YARRA
CAPITAL MANAGEMENT

WHITEPAPER

Modelling the Australian dollar: A new model for a new era

Tim Toohey
Head of Macro and Strategy

2020 | FEBRUARY

YARRA CAPITAL MANAGEMENT

Contents

Introduction ... 2
1. The linkage between capital flows, monetary control and the decision to float ... 3
2. The importance of capital flows – the 'portfolio balance' effect ... 4
3. The importance of money – the 'monetary model' of the Australian dollar ... 7
4. The Australian dollar and commodity prices – a hard tag to shake ... 9
5. Shifting drivers of the exchange rate ... 12
6. Detailing Yarra Capital's Australian dollar model relative to the RBA model ... 14
7. A decomposition of movements in the Australian dollar ... 20
8. Scenario analysis ... 22
Conclusion ... 24
Appendix A – Tests of interest parity and speculative efficiency ... 25
Appendix B – Derivation of the monetary model ... 29
Appendix C – Australian dollar stylised facts ... 33
Disclaimer ... 37

Introduction

There are few topics in economics more contentious than exchange rate modelling. In many cases the theory of what should drive an exchange rate stands juxtaposed with the available empirical evidence.[1] Even the most robust of exchange rate models is typically measured against the lowest of bars – a random walk model.[2] The idea that the best of economic theory when tested in practice cannot beat the last observed value of the exchange rate plus 'a toss of a coin' for what happens next is a sobering thought.

For those tasked with forecasting the path of exchange rates, the approach often used has been to either selectively choose parts of exchange rate theory that seem to fit recent history or to largely just ignore the theory and data mine until a combination of economic and financial market variables deliver a high historical fit. The consequence is that various exchange rate models are often presented in Australia as having good "within sample" statistical fit, but with relatively poor theoretical underpinnings. Finding a theoretically acceptable exchange rate model has been made even more difficult in recent years by the deployment of large scale quantitative easing in the wake of the Great Recession. As such, exchange rate models that rely heavily on relative interest rates as their theoretical touchstone are being rendered obsolete.

In this whitepaper we detail a theoretically robust model for the Australian dollar that explains 94% of the quarterly variation in the *level* of the exchange rate and up to 53% of the quarterly variation in the *change* of the exchange rate. The key benefit of Yarra's model is that it is specifically designed to be able to be robust enough to incorporate the innovations of unconventional monetary policy.

The motivation for seeking an alternative modelling approach is twofold. Firstly, existing exchange rate models have difficultly adapting to the transition to unconventional monetary policy. Secondly, we had observed that the two key variables in the RBA exchange rate model – the terms of trade and real short term interest rate differentials – were no longer correlating with the Australia dollar. Either we are in the midst of an extended statistical aberration, a structural break had occurred, or the model is missing one or more important variables.

The focus of Yarra's exchange rate model is to return to first principles and investigate whether a better framework for analysis exists in a world of unconventional monetary policy. In short, Yarra's model suggests that the 'monetary model' of the exchange rate is a superior variable to models based on relative interest rates, and that unhedged capital flows can be formally captured within a 'portfolio rebalancing' framework that both enhance the model's statistical fit and provide a richer specification that allows us to work through the implications of shifts in capital flows and the modern era of unconventional monetary policy.

[1] Over the past 30 years numerous studies have shown that for the major exchange rates widely held concepts such as purchasing power parity (PPP) and uncovered interest rate parity (UIP) have typically failed to pass statistical tests. See Appendix A for updated tests for these and related concepts for the Australian dollar.

[2] A random walk model assumes that in each period the variable takes a random step away from its previous value, and the steps are independently and identically distributed in size. This does not mean that movements in those prices are random in the sense of being without purpose. When they go up and down, it is always for a reason. But the direction of the next move cannot be predicted ex ante: it can only be explained ex post, because if the direction and magnitude of the next price movement could have been predicted in advance, then speculators would already have bid it up or down by that amount.

1. The linkage between capital flows, monetary control and the decision to float

The decision to float the Australian dollar in December 1983 may well have been the biggest economic reform in the post-War history of Australia. However, the decision to float the Australian dollar was less a moment of economic inspiration for the newly elected government and more a moment of desperation. The decision to float was the eventual recognition by the authorities of the important linkage between monetary stability and capital flows. Rapid innovations in the financial sector during the 1970s enabled large waves of cross-border speculative capital. The resulting shocks to the domestic money supply made it increasingly difficult for the central bank to achieve its stated economic objectives on growth and inflation and for the government to meet its Federal Budget projections.

By floating the Australian dollar the authorities reclaimed the prize of controlling monetary and price stability. However, the decision to float the exchange rate also transformed it from a security principally traded amongst local commercial banks in 1983 into today's position of the fifth most traded currency with an annual daily turnover of in excess of $447 billion, more than half of which is traded outside of Australian borders, and having a disproportionate share in both foreign central bank reserve diversification programs and in hedge fund trading accounts. Appendix C provides greater details on the role of the Australian dollar in global capital markets.

Compared to the early 1980s, the market for Australian dollars is large, liquid, sophisticated, internationalised and currently plays an important role in global investment portfolios. However, the decision to float also meant the dollar would increasingly be hostage to the ebbs and flows of global capital and foreign monetary policy decisions.

Despite the increasing role of capital flows in currency markets, empirical evidence using proxies – such as the current account deficit or net foreign liabilities – has had only limited success in explaining the path of the Australian dollar. Unprecedented efforts by central banks to counteract the largest deleveraging cycle post the Great Recession by deploying unconventional monetary policy has provided an additional challenge to exchange rate modellers who have failed to resolve how to incorporate this new monetary era within existing frameworks.

Exchange rate modellers have historically relied upon the signal from relative interest rates between Australia and the G3 economies as a principal guide to exchange rate valuation. Given interest rates are the price of money, the logic is that policy makers will then adjust interest rates to ensure money supply growth is sufficient to move economic growth towards the equilibrium state where economic growth is at "potential" growth and inflation at "target".

When interest rates are above the zero bound and money supply is reactive to movements in interest rates then there is nothing wrong with focussing on relative interest rates. However, when interest rates are already near zero, money supply growth is no longer incentivised by the price of money, so in order to achieve the equilibrium state for growth and inflation, policy makers have resorted to manually increasing the stock of money. When quantitative easing (QE) is recast in these terms, it becomes clear that the solution to exchange rate modelling in the era of unconventional monetary policy is to recognise that it is relative money supply growth and relative economic growth that provides the signal for the exchange rate, not relative short term interest rates.

The paradox is that this paper is not proposing a radically new economic theory for the exchange rate. In contrast, the foundation of modern monetary economic theory was outlined in the early 1980's and the empirical search for support of the three key components of that theory – uncovered interest rate parity (UIP), purchasing power parity (PPP) and money market equilibrium (MME) – has continued ever since. In the sections that follow, we show how UIP, PPP and MME were never designed to be separated. Jointly, they form the Monetary Model of the exchange rate, and together with unhedged capital flows they prove a superior approach to exchange rate modelling.

2. The importance of capital flows – the 'portfolio balance' effect

Australia's recent experience of posting a current account surplus is something of an historical aberration. Since 1960, 94% of the time Australia's current account has been in deficit and that deficit has averaged -3.2% of GDP on average over that period.

The rationale for linking capital flows to movements in the exchange rate stems from the simple fact that a deficit in the current account generally creates an increase in the net foreign debt of a country, which has to be financed by international investors. The associated adjustment of their portfolio structure demands a higher expected return. At given interest rates, this can only be accomplished through a depreciation of the currency of the debtor country. This is in essence the 'portfolio balance' theory of exchange rates.

Exhibit 1: Australia's has recently been highly reliant of FDI, offsetting a surge in equity outflow

Australia: Financing the Current Account Deficit

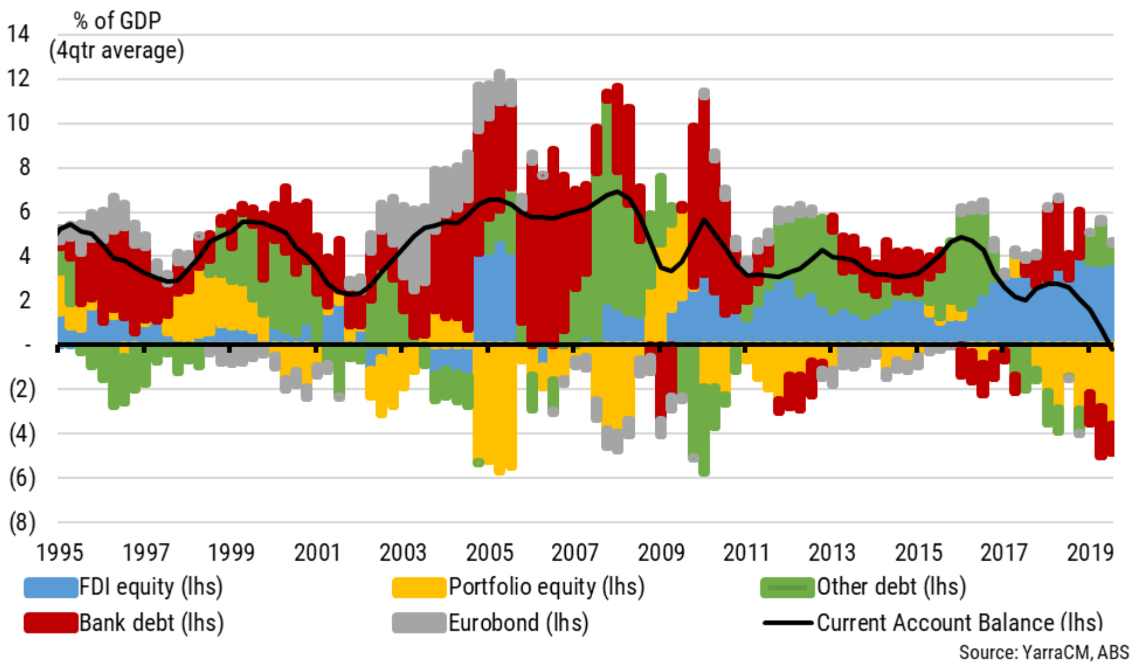


Exhibit 1 illustrates the different capital flows Australia has used to finance its current deficit and how the importance of each of these capital flows has changed over time. Since the financial crisis Australia has increasingly utilised foreign direct investment, in part to finance the mining investment boom in general and large scale LNG investments in particular. Currently, FDI flows amount to 3.8% of GDP in 2019 which has been almost completely offset by -3.6% portfolio equity capital outflow – the largest outflow of portfolio capital since the financial crisis. These are large flows that are pulling the exchange rate in divergent directions. However, during other periods of large portfolio capital outflows, such as during most of the 2000's, the offsetting inflow has come via domestic banks issuing large amounts of bank paper into offshore capital markets.

In a case of economic theory not keeping pace with financial market developments, the portfolio balance theory has not formally incorporated the role of hedging of these capital flows. The motivation for hedging an exchange rate at times of heightened volatility or periods of expected change is clear, however, it is also clear that business practices have evolved and the trend for businesses to hedge their external liabilities has continued to increase.

As Exhibit 2 shows, domestic banks and the Australian government completely hedge their external borrowing. Even non-bank financial firms hedge approximately 90% of their external liabilities. Our approach has been to model the long run equilibrium exchange rate as a function of unhedged capital flows. The rationale of excluding hedged debt flows is that, by definition, the subsequent hedging of the exchange rate from any offshore borrowing results in no new net demand for Australian dollars. As such, the inclusion of these flows in an exchange rate model would have been inappropriate. The remaining unhedged private sector debt flows are mainly Eurobond flows (of which Japanese Uridashi flows are a subset).

Exhibit 2: Government, Financials and the majority of Corporates fully hedge their debt exposures

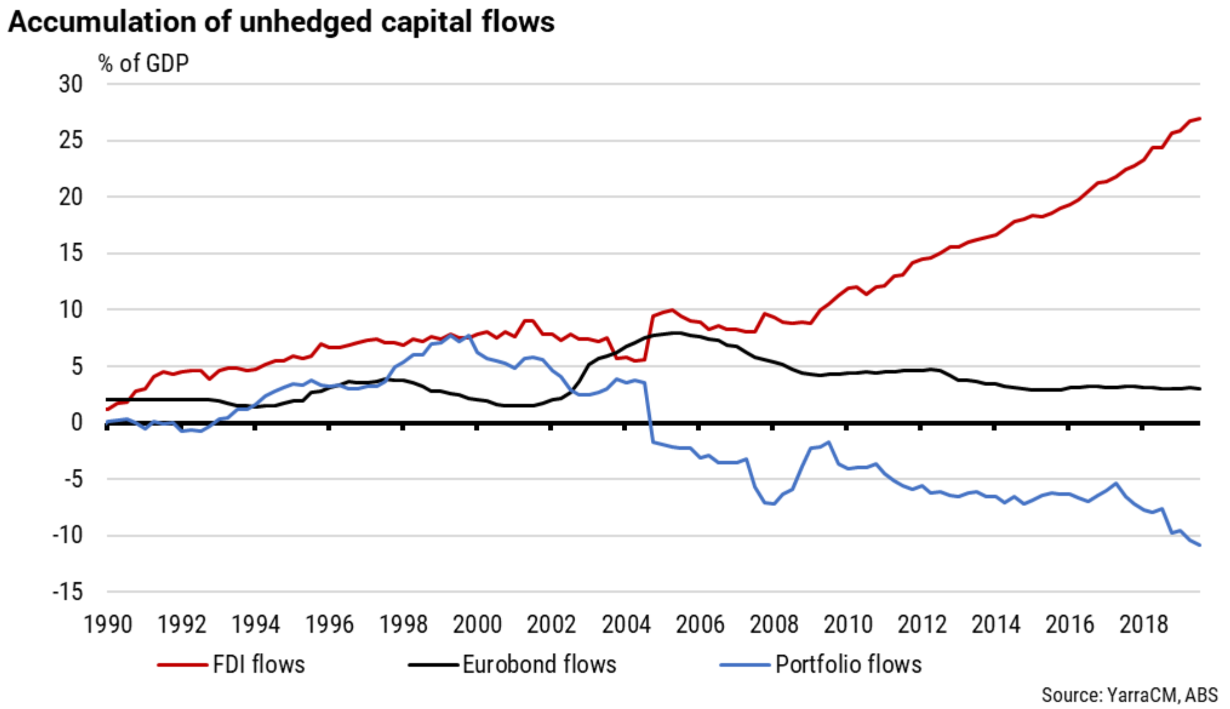
Level of Hedging as at September 2019

Institution	Equity Assets (% Hedged)	Debt Liabilities (% Hedged)
Banks	97	99
RBA/Central Borrowing Authority	99.8	100
Other financial corporations	57	89
Other resident sectors	5	63
Total	46	84

Source: YarraCM, ABS

The easiest way to visualise the shifting importance of different forms of capital flows for the A$ is to exclude the domestic bank issued paper and accumulate the largely unhedged capital flows through time. Exhibit 3 shows the result, accumulating the quarterly flows from March 1989.

