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Real exchange rate misalignment and business cycle fluctuations in Asia and the Pacific

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ONLINE APPENDIX

ADB Economics Working Paper No. 651

REAL EXCHANGE RATE MISALIGNMENT AND BUSINESS CYCLE FLUCTUATIONS IN ASIA AND THE PACIFIC

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APPENDIX 1

Table A1.1: Economies in the Sample

Armenia	Azerbaijan	China, People's Republic of	Fiji
Georgia	Hong Kong, China	India	Indonesia
Kazakhstan	Korea, Republic of	Kyrgyz Republic	Malaysia
Mongolia	Pakistan	Papua New Guinea	Philippines
Singapore	Solomon Islands	Sri Lanka	Tajikistan
Thailand	Viet Nam		

Source: Authors.

Table A1.2: Definitions of Variables Used for Constructing Real Exchange Rate Misalignment

Variable	Definitions
Real effective exchange rate (REER)	CPI-based REER is constructed based on the weights of 67 trading partners. An increase in the index indicates appreciation, which corresponds to a loss of competitiveness.
Productivity	The ratio of GDP per capita (home economy) to the OECD average of GDP per capita income at current prices as a proxy of the Balassa-Samuelson effect.
Net foreign asset position (NFA)	NFA is the ratio of net foreign assets relative to GDP at current prices.
Government expenditure	General government final consumption expenditure (% of GDP)
Terms of trade	Net barter terms of trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000.
Trade openness	Ratio of export and import to gross domestic product
GDP per capita	GDP per capita is gross domestic product divided by population in constant 2005 US dollars.
RER misalignment	Percentage difference between real effective exchange rate and its estimated equilibrium value
International interest rate	Proxy by US 3-Month Treasury Bill
Foreign aid	Official development assistance as a share of GDP
Inflation rate	Consumer prices (annual %), used as a proxy for domestic macroeconomic policy
De jure capital account openness	Chinn-Ito index of capital account openness
World capital flows	Sum of financial account liabilities (US dollar, current prices)

CPI = consumer price index, GDP = gross domestic product, OECD = Organisation for Economic Co-operation and Development, US = United States.

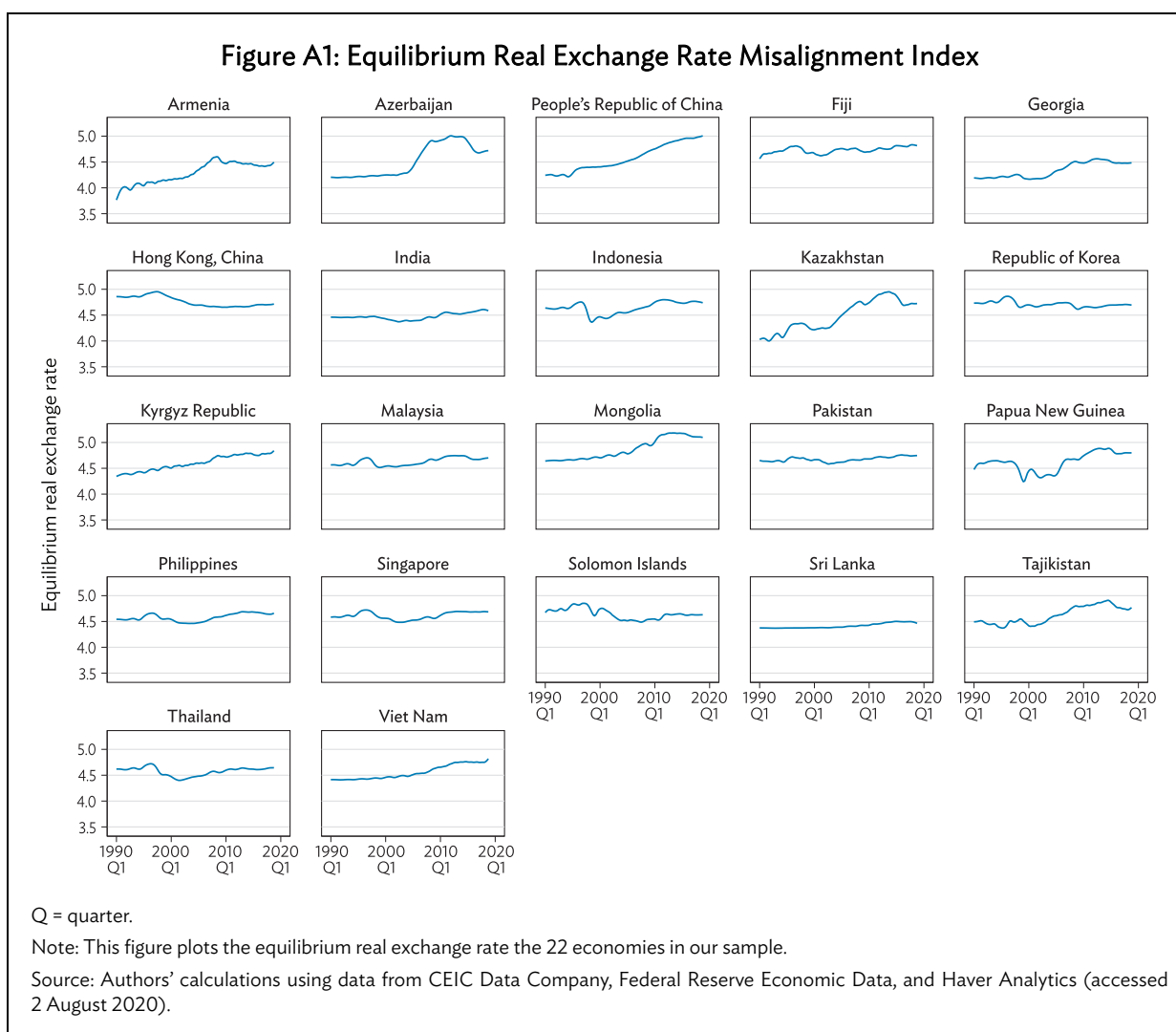
Source: Authors.

