The determinants of australian exchange rate: a time series analysis

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THE DETERMINANTS OF AUSTRALIAN EXCHANGE RATE

A Time Series Analysis

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ABSTRACT

The paper analyzes Australian exchange rate and its determinants by providing an insight into the economic and non-economic factors. By drawing a comparison between quarterly and annual data over the period of 1975 to 2012, it is suggested that Australia's trade components and macroeconomic indicators such as output and liquidity relative to the US, play a significant role in determination of its exchange rates. However, interest rate and inflation appear insignificant in this relationship. The study also emphasizes on the pertinence of unobservable effects such as political events and external shocks in influencing the exchange rate. Engle-Granger Cointegration test exhibits a long run relationship between exchange rate and its determinants, and corroborates the substantial role of macroeconomic indicators in diminishing the uncertainty in foreign exchange market.

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1. Introduction

The age of globalization has potentially aggravated the importance of countries' exchange rates. Exchange rates are among the most studied and politically sensitive economic measures. However, macroeconomists are still unable to reach any concrete agreement over long-term determinants of the exchange rate (Canales-Kriljenko & Habermeier, 2004). Consensus is seen on the theoretical importance of exchange rate depreciation or appreciation as an instrument for stimulation of a country's trade (Krugman *et al.,* 2005), however the volatility in exchange rate leads to uncertainty in the global market.

From the beginning of floating exchange rate regime, modelling the exchange rate has become a very important issue in economic studies (China, Azalia and Matthews, 2007). Along with interest rate and inflation, exchange rate is one of important indicators of a country's state of economy. Exchange rates significantly affect level of investment and trade in the economy, which are critical determinants for every country. For this reason, exchange rates are among the most observed, analyzed and governmentally manipulated economic variables (Van Bergen, 2010).

Objective of this study is to augment to the existing literature in exchange rate determination by devising a more coherent and comprehensive model, which is accomplished by investigating the causes of historical variations in Australian exchange rate (Australian dollar per US dollar). It is expected that the model devised in this study will help in establishing predictability in currency markets and provide better forecasts for the international conditions that affect domestic economic growth.

Theoretical background suggests that a country's exchange rate is determined by macroeconomic factors, speculative factors and economic expectations (Kanamori, 2006). The study therefore proposes quantifying the nature of the relationship between exchange rate and macroeconomic factors such as GDP, inflation, interest rate, capital account balance, net exports and money supply. Considering high volatility in exchange rate due to daily fluctuations, the study draws a comparison between quarterly and annual data over the same period, and attempts to provide more precise estimates for exchange rate.

The organization of this study is as follows. Chapter-2 briefly summarises the existing literature dealing with the determinants of the exchange rate, followed by Chapter-3 which provides theoretical framework of the study. Chapter-4 outlines the methodology, and provides and analyses the empirical diagnostics. The last chapter, Chapter-5, concludes the study by outlining weaknesses and suggesting policy options for stable exchange rates.

2. Literature review

A considerable amount of literature is available on determination of exchange rate deals with the problem in different ways; however consensus has not been formed over a certain factor or a group of factors to be the determinant of exchange rate.

Christopoulos *et. al.* (2012) examine the relationship between the real exchange rate (RER) and economic growth by analysing net foreign assets and productivity. They use a modified version of overlapping generations model of Obstfeld and Rogoff (1996) and observe a positive relationship between RER, and productivity and NFA for poor countries, and only productivity for richer countries.

Binici and Cheung (2011) examine the effect of monetary policy by deriving the exchange rate equation through an expectations-augmented Philips Curve and a forward looking IS curve. The study finds a significant role of monetary policy in determining exchange rates.

Kempa and Wild (2011) observe the relationship between monetary policy under Taylor Rule and exchange rate for Canada, Euro area, Japan and the UK (all relative to US) by using structural vector autoregressive model and conclude that exchange rate determination is significantly dependent upon Taylor rule fundamentals.

China, Azalia and Matthews (2007) use monetary approach for exchange rate determination to explain movements in Malaysian-ringgit-USD exchange rate. Results of the study confirm existence of long-run relationship between ringgit-USD exchange rate and variables of monetary model. Therefore empirical results are consistent with Bilson's version of the monetary approach to determination of exchange rate (1978).

Canales-Kriljenko & Habermeier (2004) examine a cross-section of 81 countries, observing that high inflation and fiscal deficits have a significant correlation with higher exchange rate volatility, however foreign exchange reserves of a country, and current account deficit appeared to be insignificant.

Frankel & Meese (1987) take an early look at the relationship between exchange rate data and macroeconomic variables in the United States and United Kingdom. They come to the conclusion that all proposed models have substantial error terms and do not adequately explain the variation in currency values.

