DYNAMICS OF THE CURRENCY EXCHANGE RATES AGAINST THE AUD: ANALYTICAL AND RISK MITIGATION PERSPECTIVES

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Abstract

In recent era, the volatility of exchange rates has drawn considerable notice, especially in the light of huge losses from foreign exchange derivatives by several major firms during the Global Financial Crisis. Australia stands out as a major economy in contemporary arena, and there have been incidents of such loss from derivatives tied to exchange rates against the Australian Dollar (AUD). Under this context, this article aims to characterize the economical aspects of Australia's major trading partners with a view to guiding corporate governance community in respect to risk mitigation actions. The time span considered is January 1999-May 2011, and 14 major currencies are incorporated in this research. The research scrutinizes the statistical and stochastic properties of the exchange rates, and segments the Australia's trading partners in terms of these aspects. The results further show that consideration of grouping produces a better approximation of the strength of Australian Dollar in the global context.

Keywords: Corporate Governance, Exchange Rates, Linear Modelling, Hedging Risk

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1. Introduction

The dynamics of foreign currency exchange rates is a particular area that has challenged the financial researches and practitioners over a number of years. Several models have been proposed to capture the exchange rate's dynamics in the different economical contexts (Davis et al., 2001; Dornbusch, 1976; M. D. Evans, 2011; Frankel, 1979; Frenkel, 1976; Fu, 2010; Kamruzzaman and Sarker, 2003; L. Liu and W. Wang, 2008; Poddig and Rehkugler, 1996), and scepticism has also been expressed in respect to the effectiveness of the proposed models over the random prediction models (M. D. D. Evans and Lyons, 2002; Flood and Rose, 1999; Frankel and Rose, 1994; Meese and Rogoff, 1983; Wolff, 1988).

Even though widely analysed from the forecasting and modelling perspectives, the issue of exchange rate dynamics has recently attracted the attention of corporate governance research community as well. Hsiao and Han (2012), for example, identify the link between the volatility of exchange rates and firm values in the context of Taiwanese economy. Won (2011) reflects on the relationship between risk management and corporate governance, and highlights on mitigating risk, including the risk arising from exchange rate volatility, as integral to the modern firms' survivals and corporate objectives. Zeidan and Rodrigues (2013) reflect on the case of Aracruz, the Brazilian company that sustained huge loss to miss-speculation of exchange rate and hedging strategies, and impose importance on good corporate governance practice in this context. Overall, these studies indicate the perception of exchange rate dynamics as a key factor in the contemporary corporate decision arena.

Australia stands out as a major open economy in the modern era, with significant growth in the investments and business opportunities. A substantial part of the Australian economy comprises trading activities with its international partners, and so the exchange rates of Australian Dollar (AUD) against the major foreign currencies play considerable roles in the corporate context.

However, while a plethora of investigations has reflected on the exchange rate dynamics for the US Dollar, studies with focus on the dynamics of currency exchange rates against the Australian Dollar (AUD) are still limited. Further, the issue addressed in most of the relevant research is the development of high performing prediction models. A study that comprehensively focuses on conceptualizing the characteristics of the exchange rates is still lacking.

This article aims to bridge this gap. More specifically, this research approaches the exchange rate dynamics from attribute analysis perspectives,

and groups the Australia's major trading partners based on volatility of the respective currency exchange rates. The research, further, shows the importance of such grouping in modelling the strength of the AUD, and reflects on significance of the outcomes from corporate governance standpoints.

In this respect, it is worth mentioning the recent article by Kearney (2012), that imposes importance on clustering and grouping based research within the financial and emerging market domains. The approach adopted in this research, thus, corresponds to this view, and the work, to the best of the authors' knowledge, is pioneer in addressing the exchange rate dynamics in this fashion.

The rest of the article is organized as follows. Section 2 presents an overview of relevant literature in the exchange rate domain. Section 3 focuses in details on the relevance of exchange rate dynamics in the corporate governance arena.

2. Exchange Rate Modelling

The research issue involving prediction of exchange rate has been in focus of the researchers for several years. The very early models concentrated on relating macro-economic aspects to exchange rates through varied assumptions: flexible-price asset view (Frenkel, 1976; Bilson, 1978), sticky-price monetary view (Dornbusch, 1976) and combination of these views (Frankel, 1979). Some of the later works, however, questioned the ability of these models in capturing exchange rate dynamics. Meese & Rogoff (1983), for example, compared the performance of a set of exchange rate models against random walk models and concluded that exchange rates and macroeconomic fundamentals are not strongly related. Wolff (1988) considered the previously published univariate time series models and concluded that the outcomes are no better than random forecasts. Similar cynical views were also expressed by other studies (Frankel and Rose, 1994; Flood and Rose, 1999; M. D. D. Evans and Lyons, 2002).