Exhibit 3: When it comes to capital flows, it's the unhedged flows that matter for the dollar



Source: YarraCM, ABS

There are five main points from the chart;

1. The accumulation of net portfolio equity flows peaked at the turn of the millennium, however, it was not until 2004 that portfolio outflow significantly exceeded inflow. By 2005 the accumulated net equity flows turned negative. While the onset of the financial crisis saw a sharp repatriation of portfolio flows to Australia, by the end of 2009 portfolio outflow again exceeded inflow by a wide margin. By the end of 2018 the accumulated net outflow exceeded that of pre-crisis 2008. Indeed, 2018-19 has seen a marked acceleration in net portfolio outflow from Australia: a record $71bn of net equity outflow was recorded compared to just $1bn of net portfolio inflows into debt securities since mid-2018, representing a significant restraint on the Australian dollar.
2. The period of maximum impact of Eurobond issuance upon the Australian dollar was 2001 through to the end of 2005. Although a rise in net issuance is a positive contributor to the A$ demand, the influence of net Eurobond issuance has been modest over the past decade.
3. 'Other debt flows' were largely flat over the 10 year period from the mid-1990s, before enjoying a strong trend rise until mid-2016. A significant jump in other debt flows in the aftermath of the financial crisis likely reflected the twin forces of the rise in sovereign wealth funds and government borrowing authority reserve diversifying programmes and the post financial crisis decision by Australian corporates to shift from domestic bank funding to direct offshore issuance of company paper. In the case of the offshore non-financial corporate bond issuance, although this source of capital has been a significant funding source of the current account deficit since the financial crisis, the issuance is largely hedged and as such has only a modest impact on A$ demand. In the case of the reserve diversification flows, IMF data suggests the A$ represented 1.7% of allocated foreign reserves globally, similar in size to the holding in Canadian dollars at 1.96% and Chinese Renminbi at 2.0%. The allocation to Australian dollars from reserve managers has remained broadly stable over the past five years, and as such has had limited impact on the direction of the Australian dollar.
4. FDI represents the largest source of accumulated capital flow. The accumulation in net FDI was on a steady trajectory over the decade to 2009, rising gently from 8% of GDP to 9% of GDP over the period. Over the 10 years to 2019, net FDI exploded by an equivalent of a further 18% of GDP over the 14-year period of 1989 to 2003 (a rise of A$420bn). This is almost three times the sum of funds raised via bank debt issuance offshore over the same period. That is, pre the financial crisis Australia was accumulating around A$5bn p.a. in FDI, however, post the financial crisis net FDI flows averaged A$23bn pa and over the past two years it has averaged A$62bn p.a. Although these are very large numbers, it is questionable as to how much of this capital flow is transferred into A$. The major resource companies that operate in Australia typically have their financial headquarters outside of Australia. For instance, investment goods imported into Australia to fuel the mining investment boom are likely paid direct from head offices based offshore in US$ rather than transferred into A$.

In short, not all capital flows are created equally when it comes to its influence on the Australian dollar. The evidence from the ABS's data on hedging behaviour suggests that commercial bank and government capital flows are almost completely hedged, portfolio flows in fixed interest is typically fully hedged and corporate debt issuance by Australian corporates offshore is largely hedged. Moreover, although FDI flows are indeed large in an accounting sense, foreign ownership structures of major investing companies complicate the interpretation. Indeed, the cleanest impact upon the A$ is via equity capital flows and Eurobond flows, both of which are unhedged.

3. The importance of money – the 'monetary model' of the Australian dollar

When it comes to discussing the likely path of exchange rates, movements in relative interest rates between Australia and major economies remain the default option for exchange rate modellers and analysts alike. Indeed, the RBA's exchange rate model relies heavily upon the gap between the RBA cash rate and the weighted average policy rate of the Fed, ECB and BoJ.

There is nothing inherently wrong with this approach. Interest rates obviously matter. However, interest rate movements are not random, independent events, they change for a reason. Our focus instead is on the real economy variables that move ahead of interest rate changes and have a strong theoretical rationale for inclusion in an exchange rate model. We are also interested in a structure that is flexible enough to incorporate the challenges presented by the innovations of 'quantitative easing' and negative interest rates.

Exhibit 4: Credit growth and QE are related forces, but its credit growth that is important for FX

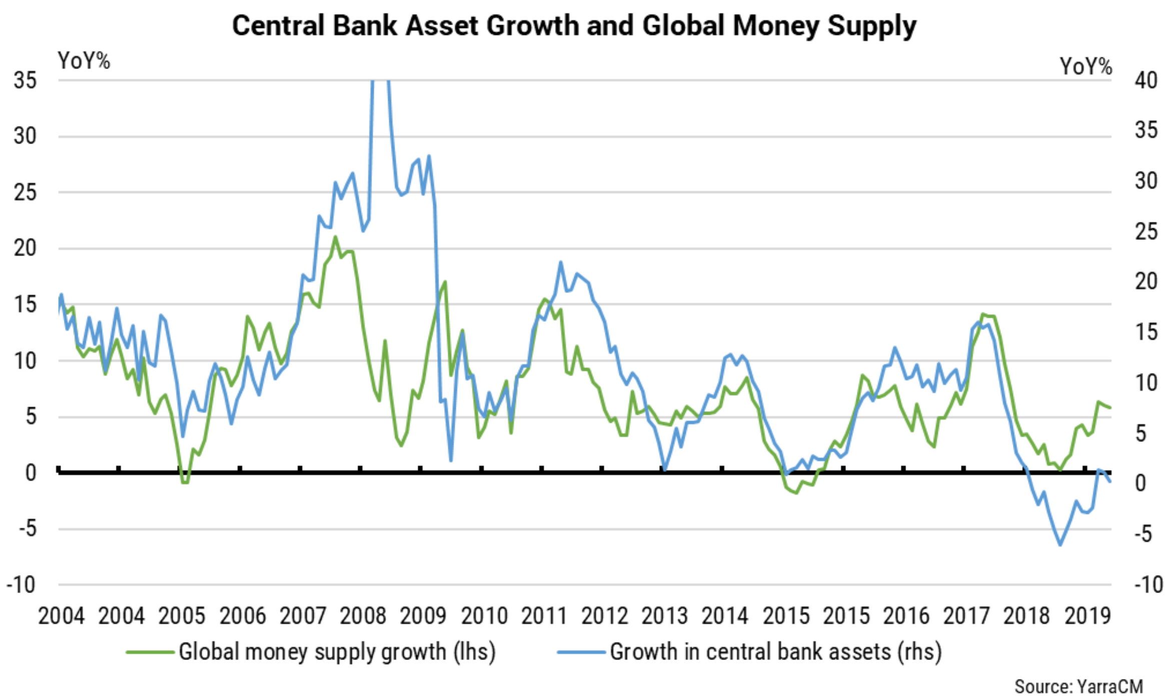


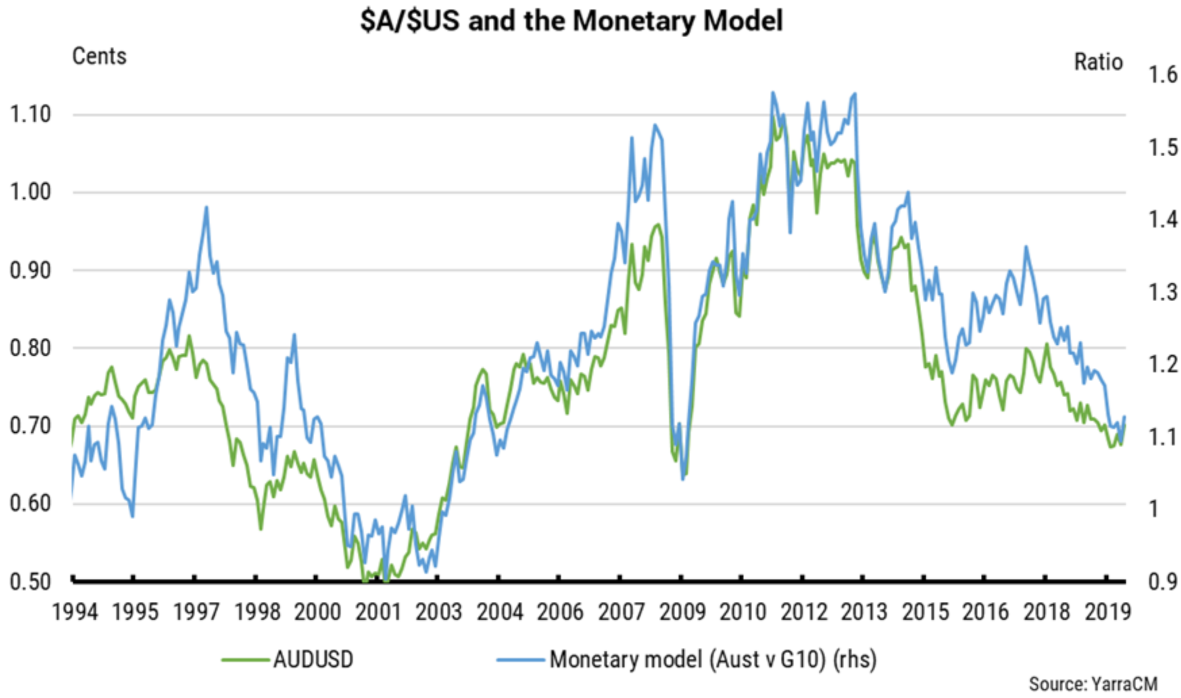
Exhibit 4 shows the aggressive expansion of central bank balance sheets in major economies. However, from an exchange rate perspective, if this balance sheet expansion by a central bank doesn't translate into an expansion in broader money supply growth then it has not increased the supply of dollars in that economy and theoretically should not be seen as a source of depreciation pressure for the exchange rate. From our perspective, attempting to capture quantitative easing impacts via the size of central bank balance sheets is an imperfect solution. The more relevant or 'deeper' economic variable is credit growth in the economy relative to its major trading partners.

The key question for exchange rate modelling is how can we deal with the modern era of monetary policy of quantitative easing, especially as speculation builds that the RBA may join its major central bank peers and embrace quantitative easing?

One approach is to ignore short term interest rates and focus on long term interest rate differentials. The problem with this strategy is that long run yields can also be hostage to concerns about fiscal sustainability with quite binary economic outcomes once financial markets switch their attention to sustainability of sovereign debt issues. This was clearly demonstrated during the sovereign debt crisis in Europe in 2011-12. Moreover, in Australia's case longer dated yields tend to be as sensitive to global as local factors and hence can be a poor relative guide.

Another approach is to focus on the primary drivers of interest rates, real economic growth and real money supply. The monetary model of the exchange rate has been the building block of international finance theory over the past 35 years. The key equations in the monetary model – purchasing power parity, uncovered interest rate parity and money market equilibrium can be manipulated into a simple equation for the exchange rate. (See Appendix B for a formal derivation of the monetary model).

Exhibit 5: Reviving the 'Monetary model' of the exchange rate



The simple monetary model stipulates the exchange rate will equal the ratio of domestic real money balances to foreign real money balances divided by the ratio of domestic and foreign real output. We denote this variable MM and included it as a key long run variable in our exchange rate model. That is:

$$MM = \frac{Money_{AUS}/Money_{MTP}}{GDP_{AUS}/GDP_{MTP}}$$

Given relative economic growth is ultimately determined by relative population growth and relative productivity growth our MM variable can be interpreted as a 'deeper' structural variable than relative productivity alone. Moreover, its focus on relative money supply growth provides a theoretically sound method for dealing with the consequences of quantitative easing. As such, we believe the monetary model will outperform exchange rate models that are based on just one of the components of the monetary model, including models based on one or more combinations of relative interest rates, relative prices, relative productivity and relative economic growth.

Exhibit 5 shows the monetary model charted against the exchange rate. A simple regression for the real trade weighted index on a constant and the monetary model finds that the monetary model can explain 80% of the quarterly variation of the real trade weighted index over the period from 1994. Given that the estimation period encompasses the surge in the terms of trade to historic highs this is a highly encouraging result.

The intuition behind the monetary model is that when real money supply growth relative to economic growth is expanding at a faster rate in the home country relative to its competitor countries, excess returns may be available in the home country (or if the home country is operating at capacity inflation is likely to accelerate) and interest rates will eventually rise to reflect that excess return.

4. The Australian dollar and commodity prices – a hard tag to shake

It is hard to ignore the role of the terms of trade in exchange rate determination for the Australian dollar. Currency market participants have long recognised the correlation between commodity price movements and the exchange rate for industrialised nations with relatively developed capital markets and a high dependency upon commodity exports. The research departments in the central banks of Australia, Canada and New Zealand have incorporated commodity prices, either directly or via the terms of trade, as a determinant of the exchange rate in numerous models for decades.

All three central banks have highlighted the ability of their models to predict the exchange rate out of sample. The correlation between commodity prices and the Australian dollar has been widely interpreted as evidence of a close link between the exchange rate and fundamentals. McKenzie was the first to make the claim from the RBA. He has been followed by a long list of other RBA researchers all arguing that the terms of trade are a fundamental determinant of the real exchange rate for a small commodity exporting country like Australia.

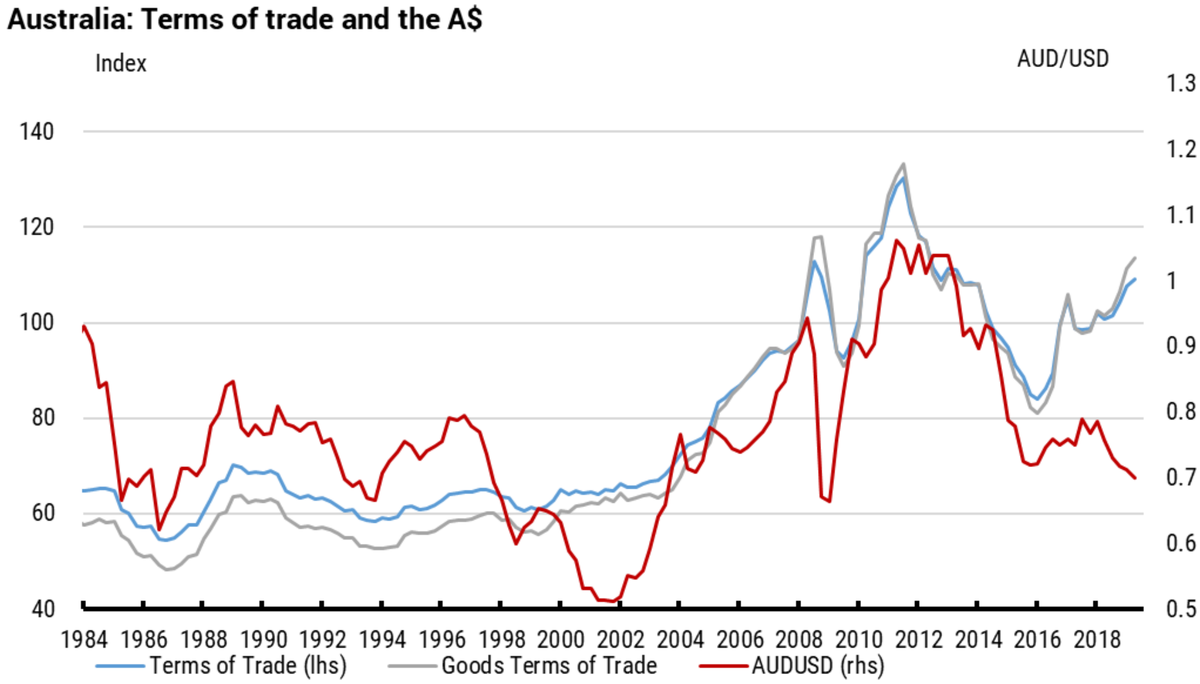
There is a reasonable basis for including the terms of trade in commodity country exchange rate models. Australian commodity exports in 2019 accounted for 60% of total exports. This compares with just 30% in 1999. Of course, large price increases for coal and iron ore explain the majority of the gain in share, however, the resulting strength in the Australian dollar also contributed to the relative shrinkage of non-commodity exports – manufacturing exports contracted from 19% share of total exports to 9% over the same period.