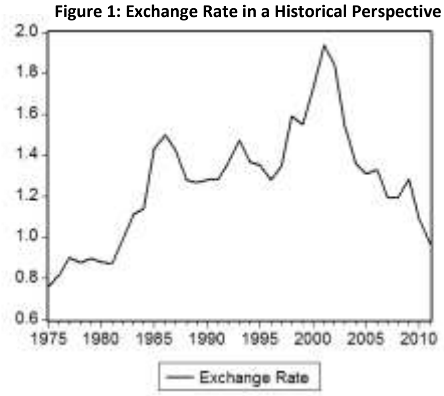
Grubacic (2002) introduces an analysis of exchange rate determination for a group of post-socialist country, assuming that they are only partially liberalized. The study asserts the existence of strong tendencies for appreciated exchange rates for countries such as Poland, Hungary and the Czech Republic, during the first five years of their economic liberalization.

Baillie and Selover (1987) examines appropriateness of some widely used models of exchange rate determination including monetary model of flexible price by Frenkel (1976) and Bilson (1978), differential model of real interest rate by Frankel (1979) and monetary model of sticky price by Dornbusch (1976) based on data available for 5 developed countries. The study detects lack of cointegration between exchange rate and variants of monetary model.

3. Theoretical Framework

3.1 Australian Exchange Rate in a Historical Perspective

Figure 1: Exchange Rate in a Historical Perspective



Australian exchange rate (E_t=USD/AUD) has gone through many variations over the history. Figure-1 provides a graphical representation of E_t over the period of 37 years, showing a positive trend, meaning thereby an overall depreciation in AUD relative to USD during 1970s to the early 2000s, reaching its maximum value of 1.93 in 2001. However, since then a negative trend in E_t shows that AUD has gained relative strength and stands at 0.941 (as of March 2012)[1].

It might be interesting to try and relate some uneven movements in the exchange rate with political and economic incidents over the history. For instance, the fact that the Australian exchange rate was lowest in 1975 (at a value of mere 0.76), meaning thereby that AUD was strongest against USD, or put another way the USD was weakest against AUD, can be related to the fact that in 1975 the US economy was recovering from the famous 'oil price crisis' of early 1970s.

Furthermore, a steep hike in E_t during the early 1980s can be related to Australia's switching from fixed to floating exchange rate regime in 1983 (Blundell-Wignall *et al.*, 1993). Overall it is widely accepted that floating exchange rate regime has been beneficial for Australia by

[1] The market exchange rate stands at 1.023 USD for 1 AUD as of 13th October 2012.

help smoothing external shocks and contributing to reduction in volatility of output (Reserve Bank of Australia n.d.).

The next interesting situation arises when $\boldsymbol{E_t}$ faces an immense decline after reaching its maximum value in 2001. This relative slump in USD value may be related to the external shock to US economy by the unfortunate incidents of terrorism. And lastly, the little peak in 2008-09 might be referred to have caused by Global Financial Crisis (commonly known as Global Meltdown).

It is therefore not wrong to suggest that exogenous shocks such as political events might play a significant role in determining the exchange rate of an economy. However quantification of such political events in the absence of any sophisticated indicators explaining the degree of severity and causation of such events, limits the analysis to observable measures. Economic indicators therefore appear to be most suited representatives to explain these variations and forecast based on historical patterns. The latter sections of this paper quantify the relationship between economic indicators and the Australian Exchange rate.

3.2 Data Dynamics

Table-1 provides the descriptive statistics for indicators used in this study, while Figure-2 shows graphical representations of all these indicators as a difference between Australian and US indicators[2] over time. It might be noteworthy that:

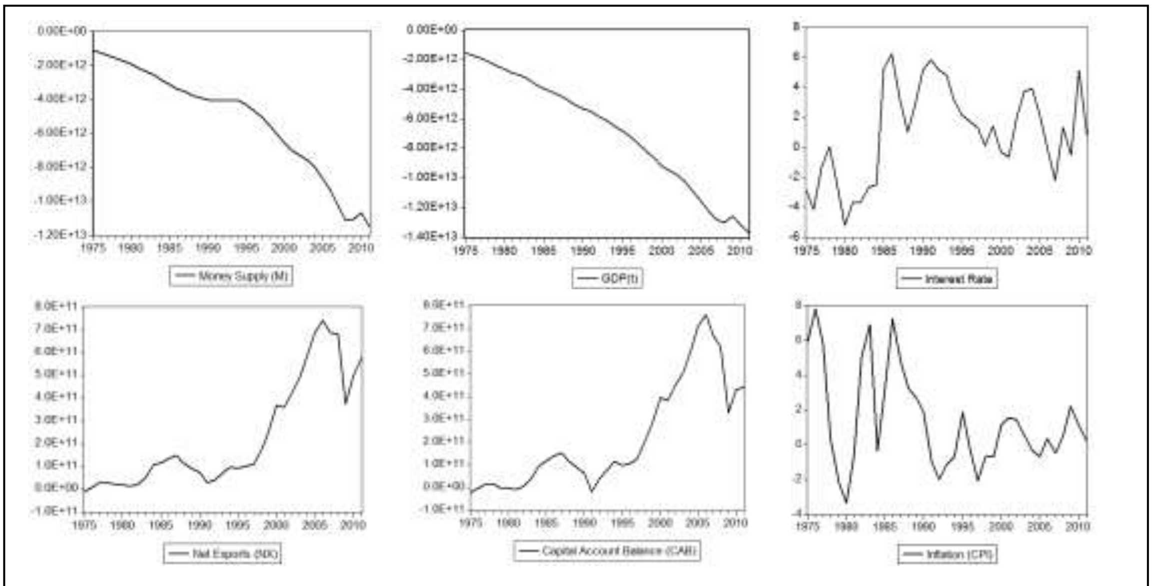
- GDP of Australia in 2011 amounted to 1391.33 billion US dollars which is maximum since 1975. Starting from 71.863billion dollars in 1975, Australia's GDP increased approximately 20 times over the period of 37 years. The Australian economy boasts 20 consecutive years of growth upto 2011 with an average rate of 3.3% (Australian Trade Comission, 2011). On the other hand, the United States GDP increased almost 10 times from 1623.4 billion dollars in 1975 to 15094 billion dollars in 2011, with average GDP over this period being 7420.6 billion dollars per year.
- Average real interest rate for Australia and US estimated for the period between 1975 and 2011 is equal to 5.47% and 4.52% respectively. One can notice significant variations in real interest rate over targeted period, ranging from -4.34% to 12.17% for Australia and between -1.47 and 8.68 percent for United States.

[2] A more rigorous definition of indicators is provided in the Data and Methodology chapter.

Table 1 - Descriptive Statistics

	Australia			United States		
Indicator	**Mean**	**Standard Deviation**	**Range**	**Mean**	**Standard Deviation**	**Range**
***E_t*, AUD/USD**	1.26	0.28	[0.76; 1.93]	NA	NA	NA
***GDP_t* (in billion $)**	534	379	[71.9;1391]	7420	4200	[1620;15100]
Real interest rate (i_t; %)	5.47	3.9	[-4.34;12.17]	4.52	2.44	[-1.47;8.68]
***CAB_t*, in billion $**	-17	14.5	[-58;-1.06]	-235	248	[-801;17.9]
***M_t*, in billion $**	405	414	[32.6;1480]	5610	3540	[1190;13000]
***CPI_t* (%)**	5.54	3.9	[0.25;15.07]	4.22	2.89	[-0.35;13.5]
***NX_t*, billion $**	-3.96	5.79	[-17.5;15.2]	-231	241	[-753;9.97]

Figure-2: Graphical Representations of all Series



- Money supply gap and GDP gap between Australia and the United States exhibit a declining trend, which is very much similar for both indicators over the targeted period. It shows that both the money supply gap and the output gap between Australia and the US have been declining during this period, with a slight tilt during the period of Global Meltdown, when this gap increased between both nations.
- All series except CPI_t exhibit a trend of some nature over the targeted time period. Exchange rate, net exports gap, interest rate gap and gap between capital account balance show a positive trend, while money supply gap and GDP gap show a negative trend. However, inflation gap between two countries varies *around* a mean value of 1.37 percent over the given time period. Regardless of the nature of trend, it is suspected that all series except CPI_t have a unit root. This claim is further corroborated by using econometric techniques in latter chapters.

4. Methodology and Diagnostics

4.1 Indicators

The determinants of exchange rate have always been of critical importance, and much work has been done in this field. However, this study stands unique on the grounds that it combines traditional monetary theories of exchange rate determination with modern literature. Baillie and Selover (1987) and Chin *et al.* (2007) examined difference of domestic and foreign indicators such as money supply, output, inflation and interest rate as the main deriving forces of exchange rate. This study however adds two additional indicators; capital account balance, and net exports to the list. These six indicators are used to analyse the variations in Australian exchange rate against the United States dollar. The functional form of study is given as:

$$E_t = f\,(GDP_t, i_t, CAB_t, M_t, CPI_t, NX_t)$$

Where E_t is the Exchange rate , measured in terms of Australian dollar (AUD) per US dollar (USD) over time[3]; GDP_t is the difference between Australian and the US Gross Domestic Product in billion dollars *(i.e.* $GDP_{AU,t}$ - $GDP_{US,t}$*)*, used as an indicator for economic performance.