Recent works, however, challenge these views. Evans (2011), for example, highlights that, in contrast to the earlier pessimistic views, recent extensions to the existing models as well as novel econometric methods have provided clearer insight to the sources and consequences of exchange rate fluctuations. Yuan (2011) also argues against the earlier pessimistic views and notes that macro-fundamentals and exchange rate dynamics are nonlinearly associated. Caporale et al. (2011) note fiscal shocks as the major driving force affecting real exchange rates for selected Latin American countries. Beckmann et al. (2011) study the temporal relationship stability between the Deutschmark/US dollar exchange rate and macro-fundamentals, and observe differing impact of the fundamentals over the varied episodes.

Research has also considered micro-economic factors to conceptualize exchange rate dynamics. A comprehensive research, in this context, is the study by Evans and Rime (2010). The work presents a portfolio-shift model to underline the dynamics of foreign exchange rate. The research also highlights through a decomposition model why macro models have often deemed to be unable in capturing exchange rate dynamics and how micro models, considering dealer centric trade perspective, can overcome the limitations.

There have also been recent attempts to bridge the macro and micro economic concepts towards explaining exchange rate dynamics. Rime et al. (2010), for example, analyse the associations between exchange rate dynamics, order flow and macro-fundamental expectations for three major exchange rates against the US Dollar and concludes that order flow as a powerful predictor of day-to-day movements in exchange rate.

The economic characteristics and currency considered in the existing strategies have also varied. For example, Berger et al. (2008) investigate the relationship between order flow and exchange rate dynamics for an Electronic Brokerage System data (covering primarily the US Dollar-Japanese Yen and Euro–US Dollar pairs) and reveal the existence of strong associations. Kandil et al. (2007) consider the relation between the exchange rate fluctuations and the real output, price level, and aggregate demand in Turkey. Scarlat et al. (2007) capture the variations in exchange rate for Romanian national currency against the US Dollar. Huang and Guo (2007) reveal the association between movements in Chinese Renimbi and macro-fundamentals.

In the very recent years, the area has noticed an increase in the application of advanced computational techniques. Davis et al. (2001), for instance, employ various Artificial Neural Network (ANN) models to realize the directional shift for the Canadian Dollar/US Dollar exchange rate and note the superiority of ANN over the conventional models. Kamruzzaman and Sarker (2003) also demonstrate the superiority of ANN over the classical ARIMA model in forecasting the exchange rates of six currencies against the Australian Dollar. In another research, Kamruzzaman et al. (2003) consider the application of Support Vector Regression (SVR), a state-of-the art technique, in exchange rate modelling. Liu and Wang (2008) note the least-squared SVR based approach as highly efficient in exchange rate prediction. Fu (2010) incorporates signal decomposition approach with SVR and highlights the effectiveness of the proposed exchange rate model. Ince & Trafalis (2006) outline a hybrid approach, involving parametric techniques and non-parametric techniques, and observe the effectiveness of the developed model for exchange rates of US Dollar against the Euro, Great Britain Pound, Australian Dollar and Japanese Yen. Huang et al. (2010) consider chaos theory in the design of a multistage forecasting technique for exchange rates. Wang et al. (2009) develop an

ensemble of classifiers using SVR and achieve considerable performance improvement in forecasting the exchange rates between US Dollar and Japanese Yen. In a previous work (Imam et al., 2012), we explore the relationship between the AUD/USD exchange rates and corresponding stock markets through a set of computational tools, and observe linear modelling as the best approach.

Overall, the exchange rate domain has been addressed by researchers from the varied domains and perspectives. A more detailed up-to-date review is in Imam (2012).

However, even with such level of undertakings, there still remain open questions and uncertainties in respect to this domain. While the forecast of exchange rates is an important issue, interpretable analysis of the exchange rate dynamics is also of interest to the financial decision makers and stakeholders. To the best of the authors' knowledge, however, only limited works have focused on this aspect and a work with particular focus on perceiving the exchange rate dynamics against the Australian Dollar is missing. This research is motivated by this issue.

3. Link to Corporate Governance

As indicated in the 'Introduction' section, the corporate governance research community is increasingly realizing the importance of perceiving the exchange rate dynamics.

A relevant issue that has drawn recent attention is the severe impact of fluctuating exchange rates on the Brazilian economy during the Global Financial Crisis (Oreiro and Basilio, 2011). As a consequence of sudden devaluation of Brazilian Real, several large Brazilian firms including Aracruz Celulose S.A., the world's major eucalyptus pulp producer, and Sadia S.A., the major food processor, sustained heavy losses on derivatives tied to the exchange rate markets (Caminada and Price, 2008; Ragir, 2008). Subsequent investigations have related the event to the agency problem and risky hedging strategies adopted by these companies (Perera et al., 2012; Zeidan and Rodrigues, 2013).

