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Australia and New Zealand Exchange Rates: A Quantitative Assessment

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Australia and New Zealand Exchange Rates: A Quantitative Assessment

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Abstract

The paper describes three empirical models commonly used to conduct exchange rate assessments and applies them to data for Australia and New Zealand. The baseline results using data and medium-term projections available as of October 2008, suggest that the Australian and New Zealand dollars were broadly in line with fundamentals, but with a wide variation across models. A battery of sensitivity tests illustrate that altering the underlying assumptions can yield substantially different assessments. The results are particularly sensitive to the choice of assessment horizon, the set of economies included in the sample, medium-term forecasts, and the exchange rate reference period.

JEL Classification Numbers: F31, F32

Keywords: Exchange rate assessments, macroeconomic balance approach, equilibrium real exchange rate approach, external sustainability approach

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I. Introduction

An integral part of the Fund's mandate is the close monitoring and careful evaluation of the exchange rates of its members. As a result, the Fund has developed a framework for assessing exchange rates. As part of this mandate, the IMF Consultative Group on Exchange Rate Issues (CGER) has developed models and provided assessments for a number of advanced and emerging market economies with the aim to inform country-specific surveillance.[1]

Australia and New Zealand are both small commodity-exporting economies with reasonably long histories of independently floating exchange rates. From 2001 to mid-2008, the currencies of both countries experienced large appreciations in nominal and real effective terms. This together with persistent current account deficits raised concerns in some corners that strong currencies were adversely affecting their external price competitiveness.

Against this background, the paper seeks to assess the level of the real effective exchange rate in Australia and New Zealand. Several related papers have been written that have used these methods that specifically focused on Australia and New Zealand, including Brooks and Hargreaves (2000), MacDonald (2001), Dvornak, Kohler, and Menzies (2003), and Wren-Lewis (2004). In contrast to the time series based assessments of these earlier studies, this paper adopts the panel based methodology of the IMF CGER group, and refines the estimation procedure.

In particular, three modifications to the conventional methods are introduced and then tested. First, each model is estimated as both a standard unrestricted panel regression using ordinary least squares and as a restricted panel regression using the generalized method of moments. Second, each model is estimated using a large sample of economies and then a narrower panel of economically similar economies. Third, the exchange rate assessments are conducted at two time horizons: the current time (within sample) and the medium-term (out of sample). A battery of robustness tests are then used to gather some insights into the sensitivity of the results to changes in various assumptions.

Several useful lessons can be drawn from this study. Econometric models used for exchange rate assessments offer some guidance in systematically analyzing the data. However, the models tend to offer conflicting results and are highly uncertain, requiring further investigation.[2] The results suggest that these models, while useful as a diagnostic tool, must be complemented with more standard country surveillance in the context of the Article IV and cannot substitute for such surveillance.

[1] Several papers have been written in this area by Lee and others (2008) and Isard (2007) containing summaries of the methodologies that underpin the analysis and references to earlier IMF literature.

[2] Similar conclusions emerged in Dunaway, Leigh, and Li (2006).

The organization of this paper is as follows. The next section provides background information on exchange rate developments for Australia and New Zealand. Section III presents the estimation results for the three empirical models. Section IV applies these results to exchange rate assessments for Australia and New Zealand and considers a battery of robustness tests. Section V concludes.

II. Real Exchange Rate Developments

In recent years up until the middle of 2008, the Australian and New Zealand currencies had appreciated significantly in nominal and real effective terms (Figures 1 and 2, panel a). From 2001 to mid-2008, the Australian dollar appreciated by more than 30 percent in nominal effective terms, while the New Zealand dollar appreciated by about 35 percent. In real effective terms, both currencies appreciated by over 30 percent. The difference between nominal and real effective exchanges rates reflects accumulated inflation rate differentials relative to trading partners. Since mid-2008, both the Australian and New Zealand dollars have depreciated significantly.[3]

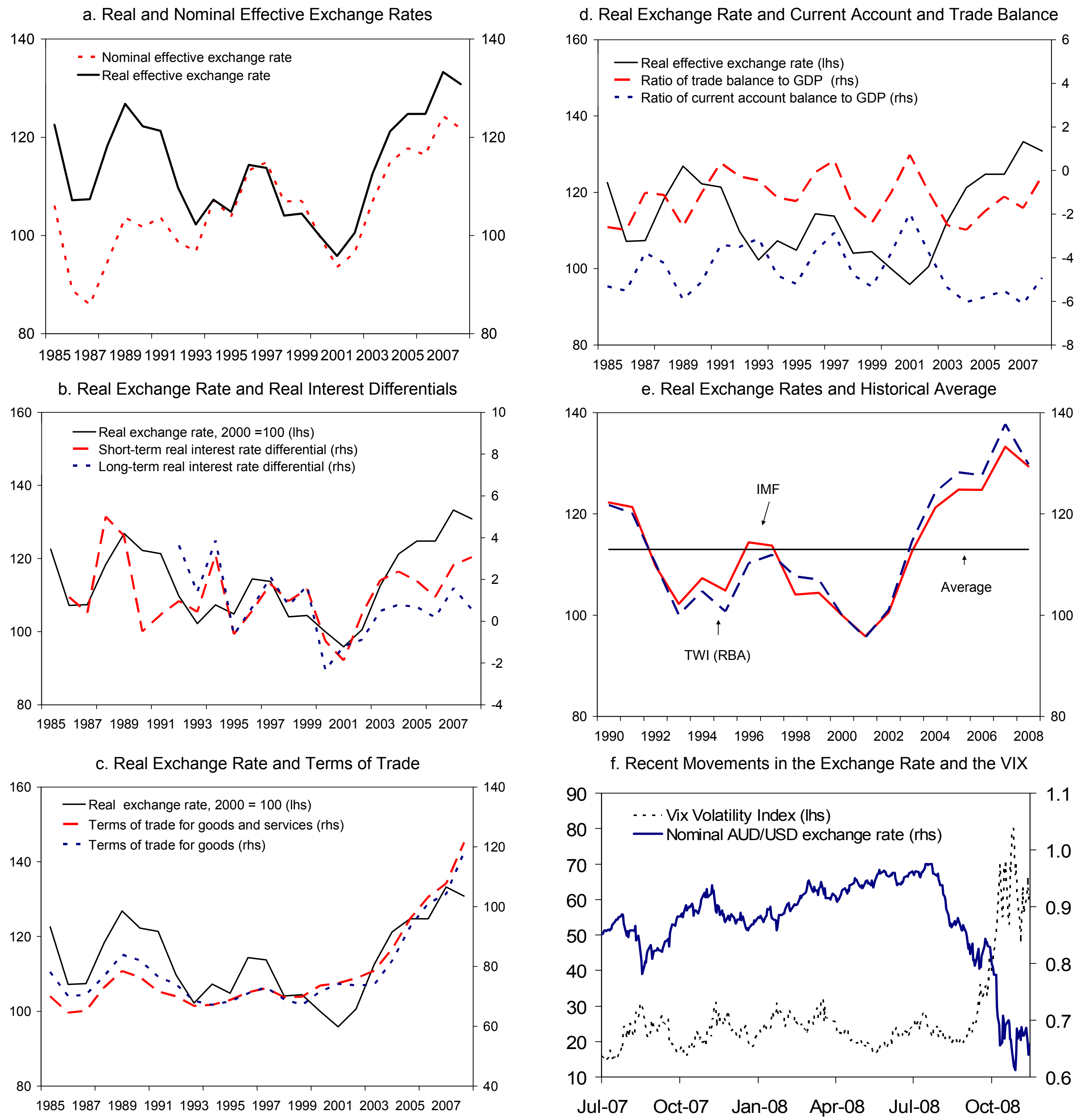
These real effective exchange rate movements have been driven in part by movements in real effective interest rate differentials (Figure 1 and 2, panel b). This relationship recently appears stronger at shorter horizons than at longer horizons, which likely reflects the emergence of the carry trade. This global search for yield has targeted Australian and New Zealand dollar assets not only because of high interest rate spreads, but also because these spreads seemed likely to persist.

The strength of these currencies has also been supported by higher terms of trade as both countries are relatively large exporters of primary commodities (Figures 1 and 2, panel c). Australia has seen a sharp increase in its terms of trade as a result of increasing coal, iron ore and other mineral prices, while New Zealand has experienced an increase in dairy prices. The relationship between the terms of trade and the exchange rate broke down around 1999 for a couple of years, but has resumed with the run up of commodity prices. Since mid-2008, the depreciations have been accompanied by a decline in global commodity prices.

The balance of payments for Australia and New Zealand have deteriorated as their exchange rates strengthened. The trade balances of Australia and New Zealand have declined, reducing their current account balances (Figures 1 and 2, panel d). Since 2001, the trade balance of New Zealand has deteriorated from a surplus and its current account deficit has widened considerably.

