doing so addresses two potential issues associated with using BAT's ToT forecasts. First, the market's expectations, which will drive the RTWI, may diverge from BAT's forecasts – even if BAT's

[1] While forecasts are available from the December quarter of 2001 onwards, the model is estimated from the March quarter of 2003 onwards; this was done to avoid the dot-com boom and bust period. As discussed in Weltewitz and Smith (2013), during this period the RTWI remained low, relative to the level implied by the medium-term fundamentals, possibly reflecting the unfashionable nature of Australia's economy, which relied on primary industries rather than 'new economy' industries.

[2] The equilibrium terms are similar no matter which forward-looking ToT measure is used.

forecasts are more accurate. Second, vintages of BAT's forecasts are only available from 2001 onwards while a market based measure can likely be constructed for a longer sample.

Comment [HJ2]: Reese 2013 talks about the fact that the expectations of permanent shocks with full and contemporaneous information are similar. This may indicate that the expectations information is more important later. Also, it shows larger transitory shocks, again possibly indicating that expectations are more important for the latter part of the sample.

One market based measure considered was Westpac's commodity futures index (WCFI). Unlike other commodities prices indices, the WCFI uses futures prices and so has a forward looking element. Though the absolute size of its movements are somewhat larger than the observed ToT, it does appear to better capture certain movements in the RTWI, such as the initial effect of the GFC (Graph x).

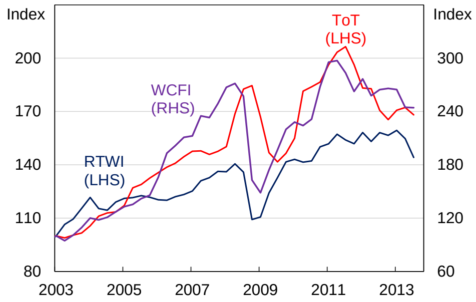
A number of forward looking measures were also constructed internally using forecast and futures data.

Graph X

Graph X

ToT, Forecast ToT and the RTWI

December 2000 = 100



Sources: RBA

Incorporating Investment

The recent ToT boom has led to an unprecedented level of investment. The higher employment and income associated with this investment have lifted the exchange rate to historical highs. Nevertheless, as the 'investment' phase ends and the 'production' phase begins, mining firms' demand for labour may decrease (Plumb et al. 2013). This may lead to a depreciation of the RTWI – despite the ToT remaining at the same elevated levels – if the mining sector is largely foreign-owned and the dividends from the production largely accrue to foreign investors (Hall and Rees 2013). This dynamic may cause the relationship between the ToT and the RTWI to weaken.

In part, the current specification of MA's ECM may capture this dynamic through the RIRD variable. The implicitly weaker economy associated with the decreased demand for labour is likely to be associated with lower interest rates, and therefore a lower RIRD and a lower equilibrium RTWI.

A more exlpicit way to capture such dynamics would be to incorporate an investment to GDP (I/GDP) variable into long-run part the ECM. By including I/GDP, a particular level of the ToT would be associated with different equilibrium levels of the RTWI, depending on the level of investment (i.e. whether the economy is in the 'investment' phase of the resource boom or the 'production' phase).

Two different measures of investment were used: private business investment from the National Accounts and total mining investment from the Capital Expenditure release.[3] The I/GDP ratio was incorporated both as a separate variable, and interacted with the ToT variable.

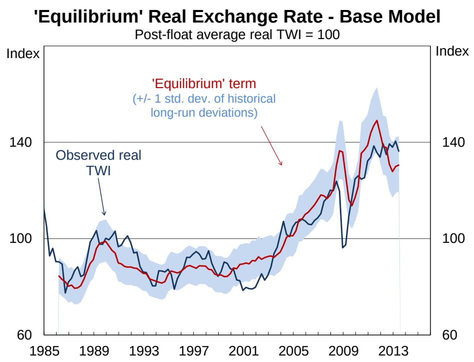
Comment [HJ3]: Need to look at the cointegration.

Table X contains the results from incorporating the I/GDP variable into MA's prefered ECM. When the I/GDP variable is included in the long-run relationship the adjusted-R^2 is slightly higher than in the base model (using both total and mining investment). With both total and mining investment, the coefficient on the ToT in the Bewley transformation is slightly lower, indicating that the influence of the ToT on the RTWI is lower. This likely reflects the separation the direct impact of the ToT on the RTWI from the impact via investment.

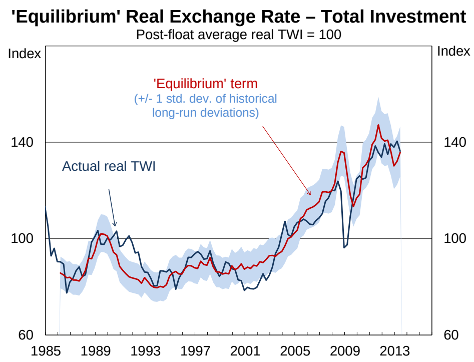
[3] Both measures were in nominal, seasonally adjusted terms.