Table A1.3: Definition of Variables Used for Panel Vector Autoregression

Variable	Definitions
CPI Inflation	Quarterly difference of log CPI, (CPI=100, 2010)
Credit-to-GDP gap (<i>crgdp gap</i>)	Standardized Christiano–Fitzgerald filtered cycle of credit and GDP ratio
Output gap (<i>output gap</i>)	Standardized Christiano–Fitzgerald filtered cycle of GDP
Short-term interest rate (<i>irate</i>)	3-month treasury yield or interbank offer rate of the respective economies

CPI = consumer price index, GDP = gross domestic product.

Source: Authors.



APPENDIX 2: CONSTRUCTING THE REAL EXCHANGE RATE MISALIGNMENT INDEX

This appendix discusses how our real exchange rate (RER) misalignment index is constructed. The discussion follows Ambaw and Sim (2021) closely, which the reader may refer to for more details.

A. The Real Effective Exchange Rate

We use the real effective exchange rate (REER) as the measure of RER. REER measures the inflation adjusted value of an economy's currency against a basket of currencies of the economy's trading partners defined as:

$$RER_{it} = \frac{\prod_{j=1}^N E(i,j)_t^{w(j)} \times CPI(i)_t}{\prod_{j=1}^N CPI(j)_t^{w(j)}} \quad (1)$$

where $E(i,j)$ is the nominal bilateral exchange rate between economy i and its trading partner (economy j) measured as the economy j 's currency per unit of economy i 's currency; $CPI(i)$ is the consumer price index of the home economy; $CPI(j)$ is the consumer price index of trading partner economy j ; and $w(j)$ is the weight that reflects the proportion of a economy i 's total trade with its partner economy j where these weights sum to one over j , i.e. $\sum_{j=1}^N w(j) = 1$ (N is the total number of trading partners). Based on equation 1, an increase in the real effective exchange rate index indicates an appreciation of economy i 's currency, and vice-versa.