Likewise, the other indicators[4] are defined as follows:

$i_t = i_{AU,t} - i_{US,t}$	Interest rate in percentage at time t
$CAB_t = CAB_{AU,t} - CAB_{US,t}$	Capital account balance in billions of dollars at time t
$M_t = M_{AU,t} - M_{US,t}$	Money supply (M_1) in billion dollars at time t
$CPI_t = CPI_{AU,t} - CPI_{US,t}$	Inflation in percentage at time t
$NX_t = NX_{AU,t} - NX_{US,t}$	Net exports in billion dollars at time t

However, the literature further suggests adding variables such as share price index[5], net foreign assets, and political stability to the list of determinants, but due to unavailability of appropriate data these variables are controlled under the idiosyncratic error term.

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[3] Given this definition of exchange rate, AUD appreciates relative to USD if the ratio (AUD/USD) falls, and it depreciates with an incline in the ratio. This definition of exchange rate has been specifically applied to synchronize it with other variables that are difference between Australian and US indicators.

[4] These indicators are also referred to as gap between Australian and US indicators.

[5] The indicator for share market prices of Australia, known as *S&P/ASX* index, started on 31st March 2000 which limits the data availability. And prior to *S&P/ASX* index, *All Ordinaries Index* (AOI) was considered as the primary index of Australian securities commission, however data availability for AOI is also restricted to 1980, which limits its inclusion in the model.

4.2 Data Sources

The study focuses on a time-series data spanning between 1975 and 2012, and draws a comparison between annual (1975-2011; 37 observations) and quarterly data (Q2:1976-Q1:2012; 144 observations). Some monthly data have been smoothed by averaging over three months in order to synchronize with the quarterly data.

The quarterly data for E_t , $GDP_{AU,t}$, $CAB_{AU,t}$, $i_{AU,t}$, $M_{AU,t}$, $CPI_{AU,t}$ and $NX_{AU,t}$ have been collected from the Reserve Bank of Australia and the Australian Bureau of Statistics, and the data for these indicators (except E_t) for the United Stated have been collected from the Federal Reserve System and the Bureau of Economic Analysis of the US. Annual data for both countries have been collected from the World Development Indicators published by the World Bank. The computer softwares *Eviews 5.0* and *Stata 11.0* have been used for analysis.

4.3 Augmented Dickey-Fuller test for Unit Root

Considering the fact that this study is based on time series, spurious regression by regressing non-stationary series appears to be a major threat for analysis. Augmented Dickey-Fuller (or ADF) test has been adopted to test the non-stationarity of each series. The ADF test, under the null hypothesis of non-stationarity (equivalently unit root), is conducted by augmenting the lagged values of the dependent variables to the model of DF-Test (Atif & Hassan, 2012):

$$\Delta Z_t = \delta Z_{t-1} + \sum_i^m \alpha_i \, \Delta Z_{t-i} + \varepsilon_t \qquad (2)$$

Table-2 provides the results of ADF test for both quarterly and annual data. While examining the quarterly data, it is observed that, at 5 percent level of significance, E_t, GDP_t, M_t , i_t, NX_t, CAB_t are non-stationary at level, however inflation (CPI_t) is stationary at level, i.e. **I(0)**.

ADF test is then applied to the first difference of non-stationary series which shows that all series are stationary at first difference, such that all series except CPI_t are I(1).

Table 2: Augmented Dickey-Fuller Test

Series	Quarterly Data		Annual Data	
	Level	First Difference	Level	First Difference
E_t	-2.08 (0.252)*	-9.435 (0.000)	-2.034 (0.272)	-4.148 (0.002)
GDP_t	1.717 (0.997)	-6.045 (0.000)	1.999 (0.998)	-3.92 (0.004)
M_t	-2.004 (0.284)	-3.213 (0.021)	4.171 (1.000)	-6.010 (0.001)
CPI_t	-4.088 (0.001)	X	-3.14 (0.031)	X
i_t	-2.718 (0.073)	-11.026 (0.000)	-2.645 (0.093)	-5.15 (0.000)
NX_t	-0.856 (0.799)	-7.753 (0.000)	-0.552 (0.869)	-5.36 (0.000)
CAB_t	1.331 (0.998)	-7.82 (0.000)	-0.927 (0.768)	-4.235 (0.002)

* Null Hypothesis of Unit Root is rejected if value in parentheses (p-value) is less than 5% (or equivalently 0.05)

4.4 Model and Estimation

This study follows the orthodox Backward Elimination Process for model selection. Based on Baillie and Selover (1987), the initial step includes estimation of AR(1) model using all indicators explained in previous sections. The basic linear model under AR(1) is given as follows:

$$\boldsymbol{E_t = \beta_0 + \beta_1 NX_t + \beta_2 CAB_t + \beta_3 M_t + \beta_4 GDP_t + \beta_5 i_t + \beta_6 CPI_t + \delta E_{t-1} + \varepsilon_t} \quad \textbf{(1)}$$

Where $\boldsymbol{\varepsilon_t}$ is the idiosyncratic error term explaining the unobserved effect in the model.