Another relevant case is that of CITIC Pacific, the Hong Kong based company, which invested into currency accumulators linked to exchange rates against the Australian Dollar and suffered losses of nearly US$ 2 billion in 2008 (Huiyin et al., 2008; Leung and Wong, 2008). Investigations revealed that the event was instituted by weak corporate governance, and the aftermath was resignation, demotion and legal punishment for some of its directors and senior officials (Chung, 2008; Tong and Yun, 2012). Yet, another similar instance is that of Cemex, the Mexican Cement company, which has also sustained losses and financial stress due to exchange rate volatility (Emmott and Lopez, 2008; Thomas Black, 2009).

Overall, these incidences reveal the significant roles exchange rates play in the contemporary corporate arena. In this respect, it is worth mentioning the recent article by Butler and Utete (2012). The authors propose a valuation framework to guide currency hedging decisions and outline exchange rate forecast as integral to the approach. In another research, Bahmani-Oskooee and Hajilee (2013) demonstrate that exchange rate volatility has transitory impacts on domestic investment in several economies. Hutson and Stevenson (2009) prescribe that firms in the open economy are more impacted by exchange rate volatility than those in the closed economy, and also point out that the creditors' rights and firms' exchange rate exposures are inversely associated. There are also other similar studies that have considered the links between corporate governance practices and exchange rate exposure (Hsiao and Han, 2012; Won, 2011).

Overall, the perception of exchange rate dynamics is noted to be important not only from the risk management perspectives, but also from corporate governance standpoints. And, this is particularly prominent with the emergence and spread of the open economies across the different countries. As per the 2013 Index of Economic Freedom Indicator, tracked by the Heritage Foundation in partnership with the Wall Street Journal, Australia ranks 3rd among the top open economies in the world (HF, 2013). Considering this and the impact of exchange rate volatility on open economies, contemporary realization of the dynamics of exchange rates against the Australian Dollar (AUD) is of imminent importance. This article is motivated also by this issue.

4. Research Design & Methods

This section provides details on the investigations carried out in this research. A particular aspect of this investigation is the consideration of exchange rate dynamics from characteristic analysis perspectives, in contrast to the common focus on forecast model design. More precisely, the research considers the exchange rates for 14 major currencies against the Australian Dollar (AUD) and focuses on addressing the following research questions:

1. *What are the relative economical characteristics of Australia's major trading partners in terms of the currency exchange rate's volatility?*
2. *Can a grouping be established among the Australia's major trading partners in terms of the currency exchange rate's characteristics?*
3. *Which major currencies play vital roles in characterizing the strength of AUD?*

The research framework involved is shown in Figure 1. Dataset used in this research is collected from the Reserve Bank of Australia (RBA) website (RBA, 2012). Followed by the dataset collection and subsequent pre-processing, statistical and stochastic

analyses are performed to realize the characteristics of the exchange rates against the Australian Dollar (AUD). The outcomes from the statistical and stochastic analysis address the *Research Question 1*. To address the *Research Question 2*, an advanced data analysis method is applied to group the economies of Australia's trading partners in terms of currency exchange rates' volatility. The outcomes from the grouping indicate the major currencies that hold substantial effect on the strength of AUD. Validity of the grouping outcome is further substantiated through modelling a one-day-ahead forecast system for the AUD's strength. Details about the methodologies are presented in the subsequent sub-sections.

4.1 Data Details & Pre-processing

Exchange rates for 14 major currencies (RBA, 2012) are considered in this re- search. These are: Canadian Dollar (CAD), United States Dollar (USD), Euro (EUR), UK Pound Sterling (GBP), Swiss Franc (CHF), Japanese Yen (JPY), Hong Kong Dollar (HKD), Singapore Dollar (SGD), Malaysian Ringgit (MYR), New Taiwan Dollar (TWD), South Korean Won (KRW), Indonesian Rupiah (IDR), Chinese Renminbi (CNY), and New Zealand Dollar (NZD). Of these currencies, 2 correspond to the North American economy, 3 to the European economy and 9 of these currencies relate to economies at the Asia and Pacific region. Further to the 14 major currencies, Trade Weighted Index (TWI), a statistic used by the Reserve Bank of Australia (RBA) to indicate the strength of Australian Dollar, is also incorporated in our research. The time span regarded for this research is: Jan 1999 to May 2011. This research considers only the trading days within this time span for which exchange rate information of all the 14 currencies are available. This consideration and removal of incomplete records result in a dataset comprising of 3113 rows and 15 columns (i.e., 3,113 trading days' information for the 14 currencies and TWI). Figure 2 briefly outlines the dataset and its characteristics.

4.2 Relative Characteristics of Australia's major trading partners

To address the *Research Question 1*, the research conducts two different analyses on the data:

1. Statistical Analysis
2. Stochastic Analysis

4.2.1 Statistical Analysis

Table 1 presents the summary statistics for exchange rates of the 14 currencies and T W I within the considered time span. The minimum, maximum, mean and standard deviation values, along with the values at 5% and 95% quantiles are depicted. Figure 3, further, highlights the coefficient of variation (CV) for the currencies and TWI.

