Is there any relationship between exchange rate and investment ? evidence from Australia

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16 August 2017

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Abstract

This paper makes an attempt to test the possible relationship between exchange rate and investment. Australia is used as a case study. It is interesting to discover the relationship, as the policy makers can use the exchange rate to encourage or discourage investment. The methods used are the standard time-series techniques. The findings based on variance decompositions analysis tend to indicate that investment is driven by exchange rate and followed by inflation rate. The findings are plausible and have strong policy implications for commodity-producing countries like Australia.

Keywords: exchange rate, investment, inflation, Australia

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INTRODUCTION: THE ISSUE MOTIVATING THIS PAPER

Australia once became one of the OECD's (Organization for Economic Co-operation and Development) fastest-growing economies. This can be attributed to the economic reforms introduced in the 1990s to boost economic diversification, export orientation, and the manufacturing industries (Wan Mansor & Nazihah 2009).

On 12 December 1983, the Australian dollar was floated and this continued up until now. Participants in foreign exchange markets, policy markets and international investors were very concerned about the future currency movements as a result of currency floating.

In light of the above background, an empirical study on the impact of foreign exchange rate on investment level in Australia would be interesting to pursue, as there exists no clear evidence whether exchange rate affects investment in a positive or negative manner in a country such as, Australia.

Formally, this study has two research questions, namely:

1. Does an exchange rate level of the Australian dollar relative to the US dollar have any effect on the levels of investments in Australia ?
2. Is there any possibility of using monetary policy to influence exchange rate ?

LITERATURE REVIEW

In the first place, is exchange rate an important factor in determining the level of investment? According to Cao (2012), exchange rate is one of the important macroeconomics variables in an open economic system. Foreign exchange rate affects the cash flow between domestic and foreign currency, which will affect investor's ability to buy stocks. As domestic currency appreciates compared to foreign currency, more currencies can be invested in the stock market, and this will promote investment in the capital market. Lim (2002) posits that the changes in exchange rate are normally small and frequent as they adjust to international portfolios, but these changes can also occasionally become quite large due to adjustment to fundamental misalignments. This is reflected in the non-normal distribution graph of exchange rates.

Since Australia is a commodity exporting country, we would expect fluctuation in the Australian dollar to come from fluctuation in commodity prices, and these fluctuations will affect allocation of investment by Australian investors (Mishra 2010). Mishra (2010) also posits that the floating exchange rate will cause the burden of adjustment resulting from external shocks to shift from foreign exchange reserves and short-term domestic interest rate to the exchange rate.

There seems to be mixed and inconsistent results on the relationship between exchange rate and stock market. Some studies reveal significant positive relationship between the stock market and exchange rate, and other studies found inverse relationship between these two variables. It is also interesting to note that some studies discovered weak or non-existence of relationship between these two variables.

Jawaid and Ul Haq (2012) posit that the relationship between exchange rate and stocks can either be positive, negative, or no significant relation at all. In a positive relationship, currency depreciation will cause local firms to be more competitive, and this will lead to an increase in export, which subsequently cause the stock price to increase. On the other hand, currency depreciation will affect production negatively (if it depends on imported input) as the cost of production will increase. This will reduce profitability and lead to decline in stock returns. The effect of exchange rate can also be negligible as both effects cancel out each other.

RESEARCH METHODOLOGY, RESULTS AND INTERPRETATION

This study uses the standard time series techniques, in particular, cointegration, error correction modeling and variance decompositions in order to find Granger-causality between exchange rate and investment. This method is more favored compared to traditional regression due to the following reasons.

One of the conditions for using traditional regression is the variable has to be stationary. However, most of the finance variables are in non-stationary form. Performing regression on the normal non-stationary form will cause the results to be misleading, as statistical test such as t-ratio is not statistically valid when applied to non-stationary variables. One of the solutions proposed is to use differenced form of the variables, but by doing so it will remove the long-term trend, i.e. the theoretical part. Thus doing regression will only captures short-term relationship, and unable to test the long-term theoretical relationships.