The above model can be represented in First-Difference form, as follows:

$$\boldsymbol{\Delta E_t = \beta_0 + \beta_1 \Delta NX_t + \beta_2 \Delta CAB_t + \beta_3 \Delta M_t + \beta_4 \Delta GDP_t + \beta_5 \Delta i_t + \beta_6 CPI_t + \delta E_{t-1} + \varepsilon_t} \quad \textbf{(2)}$$

Where **Δ,** the difference operator, is associated to all the variables, except CPI_t (which is I(0)) and E_{t-1}, which is the autoregressive operator (i.e. first-lag of dependent variable).

Following the backward elimination technique, the most insignificant variable in a step is eliminated from the model and new model is estimated in the subsequent step without that variable (Bowerman et. al., 2005). The process is repeated until all variables become significant. This method provides the best-fit model in a given set of various independent variables.

Table-3 presents estimation results for backward elimination process using eq. (2) as the basic model for both data sets; annual and quarterly. In step-I for quarterly time series, $\Delta \boldsymbol{M_t}$ **,** $\Delta \boldsymbol{GDP_t}$ **,** $\Delta \boldsymbol{i_t}$ and $\boldsymbol{CPI_t}$ are the insignificant variables, however $\boldsymbol{CPI_t}$ is the most insignificant variable (with highest p-value), which is eliminated from the model and second regression model is estimated in step-II without $\boldsymbol{CPI_t}$. Likewise $\Delta \boldsymbol{i_t}$ **,** $\Delta \boldsymbol{GDP_t}$ and $\Delta \boldsymbol{M_t}$ are eliminated in steps-III, -IV and –V respectively. Step-V gives the best-fit model for quarterly data that contains $\Delta \boldsymbol{NX_t}$ **,** $\Delta \boldsymbol{CAB_t}$ and $\boldsymbol{E_{t-1}}$ as the determinants of Australian exchange rate against US dollar.

Similar analysis is drawn for annual data where $\boldsymbol{CPI_t}$ **,** $\Delta \boldsymbol{i_t}$ and $\boldsymbol{E_{t-1}}$ are eliminated in step-II, -III and –IV respectively, and step-IV gives the best fit model under this category containing $\Delta \boldsymbol{NX_t}$ **,** $\Delta \boldsymbol{CAB_t}$**,** $\Delta \boldsymbol{GDP_t}$ **,** and $\Delta \boldsymbol{M_t}$ as the determinants of exchange rate of Australia. It is worth observing that net exports and capital account balance are present in final models under both datasets. A distinguishing feature of our study arises from the fact that both these variables were ignored by Baillie and Selover (1987) and Chin *et al*. (2007) in their analysis of exchange rate.

Table-3: Backward Elimination Process

	Steps	ΔNX_t	ΔCAB_t	ΔM_t	ΔGDP_t	Δi_t	CPI_t	E_{t-1}	Adj-R^2	F-test
Quarterly	I	0.0005 (0.0125)	3.78×10^{-6} (0.000)	0.0005 (0.0926)	-0.0002 (0.0936)	0.0046 (0.205)	-0.0008 (0.666)*	0.077 (0.008)	0.267	8.398 (0.000)
	II	0.0005 (0.0125)	3.89×10^{-6} (0.000)	0.0005 (0.0826)	-0.0002 (0.0694)	0.0046 (0.204)	X	0.078 (0.007)	0.271	9.826 (0.000)
	III	0.0005 (0.0107)	3.83×10^{-6} (0.000)	0.0005 (0.0724)	-0.0002 (0.0975)	X	X	0.077 (0.008)	0.268	11.41 (0.000)
	IV	0.0005 (0.0089)	3.14×10^{-6} (0.000)	0.0005 (0.0827)	X	X	X	0.063 (0.024)	0.259	13.398 (0.000)
	V	0.00049 (0.0136)	2.91×10^{-6} (0.000)	X	X	X	X	0.077 (0.008)	0.248	16.60 (0.000)
Annual	I	-3.26×10^{-12} (0.0053)	3.72×10^{-12} (0.000)	-2.4×10^{-13} (0.007)	3.55×10^{-13} (0.078)	0.009 (0.260)	0.001 (0.885)	-0.115 (0.087)	0.352	3.728 (0.006)
	II	-3.24×10^{-12} (0.0044)	3.72×10^{-12} (0.000)	-2.42×10^{-13} (0.006)	3.67×10^{-13} (0.043)	0.009 (0.242)	X	-0.116 (0.081)	0.374	4.497 (0.002)
	III	-2.94×10^{-12} (0.0076)	3.58×10^{-12} (0.000)	-2.2×10^{-13} (0.009)	4.13×10^{-13} (0.021)	X	X	-0.108 (0.102)	0.366	5.04 (0.002)
	IV	-2.68×10^{-12} (0.015)	3.39×10^{-12} (0.001)	-2.17×10^{-13} (0.012)	4.85×10^{-13} (0.007)	X	X	X	0.330	5.278 (0.002)