When the I/GDP variable is included, the estimated equilibrium term tracks the observed RTWI more closely than the equilibrium from the base model, leading to a smaller 'error bounds' (Graphs X and X).[4] This indicates that, while the I/GDP variable is not significant, it does appear to improve the ability of the model to explain movements in the RTWI in terms of its medium-term fundamentals.

Graph X



Graph X

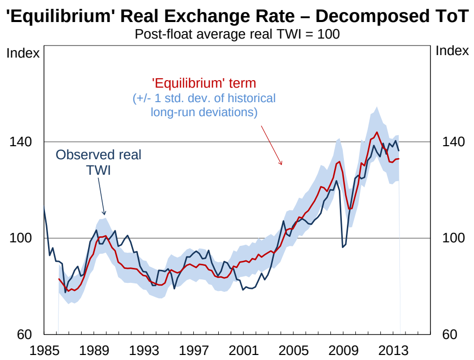


The assumption that most of the dividends from the production phase of the commodities boom accrue to foreign investors is intended to capture the relatively unique ownership structure in the bulks sector. Therefore, the dynamics may be more evident if the ToT is decomposed into a bulks ToT measure and an ToT ex-bulks measure.

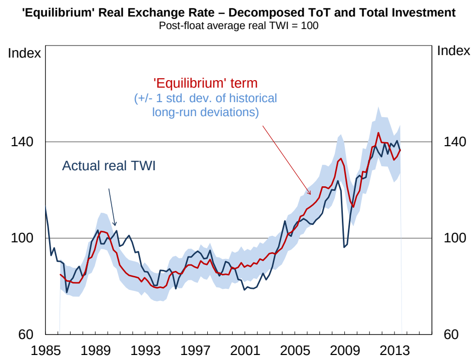
Table X contains the results from estimating MA's preferred ECM with the ToT decomposed into bulks and ex-bulks, with and without the I/GDP variables. The results for most models are faily similair to the base model. The I/GDP variable is not significant in any model, even when interacted with the bulks ToT. When the mining investment measure is used on the adjustment coefficient is lower and the coefficient on the ToT ex-bulks in the bewely transfromation is higher.

When the ToT is decomposed, the estimated equilibrium term tracks the actual RTWI mode closely than the equilibrium from MA's preferred model (Graph X). It is also fairly similar to the equilibrium term estimated when the total investment measure is included in the model.[5] Meanwhile, when the mining investment measure is included in the model, the equilibrium term tracks the actual RTWI fairly closely.

Graph X



Graph X



[4] When mining investment is used the equilibrium terms is fairly similar.

[5] The advantages of decomposing the ToT when modelling the RTWI will be discussed further in a forthcoming RDP.

Overall, the results suggest that including a measure of I/GDP may improve the performance of the ECM somewhat, though the results are not particualrily strong. It may be worthwhile revisiting this exercise in the future once the 'production' phase is more advanced.

Graph X

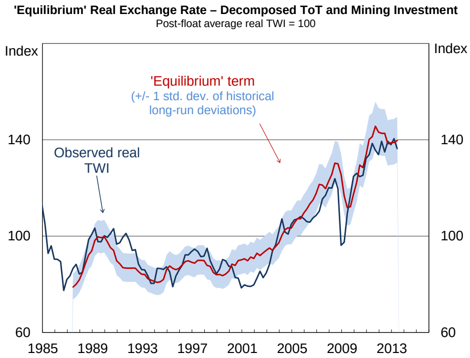


Table 1: Model Results using t quarter ahead ToT

	Base	Four-quarter ahead	Five-quarter ahead	Six-quarter ahead	Seven-quarter ahead	Eight-quarter ahead
	2003:1	2003:1	2003:1	2003:1	2003:1	2003:1
	2013:3	2013:3	2013:3	2013:3	2013:3	2013:3
Variables						
Constant	0.52***	0.51***	0.51***	0.50***	0.49***	0.48***
(s.e.)	(0.15)	(0.14)	(0.14)	(0.14)	(0.13)	(0.13)
Real exchange rate (t-1)	–0.23***	–0.32***	–0.33***	–0.34***	–0.34***	–0.34***
	(0.06)	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)
Terms of trade (t-1)	0.12***	0.20***	0.21***	0.22***	0.23***	0.23***
	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
Average ToT ‘surprise’	--	0.00**	0.00**	0.00**	0.00**	0.00**
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Equilibrium relationships						
Terms of trade	0.51***	0.63***	0.64***	0.65***	0.66***	0.67***
	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Real interest rate differential	0.24	0.02	0.02	0.06	0.02	0.01
	(2.06)	(1.4)	(1.38)	(1.33)	(1.32)	(1.31)
Observations	43	43	43	43	43	43
Durbin Watson	1.31	1.45	1.46	1.48	1.50	1.52
Adjusted R^2	0.82	0.83	0.83	0.84	0.84	0.84