Besides that, in co-integration technique, we do not determine which variable is exogenous or endogenous, but let the result inform us, instead of pre-determining which variable is exogenous and endogenous in traditional regression method which is based on prevailing theories. In other words, the cointegration technique lets the data show us which variable is leader and which is follower, as well as determining which variable is stronger or weaker leader and follower.

The data used here are the annual data collected from World Bank Index.

TESTING STATIONARITY OF VARIABLES

First of all, we begin by determining the stationarity of the variables. A variable is stationary when its mean, variance and covariance are constant over time. To proceed with testing of cointegration, the variables should ideally be in I(1), on which the variables are non-stationary in original form, and stationary in differenced form. Taking the difference of their log form creates the differenced form for each variable used. For example, DGDPG = LGDPG-$LGDPG_{t-1}$. The Augmented Dickey Fuller (ADF) test is then conducted on every variable in both log and differenced form and summarized in the table below.

Variable	Test Statistic	Critical Value	Implication
Variables in Level Form			
LGDPG	-2.3363	-2.9907	Variable is non-stationary
INF	-2.0546	-2.9907	Variable is non-stationary
ER	-1.5608	-2.9907	Variable is non-stationary
LINV	-1.8929	-2.9907	Variable is non-stationary
Variables in Differenced Form			
DGDPG	-3.4615	-2.997	Variable is stationary
DINF	-3.4958	-2.997	Variable is stationary
DER	-3.4894	-2.997	Variable is stationary
DINV	-3.6588	-2.997	Variable is stationary

Table 1: ADF test result

The ADF test is used instead of Dickey Fuller (DF) test as it can tackle the issue of autocorrelation. However, ADF test cannot solve the heteroscedasticity problem. We further test the variables using Phillips Perron (PP) test, as this technique can solve both autocorrelation and heteroscedasticity problem using Newey-West adjusted method. The results of Phillips-Perron tests are depicted in the table below.

Variable	Probability	Critical Value	Implication
Variable in Level Form			
LGDPG	0	0.001	Variable is stationary
INF	0.032	0.001	Variable is non-stationary
ER	0.117	0.001	Variable is non-stationary
LINV	0	0.001	Variable is stationary
Variable in Differenced Form			
DGDPG	0	0.001	Variable is stationary
DINF	0	0.001	Variable is stationary
DER	0	0.001	Variable is stationary
DINV	0	0.001	Variable is stationary

Table 1A: Phillips-Perron test results

Based on the Phillips-Perron test, we can confirm that the variables in differenced form are stationary. However, there seem to be issues for variables in level form. Based on the test, variables GDP Growth and Investment are found to be in stationary form instead of non-stationary form. As we have established before using the ADF test that all the variables in level form are non-stationary, we decided to use ADF result.

DETERMINATION OF ORDER OF THE VAR MODEL

After determining the stationarity of variables, we need to determine the order of the vector auto regression (VAR) that is the number of lags to be used. Table below shows the result of the test whereby both using AIC and SBC we get 3 lags

	Choice Criteria	
	AIC	SBC
Optimal order	3	3

Table 2: Determining order of the VAR

TESTING COINTEGRATION

After confirming that the variables are I(1) and determining the optimal VAR order as 3, we begin the cointegration test. Initially, we used Engle-Granger method but could not find any cointegration. We then used Johansen test and found one cointegration. But, we cannot get any cointegration by using 3 lags, so we changed the number of lags into 4. Table below summarized the finding. Based on the maximal Eigenvalue and Trace, we can find one cointegrating vector whereas according to AIC, SBC and HQC there are no cointegrating vectors.

Criteria	Number of cointegrating vectors
Maximal Eigenvalue	1
Trace	1
AIC	0
SBC	0
HQC	0

Table 3: Testing cointegration

Based on intuition, there should be at least one cointegrating vector as the variables such as inflation rate and exchange rate are typically connected or integrated in that an increase in one of the variables will cause a decrease in another variable. As such, we use the result of maximal Eigenvalue and Trace and assume that there is one cointegrating vector.