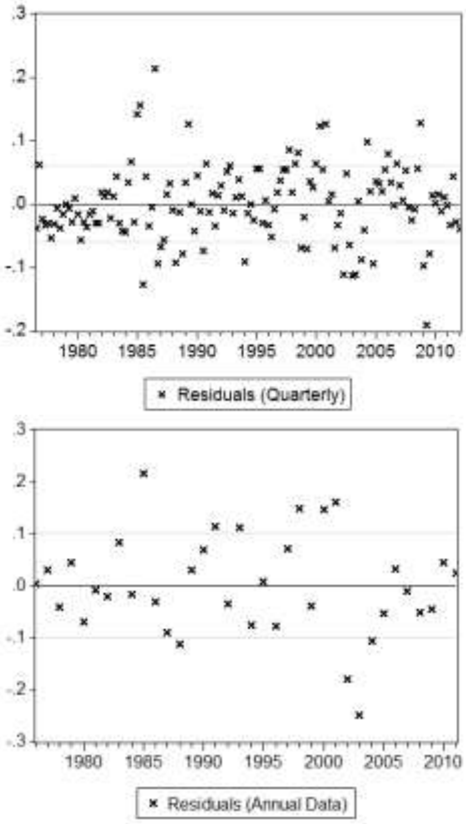
* The variable is insignificant if value in parentheses (p-value) is greater than 5 percent (or 0.05). The variable with highest p-value in a given step is eliminated from the model.

Table-4: Model Dynamics

	White's Heteroske-dasticity Test	Durbin-Watson Test for Serial Correlation	Chow Test for Structural Break	Ramsey's RESET Test
Null Hypothesis	Errors are homoskedastic	Errors are not serially correlated	Regime Change in 1983 is insignificant	Model is correctly specified
Quarterly Data	2.508 (0.011)	1.70 (≥ dU (0.05; 4, 37)=1.7)	1.96 (0.104)	3.767 (0.012)
Annual Data	0.6034 (0.833)	1.77 (≥ dU (0.05; 4, 37)=1.72)	0.175 (0.969)	1.097 (0.367)

4.5 Model Dynamics

Figure 3: Residual Plots



The residual plots for both datasets, viewed in Figure-3, do not show any trend which corroborates the usefulness of backward elimination technique as the model selection criteria. Other dynamics of the models selected in step-V and step-IV in backward elimination process of quarterly and annual datasets respectively, are given in table-4.

Given the threshold level of significance at 5 percent, Durbin-Watson's test for autocorrelation shows that dw-statistic for both models is greater than the upper-limit of critical value for the test and hence errors in both models are serially-uncorrelated[6].

White's Hetero-skedasticity test suggests that errors are heteroskedastic for quarterly data, however they are homoskedastic for annual data model.

Likewise, Ramsey's RESET exhibits that the model under quarterly data contains misspecification errors, and thus it might not be reliable to formulate the analysis on this model. On the other hand, RESET test for model under annual data shows that model is free of any misspecification errors and is correctly specified.

Furthermore, to examine the impact of structural break caused by regime change in 1983, Chow test is applied by regressing three different regression models (break-up of time series being **i**.1975-1983; **ii.**1984-2011, **iii.** 1975-2011). Residual sum of square is estimated for each regression and F-test[7] is applied to test null hypothesis of 'no structural change'. The result for the test suggests that Australia's transition from fixed to flexible exchange rate regime does not impact the regression analysis under both quarterly and annual datasets.