Australia has also been a major beneficiary of declining costs of imported manufactured goods, with the disinflationary benefits delivering relatively low inflation and higher living standards. The benefit of using the terms of trade rather than simply commodity prices in our exchange rate model is to capture the importance of global disinflation in manufactured goods relative to commodity prices.

Australia has also been a major beneficiary of declining costs of imported manufactured goods, with the disinflationary benefits delivering relatively low inflation and higher living standards. The benefit of using the terms of trade rather than simply commodity prices in our exchange rate model is to capture the importance of global disinflation in manufactured goods relative to commodity prices.

The counterpoint to the increasing commodity share of Australia's exports is the increasing foreign ownership of Australia's resource sector. It is true that the vast investment in the LNG sector is predominately foreign owned, mostly via joint venture arrangements, and that dividends will largely accrue to offshore investors. It is also true that foreign investor ownership share of the register of the large mining companies has trended higher over the past decade. However, the trend should not be overstated.

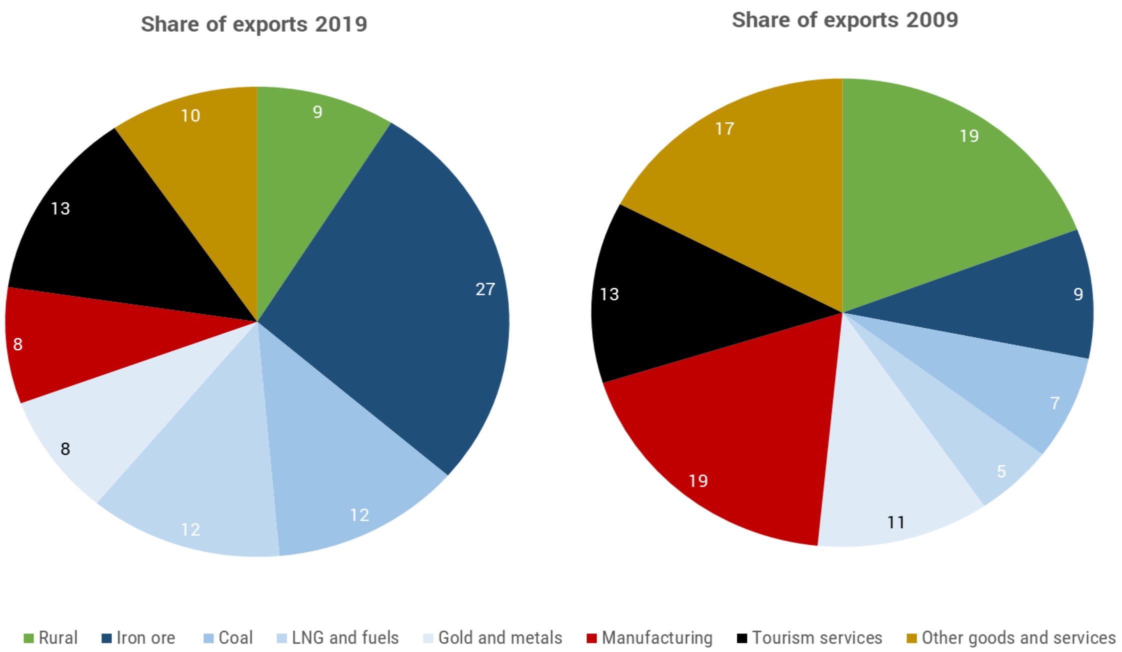
Exhibit 6: Is the historical relationship between the A$ and the terms of trade breaking down?



Source: YarraCM, ABS

Exhibit 7: Increasing commodity intensity of exports suggests the relationship should be stronger

The increasing commodity intensity of Australia's exports

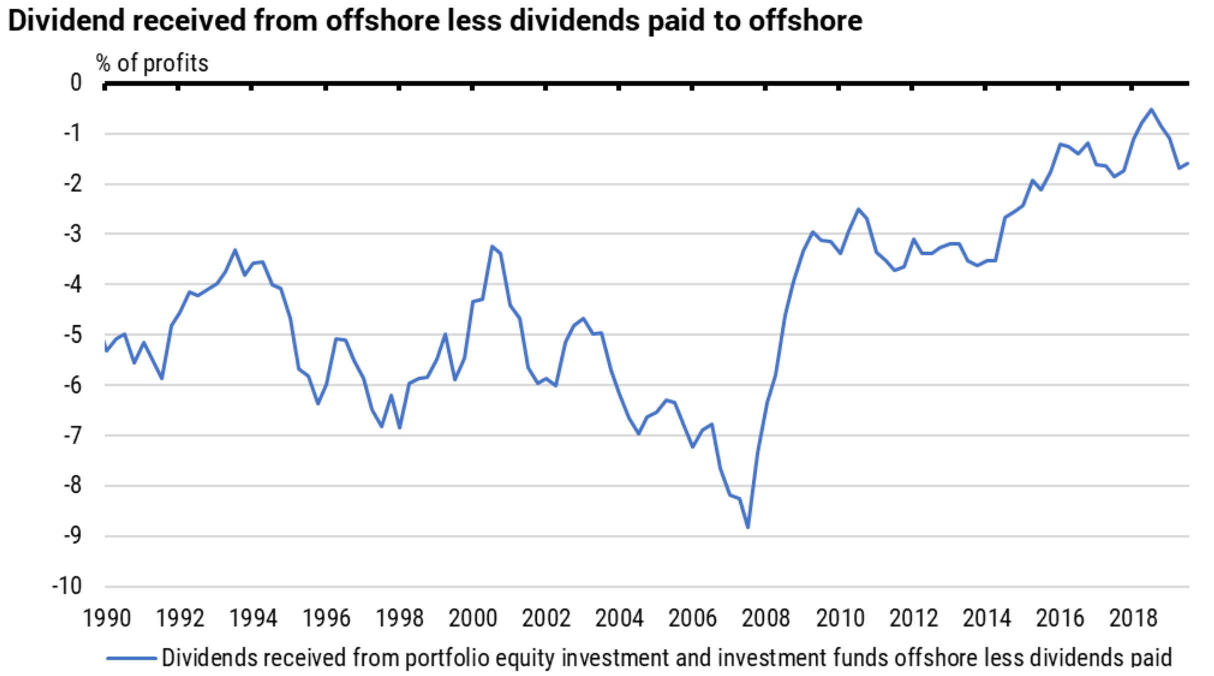


Source: BIS

Readily available data sources such as Bloomberg report that BHP has just 8% of its shares owned by Australians. However, our direct approach to the company suggests the actual figure is closer to 40%. Enquiries to each of the major Australian miners reveals a similar finding. The smaller miners tend to have a higher local shareholding; S32 has 45% of investors registered in Australia (across all listings), Fortescue has 55%, Newcrest mining has 33%, Santos has 60%, and Oil Search has 45%. In contrast, Rio Tinto has a lower share of Australian registered investors of 15% – down from 40% through the 2012-2014 period.

Australia's mining sector is clearly majority foreign owned and larger companies have seen a trend to increasing foreign ownership. However, it is important to note that Australia has been more aggressive in acquiring foreign equity income streams across a range of industries compared to foreign investors. Historically, Australia has paid more dividends to foreign investors than they received on their offshore equity investments. The ABS data on dividends paid by Australian companies to offshore owners exceeded dividends received by Australians on their offshore investments by over 6% of post-tax profits from 1995-2005. However, since the financial crisis this gap has shrunk to 1% of post-tax profits. Indeed, should Australia's rapid deployment of portfolio equity capital into offshore markets continue, it is feasible that within the next two years Australia's dividends received on its investments in offshore companies will exceed dividends paid to foreigners for the first time.

Exhibit 8: Increasing commodity intensity has been offset by Australian's investing offshore



Source: YarraCM, ABS

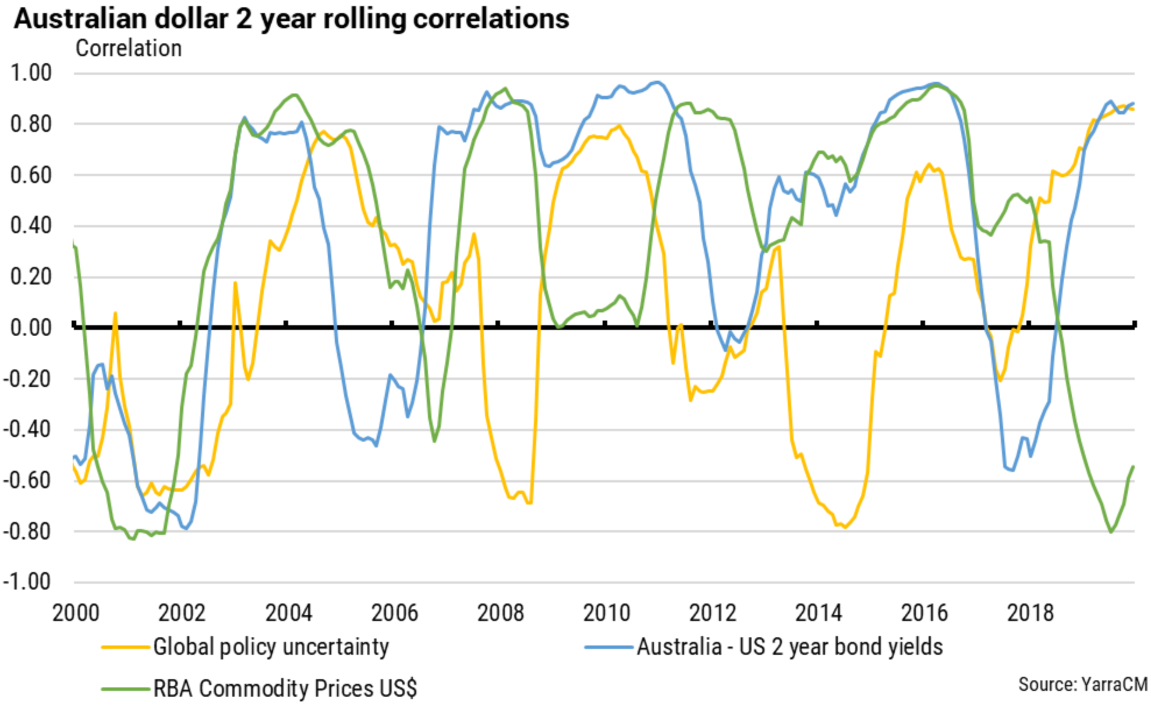
In other words, the increasing commodity sensitivity in the trade balance is being offset by the increased diversification of income via the net income balance in Australia's external accounts. While it is perhaps too early to suggest that the A$ will shed its reputation as the number one card holder in the commodity price club of exchange rates, an important transition is occurring to the diversification of unhedged income streams. This transition suggests that Australia's commodity export intensity overstates the impact that commodity prices should have on the exchange rate.

5. Shifting drivers of the exchange rate

One of the defining features of exchange rate markets relative to other financial assets is that foreign exchange markets tend to exhibit strong correlations to a particular factor for relatively short periods of time before switching to an alternative factor. Factor models of exchange rates which focus on identifying carry, volatility, value, momentum and commodity price factors are relatively common and instructive in real-time to understand what may currently be the factor in vogue moving a particular currency pair. The downside is that the factor approach is not particularly helpful in forecasting the exchange rate nor identifying when the switch to an alternative factor is likely to occur. Correlation is not the same thing as causation, and the risk of spurious results is high.

Nevertheless, it is of interest to look at correlation between the A$ and some of the more widely used variables in A$ modelling. The most telling switch in correlation is the switch of the widely used RBA commodity price index (in US$) which averaged a positive 51% 2-year rolling monthly correlation with the A$ from the mid-90s to the end of 2017. However, over the past two years the correlation has turned sharply negative and is currently -54% (after reaching a peak of -80% in July 2019). The only other time the correlation between commodity prices and the A$ was this negative was during the global recession of 2001.

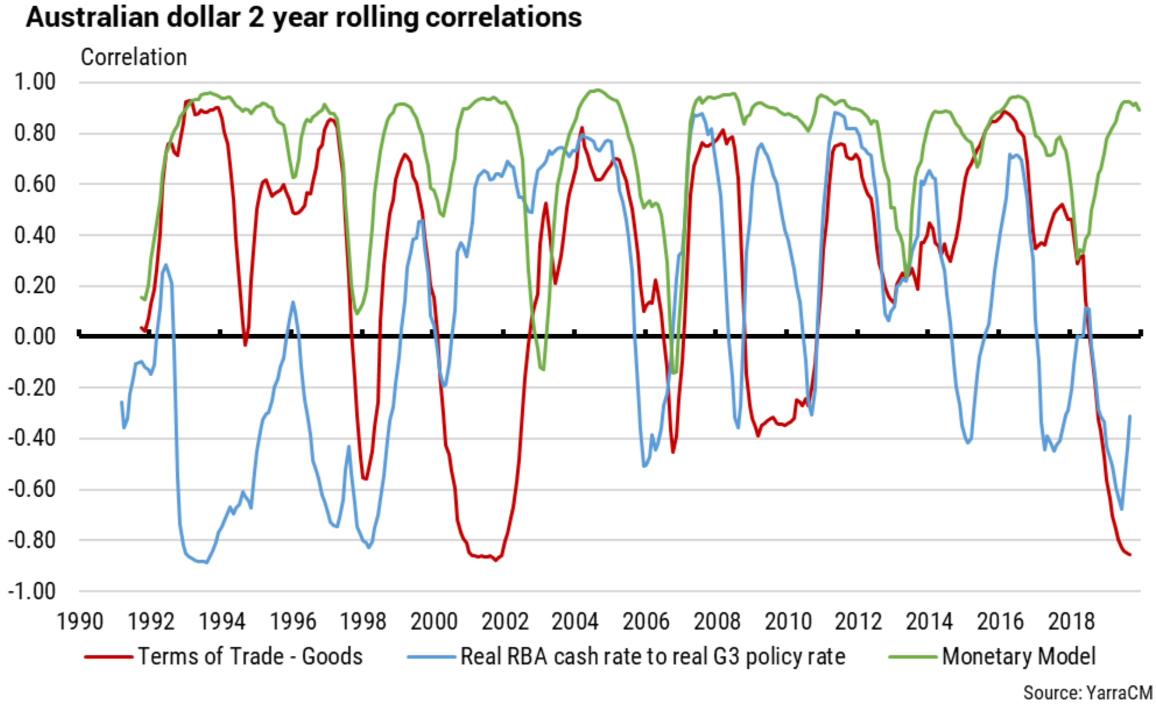
Exhibit 9: Australian dollar has been highly correlated with global policy uncertainty



In contrast, the correlation between the Australian and US 2-year bond yield and the Australian dollar, which has had just a positive 18% rolling 2-year correlation from the mid-90s to 2017 has its correlation rise to 88% over the past two years. This surge in correlation to interest rate spreads has coincided with an earlier lift in the correlation to global policy uncertainty – suggesting that the trade war between China and the US was impacting the Australian dollar months before interest rate markets began to factor in a shift to RBA interest rate easing.

For exchange rate modellers, the news that the correlation to the terms of trade has turned sharply negative in recent years is not great news. However, for the RBA's preferred exchange rate model, despite the high correlation between 2-year bond differentials shown above, the correlation has also been negative for the RBA's preferred variable: the spread between the real RBA cash rate and G3 policy rates. The idea that the RBA's chosen long run equilibrium variables have been strongly negatively correlated to the Australian dollar over the past two years is somewhat alarming.