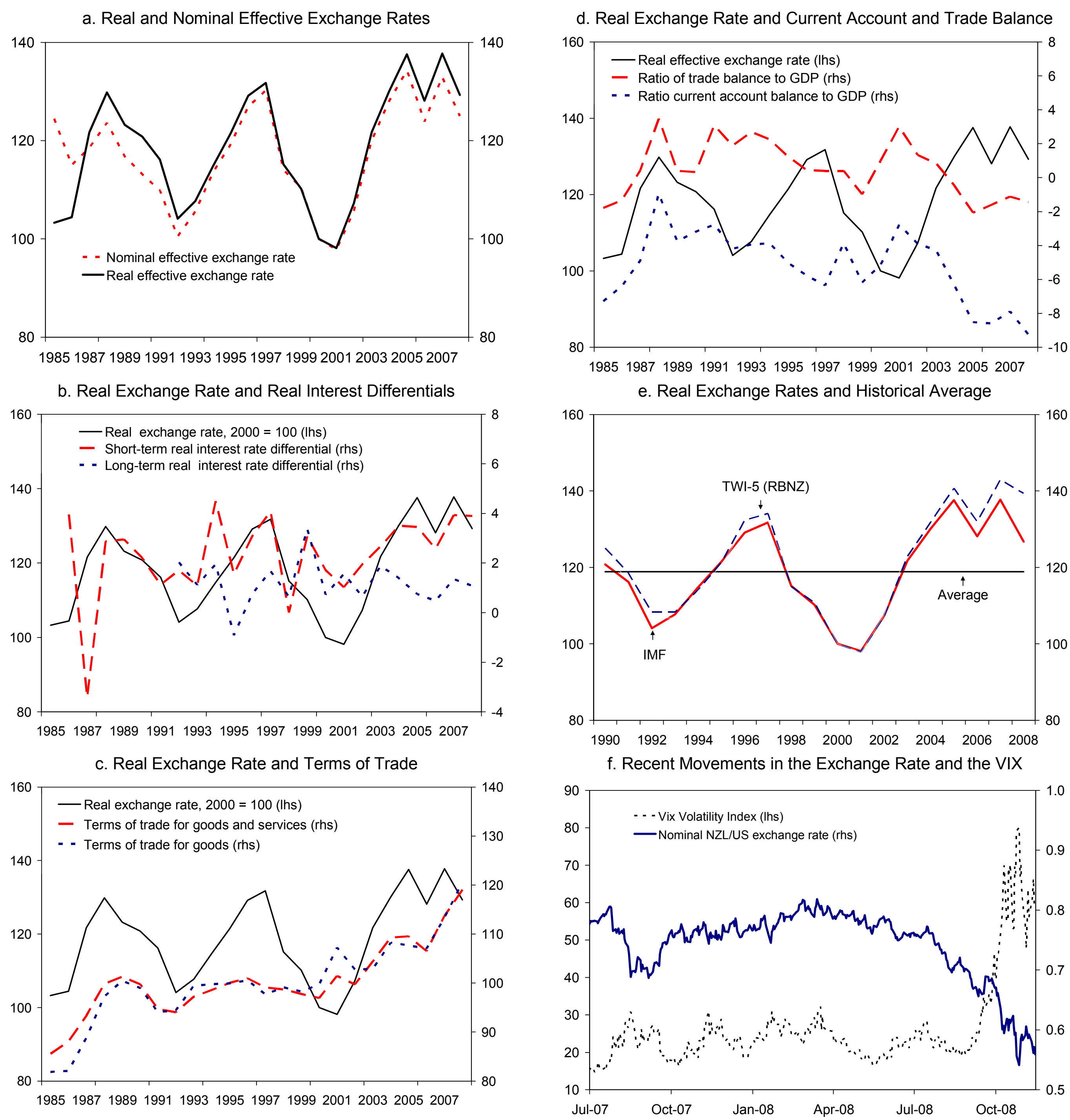
[3] The 2008 data included in these figures are mostly based on data to October.

Figure 1. Australia: Real Exchange Rate Developments



Source: IMF staff estimates.

Figure 2. New Zealand: Real Exchange Rate Developments



Source: IMF Staff estimates.

In assessing the appropriate level of the real effective exchange rate, a common first step is to compare its prevailing level to some historical average. Such a comparison assumes that the real effective exchange rate is stationary, and that the nominal effective exchange rate moves in line with relative price levels, consistent with purchasing power parity (PPP) (Rogoff 1996). This is a useful point of departure for studying the appropriate level of the exchange rate. As of October 2008, both countries' real effective exchange rate is above its long-run historical average (Figures 1 and 2, panel e)[4]. This observation applies using either the IMF or the central bank's measure of the real effective exchange rate.

Most exchange rate assessments are geared towards evaluating the consistency of the exchange rate with economic fundamentals over the medium term. Those factors that have the most influence on exchange rates over the short run, such as interest rate differentials, are not necessarily the same ones that will exercise the most influence in the medium run.[5] Nevertheless, the context within which the assessment is conducted is important. In the past few months with the global financial turmoil, there has been considerable movement in exchange rates, as illustrated by the movements in U.S. dollar bilateral exchange rates for Australia and New Zealand and the VIX, a measure of market volatility (Figures 1 and 2, panel f). This large increase in volatility has made it more difficult to conduct exchange rate assessments.

III. The Empirical Models[6]

A. Country Coverage and Econometric Methodology

The estimation dataset covers 55 industrial and emerging market economies over the period 1973–2007. For each empirical model, two country groupings are considered: a 55-country sample (wide panel) and a 9-country sample (narrow panel). (A detailed description of this panel data set is provided in Appendix I.) The wide panel spans economies that contribute significantly to global trade, because an economy with a large global presence will have greater effects on the exchange rates of other countries. This wide country coverage allows one to exploit the substantial cross-country variation among the advanced and emerging market economies in the sample. However, the wide panel also poses possible estimation

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[4] This is based on real effective exchange rate data produced by the IMF that is observed through August and then extrapolated based on nominal effective exchange rate data from the Reserve Bank of Australia and the Reserve Bank of New Zealand.

[5] In estimating the medium-run equilibrium value of the real effective exchange rate, it is standard to abstract from predominantly cyclical relationships (interest rate movements) and instead focus on factors that cause persistent deviations from long-run PPP.

[6] See Appendix II for the theoretical foundations of these models.

problems related to imposing cross-economy equality restrictions on slope coefficients.[7] In recognition of this problem, a narrow panel of nine structurally similar economies is also considered.[8] The countries are all relatively small and open economies that are relatively large exporters of primary commodities.

A common econometric methodology has been applied to derive the most suitable specification. The models are first estimated by ordinary least squares (OLS) and then by the generalized method of moments (GMM), using lagged explanatory variables as instruments, where appropriate. For the GMM model, a general to specific model specification strategy is used to derive a parsimonious specification. Both estimation techniques correct for cross-section specific unconditional heteroskedasticity and contemporaneous correlation of unknown form.[9]

B. The Macroeconomic Balance Approach

The macroeconomic balance (MB) approach focuses on the requirement for achieving internal and external balance. In practice, it involves assessing the change in the real effective exchange rate that is needed to close the gap between the "underlying" current account balance of a country and its "equilibrium" level. This approach comprises three steps:
(i) estimating the equilibrium current account balance (current account norm);
(ii) determining the 'cyclically adjusted' or underlying current account balance;[10] and
(iii) calculating the exchange rate adjustment that is required to close the gap between the underlying and equilibrium current account balances, based on the estimated elasticity of the current account with respect to the real effective exchange rate. The discussion below focuses on the estimation and interpretation of the equilibrium current account balance.

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[7] The imposition of cross-economy equality restrictions on slope coefficients generally yields asymptotic variance reductions at the cost of asymptotic bias increases. It is ambiguous whether conditioning estimation on a wide panel of structurally dissimilar economies or a narrow panel of structurally similar economies is optimal from the perspective of minimizing asymptotic mean-squared error (Davidson and MacKinnon, 2004).

[8] The economies considered are: Australia, Canada, Chile, Denmark, Finland, New Zealand, Norway, South Africa, and Sweden.

[9] The panel regression models under consideration specify contemporaneous relationships between endogenous variables. Under the assumption that these panel regression models are correctly specified, OLS consistently estimates the conditional means of their dependent variables, but does not consistently estimate coefficients due to endogeneity. If all that is required is a consistent estimate of the degree of exchange rate misalignment, then OLS is applicable. If a consistent decomposition of this misalignment estimate into contributions from different explanatory variables is also required, then OLS is not applicable, while GMM conditional on valid instruments is applicable.