Statistically, the above results indicate that some combination of the variables will result in a stationary error term. The economic interpretation to this is that the 4 variables are theoretically related, on which they tend to move together in the long term i.e. their relations is not by chance. This has an important implication for policy makers. Given that there is a relation between GDP Growth, Inflation, Exchange Rate and Investment, the policy makers can encourage or discourage investment by adjusting the inflation rate, the exchange rate, as well as monitoring the GDP Growth of the year.

LONG RUN STRUCTURAL MODELLING

After confirming there is cointegration among the variables, we quantify the apparent theoretical relationship among the variables to compare the findings with the theoretical or intuitive expectations. Using Long Run Structural Modelling (LRSM) component of Microfit, we normalized one of the variables of interest (Exchange Rate), and we initially obtained the results in the following table. Calculating the t-ratios manually, we found all the variables to be significant.

Variable	Coefficient	Standard Error	t-ratio	Implication
LGDPG	0.10446	0.020356	5.13	Variable is significant
INF	-0.25228	0.016292	-15.48	Variable is significant
ER	-	-	-	-
LINV	6.6947	0.33932	19.73	Variable is significant

To ensure that the variables are significant, we do further test by subjecting the estimates to over-identifying restrictions. Apparently the result shows that no convergence happened because of small data size. As we have proved before that there is one cointegration, we decided to use Panel A and move to next step.

From the above analysis, we arrive at the following cointegrating equation (numbers in parentheses are standard deviations):

$$ER - \underset{(0.02)}{0.1LGDPG} + \underset{(0.016)}{0.25INF} - \underset{(0.34)}{6.69LINV} \rightarrow I(0)$$

VECTOR ERROR CORRECTION MODEL (VECM)

We have established thus far that all the variables are cointegrated to a significant degree. However, the cointegrating equation only reveals about the existence of theoretical link between the variables, but not the causality, i.e. which variables is the leading variable and which variable is the following variable. The information on direction of Granger-causation can be particularly important for the policy makers. By knowing which variable is exogenous and endogenous, the policy makers can encourage investment and improve GDP

Growth by focusing on the most exogenous variable. This is because the variable would have a significant bearing on the expected movement of other variable. This variable would be the variable of interest to the policy makers.

In traditional regression technique, the variables are pre-determined whether it is exogenous or endogenous based on prevailing theories. Using cointegration technique, we will let the data determine which variable is exogenous or endogenous.

To test this, we use Vector Error Correction Model (VECM). In addition to decomposing the change in each variable to short-term and long-term components, we also able to determine which variables are exogenous and endogenous. Granger-causality is a form of temporal causality on which we determine the extent to which the change in one variable is caused by another variable in a previous period. By examining the error correction term, e_{t-1} for each variable, and checking whether it is significant, we discover that there exist three exogenous variables, GDP Growth, Exchange Rate, and Investment; and one endogenous variable, Inflation Rate as depicted in the table below

Variable	ECM(-1) t-ratio p-value	Implication
LGDPG	0.992	Variable is exogenous
INF	0.002	Variable is endogenous
ER	0.148	Variable is exogenous
LINV	0.405	Variable is exogenous

Table 5: Vector Error Correction Model

The result suggests that the variable of interest to the policy makers would be GDP growth, exchange rate and investment. These variables, being the exogenous variable, would receive market shocks and transmit the effects of those shocks to other variables. This is an important finding, as we want to establish the theory that exchange rate affects level of investment in Australia.

Besides that, the VECM produces a statistic that may be of interest to the policy makers. The coefficient of e_{t-1} tells us how long it will take to get back to long-term equilibrium if that variable is shocked. The coefficient represents proportion of imbalance corrected in each period. For instance, in the case of the Inflation rate, the coefficient is 0.002. This suggest that when there is a shock applied to the inflation rate, it would take on average 0.002 years (less than one days) for the variable to get back into equilibrium with the other variables.

VARIANCE DECOMPOSITIONS (VDC)

After discovering that the GDP growth, exchange rate and investment as the exogenous variables, we still do not have information on which variable is more exogenous compared to others i.e. the relative exogeneity and endogeneity of the variable. As the VECM cannot tell us this, we use variance decomposition (VDC) technique. VDC acts by decomposing the variance of forecast error of each variable into proportions attributable to shocks from each variable in the system, including its own. The least endogenous variable is thus the variable whose variation is explained mostly by its own past variations.