Exhibit 10: RBA's model's two main variables are currently negatively correlated with the A$



The chart above show that correlations between the Australian dollar and the RBA's preferred long run model variables, the goods terms of trade and real interest rate spreads between Australia and the G3. In the ebb and flow of forces that correlate to the Australian dollar, one can always hold out hope that a negative correlation will soon move back to its historical average positive correlation. Currently, the RBA's two preferred long run variables are collectively negatively correlated by the greatest amount since our data commenced in the late 1980s. In contrast, our monetary model variable has averaged 75% rolling 2-year correlation with the Australian dollar since the mid-1990s, and over the past two years the monetary model has had an 89% correlation.

In short, our monetary model variable not only retains a high positive correlation with the A$, it also exhibits a more stable correlation with the dollar through time.

6. Detailing Yarra Capital's Australian dollar model relative to the RBA model

The focus of Yarra Capital Management's exchange rate model is to return to first principles and investigate whether the monetary and portfolio balance models of the exchange rate offer a better framework for analysis in a world of unconventional monetary policy.

The statistical machinery in estimating the model is the same as the RBA. Both models are reduced form single equation error correction models of the real Trade Weighted Index (RTWI) based off a long run cointegrated relationship. Nevertheless, the theoretical underpinning, and therefore the explanatory variables, are appreciably different. The key differences include:

1. The RBA's model is essentially a terms of trade augmented uncovered interest rate parity (UIP) model. That is, in the RBA's model the long run cointegrated (or 'equilibrium') relationship for the real Trade Weighted Index (RTWI) is merely the goods terms of trade and the differential between Australia's and the G3's policy rates.
2. Yarra Capital's model is founded on the belief that the 'monetary model' of the exchange rate is a superior foundation to build an exchange rate model. The rationale is that the 'monetary model' has been the bedrock of exchange rate theory for 35 years which incorporates three key equations; uncovered interest rate parity (UIP), purchasing power parity (PPP) and money market equilibrium (MME). By focussing on just one component of the theoretical model, UIP, alternative exchange rate models have weakened the theoretical rationale and could potentially result in misleading conclusions. In Appendix B we show how these three key equations can be reduced to a single economic variable.
3. Yarra Capital's model also leans heavily on the 'portfolio rebalancing' framework for exchange rate modelling. Under this approach, the capital flows from funding the external trade accounts play a central role in governing the path of the exchange rate. Note that this is particularly important in Australia's case. Large shifts in unhedged capital flows, such as foreign direct investment (FDI) and portfolio equity flows, have been moving in sharply different directions in recent years. Yet models that don't account for the difference between these type of unhedged capital flows and the flows financed via retail bank debt issuance and corporate debt issuance (both of which are almost exclusively hedged and by definition do not create incremental demand for Australian dollars) are ignoring important information. As a consequence, we conclude that it is worth splitting out the three primary forms of unhedged capital flows into separate variables in our preferred model; FDI, portfolio equity flows and Eurobond flows. Each provide different impacts on the exchange rate per unit of change in capital, and each is currently on a different trajectory.

Our baseline Australian dollar exchange rate model is defined as;

$$\Delta RTWI_t = \alpha + \gamma(RTWI_{t-1} + \beta_1 ToT + \beta_2 MM_{t-1} + \beta_3 FDI_{t-1} + \beta_4 Portfolio_{t-1}) + SR\ Variables + \varepsilon_t$$

Where the long run equilibrium relationship for the real trade weighted index (RTWI) is modelled as a function of the terms of trade (ToT), our monetary model variable (MM), foreign direct investment (FDI), equity portfolio flows (Portfolio) and the net issuance of Eurobonds in Australian dollars (Eurobonds).

The model is estimated using quarterly data from 1994 to 2019, with the starting period corresponding to the commencement of the inflation targeting era for Australia. All variables in the long run equation are in logarithms and the coefficients can therefore be interpreted as elasticities. The long run model explains 91% of the quarterly variation in the RTWI in level terms, which compares to 88% for the RBA exchange rate model.

The rate at which the RTWI is expected to converge to this equilibrium is indicated by the speed-of-adjustment coefficient, γ, which is also known as the error correction coefficient. It is of interest that despite the differences between the RBA's model and Yarra's model, the speed of adjustment of both models to the estimated equilibrium exchange rate is similar. That is, both models suggest that exchange rate will converge to equilibrium in 18 months or less. The estimated value for γ is within the required range (between -1 to 0), is significant and the residuals are stationary. This indicates that a long-run cointegrated or equilibrium relationship has been identified.

The two models are also similar in the role played by the terms of trade. Under both models, the terms of trade variable is highly significant and a 1% rise in the terms of trade results in a 0.6% rise in the exchange rate. Moreover, recursive tests reveal that the coefficient on the terms of trade has remained stable over the past 15 years, albeit with some modest decline identified over the past two years. If the terms of trade sensitivity has remained broadly steady, yet the correlation with the terms of trade has recently turned negative, then it implies that over the past two years where the terms of trade have been trending higher that one or more variables have likely been pulling the exchange rate in the other direction.

Yarra's model differs from the RBA's model in a number of ways. In terms of the long run equilibrium variables the key differences are;

- Under the RBA's estimated model the interest rate differential variable is significant, albeit only weakly significant, yet its high estimated elasticity exerts significant influence over the path of the exchange rate. Under our framework we contend the monetary model is a theoretically superior variable. The monetary model variable is highly significant and its estimated coefficient has the expected positive sign. The logic supporting the monetary model variable is that periods of excess credit growth relative to economic growth are associated with higher returns/higher interest rates which result in currency appreciation.
- Positive net FDI flows result in an appreciation of the exchange rate. Although FDI flows are significant at the 10% level and the sensitivity of the equilibrium exchange rate to movements in FDI appears relatively small, it is important to note the FDI is expressed as a ratio of GDP and the accumulation of FDI flows has doubled over the past decade. As a consequence, FDI has added over 6 cents to the equilibrium exchange rate over during the past decade.
- An increase in net portfolio equity flows results in a rise of the Australian dollar. Although this may make intuitive sense to most portfolio managers, this is one of the most important findings of the model. Indeed, not only does the coefficient on portfolio equity flows have the correct sign, it is significant at the 1% level and the variable exerts a similar power over the exchange rate as the terms of trade and the monetary model variables. Consistent with our theory on hedged capital flows, portfolio debt flows were found to be insignificant. We believe the combination of a large and mature pension system with mandated domestic inflow, a large and outward looking sovereign wealth fund and a comparatively high historical home bias for domestic investors suggested significant diversification of equity capital abroad was somewhat inevitable. These factors have contributed to a large accumulation of equity portfolio investments offshore relative to foreign investors' accumulation of Australian equities. Since 2009 net portfolio outflow has increased by the equivalent of 9% of GDP.

Exhibit 11: Comparing Yarra's the RBA's exchange rate models

Baseline Real TWI model	Yarra Coefficient	RBA Coefficient
Variables		
Constant α		-0.41 (0.11)
Speed of adjustment Y	-0.16*** (0.07)	-0.22*** (0.05)
Equilibrium relationships		
Terms of Trade	0.53*** (0.04)	0.59*** (0.05)
Real Interest Rate Differential		1.62* (0.05)
Monetary Model	0.52*** (0.05)	
FDI flows	0.03** (0.02)	
Portfolio equity flows	0.49*** (0.02)	
Equilibrium model descriptive statistics		
Adjusted R^2	0.94	0.88
Short run relationships		
ΔTerms of Trade$_{t-1}$	-0.19*** (0.09)	-0.30*** (0.09)
ΔReal Interest Rate Differential$_{t-1}$		0.01** (0.01)
ΔCRB_t	0.25*** (0.05)	0.30*** (0.05)
ΔCRB_{t-1}		0.10*** (0.06)
$\Delta S\&P500_t$ / $\Delta ASX200_t$ (for RBA model $\Delta S\&P500_t$)	-0.12*** (0.06)	0.15*** (0.05)
ΔVIX_t		0.001* (0.0005)
$\Delta RTWI_{t-1}$		0.13* (0.09)
ΔPositioning$_t$	0.0007*** (0.0001)	
ΔPositioning$_{t-1}$	0.0003** (0.0001)	
ΔMM_{t-1}	0.17*** (0.07)	
ΔEurobond$_{t-1}$	2.76*** (1.06)	
Error correction model descriptive statistics		
Adjusted R^2	0.53	0.46
Durbin Watson Statistic	2.1	1.97

The equation is estimated by ordinary least squares using quarterly data; ***, ** and * denote significance at the 1, 5 and 10% levels, respectively; standard errors are reported in parentheses.

In terms of the short run exchange rate dynamics, Yarra's variables also have both similarities and differences to the RBA's model. Both models find a strong role for the lagged change in the terms of trade, and both models utilise the additional information of current period global commodity prices (represented by the widely used CRB index) to proxy the current period terms of trade. In this respect the estimated coefficients and significance levels are very similar.

Similarly, both models find a role for the current period equity price series, however, the RBA uses the S&P500 index whereas we use the S&P500 index and a ratio of the ASX200 index. Our preference of using the ratio of the S&P500 to the ASX200 is that the ratio has a direct relationship with the 'portfolio balance' framework (and hence it acts as a current period proxy for the change in the Portfolio variable from the long run equation). That is, if offshore markets are perceived as offering better future performance than the local market, then portfolio equity flows will move to offshore markets, which will increase and present downward pressure on the A$. In contrast, under the RBA's model a higher S&P500 reflects higher risk sentiment or improved global growth views which encourages speculators to buy the A$ as a proxy. From our perspective this effect is already captured in the RBA's model by their inclusion of the VIX index – essentially a measure of equity market risk – and via the inclusion of spot commodity prices.

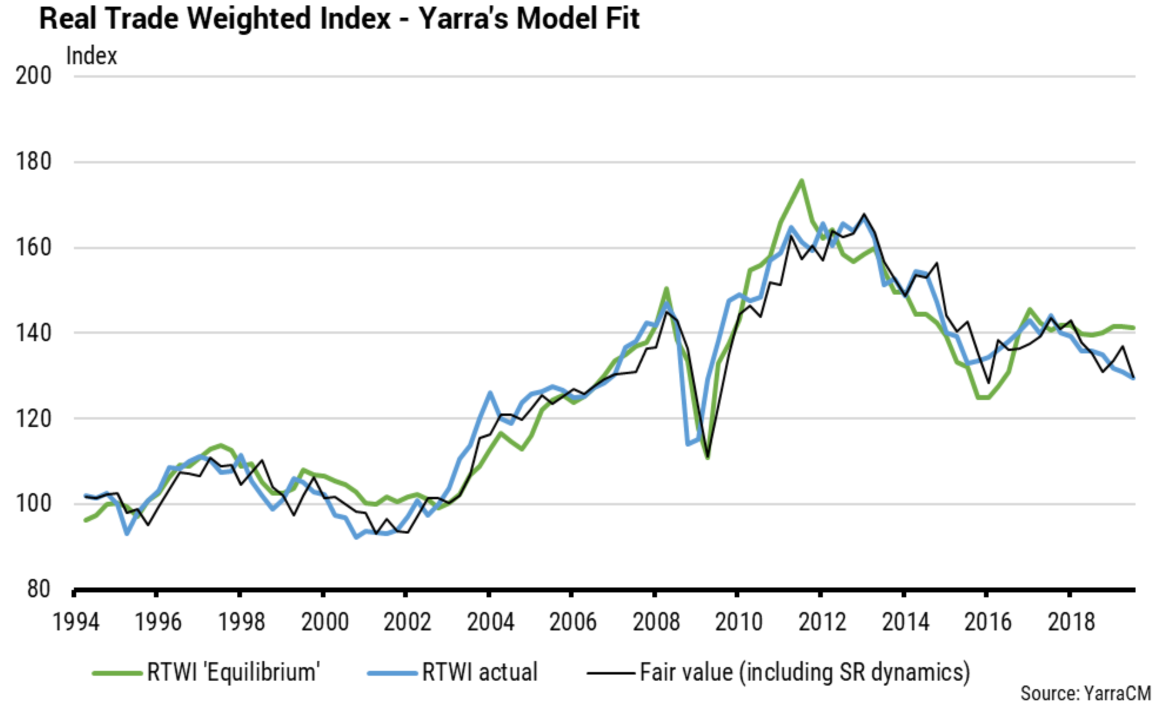
Nevertheless, we do believe that speculators play important role in short run exchange rate movements. However, we prefer to capture their role directly by including a variable for non-commercial positions in the Australian dollar (futures and options in A$ scaled by the level of open interest) as a variable in the model for which we find high significance for positions in the current quarter and the prior quarter.

Consistent with the literature on single equation error correction modelling lagged differences in the equilibrium variables are included and the monetary model variable is highly significant. An additional feature of the short run model is that the debt flow that we identify as being unhedged, the net issuance of Eurobonds, is found to be highly significant in the short run model. Note, the time series for Eurobond net issuance is stationary and therefore cannot enter the long run equation and can only enter via the short run equation.

In summary, we have presented an alternative exchange rate model with strong theoretical support which provides a better fit to the historical data compared to the RBA's model, but more importantly is designed to be sufficiently robust to deal with unconventional monetary policy and the implication of shifting patterns in global capital flows.

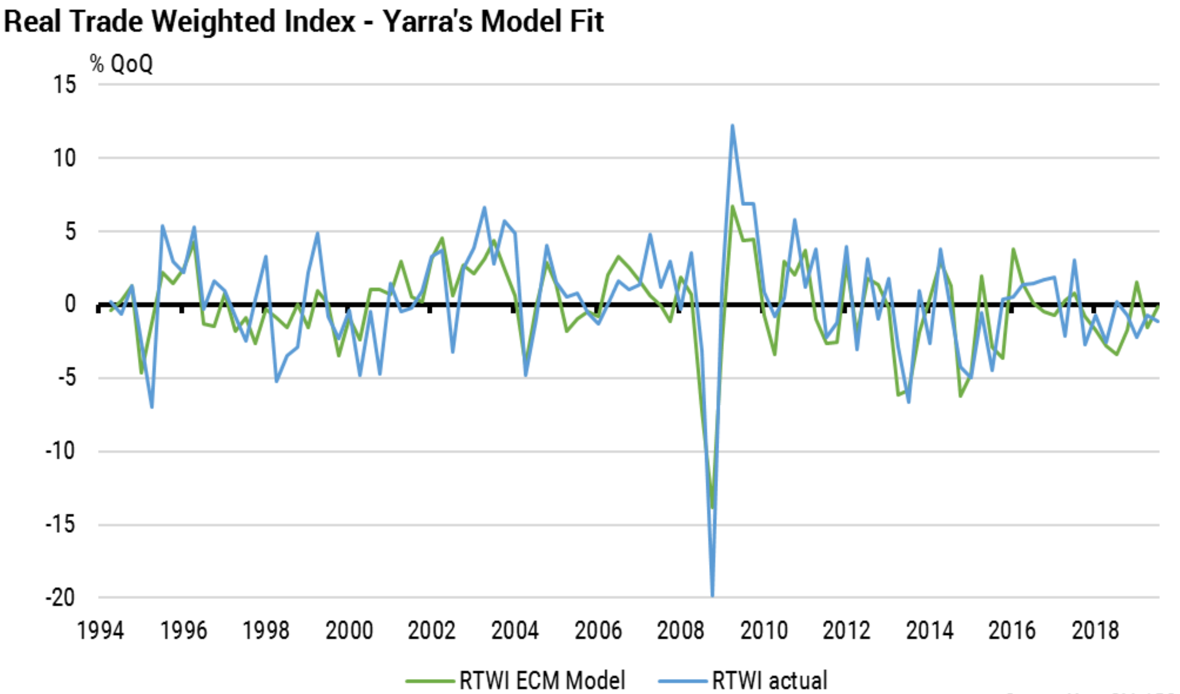
The fit of Yarra's long run equilibrium model and the full model (which includes the speed of adjustment variable and the short run dynamics) is shown in Exhibit 12 and the fit of the model in quarterly change terms is shown in Exhibit 13.