[10] In practice, the underlying current account is defined as the value of the current account that would be observed at the prevailing real effective exchange rate if all countries were operating at potential output (internal balance) and if the effects of past exchange rate changes had been completely realized.

The estimated medium-run equilibrium value of the current account balance is derived from a panel regression model,

$$ca_{i,t} = \beta_{0,i} + \boldsymbol{\beta}^{\mathsf{T}} \boldsymbol{x}_{i,t} + \varepsilon_{i,t}, \tag{1}$$

where $\beta_{0,i}$ denotes an economy specific fixed effect, and $\varepsilon_{i,t} \sim \mathrm{N}\ (0, \sigma_i^2)$. The variable $ca_{i,t}$ denotes the ratio of the current account balance to GDP, while $\boldsymbol{x}_{i,t}$ denotes a vector of explanatory variables. Following the CGER methodology, these variables include the ratio of the retirement age population to the working age population, the growth rate of the population, the logarithm of income per capita expressed in terms of purchasing power, the growth rate of income per capita expressed in terms of purchasing power, the ratio of the oil trade balance to GDP, the ratio of the fiscal balance to GDP, and the lagged ratio of the NFA position to GDP.

The estimates of equation (1) are broadly similar across econometric techniques and country coverage (Table 1). Under GMM, the estimated coefficients are statistically significant, have the expected signs, and plausible magnitudes:

- The coefficient on the old age dependency ratio is negative, indicating that a higher dependency ratio reduces the current account balance. A 1 percentage point increase in the dependency ratio relative to trading partners would lower the current account norm by about ½ percent of GDP.
- The coefficient on population growth is negative, but the size varies widely depending on the estimation method. A 1 percentage point increase in population growth relative to trading partners would lead to a worsening of the current account norm by 1 to 4 percent of GDP.[11]
- The coefficient on higher relative income growth is negative. A 1 percentage point increase in relative income growth would reduce the current account norm by 0.4 percent of GDP.
- The coefficient on the oil trade balance is positive. For Australia and New Zealand, which are net oil importers, this suggests that a widening of the oil trade deficit would imply a decrease in the current account norm.
- The coefficient on the relative fiscal balance is positive. A one percent increase in the fiscal balance implies an improvement in the current account norm of approximately 0.1 percent of GDP.
- The coefficient on the initial NFA position is positive and quite small. An increase in NFA of 10 percent of GDP would increase the current account norm by about 0.01 percent of GDP.

[11] The size of the coefficient is robust to changes in the estimation sample period.

The point estimates are decomposed into time-varying contributions from each of the explanatory variables, allowing one to give a country-specific interpretation to the equation (Figure 3). Using the wide panel GMM results, we see that the equilibrium current account deficits have been driven by a set of common factors.[12] In both countries, high relative population growth has contributed to their large current account deficits. Both countries have relatively low dependency ratios and relatively strong fiscal balances that have supported their current account deficits. In addition, relatively low income growth has reduced private investment, which has reduced their equilibrium current account deficits. Finally, oil trade deficits have exacerbated their equilibrium current account deficits.

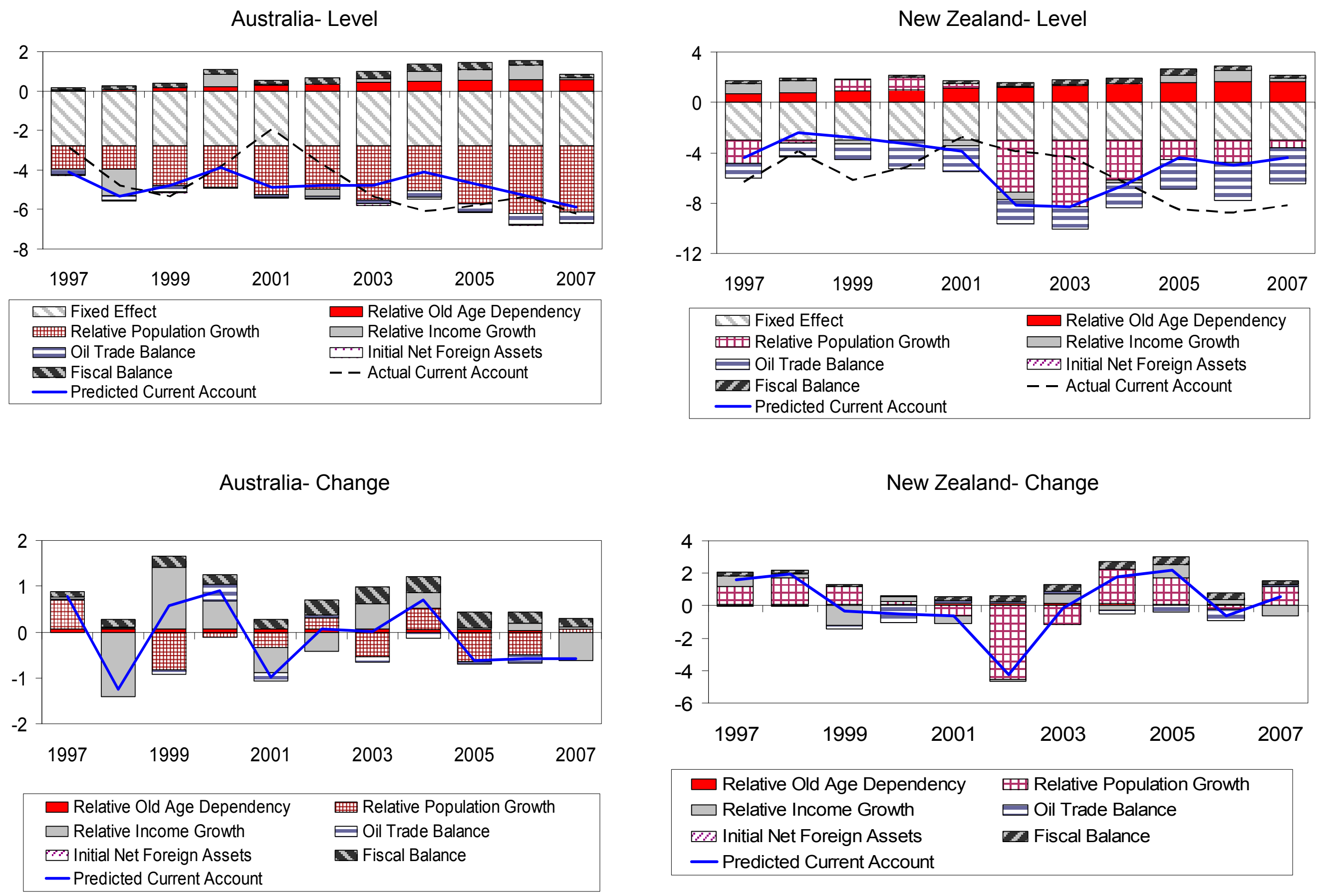
Table 1. Estimation Results for the Macroeconomic Balance Approach

	Wide Panel		Narrow Panel	
	OLS	GMM	OLS	GMM
Relative old-age dependency	-0.62***	-0.58***	-0.66***	-0.74***
Relative population growth	-0.79**	-4.26**	0.49	-1.14
Relative income	-0.09***	...	0.07	0.06
Relative income growth	-0.02***	-0.38**	0.38***	...
Oil trade balance	0.73***	0.88***	1.26***	1.31***
Relative fiscal balance	0.17***	0.08***	0.18**	0.15**
Initial net foreign assets	0.001**	0.001**	-0.002	0.001
Observations	735	714	174	169
R-squared	0.73	0.67	0.76	0.78

Note: Statistical significance at the 1 percent, 5 percent, and 10 percent levels is indicated by ***, **, and *, respectively. Variables excluded from the final specification are indicated by "...".
Dependent variable: Ratio of current account balance to GDP.

[12] The results for the narrow panel are broadly similar with some variation in the size of coefficient estimates, partly reflecting lower degrees of freedom.

Figure 3. MB Approach: Estimated Contributions—Level and Change
(In percent of GDP)



Source: IMF staff estimates: GMM estimates for wide panel.

C. The Equilibrium Real Exchange Rate Approach

The equilibrium real exchange rate (ERER) approach models the real effective exchange rate as a function of factors that cause temporary but persistent deviations from long-run PPP. As discussed in a survey paper by Froot and Rogoff (1995), a variety of theoretical models predict the existence of such factors. The model takes the form,

$$\ln \overline{Q}_{i,t} = \beta_{0,i} + \boldsymbol{\beta}^{\mathrm{T}} \boldsymbol{x}_{i,t} + \varepsilon_{i,t}, \qquad (2)$$

where $\beta_{0,i}$ denotes an economy specific fixed effect, and $\varepsilon_{i,t} \sim \mathrm{N}\,(0,\sigma_i^2)$. The dependent variable denoted as $\overline{Q}_{i,t}$ is the real effective exchange rate, while $\boldsymbol{x}_{i,t}$ denotes a vector of explanatory variables. Following the CGER methodology, these variables include the logarithm of the terms of trade, the logarithm of output per worker expressed in terms of purchasing power, the ratio of government consumption to GDP, and the ratio of the NFA position to GDP.