From the statistical characteristics, it is observable that the numerical values of the different exchange rates have varied considerably over the time span. Among the 14 considered currencies, NZD is seen to have the lowest coefficient of variation. This implies that the exchange rates for NZD have tended to remain stable against the AUD over this time span. In contrast, IDR has the highest coefficient of variation, implying that the exchange rates for IDR against the AUD tend to be volatile. Comparing the two North American currencies, we observe that the CAD has the lower coefficient of variation. Further, the coefficient of variation for the CAD is the second lowest after that for the NZD. On the other hand, the coefficient of variation of exchange rates for USD is the second highest after the IDR. Among the three European currencies, exchange rates for the GBP have noticeably higher dispersion than the other two currencies. Also, all the Asian currencies have coefficient of variation greater than 10%, implying that exchange rates for the Asian currencies are considerably volatile against the AUD.

The outcomes of this analysis can be interpreted from risk analysis perspective. As per the outcomes, transactions involving NZD/AUD or CAD/AUD exchange rates are less risky and susceptible to fluctuations compared to those involving USD/AUD or GBP/AUD exchange rates. Further the analysis depicts that the transactions involving exchange rates between the Asian currencies and AUD are associated with considerable risks. Overall, the analysis provides guidance on the diverse risks associated in transactions with currencies of the Australia's major trading partners, and thereby links to the broader issue of risk management in corporate governance.

4.2.2 Stochastic Analysis

To conduct stochastic analysis, the exchange rate information for the different currencies is first discretised into a number of states, subsequent to which the relative probabilistic characteristics of the states are examined.

To be more precise, let ER_i denote the numerical exchange rate value for a particular currency against the AUD on a specific day, while $ER_{5\%}$ and $ER_{95\%}$ indicate the 5% and 95% quantile values for the currency over the considered period. Then, using the criteria outlined in Eq. 1, ER_i is discretized into one of the states, S_i: *LE*, *NM* and *HE*.

if $(ER_i \leq ER_{5\%})$ **then** $(S_i = LE)$
if $(ER_{5\%} < ER_i \leq ER_{95\%})$ **then** $(S_i = NM)$
if $(ER_i \geq ER_{95\%})$ **then** $(S_i = HE)$ (1)

LE indicates the event that the exchange rate value is either equal to or less than the 5% quantile (we consider this as the *low extreme state*), *NM* indicates the event that the exchange rate value is greater than the 5% quantile and either less than or equal to the 95% quantile (we consider this as the *normal state*), and *HE indicates* the event that the

exchange rate value exceeds the 95% quantile (we consider this as the *high extreme state*).

In other words, *NM* denotes the event that exchange rate for a particular currency on a specific day is within the generally expected range (as based on historical values), while *LE* and *HE* reflect anomalous states of the exchange rate for that particular currency on the considered day. *LE* signifies that value of the corresponding currency has considerably appreciated against the AUD (i.e., AUD has notably weakened against the currency), while *HE* signifies that value of the corresponding currency has considerably depreciated against the AUD (i.e., AUD has notably strengthened against the currency).

With the states defined as such for exchange rates of the considered currencies, we focus on the probability of the currencies being in one of these states, as well as the on transitional probability between the states. Figure 4 (a)-(b) outline the probability of the currencies being in the *NM* state, and the *LE* and *HE* states respectively. The transitional probabilities are outlined in Figure 5. Figure 5(a) depicts the probabilities that a currency in *NM* state on a particular trading day transits to any of the extreme states on the next considered trading day. Figure 5(b), on the other hand, depicts the probabilities that a currency in an anomalous state on a particular trading day transits to *NM* state on the next considered trading day. Similarly Figure 5(c)-(d) highlight the probabilities that a currency in *NM* state or an anomalous state on a particular trading day transits to the same state on the next considered trading day.

As per the Figure 4 and Figure 5, the characteristics of majority of the exchange rates are comparable in terms of the stochastic properties. Figure 4 indicates that exchange rate for the NZD has the largest probability of being in the *NM* state, while that for the GBP has the lowest probability of being in the *NM* state. This implies that, if historical data are considered and the 5%-95% quantile of exchange rate information is assumed to be the expected range, exchange rate for NZD has the highest and that for the GBP has the least chance of being within an expected range on a particular trading day.

Figure 4 also shows the probabilities of exchange rates being in an anomalous state on a particular day. Particularly notable characteristic from this angle is the nearly equal probability of acquiring anomalous values in either direction for all the Asian currencies except for the TWD. In other words, other than TWD, the Asian currencies have nearly equal chance of being in anomalously appreciated or depreciated state against the AUD on a particular trading day. For TWD, the probability of its anomalous depreciation against the AUD on a particular trading day is higher than the probability of its appreciation. Similar property is noted for the exchange rates of USD and CHF. However, for the CAD, EUR, GBP and NZD, the probability of these currencies being in anomalous appreciation state against the AUD on a particular trading day is higher than the probability of being in depreciation state.