Exhibit 12: Long-run equilibrium and short run dynamics model fit



Source: YarraCM

Exhibit 13: Quarterly change in the exchange rate and error correction model fit

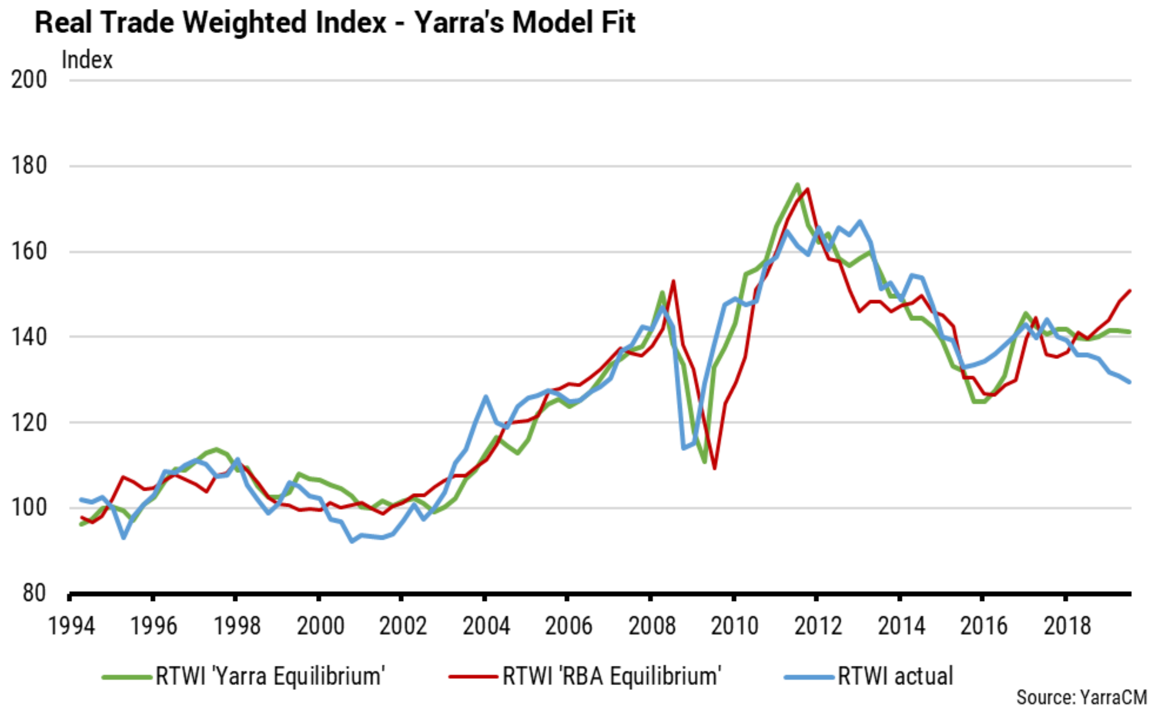


Source: YarraCM, ABS

In comparison to the RBA's model, Yarra's alternative equilibrium model also yields a very different conclusion as to where the equilibrium value of the exchange rate is at present. Yarra's model suggests that the exchange rate is currently 9% undervalued relative to its equilibrium value, which is a large gap by historical standards (specifically it is at the 90th percentile). Updating the RBA's model reveals a valuation gap of 13% below fair value (99th percentile and the equal largest valuation gap over the entire estimation period).

In other words, despite the very different specification between the RBA's and Yarra's models, both models suggest the A$ is significantly undervalued currently relative to their long run equilibrium values. The inference is that the Australian dollar could be expected to converge to the long run valuation in a little over 12 months, assuming short run factors remain unchanged.

Exhibit 14: The RBA's model's suggests the A$ should be even higher than Yarra's model

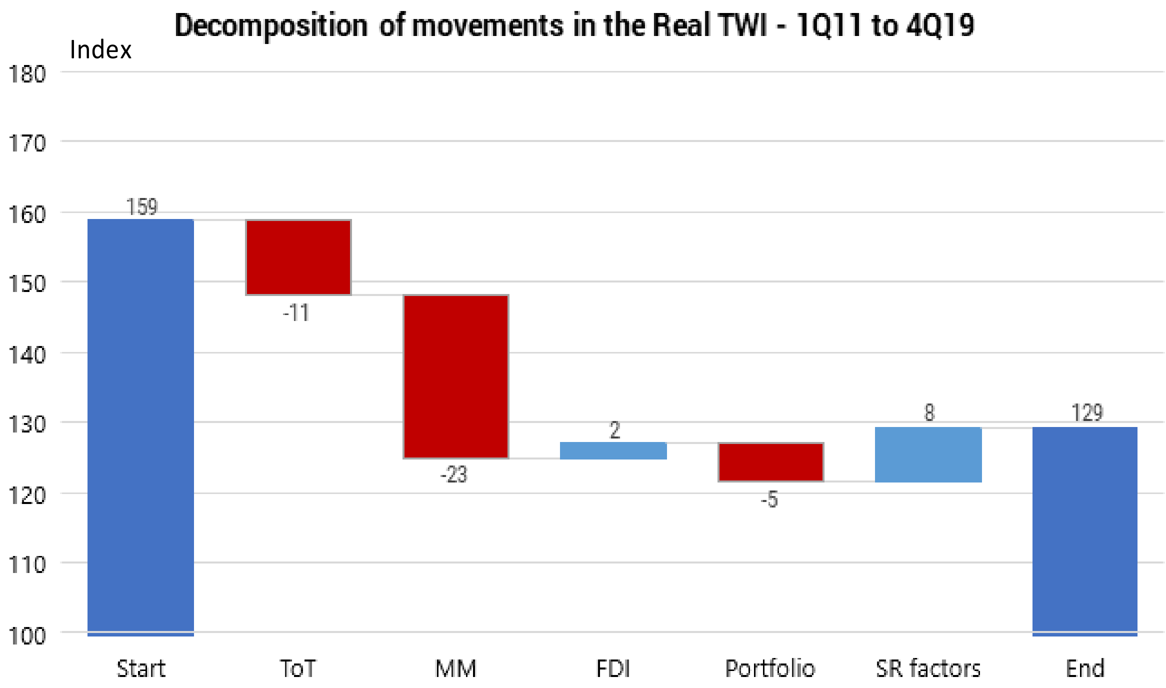


7. A decomposition of movements in the Australian dollar

In order to understand where the Australian dollar may go over the next 12 months, it is important to understand how important both the long run and short run forces have been in governing the Australian dollar over recent quarters.

Exhibit 15 provides a decomposition of Yarra's model over the period from 2011 to 2019, the period that covers the peak in the terms of trade and the weak credit / weak economic growth environment in Australia relative to its trading partners. Over this period the Real Trade Weighted Index declined 9.5% (and the A$/US$ fell by 33%).

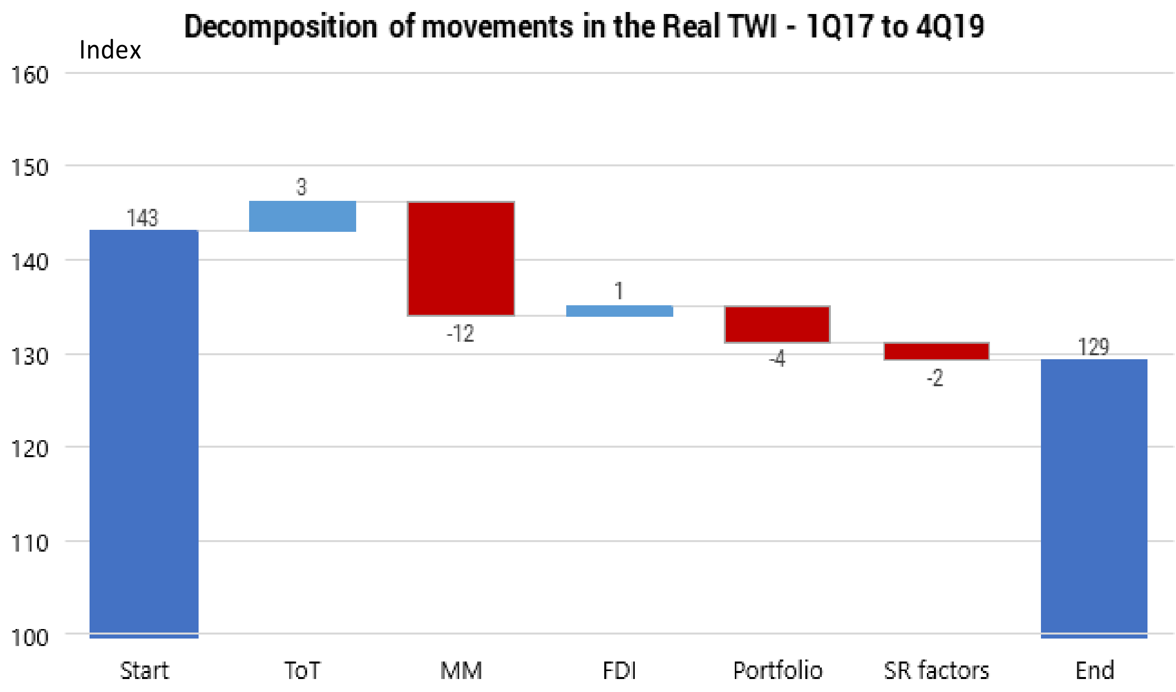
Exhibit 15: Since 2011 deleveraging was twice as important as commodity prices in driving A$ weakness



Source: YarraCM

Although the decline in the terms of trade was a significant contributor to the decline, the relative deleveraging of the Australian economy (weak economic growth, credit growth and declining interest rates) provided twice the impact upon the exchange rate. Ongoing FDI inflow provided modest support, however the outflow of portfolio equity capital proved to be a greater counterweight. Short run factors provided a significant offset over the period, however, much of this can be attributed to two factors; i) as can be seen in Exhibit 14, the trend decline in our long run valuation slightly predated the actual fall in the exchange rate – in essence the exchange rate was playing catch-up to the valuation shift and hence the 'speed of adjustment' variable was capturing this time delay; and ii) speculative positioning in the A$ moved from a net long position in 2011 to a large short through 2013, however during both 2014 and 2016-17 speculators moved significantly long the A$ and this provided a significant offset.

Exhibit 16: Since 2017 commodity price gains have been offset by equity portfolio outflow



Source: YarraCM

If we focus in on the past two years, the decomposition shows that the recent rise in the terms of trade was not ignored by financial markets. Instead, the positive contribution provided by the terms of trade has been completely offset by the acceleration in portfolio equity capital outflow. The relative deleveraging of the economy captured by the monetary variable continued to be the main down-weight on the exchange rate over the period. In terms of short run factors, the two dominate forces were a return to historically large levels of Australian dollar short interest by speculators and the relative outperformance of the S&P500 to the ASX200 (22% outperformance over 2017-2019).

Exhibit 16 also provides some guidance in thinking about what happens next with the Australian dollar.

- Fears that the conclusion of Australian LNG investment surge and a potential decline in FDI will drive the Australian dollar sharply lower are misplaced. FDI is a significant variable in our long run model, however, even large movement in FDI has low impact empirically on the Australian dollar.
- The sharp recovery in house and financial asset prices in 2H11, in concert with a sharp recovery in M1 credit growth in concert with improving leading indicators for the Australian economy, suggests that the monetary model will turn incrementally positive for the A$ in coming quarters.
- A recent upturn in global leading indicators is important on several fronts. Firstly, it should support commodity prices. Secondly, it will encourage capital flows into emerging markets and hence US$ weakness. Thirdly, a broader based economic recovery may limit US equity market relative outperformance, which under our model is A$ supportive. Finally, a more positive global outlook would encourage the removal of A$ speculative short positions.

8. Scenario analysis

While the model's historical fit is high, model based predictions are obviously highly dependent upon the assumptions used for the explanatory variables in the forecast horizon. In this section we present three scenarios: our base case, a high case and a low case. The broad assumptions used under each scenario are:

Base case:

- Global cyclical recovery continues at a solid pace through 2020 towards a cycle average pace for the industrial cycle. Emerging market equities to outperform the S&P500.
- Iron ore stabilises close to spot, then declines in 2021-22. Base metals rise 10-15%.
- After a weak 1Q2020, Australia's economic growth divergence to the US closes through the remainder of 2020.
- RBA leaves interest rates unchanged in 2020-21. Australian credit growth enjoys a modest recovery in 2020-21.
- Net portfolio equity outflow continues but at a moderating pace.
- Speculative short positions are reduced to a neutral setting.

High case:

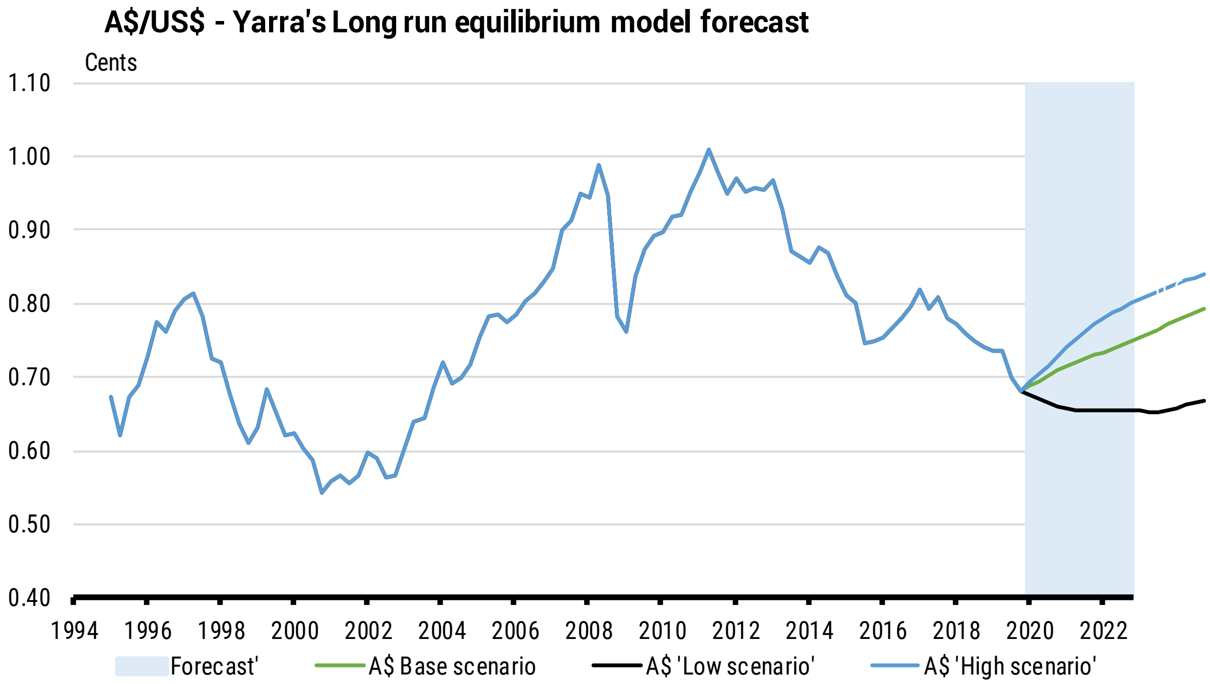
- Global economic recovery surprises to the upside supported by China monetary stimulus, excessive liquidity support from central banks and incremental fiscal support. Largest economic recovery comes via Asia, core-Europe and Japan.
- Iron ore, copper and oil enter deficit. Australia terms of trade rises 6%. Mining companies rally.
- Global portfolio managers cut underweight Australia equity positions. Australia receives portfolio equity inflow.
- RBA flags the end of the easing cycle. Federal government pulls forward income tax cuts.
- Speculative long positions move back to the top of their historical range.