The first column in Table 2 reports the OLS estimate of the medium-run relationship between the real effective exchange and the above mentioned set of explanatory variables. Column 2 reports coefficient estimates for a parsimonious specification, which has been estimated using GMM. The coefficients on all three explanatory variables are positive, implying that an increase in any variable would lead to an appreciation.

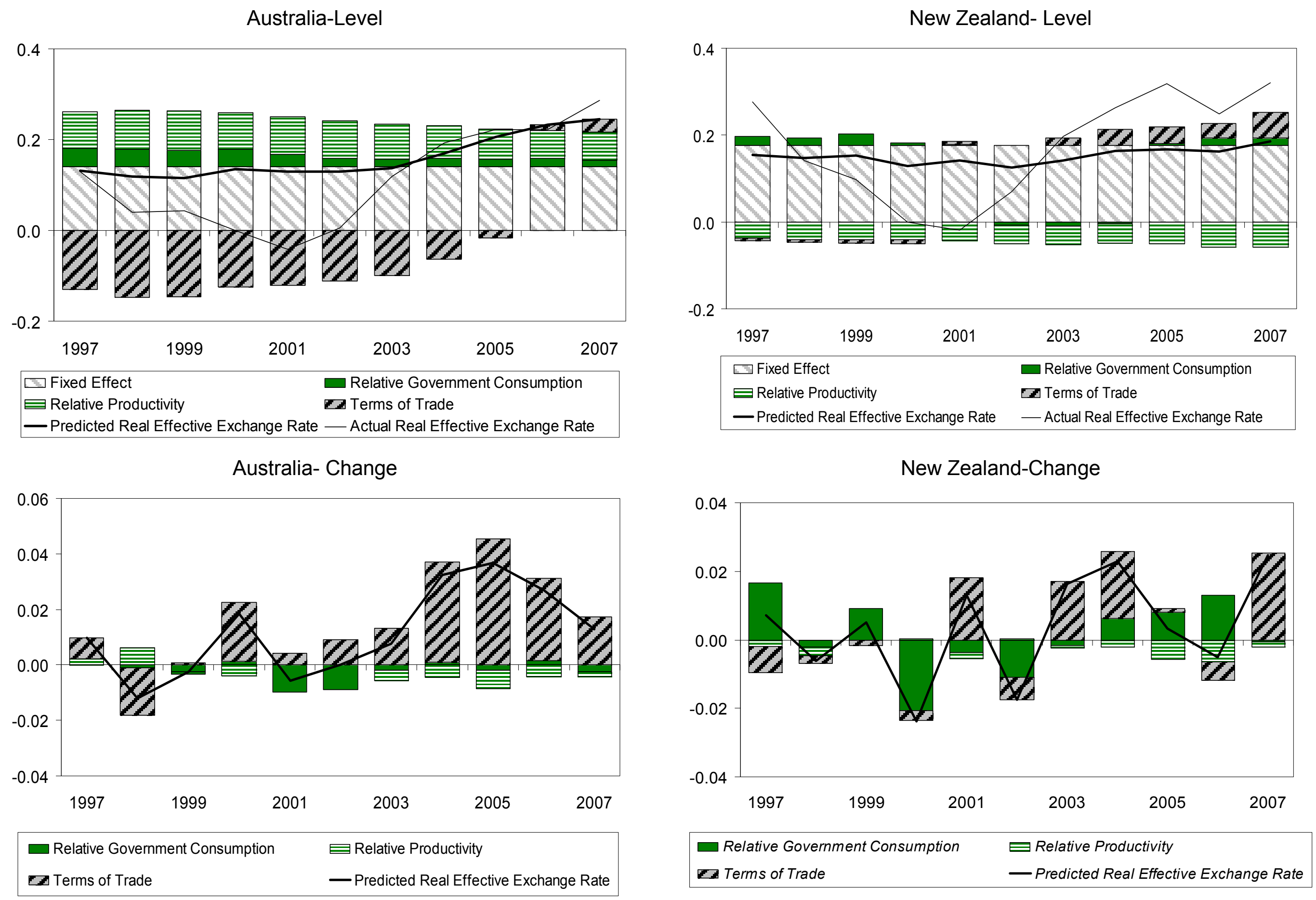
Table 2. Estimation Results for the Equilibrium Real Exchange Rate Approach

	Wide Panel		Narrow Panel	
	OLS	GMM	OLS	GMM
Terms of trade	0.33***	0.41***	0.34***	0.39***
Relative productivity	0.15	0.26***	-0.42**	...
Relative government consumption	0.38***	1.76***	3.54	...
Initial net foreign assets	0.00**	...	-0.03***	...
Observations	724	1006	165	238
R-squared	0.52	0.67	0.48	0.19

Note: Statistical significance at the 1 percent, 5 percent, and 10 percent levels is indicated by ***, ** and *, respectively. Variables excluded from the final specification are indicated by "...".
Dependent variable: Real effective exchange rate.

Looking more closely at the decomposition of the equilibrium real effective exchange rate for Australia and New Zealand highlights the role of the terms of trade in driving the strength of the currencies (Figure 4). As shown by the decomposition of changes, the improvement in the terms of trade was the primary source of the persistent appreciation of the Australian dollar. As shown by the decomposition of levels, high relative productivity and government consumption held the equilibrium exchange rate above its PPP level, but these contributions have diminished over time. For New Zealand, the improvement in the terms of trade has been associated, on average, with the persistent appreciation of the dollar in real effective terms. The estimation of a large fixed effect does not necessarily indicate that relevant time invariant explanatory variables have been omitted from the model. Rather, it may reflect the fact that the real effective exchange rate is measured as an index that equals an arbitrary value in a base year.

Figure 4. ERER Approach: Estimated Contributions—Level and Change



Source: IMF staff estimates: GMM estimates for wide panel.

D. The External Sustainability Approach

The third approach, the external sustainability approach (ES), focuses on the relationship between the sustainability of a country's external stock and its current account flow, and the real effective exchange rate. Similar to the MB approach, it involves three steps:
(i) estimating the ratio of the current account balance to GDP that would stabilize the NFA position at a given benchmark value, (ii) determining the level of the current account balance expected to prevail over the medium term, and (iii) assessing the adjustment in the real effective exchange rate that is needed to close the gap between the medium-term current account and the NFA-stabilizing current account balance. The medium-run equilibrium value of the ratio of the NFA position to GDP is modeled from an intertemporal perspective.

The benchmark level of the NFA position is the key element in the ES approach. It is common to calibrate this benchmark level to match the most recently observed value of the NFA position, or some measure of the central tendency of its recently observed values. Alternatively, the medium-run equilibrium value of the NFA position is modeled in a panel regression taking the form,

$$nfa_{i,t} = \beta_{0,i} + \boldsymbol{\beta}^{\mathsf{T}} \boldsymbol{x}_{i,t} + \varepsilon_{i,t}, \tag{3}$$

where $\beta_{0,i}$ denotes an economy specific fixed effect, and $\varepsilon_{i,t} \sim \mathrm{N}\,(0, \sigma_i^2)$. As specified, $nfa_{i,t}$ denotes the ratio of the NFA position to GDP, while $\boldsymbol{x}_{i,t}$ denotes a vector of explanatory variables.[13] These include the logarithm of output per worker expressed in terms of purchasing power, the ratio of the retirement age population to the working age population, and the ratio of the government net asset position to GDP.

Table 3 reports the estimation results for the ratio of the NFA position to GDP. The GMM results for the wide panel suggest that higher relative productivity would reduce the NFA position, while a higher dependency ratio and government net asset position would increase the NFA position. The results for the narrow panel are mixed; only the coefficient on the government net asset position is positive and significant.