Considering the transitional probability, Figure 5 highlights that other than CNY, TWD, MYR, SGD and CHF, the currencies have higher chance of moving from normal state on a particular trading day towards an anomalous appreciation state against the AUD on the next trading day, as compared to the transition from normal state to anomalous depreciation state. Interestingly, similar characteristics are observed when the considering the transition from anomalous states to the normal state. More specifically, except for the CNY, TWD, MYR, SGD and CHF, the currencies have higher chance of moving from anomalous appreciation state against the AUD on a particular trading day towards a normal state on the next trading day, as compared to the transition from anomalous depreciation state. Considering the transitions from normal state on a particular trading day to normal state on the next trading day, the characteristics of the currencies are comparable. Considering the transitions from an anomalous state on a particular trading day to the same anomalous state on the next trading day, it is notable that except for the CNY, TWD, MYR, SGD and CHF, the currencies have higher probability of remaining in the anomalous depreciation state as compared to the anomalous appreciation state.

Overall, the stochastic properties of the exchange rates for the currencies of Australia's major trading partners vary. We also observe that the stochastic properties of five currencies (CNY, TWD, MYR, SGD and CHF) are very similar. This implies the existence of .a grouping among the Australia's major trading partners in terms of economical characteristics. .The outcomes are also of importance from the corporate governance interpretation. As in the earlier analysis, transactions involving GBP/AUD exchange rates are again noted to be associated with high risk. The analysis also reveals the expected transition of the exchange rates on basis of a given state of the currencies. For instance, given that exchange rates for USD is in an anomalous state, its probability of moving towards the normal state is over 10% for anomalous appreciation to normal state transition and much less than 5% for anomalous depreciation to normal state transition. Also, when in an anomalous state, exchange rate for USD has over 95% probability to remain in the depreciation state compared to less than 90% probability for appreciation state. Also, the probability of USD moving from depreciation state to normal state is lower than that for the appreciation state to normal state transition. In other words, the analysis indicates that when the USD sustains considerable depreciation against the AUD on a particular trading day, it has a notable chance of remaining depreciated on the next trading day. Similar characteristics are also observed for the other currencies except the CNY, TWD, MYR,

SGD and CHF. For these five currencies, the tendency of remaining in appreciation is higher than that for depreciation. This information is of significance to the corporate managers, specifically from the hedging and exchange rate dynamics analysis perspectives. Thus, the stochastic analysis, also, links to the broader issue of risk management in corporate governance.

4.3 Grouping of Australia's major trading partners

From the analysis in the previous sections, it is notable that exchange rates for the different currencies against the AUD behave differently. Further, two categories of currencies are noted when considering the transitional stochastic properties of the currencies. This section expands the statistical and stochastic analysis even further, and aims to group the Australia's major trading partners based on the exchange rate dynamics. The idea of such grouping is to realize the similarities between the foreign economies when considering characteristics of the corresponding exchange rates against the *AUD*, and also to perceive the economies having the major impact on the global strength of AUD.

In particular, we employ Agglomerative Hierarchical Clustering (*AHC*), an advanced computing technique, to segment the foreign currencies. AHC (Hastie et al., 2005; Izenman, 2008) initially assumes that each input data belongs to its own cluster (i.e., group), and then proceeds iteratively by merging similar clusters, based on a dissimilarity metric, to form a larger sub-cluster. This formation of sub-clusters and merging of similar sub-clusters are iteratively continued until all the data points have been included in a large cluster.

For the experiment conducted in this research, we consider a dataset comprising the stochastic properties of the exchange rates. More precisely, four logical information (B_1, B_2, B_3, B_4) and three rank information ($R_{1\text{-}3}$), as presented in Table 2, are considered for each of the currencies. In more details, the information considered are:

1. Whether the probability of appreciation against the AUD is greater than the probability of depreciation for a particular currency – B_1
2. Whether the probability of transition from normal state to appreciation state against the AUD is greater than the transition from normal state to depreciation state for a particular currency – B_2
3. Whether the probability of transition from appreciation state to normal state against the AUD is greater than the transition from depreciation state to normal state for a particular currency – B_3
4. Whether the probability of transition from appreciation state to appreciation state against the AUD is greater than the transition from depreciation state to depreciation state for a particular currency – B_4
5. The relative rank of probability of the currencies being in the appreciation, normal and depreciation state on a particular trading day, with the lower number indicating the higher probability – $R_{1\text{-}3}$

Table 2 also provide details on the value of these variables for the considered currencies. With the dataset built as such, the *AHC* implementation in R (Maechler et al., 2012) is employed to group the currencies based on these variables. To calculate the dissimilarity measure between the currencies, as required by the *AHC* technique, the *daisy algorithm* implemented in R (R Development Core Team, 2008; Struyf et al., 1997) is applied.

Figure 6 presents the outcome generated by the *AHC* in the form of a dendogram (Izenman, 2008). A dendogram is a tree-like representation of the clusters in data, with the heights indicating the similarities and dissimilarities between the clusters. Closely related items are combined at lower levels, while dissimilar items are linked at the higher levels of a dendogram. The tool has been applied in quantitative finance to depict segmentations within experimental data (Mergner, 2009), and is also used in this research to highlight the grouping of Australia's major trading partners in terms of exchange rate dynamics.