Low case:

- Global growth recovery falters and industrial business surveys retrace towards cycle low.
- Commodity prices falters on renewed Brazilian supply of iron ore, falling spot LNG as US supply ramps up and an acceleration in the shift from coal from trading partners. Terms of trade falls 3%.
- Australia suffers from falling tourist inflow, ongoing weak consumer confidence, and delayed fiscal response.
- RBA cuts policy rate to 25bps and commences QE by 1H2021.
- Net portfolio equity outflow continues at the same pace at the 2017-2019 period.
- Speculative short positions are established.

In the interest of ease of interpretation, the model is converted to a A$/US$ specification. The model's prediction under each of the three scenarios is shown in Exhibit 17. Given an almost infinite combination of values for the explanatory variables, it is possible to generate many different forecast paths for the Australian dollar. However, we believe the three scenarios chosen are internally consistent combinations with the "high" and the "low" case marking the boundaries of plausible outcomes.

Exhibit 17: Our base case suggests A$/US$ will rise to 73c by end-2020. Downside risks are contained



Source: YarraCM

It is notable that the scenarios reveal greater upside risk than downside risk to the Australian dollar. Moreover, in assigning probabilities to each scenario the likelihood of the A$/US$ moving through the bottom of our forecast for the low scenario is relatively low, whereas the likelihood of the A$/US$ surpassing our base scenario has increased on the increasing evidence of a trough having been reached in the global industrial cycle. As such, the prospects for the Australian dollar are currently demonstrating asymmetric risk to the upside. Our base case scenario is that the A$/US$ will rise to 73c by end-2020.

Conclusion

Yarra's exchange rate model suggests that the 'monetary model' of the exchange rate is a superior variable to models based on relative interest rates, and that unhedged capital flows can be formally captured within a 'portfolio rebalancing' framework. This framework both enhances the model's statistical fit and provides a richer specification that allows us to work through the implications of shifts in capital flows and the modern era of unconventional monetary policy.

The model's advantage is twofold. Firstly, it includes the three key components of monetary theory – uncovered interest rate parity (UIP), purchasing power parity (PPP) and money market equilibrium (MME) – and thereby provides a more holistic approach than UIP-based exchange rate models. Secondly, it provides a platform to simulate unconventional monetary policy scenarios and the resulting implications on capital flows.

It is notable that the alternate plausible scenarios reveal greater upside risk than downside risk to the A$. Moreover, in assigning probabilities to each scenario, the likelihood of the A$/US$ moving through the bottom of our forecast for the low scenario is relatively low, whereas the likelihood of the A$/US$ surpassing our base scenario has increased on the increasing evidence that a trough has been reached in the global industrial cycle. As such, the prospects for the A$ are currently demonstrating asymmetric risk to the upside.

Appendix A – Tests of interest parity and speculative efficiency

Covered interest parity

If foreign exchange markets are operating efficiently, then the returns over k periods on similar domestic and foreign assets should be equalised by arbitrage i.e. covered interest parity (CIP) will hold:

$$(1+i)_t = \left[(1+i^*)\frac{S_t}{F_{t,t+k}}\right] \qquad A1$$

where i is the interest rate on the domestic asset, i* is the interest rate on the foreign asset, S is the spot exchange rate (foreign currency per units of domestic currency, so an increase in S is an appreciation of the domestic currency) and $F_{t,t+k}$ is the forward exchange rate at time t for maturity k periods ahead. Equation (A1) assumes no transactions costs and no default or political risk (e.g. the imposition of capital controls) for either asset. A linear approximation of equation (A1) can be found by taking logs of both sides:

$$(f_{t,t+k} - s_t) = [(i^* - i)_t] \qquad A2$$

where $f_{t,t+k}$and s_t are the logs of the forward rate and spot rate, respectively. Thus CIP is the condition that the forward premium, in each period is equal to the interest rate differential. Covered interest parity is tested for by estimating the following regression equation:

$$(f_{t,t+k} - s_t) = \alpha + \beta[(i^* - i)_t] + \varepsilon_t \qquad A3$$

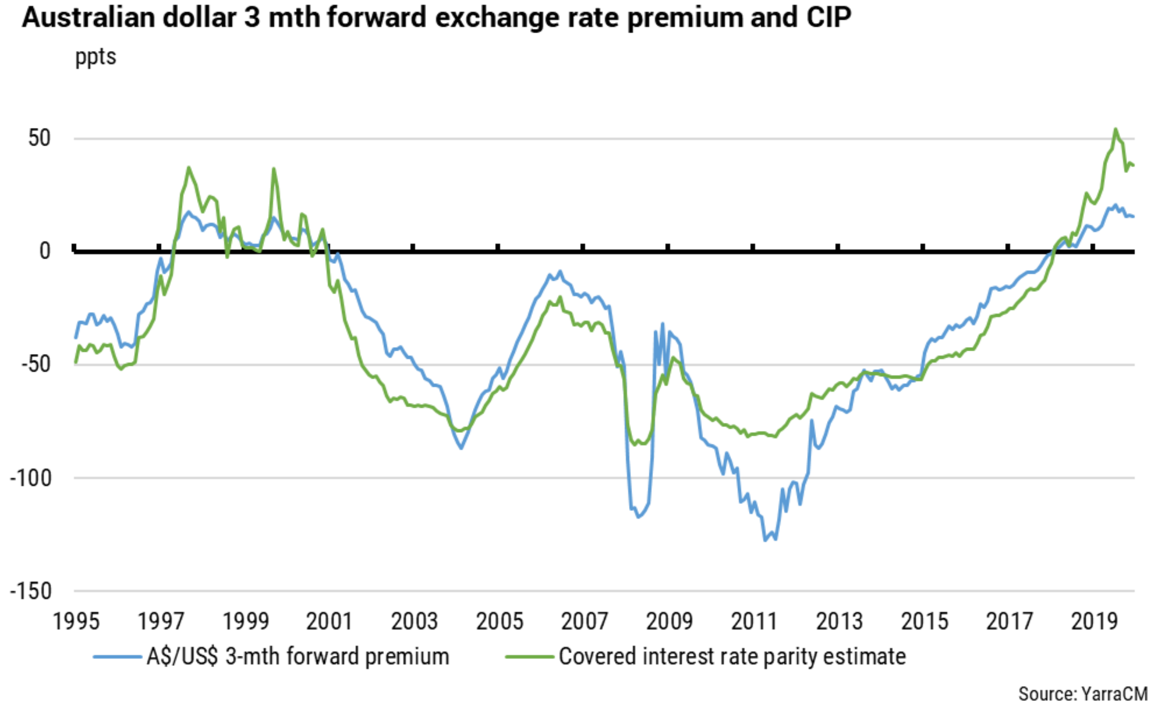
Where ε_t is an independently and identically distributed random error. The test for CIP is that a = 0 and b = 1. This equation was estimated with the US$/A$ exchange rate, the 90-day bill for Australia and the three-month libor rate for the US, using monthly data over the period 1994M1 to 2019M12, with the following result:

$$(f_{t,t+k} - s_t) = 0.0038 + 0.9968[(i^* - i)_t] + \varepsilon_t \qquad A4$$

(0.001) (0.0008)

R^2 = 0.83 SE = 0.000785 Chi^2(a = 0, b = 1) = 2803 where standard errors are in parentheses below the estimated coefficients. Although a is close to zero and b is close to one, the standard errors are sufficiently high that on strict statistical grounds, CIP is rejected by the data: the joint test that a = 0, b = 1 is rejected at a significance level of less than 1%. This rejection possibly reflects transactions costs or measurement error. In any case, the economic (as distinct from statistical) departure from CIP appears to be very small.

Exhibit A1: Covered interest parity holds in an 'economic' sense, although fails its statistical test



Uncovered interest parity (UIP)

Under the hypothesis of uncovered interest parity the interest differential between a foreign and domestic asset each with k periods to maturity should be equal to the expected appreciation of the domestic currency over the k periods, provided agents in the foreign exchange market are risk neutral and so do not demand a premium on the foreign asset's return, which is subject to currency risk.

UIP can thus be written as:

$$[(i^* - i)_t] = (s^e_{t,t+k} - s_t) \qquad A5$$

where the right-hand side is the expectation, held at time t, of the percentage change in the exchange rate over the next k periods. Under the assumption of rational expectations, the exchange rate expected in k periods time is equal to the exchange rate that is actually realised, plus a random error whose average value is zero:

$$s^e_{t,t+k} = s_{t+k} + \varepsilon_{t+k} \qquad A6$$

Assuming both rational expectations and risk neutrality, the test for UIP is that a = 0 and b = 1 in the regression equation:

$$s_{t+k-}s_t \ = \alpha + \beta[(i^* - i)_t] + \varepsilon_t \qquad A7$$

where k=3, and which was estimated over the period 1995M1 to 2019M12 with the following results:

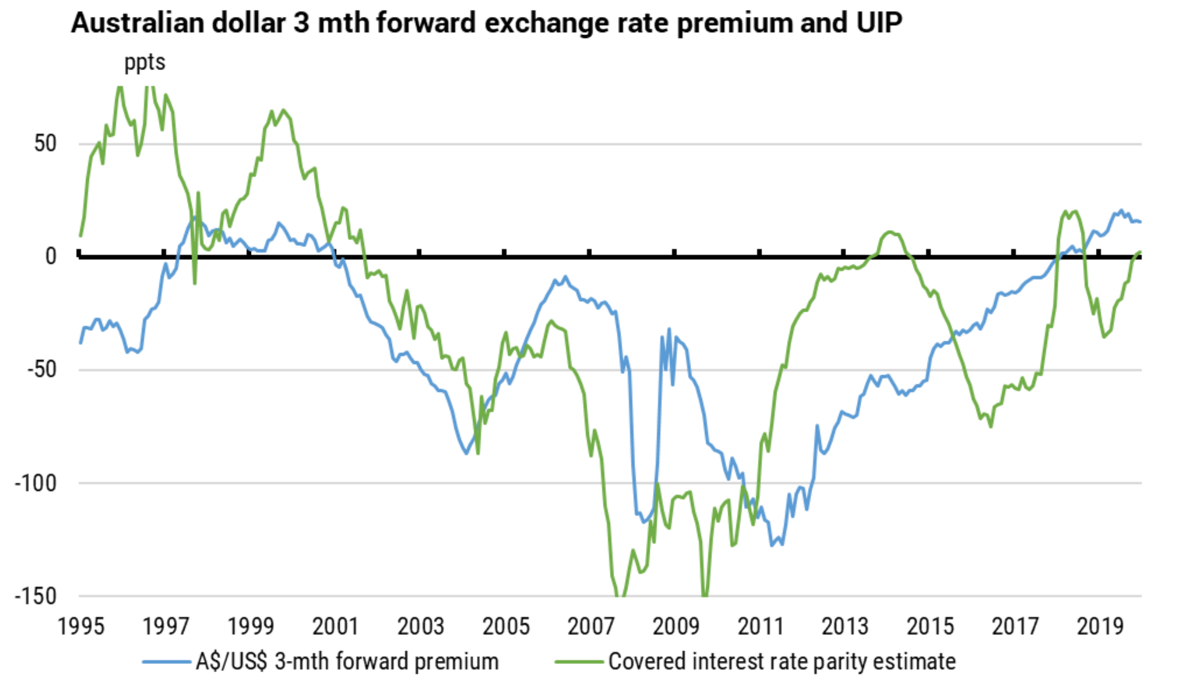
$$s_{t+k-}s_t \ = 0.0028 + 1.0028[(i^* - i)_t] + \varepsilon_t \qquad A8$$

(0.0029) (0.0018)

R^2 = 0.01 SE = 0.0228 Chi^2(a = 0, b = 1) = 13633 where standard errors are in parentheses below the estimated coefficients.

The hypothesis of UIP is rejected at the 1% level, a result which is commonplace in the literature on testing for uncovered interest parity. RBA researchers have previously noted that no economic hypothesis has been rejected more decisively, over more time periods, and for more countries, than UIP. Moreover, we find that explanatory power of UIP estimates post 2007 have deteriorated materially. Since equation (A7) embodies two assumptions, rational expectations and risk neutrality, it is difficult to determine which of these maintained hypotheses is being rejected when UIP is rejected. Many researchers interpret rejection of UIP as evidence of a time-varying risk premium, while still maintaining the assumption of rational expectations. However, as the risk premium is then typically defined to be the deviation from UIP, this interpretation is problematic.

Exhibit A2: UIP failed to hold statistically prior to the financial crisis, and this has worsened since 2008



Source: YarraCM

Speculative efficiency

If covered interest parity is assumed to hold, uncovered interest parity can be rewritten as:

$$s_{t+k-}s_t \;= \alpha + \beta\big[(f_{t,t+k} - s_t)\big] + \varepsilon_t \qquad A9$$

If a=0 and b=1, the forward premium is an unbiased predictor of the expected appreciation of the exchange rate, provided, once again, that agents hold rational expectations and are risk neutral.

Equation (A9) was estimated over the period 1995M1 to 2019M12 with the following results:

$$s_{t+k-}s_t \;= 0.0547 + 0.9610\big[(f_{t,t+k} - s_t)\big] + \varepsilon_t \qquad A10$$

(0.3140) (0.4548)

R^2 = 0.001 SE = 0.0471 Chi^2(a = 0, b = 1) = 7.889

If we were to take the view that CIP holds, then in theory the estimated coefficients from A9 should be similar to those of the UIP regression, however, this fails to be the case. The null hypothesis of speculative efficiency is clearly rejected.

Summary

The finding that covered interest rate parity fails in an empirical sense is of less concern in the context that both a and b are very close to their theoretical values and the model fit is high. However, the failure of both UIP and its close cousin speculative efficiency suggest that the empirical failure of CIP is at least a contributory factor to their failure. While transaction costs, measurement error and time varying risk premia are often cited as reasons for failure of UIP we believe that UIP is just one part of the machinery of the monetary model of the exchange rate. The monetary model was designed to estimate jointly, not as individual components.

Appendix B highlights the algebraic derivation of the monetary model.