We started out by applying orthogonalized VDCs and obtained the following results

	LGDPG	INF	ER	LINV
LGDPG	**74.6%**	2.2%	9.5%	1.4%
INF	67%	**13.2%**	3.9%	18%
ER	5.3%	39.4%	**54.2%**	1.1%
LINV	58.1%	0.8%	10.8%	**30.3%**

Table 6A: Orthogonalized VDCs forecast at Horizon=25 (years)

	LGDPG	INF	ER	LINV
LGDPG	**71.8%**	2.0%	11.2%	15%
INF	65.3%	**12.9%**	3.8%	18%
ER	5.4%	39.1%	**54.8%**	0.6%
LINV	58.6%	0.5%	10.9%	**30%**

Table 6B: Orthogonalized VDCs forecast at Horizon = 50 (years)

For the above two tables, rows read as the percentage of the variance of forecast error of each variable into proportions attributable to shocks from other variables (in columns), including its own. The column read as the percentage in which that variable contributes to other variables in explaining observed changes. The diagonal line of the matrix (highlighted) represents the relative exogeneity. According to these results, the ranking of variables by degree of exogeneity (extent to which variation is explained by its own variations) is as per table below:

No	Variable Relative Exogeneity	
	At Horizon=25	At Horizon=50
1	GDPG	GDPG
2	ER	ER
3	INV	INV
4	INF	INF

Table 6C: Relative Exogeneity using Orthogonalized VDCs

The result confirmed earlier VECM analysis, which classified inflation as the only endogenous variable as it is ranked at the lower in terms of exogeneity. However, we also discover result to be slightly different from previous VECM analysis, on which exchange rate is rank higher than investment. We assume the differenced results may be due to the limitation of orthogonalized VDCs. There are two important limitations of orthogonalized VDCs. Firstly, orthogonalized VDCs assumes that when a particular variable is shocked, all other variables are "switched off". But more importantly, orthogonalizes VDCs do not produce a unique solution, on which the generated numbers are dependent upon the ordering of the variables in the VAR. Typically, the first variable would report the highest percentage and as such would be specified as the most exogenous variable.

To tackle this issue, we do further testing using Generalized VDCs. In generalized VDCs, when one variable is shocked, the other variables will not be switched off. Besides that, the order of the variables does not have an impact on the generated numbers.

In interpreting the numbers generated by the Generalized VDCs, additional computations is needed as the numbers do not add up to 1.0 as in the case of orthogonalized VDCs. For a given variable at a specified horizon, we total up the numbers of the given row and we then divide the number for that variable (representing magnitude of variance explained by its own past) by the computed total. The numbers in a row will now add up to 1.0 or 100%. Tables below show the result.

	LGDP	INF	ER	LINV
LGDP	**51.5%**	32.5%	5.7%	10.3%
INF	38.6%	**16.3%**	5.7%	39.4%
ER	4%	20.9%	**70.3%**	4.8%
LINV	28.6%	21.7%	5.9%	**43.8%**

Table 6D: Generalized VDCs forecast at horizon = 25 (years)

	LGDP	INF	ER	LINV
LGDP	**53.2%**	32.6%	7%	7%
INF	38.9%	**15.6%**	5.5%	39.9%
ER	4%	20.9%	**70.3%**	4.8%
LINV	28.6%	21.8%	5.9%	**43.6%**

Table 6E: Generalized VDCs forecast at horizon = 50 (years)

We can now rank the variables by relative exogeneity, as depicted in the table below.

No	Variable Relative Exogeneity	
	At Horizon=25	At Horizon=50
1	ER	ER
2	GDPG	GDPG
3	INV	INV
4	INF	INF

Table 6F: Relative Exogeneity using Generalized VDCs

From the above results, we can make the following observations:

- The Generalized VDCs ranked Exchange Rate as the most exogenous variable. This result contradicts earlier VECM result, as well as the Orthogonalized VDCs, which specify GDP Growth as the most exogenous variable.
- The relative rank in exogeneity is somewhat stable as time passes. Between 25 years and 50 years, there is no change in the ranking.
- The difference in exogeneity between the variables is quite substantial. For example, in the horizon of 25 years, the difference between the most exogenous and the least exogenous (the most endogenous) variable is 37.8%.