Table 3. Estimation Results for the External Sustainability Approach

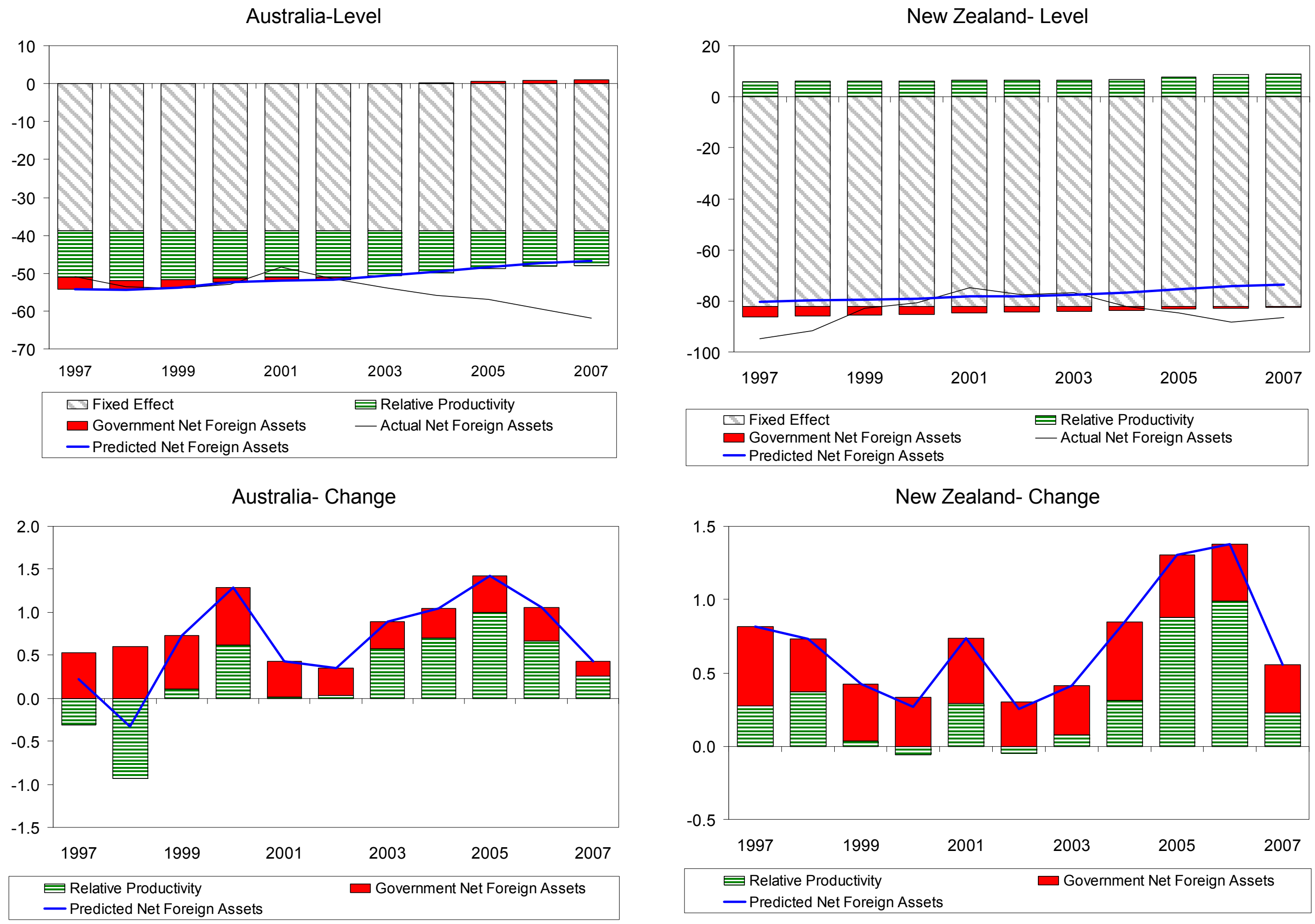
	Wide Panel		Narrow Panel	
	OLS	GMM	OLS	GMM
Relative productivity	-0.34***	-0.39***	-0.12	...
Relative old age dependency	0.69**	...	-0.95	...
Government net assets	-0.21***	0.17***	0.53***	0.58***
Observations	527	514	159	198
R-squared	0.90	0.67	0.71	0.69

Note: Statistical significance at the 1 percent, 5 percent, and 10 percent levels is indicated by ***, **, and *, respectively. Variables excluded from the final specification are indicated by "...".
Dependent variable: Ratio of net foreign assets to GDP.

Looking more closely at the results for Australia and New Zealand, reveals that fixed effects account for the majority of the estimated equilibrium net foreign debt positions (Figure 5). This result suggests that relevant explanatory variables that vary significantly across economies but not over time have been omitted from the panel regression model. A candidate is the real value of the stock of natural resources.

[13] Estimating the benchmark NFA position is one of the refinements of the CGER methodology introduced in this paper.

Figure 5. ES Approach: Estimated Contributions—Level and Change



Source: IMF staff estimates: GMM estimates for wide panel.

IV. Exchange Rate Assessments

A. Baseline Results

For the purposes of comparability, we develop a baseline where each approach is applied to Australian and New Zealand data. Since exchange rates are notoriously difficult to forecast in the short run, the medium-run horizon (2013) was deemed best for the construction of the baseline benchmark.[14] In addition, to construct the baseline we use the GMM model estimates for the sample of 55 countries, as coefficient estimates were sensitive to economy

[14] The 2013 projection is taken to be the underlying current account, the level reached after lagged exchange rate effects have worked themselves out and output gaps have closed. In other words, we are trying to model the trend and abstract from the cycle.

coverage in the narrow panel. To complete this exercise, the medium-term forecast of the explanatory variables is based on the October 2008 *World Economic Outlook* (WEO), unless otherwise indicated.

For the MB and ES approaches, the assessments are based on the required real effective exchange rate adjustment that would close the gap between the estimated current account norm and the underlying (projected) current account based on the WEO forecasts.[15] The magnitude of the exchange rate adjustment is derived by dividing the current account gap by the semi-elasticity of the current account with respect to the real effective exchange rate. The notion is that a country more open to trade will be able to close its current account gap with less real exchange rate adjustment. For the ERER approach, the magnitude of the exchange rate adjustment is calculated directly as the difference between the country's real effective exchange rate and its estimated equilibrium value.[16]

The baseline estimates for the level of the exchange rate are wide-ranging, varying considerably across models. For Australia, the ERER model indicates the dollar is 18 percent undervalued while the ES model produces estimates that suggest the dollar to be overvalued by 17 percent.[17] The estimates from the MB model fall in the middle, at 3 percent overvalued. For the New Zealand dollar the baseline estimates are similarly spread, ranging from 7 percent undervalued (ERER) to 11 percent overvalued (ES) (Table 4). These results are based on the assumption that the underlying current account deficit for Australia is 5.0 percent of GDP and 5.6 percent of GDP for New Zealand (i.e., the WEO forecast for 2013). For the MB and ES approaches, the elasticities are taken from the IMF CGER methodology (Lee and others, 2008).

[15] Under the baseline implementation of the ES approach, the current account norm is derived from the estimated NFA norm. As such, the assessment does not account for valuation effects related to the currency composition of foreign assets and liabilities.

[16] Under the ERER approach, the reference period for the real effective exchange rate is end-October 2008.

[17] The ERER model uses a terms of trade projection that may not reflect market expectations.

Table 4. Baseline Results: Quantitative Exchange Rate Assessments 1/

	Current Account Balance		Real Effective Exchange
	Norm	Forecast	Rate
Australia 2/			
Macroeconomic balance	-4.5	-5.0	2.8
Equilibrium real exchange rate	...	...	-17.8
External sustainability	-2.4	-5.0	16.7
New Zealand 3/			
Macroeconomic balance	-5.2	-5.6	1.6
Equilibrium real exchange rate	...	...	-7.0
External sustainability	-3.3	-5.6	11.1

Sources: IMF staff estimates.

1/ All figures are based on five year conditional forecasts, and are expressed in percent.
2/ Estimates are based on a medium-run semi-elasticity of the ratio of the current account balance to GDP with respect to the real effective exchange rate of -0.16, a NFA to GDP norm of -49.5, and a medium-run equilibrium nominal GDP growth rate of 5.3 percent.
3/ Estimates are based on a medium-run semi-elasticity of the ratio of the current account balance to GDP with respect to the real effective exchange rate of -0.21, a NFA to GDP norm of -71.2, and a medium-run equilibrium GDP growth rate of 4.8 percent.