Even though the analysis so far has been drawn as a comparison between quarterly and annual data, further diagnosis is based on a certain type of data. The selection between quarterly and annual data model is based on dynamics of both models. Given the above results, annual data has exhibited more profound and significant results. Moreover, the higher adjusted-R^2 value

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[6] The criterion for rejection of null hypothesis under Durbin Watson test available on: http://www.eco.uc3m.es/~ricmora/MEI/materials/Durbin_Watson_tables.pdf, accessed: 05th October 2012

[7] $F^* = \frac{(RSS_R - RSS_{UR})/k}{RSS_{UR}/n_1+n_2-2k} \sim F(a, k, n_1 + n_2 - 2k)$; where $RSS_R=RSS_{1975\text{-}1983}+RSS_{1984\text{-}2011}$ and $RSS_{UR}=RSS_{1975\text{-}2011}$

provides another justification for superiority of annual data over quarterly data. Therefore, further analysis is based on the annual-data version of the model.

In the annual data model, the effect of macroeconomic factors on exchange rates is given by the beta coefficients. All coefficients have, with a degree of certainty greater than 98%, a non-zero value. Moreover, the signs of these coefficients conform to theory. A further segmentation of the macroeconomic factors can be done as follows.

4.5.1 Trade Indicators

The two trade indicators have a strong and theoretically sound relationship to the exchange rate. When Australia's Net Exports rise, the Australian Dollar appreciates, as demand for Australian goods is reflected in the currency. This is also the case when Australia's Net Capital Account increases.

4.5.2 Monetary Policy

In Australia, monetary policy is determined centrally. The investigation shows that, as the money supply rises, the exchange rate falls and the dollar appreciates. This result is counter-intuitive, but highly significant. One explanation could be that an increase in the money supply increases the viability of the Australian dollar as a reserve, but any hypothesis would need to undergo thorough further investigation. Most likely, money supply is acting as a proxy for some other force which is yet to be identified. This odd result is compounded by the insignificance of interest rates and inflation in determining currency values. Thus at this stage, no policy conclusions can be drawn from the data.

4.6 Engle-Granger Test for Cointegration

Cointegration corroborates the existence of long run relationship between dependent and independent variables. Estimation of cointegration is possible only if (i) all the variables in regression model have same order of integration and (ii) there exists a *stationary* linear combination between the *non-stationary* variables. The preceding section established $\Delta \boldsymbol{NX_t}$ **,** $\Delta \boldsymbol{CAB_t}$**,** $\Delta \boldsymbol{GDP_t}$ **,** and $\Delta \boldsymbol{M_t}$ as the determinants of Australian exchange rate under the annual-data model and it can be observed from table-2 that all these variables are I(1).

The second condition of cointegration is tested by regressing E_t on its determinants, and observing stationarity of residuals using ADF test with the null hypothesis of ‘no cointegration between variables'. Rejection of null hypothesis leads to the existence of a long run relationship between the regressors and the regressand.

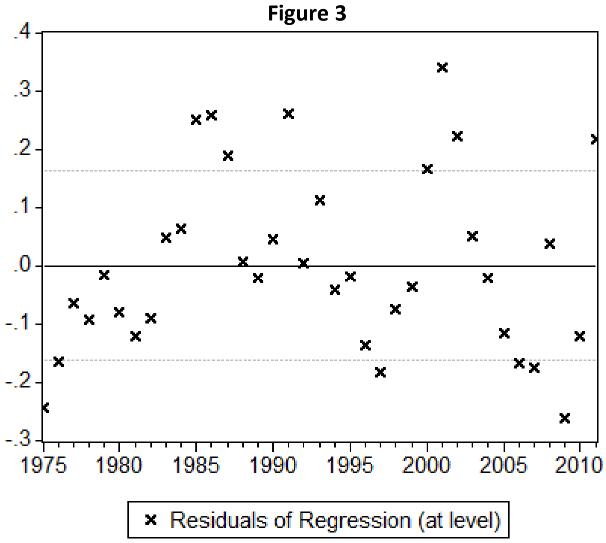
However, this regression has to be estimated at level state, instead of the first difference state of the I(1) variables, regardless of the fact that all series might be non stationary at level (Atif & Hassan, 2012). The least square estimates of exchange rate against its determinants at level, i.e. NX_t, CAB_t, GDP_t, and M_t are given as:

$$\hat{E}_t = 0.937 - 8.29x10^{-12}(NX_t) + 7.42x10^{-12}(CAB_t) - 1.25x10^{-13}(M_t) + 9.79x10^{-15}(GDP_t) \quad (3)$$

S.E. (0.0712) $(1.46x10^{-12})$ $(1.31\ x10^{-12})$ $(8.65\ x10^{-14})$ $(6.30\ x10^{-14})$

Adj- R^2=0.667 SSR=0.846

Figure 3



The graph of residuals for equation (3), represented in Fig.3, exhibits that residuals are stationary at level or I(0). This result is further verified by applying Augmented Dickey-Fuller test on the residuals of equation (3).