Figure 6 reveals 3 distinct clusters, comprising of 11 currencies:

a) *Cluster 1* (EUR, CAD),
b) *Cluster 2* (USD, HKD, IDR, KRW, JPY), and
c) *Cluster 3* (CHF, MYR, CNY, SGD).

This implies that exchange rates for EUR and CAD possess strong similarities in terms of the seven information considered. Also, exchange rate for USD is closely tied to that for the four Asian currencies (HKD, IDR, KRW, JPY), while exchange rate for CHF is closely related to that for the three Asian currencies (MYR, CNY, SGD). Of the other 3 currencies, GBP *is* similar in characteristics to the currencies in *Cluster 1*, while TWD is related to the currencies in *Cluster 3*. NZD, although having a considerable height difference (i.e., dissimilarity) from the currencies in *Cluster 2*, is best related to this cluster among the 3 clusters.

Overall, the *AHC* based analysis reveals the closeness of the foreign economies when considering the dynamics of corresponding exchange rates against the AUD. From a corporate governance perspective, this information is particularly useful and provides guidance on how the foreign economies relate to each other in respect to Australian Dollar's transaction perspectives. It is hypothesized that among the 14 considered currencies, the 11 currencies, constituting the 3 clusters, have the most influential impact on the strength of AUD – a hypotheses which will be examined in the next section. Thus, any transaction involving the AUD and one of the 11 currencies, should also take into account the state of the other 10

economies when considering the mitigation of involved risk. Further, the analysis shows that transactions involving AUD/GBP, AUD/NZD and AUD/TWD are relatively less impacted by the state of economy of the other trading partners, with AUD/NZD transactions considerably less prone to the conditions of other exchange rates. This, again, highlights the notably less risk associated with AUD/NZD transactions, as shown in the previous analysis.

4.4 Characterization of the Strength of AUD

To examine the hypotheses that 11 currencies have the most influential impact on the strength of AUD, an empirical investigation is conducted.

The strength of AUD is expressed in terms of Trade Weighted Index (TWI). TWI (calculated by RBA) is an index based on a weighted basket of currencies and reflects the strength of *AUD* in regards to Australia's trading partners. Increase in TWI implies strengthening (appreciation) of AUD, while decrease in TWI implies weakening (depreciation) of AUD. From Figure 3, we observe that the coefficient of variation for TWI is 12.46%, highlighting that TWI has varied noticeably over the considered period. Discretization of this index, in a similar fashion to the 14 currencies and using Eq. 1, reflects that the probability of its being in *NM* state is very low (Figure 4) and it has a higher probability of acquiring the *LE* state than the *HE* state. This implies, when considering extreme conditions, AUD has greater chance of being depreciated than appreciated. The state transition probabilities in Figure 5 show that transition probability of TWI from the *NM* to *LE* state (i.e., transition from normal state to depreciation of the *AU D*) is higher than that from the *NM* to *HE* state (i.e., transition from normal state to appreciation of the AUD). Also, *TWI* has a notable probability of transiting from the *NM* state to *NM* state. Overall, we observe that there is a considerable dispersion and uncertainty level associated with TWI, and so it's worth-noting how this index of the strength of AUD relates to the other currencies.

We presume that the 11 currencies (EUR, CAD, USD, HKD, IDR, KRW, JPY, CHF, MYR, CNY, SGD), comprising the 3 clusters indicated in the previous section, together have a considerable impact on the Australian economy, and thereby on TWI. We substantiate this presumption by considering two models functionally relating the TWI to the exchange rate of the currencies. The models are as shown below:

Model 1 (M_1):

$$\mathrm{TWI} = \sum_i \alpha_i C_i + b \qquad (2)$$

Here,

$C_i \in$ {EUR, CAD, USD, HKD, IDR, KRW, JPY, CHF, MYR, CNY, SGD, TWD, GBP, NZD}

Model 2 (M_2):

$$\mathrm{TWI} = \eta\left(\sum_i \beta_i C_{1i} + b_1\right) + \sum_i \gamma_i C_{2i} + b_2 \qquad (3)$$

Here,

$C_{1i} \in$ {EUR, CAD, USD, HKD, IDR, KRW, JPY, CHF, MYR, CNY, SGD}

$C_{2i} \in$ {TWD, GBP, NZD}

The models are also shown in Figure 7. In Model M_1, it is assumed that the TWI is related to the exchange rates of the 14 currencies through a linear relationship. In Model M_2, however, the TWI is assumed to be related to the exchange rates of the 14 currencies through a two stage process. Based on the hypotheses that the 11 currencies, constituting the 3 clusters indicated in the previous section, have the most significant impact on the strength of AUD, M_2 comprises a combination of two linear models. The first linear model relates only the 11 currencies to an estimate of the TWI. The second linear model relates the estimate of TWI from the first model and the exchange rates for the other 3 currencies to TWI.