The above results would have the following plausible implication for policy makers, as well as investors. As we have ranked exchange rate, GDP growth and investment as the exogenous variables, the policy makers in Australia can monitor these variables to control inflation. The best result to contain inflation would be by monitoring exchange rate, as exchange rate is the most exogenous variable among others.

As we have mentioned earlier in the introduction, Australia is a commodity exporting country. The emergence of China as the "factory of the world" requires lots of raw material, which are supplied by Australia, one of their main trading partners. With China (and other countries) buying their commodities, this will cause the Australian Dollar to be in demand and as such appreciated in value. When the demand for Australian Dollar increases, money supply will increase as well; this on the long term will cause inflation to spike. In other words, inflation being the endogenous variable will react to the changes in the exchange rate.

IMPULSE RESPONSE FUNCTIONS (IRF)

The impulse response functions (IRFs) produce the same information as the VDCs, except that the information is presented in the graphical form.

PERSISTENCE PROFILE

The persistence profile illustrates the situation where the entire cointegrating equation is shocked by outside variable, and shows how long it would take for the cointegrating equation to get back to equilibrium. Here the effect of a system-wide shock on the long-run relations is the focus instead of variable-specific shocks as in the case of IRFs. The chart below shows the persistence profile for the cointegrating equation of this study.

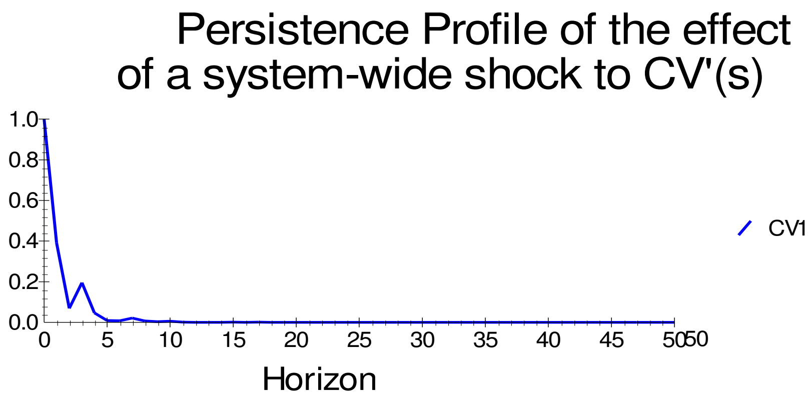

Chart 7: Persistence Profile

The chart indicates that it would take approximately 5 years for the cointegrating relationship to return to equilibrium following a system-wide shock.

CONCLUSION

In conclusion, we revisit the two researches question posed at the beginning of the study. Based on the above quantitative analysis, we found the answers as below:

1. Exchange rate of the Australian dollar does have an effect on the level of investment in Australia since investment is driven by exchange rate.

2. We discover that exchange rate is exogenous and inflation rate is endogenous. As such, we cannot use inflation rate to influence exchange rate in Australia.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This paper must be read whilst bearing in mind that the model is limited to only one focal variable to give more focus on the research topic. Hence, we acknowledge that there might be a danger of excluding significant variables that may cause the model to be biased. However, we have confirmed that the variables are cointegrated.

Furthermore, we recognize that the research lacks further explanation of the role of monetary policy towards the change in exchange rates and how it would influence investments. As we went further into our analysis and literature review, we realize that in order to do so, we needed more data and a broader scope of research. As such this can be pursued in further research in the future to provide more convincing interpretations.

We also proposed that the data should be expanded to include larger observations by including weekly or monthly data to look into the effects of structural breaks from exchange rate regime changes and other significant policy changes in Australia on the investment levels. However, we failed to do so due to lack of data available from DataStream, Business Monitor International as well as World Bank Data.

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