Table-5 suggests that there is sufficient evidence to reject null hypothesis of unit root in the residuals which validates the existence of cointegration between the dependent and the independent variables. It is therefore inferred that there exists a long-run relationship between the Exchange Rate of Australia (E_t: AUD/USD) and net exports gap ($NX_t = NX_{AU,t}-NX_{US,t}$), gap between capital account balance ($CAB_t = CAB_{AU,t}-CAB_{US,t}$), money supply gap ($M_t = M_{AU,t}-M_{US,t}$) and output gap ($GDP_t=GDP_{AU,t} - GDP_{US,t}$) of Australia and the United States.

Table-5: Engle-Granger Cointegration test	
Hypothesis	Residuals have unit root
Test Statistic	-3.171 (p-value= 0.032)
Conclusion	Null hypothesis is rejected at 5% level of significance

5. Conclusion and Policy Implications

5.1 Conclusion

By far the most important result seen here is the effect of data smoothing. In the shorter term using quarterly data, no combination of variables returned an acceptable RESET test. This is surprising, as investors (including short-term speculators) are thought to be sensitive to macroeconomic data. It would be interesting to test the daily impact of releases of macroeconomic information, but unfortunately the data do not allow for this. It does however show that macroeconomic data carries different characteristics for different breakups of data.

The end result is a correctly specified model. This suggests that macroeconomic data have maximum explanatory power during the long term. This point is crucial, because it confirms economic theory which explains currency rates in terms of macroeconomic indicators.

The coefficient of determination however unveils another dimension. The model for quarterly data had a very low adjusted R-squared value of 0.299, indicating that the majority of exchange-rate fluctuations were left unexplained by the data. Upon switching to annual data, the adjusted R-squared value improved somewhat to 0.330. Thus a reasonable proportion (33%) of variation in the dependent variable is still explained. This is echoed in earlier studies such as Frankel and Meese (1987), who concluded "measurable fundamental variables do not adequately explain movements in exchange rates". However, upon estimation of same model at level instead of first difference variables, in equation (3), the adjusted R-squared rose to 0.667 (66.7%) which is apparently an ideal result for a time series analysis.

It is therefore pertinent to mention that the study has met all its objectives by providing some very intuitive results that contribute to the literature surrounding exchange rates and their movements. The results provide additional insight into the matters that have not been brought to consideration earlier. It is maintained that trade components of an economy and its fundamental macroeconomic indicators such as economy's relative output and liquidity levels with the foreign country have a significant role in determination of its exchange rates, which is very much in line with the available literature. However, it contradicts with existing literature by diminishing the role of interest rate and inflation in determination of exchange rate. It appears to be a surprising result, and a further investigation into this matter may reveal more dimensions into the exchange rate literature.

Existence of long run relationship further substantiates the relationship between exchange rate and its determinants. This does not fully correspond with previous studies such as Baillie and Selover (1987), who concluded inexistence of cointegration between exchange rate and its determinants using medium-term (quarterly) data.

Furthermore, the study emphasizes the pertinence of unobservable effects such as political events and external shocks to have a considerable impact on historical patterns of exchange rate. This claim is further substantiated by the fact that unobserved effect explains 33.3% of the total variation in exchange rate, in the level-state of annual data model.

It is worthy to be underlined how the flexibility and simplicity of this model incorporated many insightful issues that have not been addressed by earlier studies. However, there are other results that require further investigation, most notably the unexpected effect of the money supply. It would be interesting to analyse this relationship further, and see if a plentiful currency is indeed more valued, or there is some other force at work.

5.2 Policy Implications

- First and foremost, any government that elects a free-floating currency priced by international markets has little control over the price of that currency. While currency rates are universally accepted to be unpredictable in the short term, in the long term this aspect only diminishes rather than vanishes. Thus the point remains for currency policy, that a free-floating exchange rate carries with it an inherent unpredictability, even in the long term.
- Government could use this information in order to better predict the outcomes of trade policy. Here, both the capital account and export balance sheet have an impact on the exchange rate. However, trade policy is often beyond government influence, especially in more liberalised economies. As a result, trade is most useful as policy indicator. The strength of Australian exports can serve as measurement of foreign non-speculative forces on the Australian dollar.
- By explaining all dimensions of economic and non economic indicators, the study provides an insightful framework for researchers and analysts to predict exchange rate with a higher degree of accuracy.
- The knowledge of correct determinants reduces the uncertainty prevalent in foreign exchange market, and hence important implications can be drawn for determining the levels of international trade with a higher precision than before.

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