The performances of M1 and M2, in terms of characterizing TWI, are then compared to examine the validity of the hypotheses. A Monte Carlo approach, comprising of 100 trials, is employed, and Support Vector Regression (Vapnik, 1999), a state-of-the-art regression technique, is adopted in this respect. At each trial, 80% of the exchange rate information are randomly selected to train/build both of the models and the rest of the information are used to evaluate the performance in terms of Root Mean Squared Error (RMSE). Figure 8 shows the outcomes from these 100 trials. We observe that, for all the trials, the RMSE for M_2 is less than that for M_1, implying that the model M_2 is a better estimator of TWI. In other words, the model considering the existence of grouping among the foreign currencies (based on the stochastic properties of the exchange rates) has performed better in reflecting the global status of AUD than that with no such considerations. Using the Wilcoxon rank sum test, this difference in estimation performance is noted to be statistically significant at the 99.99% confidence level ($p < 0.00001$).

The results, thus, imply that the two stage functional relationship in M_2 captures the variance in TWI better than the single stage relationship in M_1. Considering the structure of the two models, the improvement can be linked to the estimation of TWI based upon the 11 currencies, which is further weighted along with the other 3 currencies in characterizing the final estimation of TWI. In other words, the 11 currencies in combination capture the major part of the variance in TWI. So, the results indicate that the 11 currencies (EUR, CAD, USD, HKD, IDR, KRW, JPY, CHF, MYR, CNY, SGD)

indeed have a considerable impact on the strength of AUD.

We observe that these outcomes also correspond to relevant statistics. From information provided by the Australian Department of Foreign Affairs and Trade (DFAT, 2012a, 2012b), we note that the three Asian countries: Hong Kong, Indonesia, and Republic of Korea all have China and Japan within the top 5 principal export and import destinations, implying a close tie between these five economies. Also, the economies of Malaysia and Singapore are closely tied with high volume of import and export relationships, as well as having similar trade relationships with China. Also, USA is within the top 5 import and/or export partners for all these economies. In terms of overall trading, China, Japan, USA, Republic of Korea and Singapore are the Australia's top 5 two-way trading partners. Further, the real GDP growth of the European Union and Canada has followed similar patterns over the years, with import into Australia from these sources exceeding export to these destinations, thereby indicating similarities among these economies from Australian perspectives. Overall, these facts highlight the close inter-link between these economies. We argue that this has also been reflected in the clustering results and the experiment conducted in this section.

From corporate governance perspectives, the results can again be linked to the issue of risk management. While the exchange rates of major currencies like the USD or EUR are most often considered in deciding cross-currency transactions, the results highlight that, in the case of transactions involving AUD, exchange rates and relative economic status of all the 11 currencies should be well considered in such decision. Referring back to the incident of CITIC Pacific (Huiyin et al., 2008; Leung and Wong, 2008), it is observable that the organization entered into accumulator contract involving USD/AUD exchange rates. However, the corresponding economic characteristics of the relevant Asian countries could also have been well-considered in this hedging process. It is worth mentioning the views of Fratzscher (2009), who has investigated the impact of USA associated macro-economic shocks on exchange rate movements and concluded that countries having direct trade relations with USA, low foreign exchange reserve and weak current account suffered most during the global financial crisis in terms of devaluation of the respective currency. As per a report on Global Finance (GF, 2013), Australia and majority of its trading partners, particularly the Asian countries other than China and Japan, are ranked considerably below the top 5th in terms of foreign exchange reserve. From this angle, as well, we argue that the incident of CITIC Pacific may have been avoided if proper consideration of the Australia's trading partners' economy were also taken into account. Overall, the results, outlined in this section, correspond to economical interpretation, and thereby are of value to the corporate governance community.

5. Conclusion

While the issue of exchange rate modelling has been addressed in literature principally from the forecasting and prediction perspectives, this article is in unique in the sense that it considers the statistical and stochastic properties of the exchange rates against the AUD in characterizing Australia's trading partners. Further to this, the research focuses upon segmenting the partners on these aspects. The results reveal that the exchange rates of the 14 major currencies against the AUD vary considerably in terms of statistical and stochastic properties. It is further observed that AUD/NZD exchange rates are relatively stable and less prone to global financial issue. Also, the Asian economies are noted to be volatile in respect to the fluctuations for exchange rates of the corresponding currencies. The experiments, further, reveal that the global strength of AUD is highly influenced by 11 economies - Eurozone, Canada, USA, Hong Kong, Indonesia, Republic of Korea, Japan, Switzerland, Malaysia, China and Singapore. The links of the findings in this research to the corporate governance issues are also highlighted in the article. Overall, the article provides a comprehensive analysis, both from the empirical and the corporate governance's risk perspectives, on the economic aspects of AUD in the global arena. In a future research, we shall provide further focus on segmentations within the Australia's trading partners, and realize the significance from the corporate governance aspects.