Table 2: Model Results average forecast ToT over the next t quarters (as well as the current quarter)						
	Base[9]	Four-quarter average	Five-quarter average	Six-quarter average	Seven-quarter average	Eight-quarter average
	2003:1	2003:1	2003:1	2003:1	2003:1	2003:1
	2013:3	2013:3	2013:3	2013:3	2013:3	2013:3
Variables						
Constant	0.54***	0.50***	0.51***	0.51***	0.51***	0.51***
(s.e.)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
Real exchange rate (t-1)	−0.23***	−0.29***	−0.30***	−0.31***	−0.32***	−0.32***
	(0.06)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)
Terms of trade (t-1)	0.12***	0.17***	0.18***	0.19***	0.20***	0.20***
	(0.04)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
Average ToT ‘surprise’	0.00*	0.00**	0.00**	0.00**	0.00**	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Equilibrium relationships						
Terms of trade	0.50***	0.60***	0.61***	0.62***	0.62***	0.63***
	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)
Real interest rate differential	1.09	0.00	0.01	0.0	0.04	0.08
	(1.92)	(1.57)	(1.52)	(1.47)	(1.44)	(1.42)
Observations	43	43	43	43	43	43
Durbin Watson	1.31	1.45	1.45	1.45	1.46	1.46
Adjusted R^2	0.83	0.83	0.83	0.83	0.84	0.84

[9] The surprise variable was included for comparability of the adjusted R^2. It’s inclusion has little impact on the coefficients for other variables.

Table 3: Model Results using models including I/GDP					
	Base	Total Investment	Total Investment	Mining Investment	Mining Investment
	1986:2	2003:1	2003:1	2003:1	2003:1
	2013:2	2013:3	2013:3	2013:3	2013:3
Variables					
Constant	0.29**	0.33***	0.27***	0.26*	0.09
(s.e.)	(0.12)	(0.12)	(0.13)	(0.15)	(0.15)
Real exchange rate (t-1)	–0.17***	–0.18***	–0.08**	–0.14***	–0.02
	(0.05)	(0.05)	(0.03)	(0.05)	(0.03)
Terms of trade (t-1)	0.11***	0.10***	--	0.08***	
	(0.03)	(0.03)		(0.03)	
I/GDP(t-1)	--	0.00	--	0.00	
		(0.00)		(0.00)	
I/GDP(t-1)*Terms of trade (t-1)			0.01***		0.00
			(0.00)		(0.00)
Equilibrium relationships					
Terms of trade	0.63***	0.54***		0.59***	
	(0.06)	(0.08)		(0.14)	
Real interest rate differential	1.23	1.22	-0.50	1.20	-6.76
	(1.19)	(1.57)	(2.73)	(1.44)	(18.69)
I/GDP(t-1)		0.02		0.01	
		(0.01)		(0.03)	
I/GDP(t-1)*Terms of trade (t-1)			0.02***		0.03
			(0.00)		(0.03)
Observations	109	109	109	105	105
Durbin Watson	1.79	1.86	1.94	1.68	1.70
Adjusted R^2	0.48[10]	0.49	0.46	0.52	0.48

[10] When the sample is reduced to 105 observations the adjusted-R^2 is 0.51

Table 4: Model Results using models including I/GDP when the ToT is decomposed in bulks and ex-bulks

	Base	Total Investment	Total Investment	Mining Investment	Mining Investment
	1986:2	2003:1	2003:1	2003:1	2003:1
	2013:2	2013:3	2013:3	2013:3	2013:3
Variables					
Constant	0.18	0.27	0.22	0.14	0.07
(s.e.)	(0.18)	(0.19)	(0.17)	(0.21)	(0.15)
Real exchange rate (t-1)	–0.19***	–0.19***	–0.18***	–0.16***	–0.15***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Terms of trade ex-bulks (t-1)	0.13**	0.10	0.12**	0.11**	0.13***
	(0.06)	(0.06)	(0.05)	(0.06)	(0.04)
Bulks terms of trade (t-1)	0.02	0.03	--	0.01	
	(0.02)	(0.02)		(0.02)	
I/GDP(t-1)	--	0.00	--	0.00	
		(0.00)		(0.00)	
I/GDP(t-1)*bulks terms of trade (t-1)			0.00		0.00
			(0.00)		(0.00)
Equilibrium relationships					
Terms of trade ex-bulks	0.67**	0.51*	0.67***	0.73**	0.89***
	(0.28)	(0.30)	(0.22)	(0.36)	(0.21)
Bulks terms of trade	0.11	0.13		0.06	
	(0.10)	(0.10)		(0.13)	
Real interest rate differential	1.39	1.35	1.27	1.19	1.00
	(1.09)	(1.06)	(1.11)	(1.33)	(1.38)
I/GDP(t-1)		0.02		0.01	
		(0.01)		(0.02)	
I/GDP(t-1)*Terms of trade (t-1)			0.00		0.00
			(0.00)		(0.00)
Observations	109	109	109	104	104
Durbin Watson	1.81	1.86	1.87	1.69	1.70
Adjusted R^2	0.49[11]	0.49	0.49	0.52	0.52

[11] When the sample is reduced to 105 observations the adjusted-R^2 is 0.52