Appendix B – Derivation of the monetary model

The standard building block of international finance over the past 30 years has been the monetary model of the exchange rate. It begins with the proposition that if the exchange rate is the relative price of foreign and domestic money, it should be determined by the relative supply and demand for that money. The typical model stems from three equations. The first is money market equilibrium

$$m_t - p_t = \beta y_t + \alpha i_t + \epsilon_t \qquad B1$$

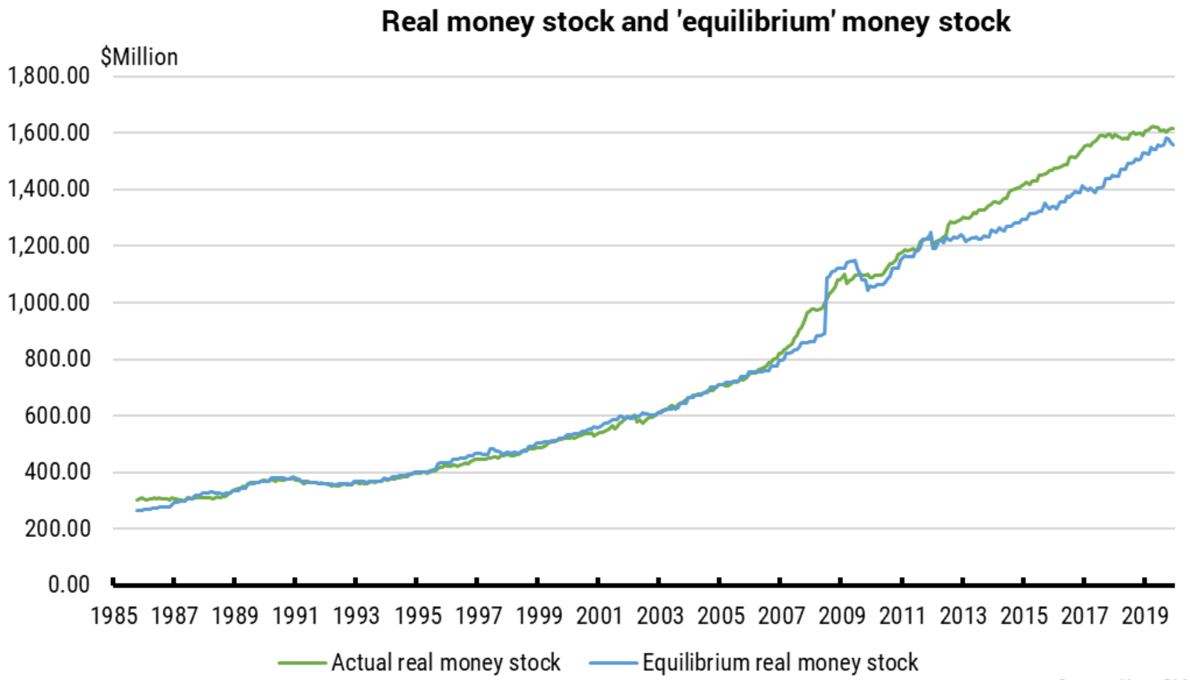
where m denotes the log of the stock of money; p denotes the log of the price level; y denotes the log of real income; and i denotes the log of the nominal interest rate. That is, the real money supply is a function of income and the price of money. In this version of the model we have used the CPI as the deflator for nominal money supply. It is worth noting that at present the conclusions from the monetary model are not materially altered by substituting in economy-wide deflators such as the GDP deflator. Estimated for Australia over the 1991-2019 period using quarterly data we find that money market equilibrium yields:

$$m_t - p_t = 1.70 y_t + 0.216 i_t + \epsilon_t \qquad B2$$

(0.0207) (0.0139)

R^2=0.99 SE=0.042

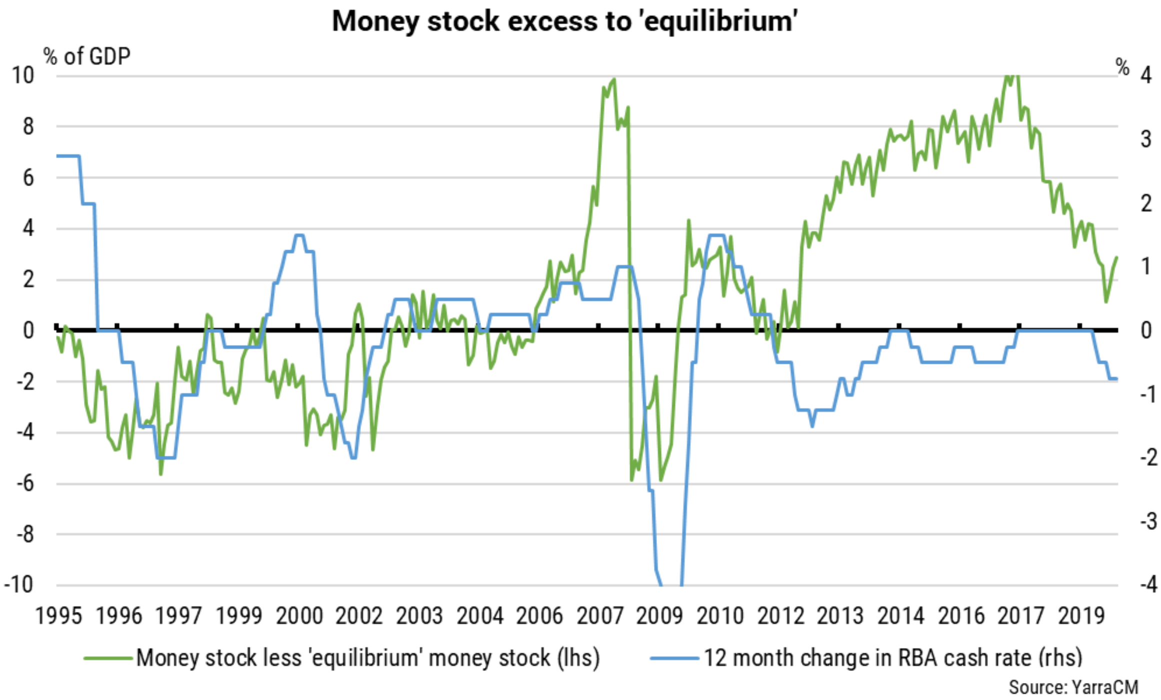
Exhibit B1: Post the financial crisis real economic growth undershot real money supply growth



Source: YarraCM

While this is a very high fit in level terms, the implications of money market equilibrium can be better seen by charting the gap between the estimated equilibrium value for the real money supply and the actual real money supply. As shown to the right, real money supply is currently at a rate of growth inconsistent with stable interest rates least an extended period of weak output growth is desired by policy makers. From this perspective the RBA has commenced an easing cycle, however, the model indicates that further cash rate easing would be required to bring the real money supply back towards equilibrium.

Exhibit B2: During the deleveraging phase post 2008, economic growth became less sensitive to falling interest rates

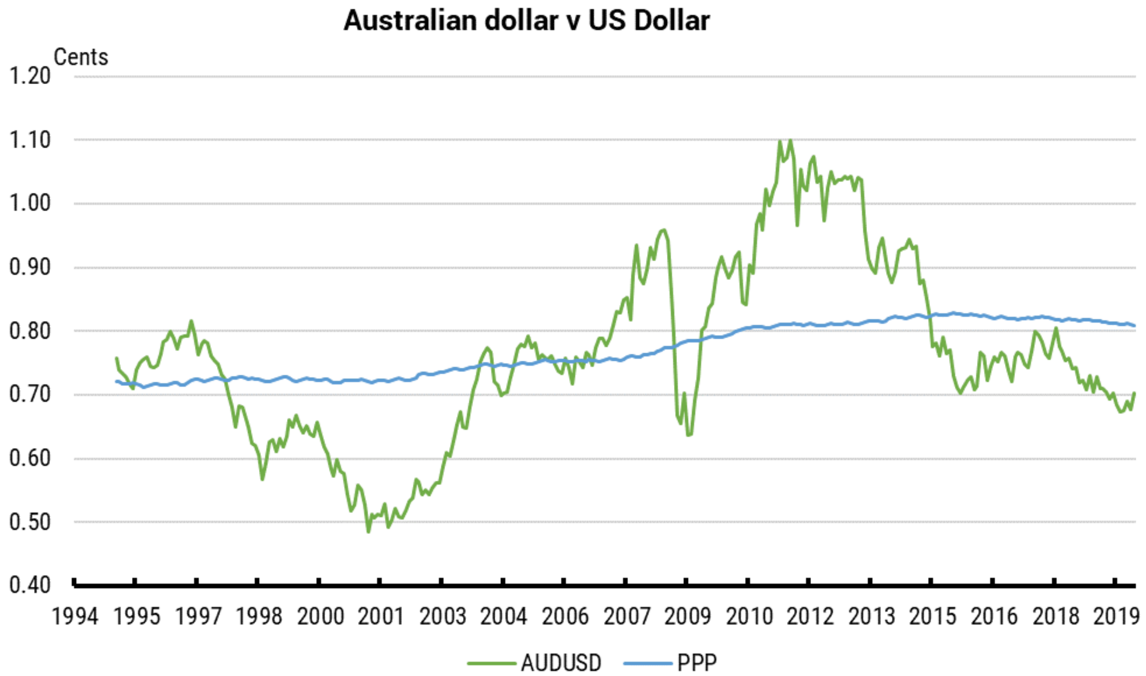


The second equation is purchasing power parity (PPP):

$$(p - p^*)_t = e_t + \omega_t \qquad B3$$

where p* is foreign prices, e is the spot exchange rate and ω_t is an error term. In this 'absolute' form of PPP the exchange rate is determined by relative prices of domestic and foreign goods. A simple model of purchasing power parity using this specification finds that PPP can explain 22% of the quarterly variation in the level of the A$/US$ and that the level of PPP has crept up over the past decade from the low 70 cent mark to just above 80 cents currently.

Exhibit B3: The A$ remains significantly undervalued relative to Purchasing Power Parity



Source: YarraCM

The third equation is a modified form of uncovered interest rate parity (UIP) discussed in the previous section:

$$(i - i^*)_t - \rho_t = E[e_{t+1} - e_t] \qquad B4$$

where E_t denotes the expectations operator conditional on information available at time t, i* is foreign interest rates and ρt is a possible risk premium. That is, the interest rate differential will equal the expected depreciation of the exchange rate plus a risk premium. From these three equations it can easily be shown that the simple flexible price monetary 'fundamental' model can be defined as:

$$f_t = (m - m^*)_t - \beta(y - y^*)_t - (\epsilon - \epsilon^*)_t - \omega_t - \rho_t \quad B5$$

and the exchange rate equation can be defined as:

$$e_t = f_t - \alpha E[e_{t+1} - e_t] \qquad B6$$

taking expectations, holding the risk premium constant and substituting back into the PPP condition gives:

$$e_t = (m - m^*)_t - (p - p^*)_t - \beta(y - y^*)_t \qquad B7$$

That is, the exchange rate will equal the ratio of domestic real money balances to foreign real money balances divided by the ratio of domestic and foreign real output. We denote this variable MM and included it as a key long run variable in our exchange rate model. That is for the A$/US$ version of the monetary model is:

$$MM = \frac{Money_{Aus}/Money_{MTP}}{GDP_{Aus}/GDP_{MTP}} \qquad B8$$

The empirical evidence in support of the monetary model had historically been particularly poor, except during periods of hyperinflation. However, in response to positive findings in support of PPP during the mid-1990s, the monetary model has been given a new lease of life. In particular, Mark and Sul found a long run relationship between the exchange rate and monetary fundamentals across a range of countries including Australia. Mark and Sul found monetary variables demonstrated notable explanatory power and assisted in out-performing the random walk model. While our use of the monetary model in modelling the Australian dollar was independently uncovered at the same time of the publication of Mark and Sul's research, their analysis relied on a different estimation approach, did not converge to a long run model in a manner that resolves Rogoff's PPP puzzle and did not specify a model that incorporated capital flow variables consistent with the portfolio balance theory of exchange rate determination. Estimating the monetary model using quarterly data since 1994 we find:

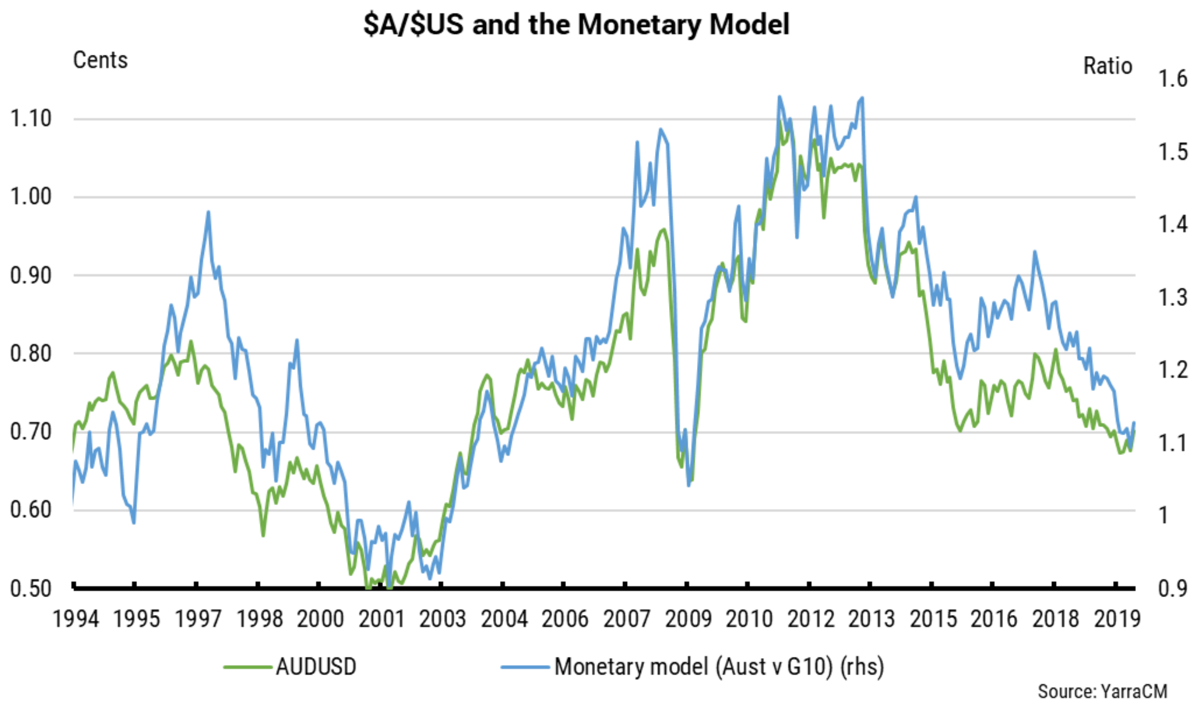
$$e_t = -0.504 + 1.152mm_t + \epsilon_t \qquad B9$$

(0.0066) (0.0290)

R^2 = 0.80 SE = 0.07328

The monetary model has high explanatory power, incorporates the central tenets of UIP and PPP while bypassing their statistical weakness and is a 'deep' variable in that it is capable of dealing with evolving monetary regimes, structural change and shifting trends in productivity via its focus on relative money supply and relative output growth.

Exhibit B4: Relative growth in money and economic growth provides A$ signal



1 Mark. N., Sul. D. "Nominal exchange rates and monetary fundamentals: Evidence from a small post-Bretton Woods panel". (2001) Journal of International Economics Vol. 53.