Not only are these point estimates wide ranging across models, but there is also a great deal of uncertainty for each model. Figure 6 shows both the point estimate (depicted with bars) and the 90 percent confidence intervals, which capture model uncertainty.[18] For Australia, the estimate ranges from 30 percent undervalued to 25 percent overvalued. For New Zealand, the range is almost as wide, spanning from -22 percent undervalued to 20 percent overvalued. However, these confidence intervals may overstate the uncertainty surrounding the exchange rate overvaluation estimates, as they are inflated by model misspecification.[19]

[18] Projections for the ERER model are based on:

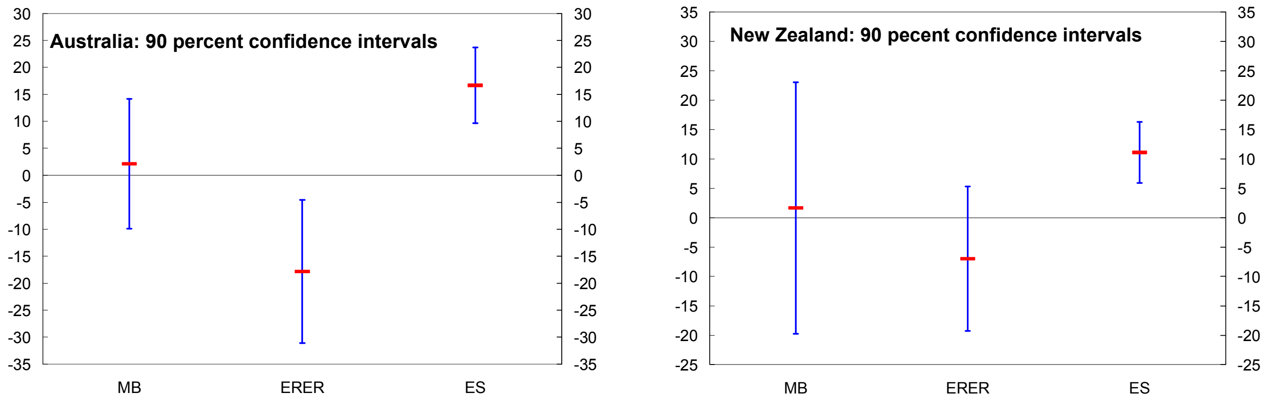
ERER Model: Forecasts of Explanatory Variables

		Terms of Trade	Relative Productivity	Relative Government Consumption
Australia				
	2008	1.21	1.25	1.00
	2013	1.15	1.19	1.00
New Zealand				
	2008	1.19	0.80	1.01
	2013	1.24	0.77	1.02

[19] Modeling observed levels as a function only of the determinants of unobserved trend components adds unobserved cyclical components to the residuals, increasing their variances. If cyclical and trend components were jointly modeled within an unobserved components framework, then the variances of estimates of medium-run equilibrium values would be reduced. Moreover, deviations of observed levels from estimated medium-run equilibrium values could be explained in terms of cyclical factors.

Figure 6. Confidence Intervals

The models yield wide confidence bands for Australia... *...and bands are even wider for some models for New Zealand.*



Source: IMF staff estimates.

B. Robustness Tests

Given the large differences in the baseline results and the model uncertainty, there are serious questions regarding the robustness of estimates of overvaluation. While the baseline construction appears somewhat arbitrary, it was chosen because it broadly reflected the assumptions made when these models are applied at the IMF. To gain a better understanding of what lies behind these results, we consider a battery of robustness tests. The remainder of this section considers alternative specifications by changing the underlying WEO forecasts and reference exchange rate, auxiliary parameters, assessment horizon, country sample, and estimation method.

Reference Period

The medium-term forecast used to derive the explanatory variables and the reference period for the exchange rate may have a large impact on the assessment, especially during turbulent times. Since June 2008, there has been a considerable downgrading of the global outlook and large changes to the WEO forecasts. Over this period, the Australian and New Zealand dollars have come under substantial downward pressure as commodity prices eased and interest rate differentials narrowed. At the end of October, the Australian dollar was more than 30 percent off its mid-year peak in nominal effective terms and the New Zealand dollar was nearly 20 percent lower than mid-year. These large moves make an exchange rate assessment ephemeral.

Against this background, we illustrate how rapidly the exchange rate assessment can change over a short period of time and how the different models tend to reflect these changes. Three different WEO forecasts (June, August, and October) with corresponding reference exchange rates are used to compute the degree of overvaluation (Table 5). For example, for Australia the June MB approach indicated that the dollar was overvalued by 8 percent, while in October the gap was 3 percent. Over the same period, the ERER model showed a large swing, moving from being overvalued by 8 percent in June to being undervalued by 18 percent in October. The results for New Zealand also show a narrowing overvaluation or a move to being undervalued depending on which model is being used. In contrast, the ES model seems to be less affected by these changes and furthermore consistently projects a greater overvaluation than the other models.

Table 5. Sensitivity Analysis: Reference Data 1/

	MB	ERER	ES
Assessment date:	2013	2013	2013
Australia			
June 2008 2/	8.1	8.0	18.4
August 2008 3/	5.0	3.3	21.4
October 2008 4/	2.8	-17.8	16.7
New Zealand			
June 2008 2/	13.9	12.2	19.1
August 2008 3/	6.7	1.5	19.0
October 2008 4/	1.6	-7.0	11.1

Source: Fund staff estimates.

1/ Results reported are based on models estimated for the sample of 55 countries using GMM.
2/ Based on Spring 2008 WEO and reference period for exchange rate is end-December 2007.
3/ Based on Spring 2008 WEO and reference period for exchange rate is end-August 2008.
4/ Based on October 2008 WEO and reference period for exchange rate is end-October 2008.

Auxiliary Parameters

The degree of overvaluation also depends on the auxiliary parameter assumptions. Below we consider the impact of changes in key parameters for the macroeconomic balance approach and external sustainability approach.

MB Approach: Current account norms and trade elasticities

Two key parameters for the macroeconomic balance approach are: the underlying current account projection and the medium-run semi-elasticity of the ratio of the current account balance to GDP with respect to the real effective exchange rate (trade elasticity). A larger current account deficit creates a large gap between the projection and the norm, which requires a larger exchange rate adjustment. For a given current account gap, a larger trade elasticity reduces the exchange rate overvaluation.

Using the baseline as a point of departure, plausible sensitivity analysis suggests that the Australian exchange rate assessment ranges between an undervaluation of 5 percent and an overvaluation of 13 percent. For New Zealand, the range is from an undervaluation of

4 percent to an overvaluation of 8 percent (Table 6). These results underscore the uncertainty surrounding the equilibrium level of the real effective exchange rate.[20]

Table 6. Sensitivity Analysis: MB Approach—CA Projection and Trade Elasticity 1/

	Elasticity	CA/GDP Projection 2/		
Australia		-4.0	-5.0	-6.0
	-0.11	-5.2	3.9	13.0
	-0.16	-3.6	2.8	8.9
	-0.21	-2.7	2.0	6.8
New Zealand		-4.6	-5.6	-6.6
	-0.16	-4.1	2.1	8.4
	-0.21	-3.1	1.6	6.4
	-0.26	-2.5	1.3	5.2

Source: IMF staff estimates.

1/ REER under/overvaluation is expressed in percent.
2/ Projection of the underlying current account (CA) in percent of GDP in 2013.

ES Approach: Net foreign asset norms and nominal growth assumption

The ES approach relies on an intertemporal budget constraint that requires the present value of future trade surpluses be sufficient to pay for the country's outstanding external liabilities. A key parameter in this approach is the rate of growth of the economy. The current account norm consistent with stabilizing net foreign assets at a given level is approximately proportional to this growth rate. Thus, for net debtor countries, higher growth rates are associated with higher equilibrium current account deficits. Taking this one step further, this will tend to reduce the current account gap, which will lead to a smaller overvaluation of the exchange rate.

The benchmark level of the NFA position is also key in the ES approach. It is common to calibrate this benchmark level to the most recently observed value of the NFA position, or to some measure of the central tendency of its recently observed values. The baseline estimates use model derived NFA norms. For comparison, we also compute the degree of overvaluation using the end-2007 NFA to GDP ratio. For both Australia and New Zealand, the models yield relatively low NFA norms. Replacing those norms with end-2007 values lifts the current account norms, which in turn reduces overvaluation estimates (Table 7).

[20] These specific results need to be interpreted with caution because they have not been derived by statistical methods and therefore it is not possible to assign any level of confidence to them.

Table 7. Sensitivity Analysis: External Sustanability—NFA Norm 1/

	Baseline - Estimated	Alternative - Observed 2007
Australia 2/		
NFA norm	-47.4	-61.9
Current account norm	-2.4	-3.1
Degree of misalignment	16.7	12.0
New Zealand 3/		
NFA norm	-71.2	-87.2
Current account norm	-3.3	-4.0
Degree of misalignment	11.1	7.6

Source: IMF staff estimates.

1/ Results reported are based on 2013 projections, using a GMM estimator applied to 55 countries.
2/ For Australia, the baseline NFA/GDP is estimated from the model (table 3), the alternative measure is observed at end-2007, the growth rate is 5.3 percent.
3/ For New Zealand, the baseline NFA/GDP is estimated from the model (table 3), the alternative measure is observed at end-2007, the growth rate is 4.8 percent.

To illustrate the sensitivity of the assessment to changes in the growth rate, we use the baseline as the point of departure and recomputed the degree of overvaluation assuming a 1 percentage point higher and lower growth rate. The degree of overvaluation clearly changes as we vary the growth rate of the economy. For both countries, a 1 percentage point change in the growth rate alters the estimate of overvaluation by nearly 3 percentage points (Table 8).