B. The Equilibrium Real Exchange Rate

To estimate the equilibrium RER, we first specify a model that links the real exchange rate to the RER fundamentals. We follow the literature (for example, Edwards 1989; Goldfajn and Valdes 1999; and Elbadawi, Kaltani, and Soto 2012) and model the real (effective) exchange rate as function of economic fundamentals represented by the vector \mathbf{F}_{it} ,

$$\ln(RER_{it}) = \alpha_i + \beta_0 \mathbf{F}_{it} + \varepsilon_{it} \quad (2)$$

The economic fundamentals consist of both external and domestic fundamentals. The external fundamentals are the terms of trade, net foreign asset, international interest rate, and foreign aid as a percentage of GDP. The domestic fundamentals are productivity capturing the Balassa-Samuelson effect, the ratio of government expenditure to GDP, and trade openness.¹ The definition of these variables can be found in Table A1.2.

The equilibrium RER is derived by first estimating the RER model expressed in equation 2, and then feeding the long-run components of the RER fundamentals into the estimated model. To estimate equation 2, we may employ three different econometric techniques with error correction formulation that suits non-stationary heterogeneous panels with large N and T : the mean group, the pooled mean group, and the dynamic fixed effects estimator.² The mean group estimator is the most general estimator among these three, in that it allows for potential differences in the intercept, the

¹ Edwards (1989); Goldfajn and Valdes (1999); and Elbadawi, Kaltani, and Soto (2012) discuss why these variables are chosen for the RER model and what their effects (sign-wise) on the RER are.

² Further discussions are in Ambaw and Sim (2021).

short-run parameters (capturing short-run relationships), the long-run parameters (capturing long-run relationships), and error variances across economies. The pooled mean group estimator is more constrained than the mean group estimator in that it restricts the long-run coefficients to be equal across economies, but allows the intercept, short-run coefficients, and error variances to potentially differ as before. The dynamic fixed effects estimator is the most restrictive of the three, as it imposes constant short and long-run coefficients across economies, and only allows for potentially heterogeneous intercepts.

Concerning the pooled mean group, mean group, and dynamic fixed effects estimators, there are trade-offs between consistency and efficiency. If all the long- and short-run parameters in the underlying data generating process are heterogeneous, only the (most flexible) mean group estimator will be consistent. However, if all the parameters are constant, all three estimators will be consistent but the (most restrictive) dynamic fixed effects estimator is the most efficient. The pooled mean group estimator lies between the mean group and the dynamic fixed effects estimator in terms of the trade-offs between consistency and efficiency, in that it constrains only a subset of parameters (i.e., the long-run parameters) to be constant, rather than allowing all the parameters to be heterogeneous like the mean group estimator or most of the parameters to be fixed like the dynamic fixed effects estimator.

To model the short-run process for the RER, we follow Pesaran, Shin, and Smith (1999) in using the Schwarz Bayesian Information Criterion (SBIC) to determine which RER fundamentals should be modeled with a lag. We find that the terms of trade, productivity, the international interest rate, and net foreign asset should be modeled with one lag, while trade openness, government expenditure, and foreign aid should be modeled without a lag (for this reason, there are no short-run coefficients for trade openness, government expenditure, and foreign aid).³ Our estimates based on the three approaches are reported in equation 2.

Step 2. The equilibrium RER can be interpreted as the long-term RER. To construct it, we first employ the Hodrick-Prescott (HP) filter to decompose the trend and the cyclical components of the RER fundamentals. The trend component of each fundamental is its permanent component. It is sometimes called the “sustainable fundamental” (Goldfajn and Valdes 1999; Sekkat and Varoudakis 2000; Elbadawi, Kaltani, and Soto 2012), as it is the component in the fundamental that is sustained across time as opposed to the cyclical components that die out more rapidly.

³ The estimated parameters of the mean group and the pooled mean group estimators are robust to the choice of the lag length order if T is sufficiently large (Pesaran, Shin, and Smith 1999).