Appendix C – Australian dollar stylised facts

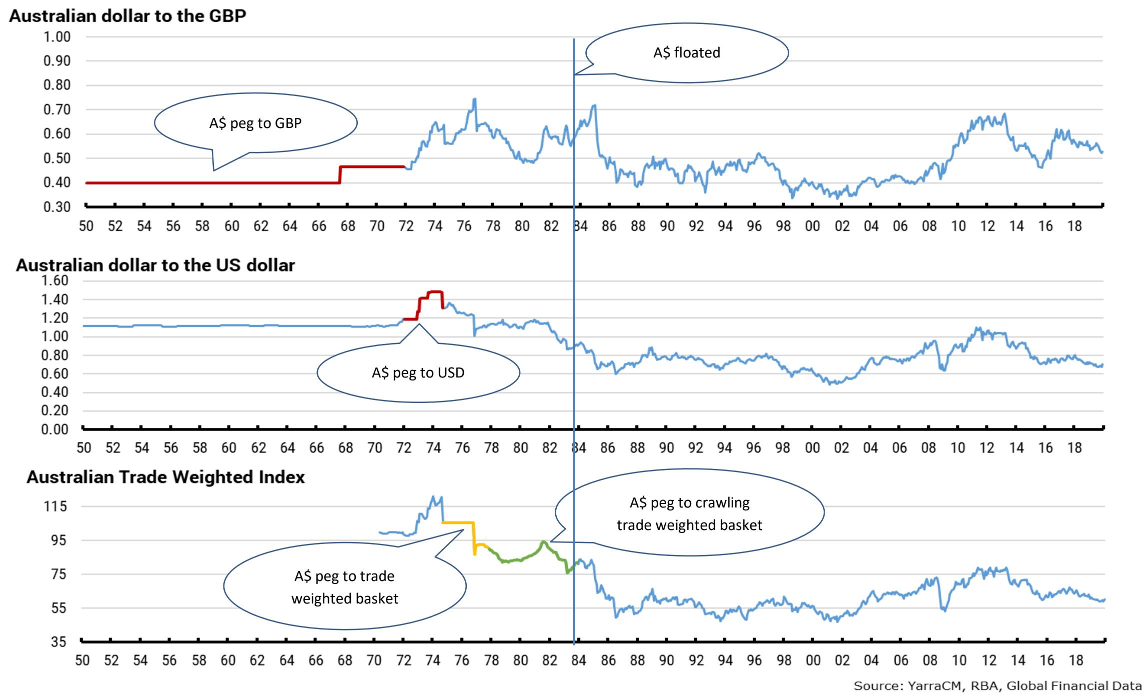
Monetary control, capital flows and currency flexibility

Although the Australian Treasurer in 1983, Paul Keating, is often credited with the decision to float the Australian dollar as part of a broader deregulation agenda, in reality the floating of the A$ on 9 December 1983 was the final step in a long process which commenced in the mid-1960s. The earlier advocates for the floating of the A$ could be traced to the mid-1960's to successive heads of the RBA's research departments. The lobbying led to multiple government and Reserve Bank Inquiries and eventually RBA Governor Bob Johnston reversed the position of his predecessor, Harry Knight, and advocated strongly for a managed float of the Australian dollar.

The path from a fixed exchange rate to a freely floating exchange rate was bumpy ride. Indeed, Australia appeared determine to try virtually all other alternatives first before finely deciding on the decision to float. From September 1949 to December 1971 the value of the Australian currency was pegged against sterling and remained almost completely stable against the US dollar and gold during that period. It was then revalued against the US$ and pegged to that currency, breaking a link to the sterling that had existed since 1931. The A$ was revalued again in December 1972, in February 1973 and once more in August 1973. In September 1974, it was devalued against the US$ and pegged to a trade-weighted index (TWI). It was devalued again in November 1976.

Exhibit C1: The path from fixed peg, to a fixed basket, to crawling basket, to a floating exchange rate

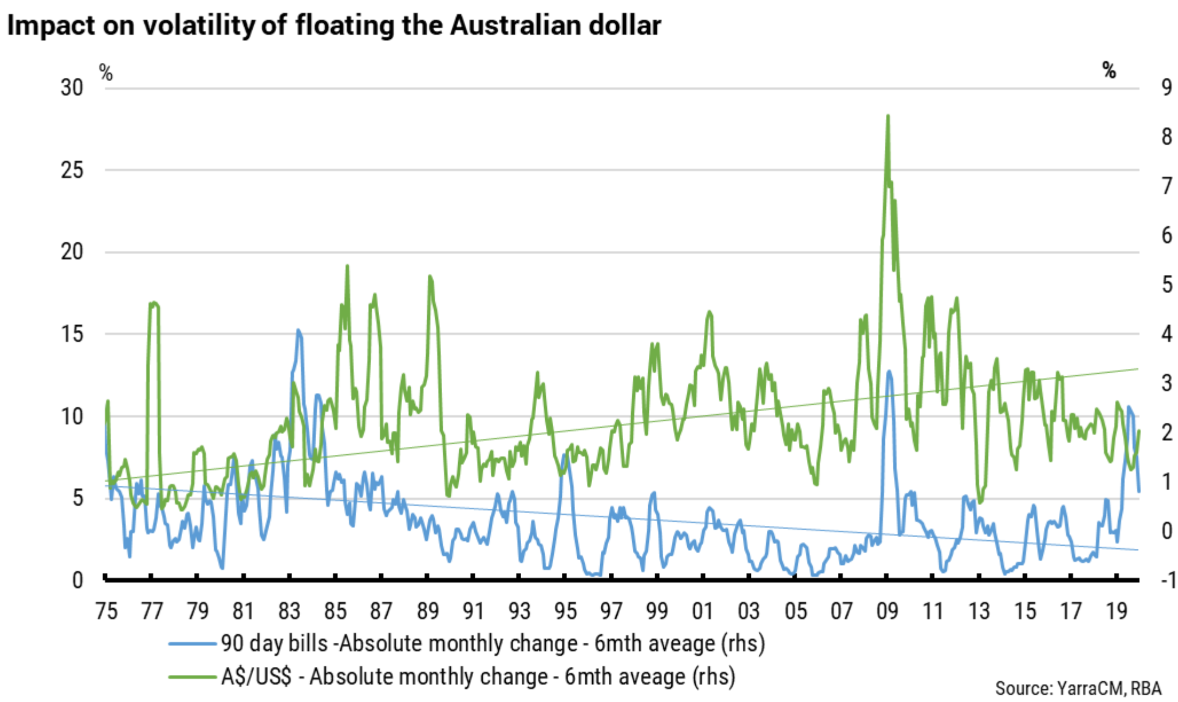
The evolution of Australia's exchange rate regime



These changes in the value of the A$ were the result of discrete adjustments made by the government with the exchange rate being used as a policy instrument to achieve the goals of internal (economic growth and inflation) or external (a targeted current account) balance. At times, the conflict between those goals was the very catalyst forcing change in the exchange rate regime. The final iteration prior to the float was in November 1976, when a crawling peg arrangement was adopted. Even at this time the then Prime Minister Malcom Fraser expressed interest in floating the exchange rate.

The main problem with the fixed exchange rate regimes through the 1970s was as financial markets were becoming increasingly sophisticated and integrated into world markets, each recalibration of the peg led to large speculative flows of capital. These large and volatile international capital flows made it difficult for the authorities to control domestic monetary conditions and hence policy makers had trouble meeting their objectives. The eventual decision to float the currency was not so much a moment of genius by a new young Treasurer, but the eventual recognition after years of evidence that in the face of large inflows of capital the authorities were losing monetary control.

Exhibit C2: The floating of the A$ did result in lower interest rate volatility



The point of this brief rendering of the history of the exchange rate regimes in Australia is to stress the principal factors behind the decision to float the A$ was the authorities' recognition of the important linkage between monetary stability and capital flows. By floating the currency the authorities reclaimed the prize of controlling monetary and price stability. However, by definition this meant the Australian dollar would forever more be hostage to the ebb and flow of global capital.

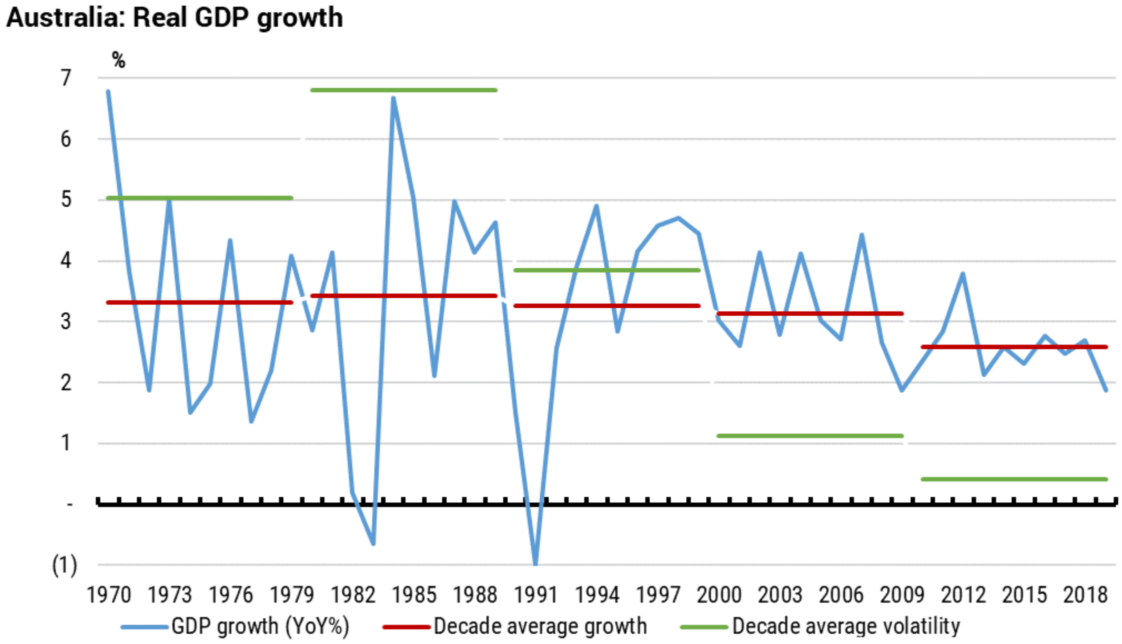
The decision to float the Australian dollar may have been slow in coming, however, its impact upon the Australian economy has been profound.

- In the post-float era the volatility of the exchange rate has naturally increased, but importantly the volatility of short term interest rates has declined. More importantly, the volatility of credit growth relative to volatility of economic growth has declined by two-thirds since the float of the A$. This re-tethering of economic growth to monetary growth re-empowered the central bank's ability to deliver effective counter-cyclical policy.
- The variability of the Australia dollar added a new tool in the policy makers' toolkit and, in concert with deepening capital markets and the loosening of capital controls, amplified the impact of the equity, corporate bond and longer dated fixed interest markets in determining overall monetary conditions. The

decision to float the dollar and open up the economy to global capital flows was by default a decision to modernise the Australian financial system.

- Quite apart from improving the operation and sophistication of monetary policy, the floating of the A$ enabled divergent trends in Australia's fundamentals relative to global fundamentals (e.g. relative productivity growth or wage rates) to be reflected in movements in the 'real exchange rate'. The ability for the exchange rate to gradually adjust to trend differences in the real economy relative to Australia's trading partners has likely been a key factor in lowering interest rate volatility.
- The floating of the Australian dollar was not the only, nor was it the most difficult, economic reform in Australia since the early 1980s. Nevertheless, it was almost certainly the most important. It was a main contributor to maintaining Australia's impressive long run average rate of economic growth in recent decades while dramatically lowering the volatility of that economic growth.

Exhibit C3: The floating of the A$ also contributed to lower economic growth volatility



Source: YarraCM, ABS

The Australian dollar's role in global capital markets

In the early 1980s the participants in the Australian foreign exchange market were mostly the domestic commercial banks. The Australian dollar's share of the global FX turnover was less than 1%. Post the float the combination of increased competition, new hedging products, technological developments and the introduction of a number of foreign banks being granted licences saw the market for Australian dollars develop quickly. The A$ is now one of the most actively traded currencies globally. Specifically;

- Global daily turnover for Australian dollars was $447 billion in 2019, accounting for 7% of global foreign exchange turnover. Compared to the US dollar (88% share), the Euro (32% share) or Yen (13% share), this is a relatively small number but compared with currencies of other countries whose economies are noticeably larger than Australia's the size of the A$ market is remarkably large. For instance, the Canadian dollar has a 5% share of global turnover and the Chinese Yuan has just a 2% share.

- The AUD/USD currency pair is the fourth most traded currency in the world (representing 5.4% of all transactions). This compares with 24% of all transactions for the EUR/USD, 13% for USD/JPY and 10% for USD/GBP.
- The A$ has a higher weighting to spot trading and shorter term swaps compared to other major currencies, nevertheless, the use of hedging and forward contracts is widely utilised. Transactions at the spot rate represent 38% of transactions, 12% are outright forwards, 42% are FX swaps (<1 year contracts), 3% are currency swaps (>1 year contracts) and 3% of transactions are FX options.
- Currently 51% of all Australian dollar transactions are done by non-local dealers in offshore markets. Hedge funds represent a sizeable 19% of all transactions in Australian dollars, compared to 11-13% for other major currencies.
- The A$ represented US$183bn in central bank official foreign exchange reserves at the end of 2019. This represented 1.7% of allocated reserves globally, similar in size to the holding in Canadian dollars at 1.96% and Chinese Renminbi at 2.0%. Despite widespread speculation over the past decade that FX managers would diversify holding away from US dollars, the reality is that the USD share of global FX reserves has remained steady within the 60-70% range since the 1980s. Instead, it has been a reduction in FX reserves held in Euro over the past decade from 28% to 20% that has seen the most significant shift. In contrast, the share of Australian dollars in FX reserves has remained constant over the past five years, suggesting FX managers still value the diversification benefits of the A$.[3]

In summary, compared to the early 1980s, the market for Australian dollars is currently large, liquid, sophisticated, internationalised and currently plays an important role in global investment portfolios.

Foreign exchange average daily turnover – 2019

Currency	% Share	Rank
USD	88.3	1
EUR	32.3	2
JPY	16.8	3
GBP	12.8	4
AUD	6.8	5
CAD	5.0	6
CHF	5.0	7
CNY	4.3	8
HKD	3.5	9
NZD	2.1	10
SEK	2.0	11

Source: BIS

[3] The IMF Currency Composition of Official Foreign Exchange Reserves (COFER) commenced separately identifying A$ holdings from March quarter 2013.

Disclaimer

This material is distributed by Yarra Funds Management Limited ABN 63 005 885 567, AFSL 230251. This document may not be reproduced or distributed to any person without the prior consent of Yarra Funds Management Limited. The information set out has been prepared in good faith and while Yarra Funds Management Limited and its related bodies corporate (together, the "Yarra Capital Management Group") reasonably believe the information and opinions to be current, accurate, or reasonably held at the time of publication, to the maximum extent permitted by law, the Yarra Capital Management Group: (a) makes no warranty as to the content's accuracy or reliability; and (b) accepts no liability for any direct or indirect loss or damage arising from any errors, omissions, or information that is not up to date.

To the extent that any content set out in this document discusses market activity, macroeconomic views, industry or sector trends, such statements should be construed as general advice only. Any references to specific securities are not intended to be a recommendation to buy, sell, or hold such securities. Holdings may change by the time you receive this report. Future portfolio holdings may not be profitable. The information should not be deemed representative of future characteristics for the strategies listed herein. Past performance is not an indication of, and does not guarantee, future performance. References to indices, benchmarks or other measures of relative market performance over a specified period of time are provided for your information only and do not imply that the portfolio will achieve similar results. The index composition may not reflect the manner in which a portfolio is constructed. Portfolio characteristics take into account risk and return features which will distinguish them from those of the benchmark.