Table 8. Sensitivity Analysis: External Sustainability—Growth Rate 1/

	Lower Growth	Baseline	Higher Growth
Australia 2/			
Current account norm	-2.0	-2.4	-2.8
Degree of misalignment	19.5	16.7	13.9
New Zealand 3/			
Current account norm	-2.6	-3.3	-3.9
Degree of misalignment	14.3	11.1	8.0

Source: IMF staff estimates.

1/ Results reported are based on 2013 projections, using a GMM estimator applied to 55 countries.
2/ For Australia, the baseline growth rate is 5.3 percent, low growth rate is 4.3 percent, and high growth rate is 6.3 percent.
3/ For New Zealand, the baseline growth rate is 4.8 percent, low growth rate is 3.8 percent, and high growth rate is 5.8 percent.

Assessment Horizon

The time horizon that is used to evaluate the consistency of the exchange rate with economic fundamentals is another important factor. For the baseline, the adjustment was calculated based on medium-term fundamentals projected five years hence. It is assumed that at this point in time, the economy is operating at its potential and therefore one is able to abstract from cyclical and short-term influences on the exchange rate. However, some argue that the assessment should also be made based on the current values of fundamentals.

In the cases of Australia and New Zealand, exchange rate assessments taken at the current horizon (2008) tend to suggest larger overvaluations, but this result varies across models and by country (Table 9). The MB model for Australia suggests the size of overvaluation is broadly similar across the two horizons. In contrast, the ERER model suggests that the exchange rate is relatively close to its equilibrium level in the short run, but the medium-term baseline estimates suggested the exchange rate was nearly 18 percent undervalued. For New Zealand, the size of overvaluation is larger for all models for the current period. Once again, for both countries, the ES model appears to be less sensitive to changes in the time horizon and tends to register the largest overvaluation.

Table 9. Sensitivity Analysis: Assessment Period 1/

	2008	2013
Australia		
Macroeconomic balance	7.8	2.8
Equilibrium real exchange rate	0.5	-17.8
External sustainability	24.2	16.7
New Zealand		
Macroeconomic balance	16.8	1.6
Equilibrium real exchange rate	10.7	-7.0
External sustainability	23.4	11.1

Source: IMF staff estimates.
1/ Results reported are based on a GMM estimator applied to 55 countries.

Country Coverage

The set of economies that are included in the sample also influences the assessment. Two panel estimates for each model are considered, varying the country coverage. In contrast to the baseline, which uses the wider sample, the narrow sample tends to produce smaller overvaluation estimates for Australia. The results are mixed for New Zealand (Table 10). The differences reflect changes in the selected model specifications and coefficient estimates. Consistent with earlier robustness tests, the ES model tends to produce large overvaluations.

Table 10. Sensitivity Analysis: Country Coverage 1/

	Wide Sample 2/	Narrow Sample 3/
Australia		
Macroeconomic balance	2.8	0.0
Equilibrium real exchange rate	-17.8	-26.9
External sustainability	16.7	14.8
New Zealand		
Macroeconomic balance	1.6	-1.4
Equilibrium real exchange rate	-7.0	-8.4
External sustainability	11.1	12.9

Source: IMF staff estimates.

1/ Results reported are based on 2013 projections.
2/ Sample 55 countries.
3/ Sample 9 countries.

Estimation Method

For comparison to other results, exchange rate assessments were also based on models estimated by OLS (Table 11). For the MB model, the OLS estimate for Australia suggests a 9 percentage point adjustment where as the GMM estimates suggest a 2.8 percentage point adjustment. However, the size of the difference varies considerably by model.

Table 11. Sensitivity Analysis: Estimation Method 1/

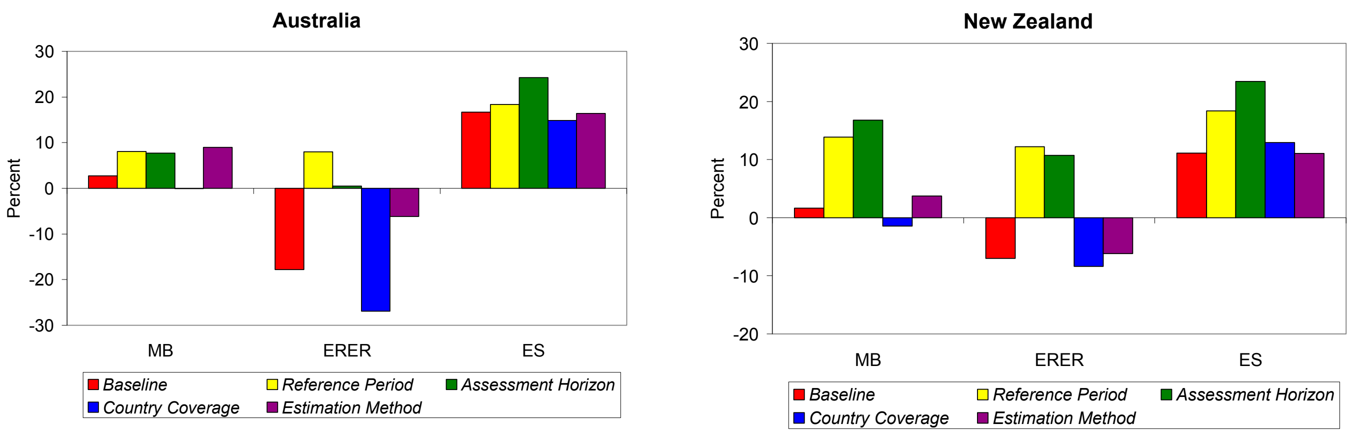
	OLS	GMM
Australia		
Macroeconomic balance	9.0	2.8
Equilibrium real exchange rate	-6.2	-7.0
External sustainability	16.4	16.7
New Zealand		
Macroeconomic balance	3.7	1.6
Equilibrium real exchange rate	-6.2	-7.0
External sustainability	11.0	11.1

Source: IMF staff estimates.

1/ Results reported are based on 2013 projections.

In sum, the quantitative assessments are sensitive to variations in assumptions. For Australia and New Zealand, small deviations from the baseline assumptions can lead to substantial changes in exchange rate overvaluation estimates (Figure 7).

Figure 7. Quantitative Exchange Rate Assessment: Summary



Source: IMF staff estimates.

V. Concluding Remarks

Drawing on existing literature, this paper has estimated three commonly used equilibrium exchange rate models and applied them to Australia and New Zealand. The baseline results used data as of October 2008 and suggest that the Australian and New Zealand dollars were broadly in line with fundamentals, but with a wide variation across models. The ERER model suggests undervaluation for both currencies, while the MB model results imply the currencies are broadly in line with fundamentals. In contrast, the ES model results indicate that both currencies are overvalued.

Numerical exchange rate assessments need to be treated with caution as the size of misalignment, even under the baseline, can give very imprecise answers. There are a number of potential factors that can create this uncertainty, which we investigated. For example, the empirical relationships of the different models were estimated for a large pool of heterogeneous countries and there could be large differences between the resulting 'average' country and Australia or New Zealand. This was partially addressed in the paper by reestimating the model over a narrow more homogenous panel of countries, but this too has its shortcomings.

The lesson drawn from this exercise is simple: there is a great deal of weakness to numerical exchange rate assessments and they should be viewed as a diagnostic tool and not as the golden yardstick from which to judge the appropriate level of the exchange rate.

Appendix I. Dataset Description

Country Coverage

Wide panel sample. Algeria, Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Colombia, Croatia, the Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malaysia, Mexico, Morocco, the Netherlands, New Zealand, Norway, Pakistan, Peru, the Philippines, Poland, Portugal, Russia, Saudi Arabia, Singapore, the Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan POC, Thailand, Tunisia, Turkey, the United Kingdom, the United States, and Venezuela.

Narrow panel sample. Australia, Canada, Chile, Denmark, Finland, New Zealand, Norway, South Africa, and Sweden.

Dataset

The dataset consists of annual observations on several macroeconomic variables over the period 1973–2007. In addition, for the medium-term analysis it uses forecasts from the *World Economic Outlook* over the period 2008–2013. This panel is unbalanced, in the sense that the number of observations varies across macroeconomic variables along both the cross sectional and time-series dimensions.

Variables[21]

Macroeconomic balance approach

Dependent variable: the ratio of the current account balance to GDP.
Explanatory variables:

- the ratio of the retirement age population to the working age population,
- the growth rate of the population,
- the logarithm of income per capita expressed in terms of purchasing power,
- the growth rate of income per capita expressed in terms of purchasing power,
- the ratio of the oil trade balance to GDP,
- the ratio of the fiscal balance to GDP, and
- the lagged ratio of the NFA position to GDP.

[21] Where appropriate, the explanatory variables for each approach are expressed as deviations from trade-weighted averages across trading partners.