**Table A2: Real Exchange Rate Fundamentals and Real Exchange Rate:
Various Estimation Approaches**

	(1)	(2)	(3)
	Estimation Techniques		
	Mean Group	Pooled Mean Group	Dynamic Fixed Effects
Long-run coefficients:			
Terms of trade (in logs)	-0.009 (0.153)	0.117*** (0.041)	0.141* (0.073)
Productivity (in logs)	0.317*** (0.056)	0.340*** (0.022)	0.245*** (0.034)
Government expenditure (in logs)	-0.078 (0.095)	0.007 (0.024)	0.028 (0.052)
Trade openness (in logs)	-0.237** (0.096)	-0.108*** (0.034)	0.058 (0.069)
International interest rate	0.008* (0.005)	0.001 (0.003)	0.003 (0.007)
Net foreign asset	0.001 (0.002)	-0.000* (0.000)	-0.000 (0.000)
Short-run coefficients:			
Error correction coefficient	-0.187*** (0.020)	-0.084*** (0.015)	-0.082*** (0.007)
D.(terms of trade, logs)	0.003 (0.076)	0.024 (0.079)	-0.045*** (0.015)
D.(productivity, logs)	0.049 (0.034)	0.082** (0.038)	0.006 (0.007)
D.(international interest rate)	0.002 (0.003)	0.000 (0.003)	0.000 (0.003)
D.(net foreign asset)	0.000 (0.000)	0.001* (0.000)	0.000 (0.000)
Observations	2,530	2,530	2,530

Note: The dynamic specification of the real exchange rate model presented here is chosen using the Schwarz Bayesian information criterion (SBIC), following Pesaran, Shin, and Smith (1999). *, **, *** represent the level of statistical significance at 1%, 5%, and 10%, respectively. The constant is suppressed.

Source: Authors' calculations using data from CEIC Data Company, Federal Reserve Economic Data, and Haver Analytics.

To estimate the equilibrium RER, we feed the long-run sustainable components of the RER fundamentals, collectively represented by the vector F_{it}^S , into the estimated version of the RER model expressed by equation 2.⁴

$$\ln(\widetilde{RER}_{it}) = \tilde{\gamma}_i + \hat{\beta}' F_{it}^S \quad (3)$$

⁴ Equation 3 is estimated either by the mean group, pooled mean group, or the dynamic fixed effects estimator.

The vector \mathbf{F}_{it}^S contains the sustainable components of the RER fundamentals and $\hat{\beta}$ is the factor loading. The parameter $\tilde{\gamma}_i$ is a scaled economy-specific intercept term, which is given by:

$$\tilde{\gamma}_i = \overline{RER}_i - \hat{\beta}'\overline{\mathbf{F}}_i^S \quad (4)$$

where \overline{RER}_i is the average observed RER and \mathbf{F}_i is the vector of the average sustainable RER fundamentals. The scaled intercept term, expressed by equation 4, ensures that for each economy, the RER misalignment index has an expected value of zero. This ensures that the actual RER will always revert to its long-run equilibrium should they diverge, so that any deviation in the actual RER from equilibrium represents a temporary than a permanent misalignment.⁵

To proceed further, by substituting $\tilde{\gamma}_i$ from equation 4 into equation 3, we obtain a second expression for the equilibrium RER as:

$$RER_{it}^E = \overline{RER}_i + \hat{\beta}'(\mathbf{F}_{it}^S - \overline{\mathbf{F}}_i^S) \quad (5)$$

This expression shows that for each economy i , the equilibrium RER is equal to the sum of the average RER and the weighted deviation of RER fundamentals from their averages.

C. The Misalignment Index

Once the equilibrium RER is computed in Step 2, we may take the difference between the observed RER in equation 1 and the estimated equilibrium RER in equation 5 to construct the RER misalignment index:

$$misalign_{it} = \underbrace{(RER_{it} - \overline{RER}_i)}_I - \hat{\beta}' \underbrace{(\mathbf{F}_{it}^S - \overline{\mathbf{F}}_i^S)}_{II} \quad (6)$$

Equation 6 contains two parts. Part I is the difference between the actual RER and its average value. Part II reflects the adjustment of the RER that should occur in equilibrium. If the difference between the actual RER and its average value exceeds the appreciation (or depreciation) that should occur in equilibrium, the RER is overvalued. This is represented by $misalign_{it} > 0$. If the difference between actual RER and its average value falls short of the equilibrium appreciation (or depreciation), the RER is undervalued. This is represented by $misalign_{it} < 0$.

⁵ See Appendix C in Elbadawi, Kaltani, and Soto (2012) for more detail.