Equilibrium real exchange rate approach

Dependent variable: the logarithm of the real effective exchange rate.
Explanatory variables:

- the logarithm of the terms of trade,
- the logarithm of output per worker expressed in terms of purchasing power,
- the ratio of government consumption to GDP, and
- the ratio of the NFA position to GDP.

External sustainability approach

Dependent variable: the ratio of the NFA position to GDP.
Explanatory variables:

- the logarithm of output per worker expressed in terms of purchasing power,
- the ratio of the retirement age population to the working age population, and
- the ratio of the government net asset position to GDP.

Data Sources

Data and forecasts, where possible, are from the October 2008 vintage of the *World Economic Outlook* database maintained by the International Monetary Fund. These forecasts are conditional on a constant real effective exchange rate. Other data were retrieved from other databases maintained by the International Monetary Fund or the World Bank Group, and conditional forecasts were generated. In particular, effective exchange rate data were obtained from the Information Notice System database, NFA position data were retrieved from the International Investment Position database, and population share data were extracted from the World Development Indicators database.

Appendix II. The Theoretical Framework

This appendix discusses the theoretical foundation of the three approaches.

Macroeconomic Balance Approach

Under the macroeconomic balance approach, the medium-run equilibrium value of the ratio of the current account balance to GDP is jointly modeled from intertemporal and intratemporal perspectives. The medium-run equilibrium value of the real effective exchange rate is then inferred as that value of the real effective exchange rate that reconciles these intertemporal and intratemporal current account balance estimates.

As discussed in a survey paper by Obstfeld and Rogoff (1995), intertemporal models of the current account balance are based on the saving and investment behavior of domestic economic agents. Private saving is typically modeled within the framework of household utility maximization, while private investment is typically modeled within the framework of firm value maximization. Public saving and investment are typically treated as exogenous.

Within the framework of overlapping generations models, household utility maximization predicts temporary but persistent deviations of the private saving rate from its long-run equilibrium value in response to demographic change. The profile of household disposable income over the life cycle is typically hump-shaped. Given this household disposable income profile, consumption smoothing behavior implies a reduction in the private saving rate in response to an increase in the economically inactive share of the population. It is common to proxy for this effect of demographic change with the ratio of the retirement age population to the working age population, and the growth rate of the population, both of which are expected to be negatively associated with the private saving rate, and by implication with the ratio of the current account balance to output.

Within the framework of neoclassical growth models, firm value maximization predicts temporary but persistent deviations of the private investment rate from its long-run equilibrium value in response to unbalanced economic growth. Under the conditional convergence hypothesis discussed in Barro and Sala-i-Martin (1999), technological diffusion across economies having similar saving rates and population growth rates implies a negative association of the private capital investment rate with the level of income per capita, and a positive association with the growth rate of income per capita. This implies a positive association of the ratio of the current account balance to output with the level of income per capita, and a negative association with its growth rate.

Under Ricardian equivalence, households fully internalize the intertemporal budget constraint of the government, implying invariance of the current account balance to the fiscal balance. A variety of theoretical models predict departures from Ricardian equivalence, in which case the ratio of the current account balance to output is typically positively associated with the fiscal balance. Departures from Ricardian equivalence are well documented empirically.

Equilibrium Real Exchange Rate Approach

Let $\bar{S}_{i,t}$ denote the nominal effective exchange rate, defined as a geometric trade-weighted average of nominal bilateral exchange rates $S_{i,t}$, each of which measures the price of the domestic currency in terms of foreign currency. Also, let $\bar{Q}_{i,t}$ denote the real effective exchange rate, defined as a geometric trade-weighted average of real bilateral exchange rates $Q_{i,t}$, each of which measures the price of a basket of domestic goods and services in terms of a basket of foreign goods and services. If $P_{i,t}$ denotes the price of this basket of domestic goods and services, then the real effective exchange rate satisfies

$$\ln \bar{Q}_{i,t} = \ln \bar{S}_{i,t} + \ln P_{i,t} - \ln \bar{P}_{i,t}, \qquad \text{a)}$$

where $\bar{P}_{i,t}$ denotes a geometric trade-weighted average of the prices of these baskets of foreign goods and services. Suppose that $P_{i,t}$ may be expressed as a geometric trade-weighted average of the prices of tradables $P^T_{i,t}$ and nontradables $P^N_{i,t}$,

$$\ln P_{i,t} = \theta \ln P^T_{i,t} + (1-\theta) \ln P^N_{i,t}, \qquad \text{b)}$$

where $0 \le \theta \le 1$. Combination of this definition with result a) yields the following decomposition of deviations from long-run PPP into deviations from the law of one price for tradables, and deviations of the price of nontradables in terms of tradables from a geometric trade-weighted average of this relative price across trading partners:

$$\ln \bar{Q}_{i,t} = \ln \frac{\bar{S}_{i,t} P^T_{i,t}}{\bar{P}^T_{i,t}} + (1-\theta)\left[\ln \frac{P^N_{i,t}}{P^T_{i,t}} - \ln \frac{\bar{P}^N_{i,t}}{\bar{P}^T_{i,t}} \right]. \qquad \text{c)}$$

This decomposition is useful for classifying theoretical models which predict temporary but persistent deviations of the real effective exchange rate from its long-run equilibrium value.

Let $T_{i,t}$ denote the terms of trade, defined as the price of exports of goods and services in terms of imports of goods and services. If exchange rate pass through is complete, then the domestic currency price of imports equals the foreign currency price of exports converted into domestic currency, and decomposition c) may be expressed as:

$$\ln \bar{Q}_{i,t} = \ln T_{i,t} + (1-\theta)\left[\ln \frac{P^N_{i,t}}{P^T_{i,t}} - \ln \frac{\bar{P}^N_{i,t}}{\bar{P}^T_{i,t}} \right]. \qquad \text{d)}$$

In an empirical investigation of the degree of exchange rate pass through among developed economies, Campa and Goldberg (2002) find that exchange rate pass through is incomplete in the short run, but complete in the long run.[1] This empirical evidence suggests a positive association between the real effective exchange rate and the terms of trade.

The existence of deviations from long-run PPP attributable to the existence of nontradables is rationalized by the model due to Balassa (1964) and Samuelson (1964). They consider a small open economy which produces tradable and nontradable outputs with capital and labor inputs. Consistent with a medium-run interpretation, they assume that capital is freely mobile both internationally and across sectors domestically, while labor is only freely mobile across sectors domestically. Within this theoretical framework, if productivity growth in the tradables sector exceeds that in the nontradables sector, then in competitive equilibrium, wage equalization across sectors implies that the price of nontradables in terms of tradables will increase over time. If the relative price of nontradables rises faster domestically than among trading partners, then appreciation of the domestic currency in real effective terms is induced. As emphasized by Froot and Rogoff (1995), this mechanism remains operative even in the absence of a productivity growth differential across the tradables and nontradables sectors, provided that tradables are relatively capital intensive, as is generally observed. Following Balassa (1964), it is common to assume that tradables productivity bias is pronounced in relatively productive economies, implying a positive association between the real effective exchange rate and output per worker, expressed as a deviation from a trade-weighted average across trading partners.[2]

Under the model associated with Balassa (1964) and Samuelson (1964), the real effective exchange rate depends only on supply factors. However, if the strong assumptions underlying this theoretical framework are relaxed, then the real effective exchange rate can also depend on demand factors. It is common to assume that government consumption is biased toward nontradables, implying a positive association between the real effective exchange rate and the ratio of government consumption to output, expressed as a deviation from a trade-weighted average across trading partners.

In medium-run equilibrium, intertemporal budget balance implies that net creditor economies will tend to run trade deficits, while net debtor economies will tend to run trade surpluses. To induce the necessary expenditure switching, economies running trade deficits will tend to have relatively overvalued currencies in real effective terms, while economies running trade surpluses will tend to have relatively undervalued currencies. This suggests a positive association between the real effective exchange rate and the ratio of the NFA position to output.

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[1] The derivation of this result assumes that the real effective exchange rate is GDP-based.

[2] This bypasses separate measurement of tradables productivity and nontradables productivity, expressed as deviations from trade-weighted averages across trading partners. This is desirable in practice, as the sectoral output and employment data required to construct these explanatory variables are released with long delays for many economies, while the distinction between tradables and nontradables sectors is somewhat arbitrary.

External Sustainability Approach

Whether an economy is a net foreign creditor or debtor depends on accumulated net capital flows. Private net capital flows have a tendency to equalize the marginal product of capital across economies, while public net capital flows may arise independently of such rate of return considerations.

Within the framework of neoclassical growth models, the marginal product of capital is increasing in the productivity with which inputs are combined to produce output, and is decreasing in the abundance of capital relative to other inputs. This suggests a negative association of the ratio of the NFA position to output with output per worker, and a positive association with the ratio of the retirement age population to the working age population.

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