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Figure 1. Research Framework

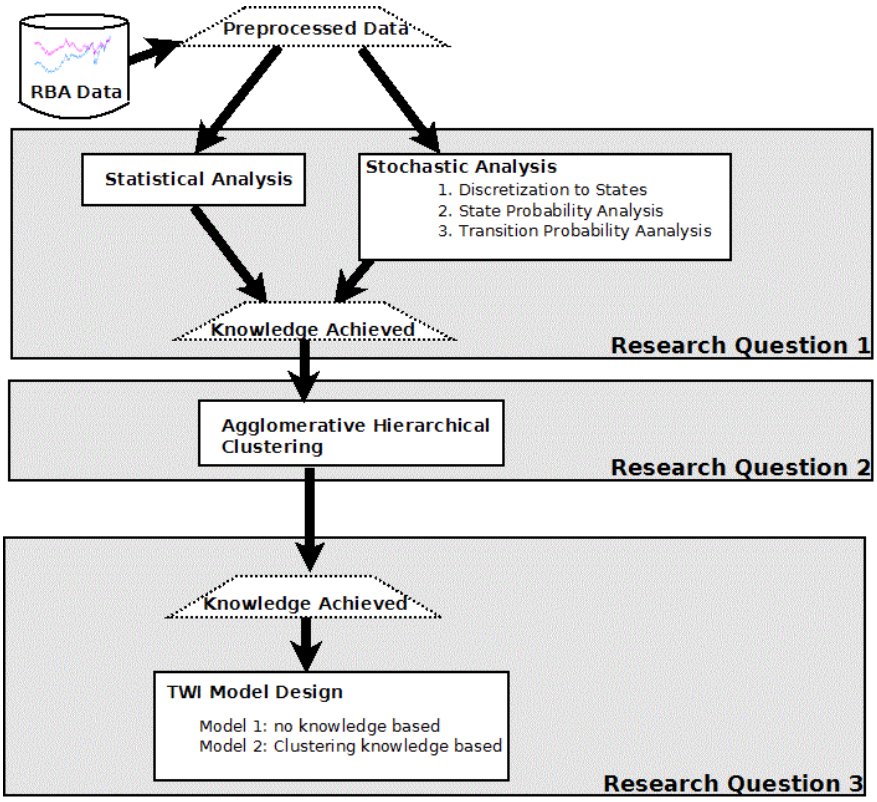


Figure 2. Outline of the dataset used, depicting the considered currencies grouped by geographical region

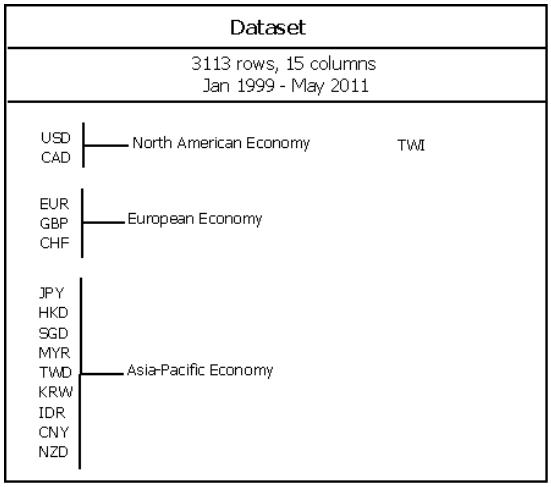


Table 1. Summary Statistics for exchange rate of the currencies against AUD

Currency	Minimum	Quantile (5%)	Mean	Standard Deviation	Quantile (95%)	Maximum
USD	0.4833	0.5169	0.7267	0.1423	0.9757	1.0939
CAD	0.7627	0.7991	0.9005	0.0600	0.9949	1.0504
EUR	0.4806	0.5422	0.6061	0.0475	0.7122	0.7716
GBP	0.3303	0.3550	0.4327	0.0750	0.6147	0.6642
CHF	0.7098	0.8010	0.9246	0.0660	1.0157	1.0798
JPY	55.820	61.028	78.155	11.653	99.512	107.620
HKD	3.7691	4.0313	5.6542	1.1047	7.5866	8.4964
SGD	0.8537	0.9292	1.1474	0.1294	1.3049	1.3533
MYR	1.8400	1.9640	2.6071	0.3682	3.0920	3.2522
TWD	15.910	17.476	23.607	4.030	29.690	31.380
KRW	587.620	650.612	815.808	140.883	1102.728	1170.340
IDR	4299.0	4676.2	6673.5	1396.5	8834.4	9371.0
CNY	4.0006	4.2747	5.5914	0.7932	6.6183	7.1028
NZD	1.0448	1.0749	1.1906	0.0742	1.3101	1.3729
TWI	46.40	49.60	60.94	7.59	73.44	79.20

Figure 3. Coefficient of Variation (CV) for TWI and currency exchange rates against the *AUD*

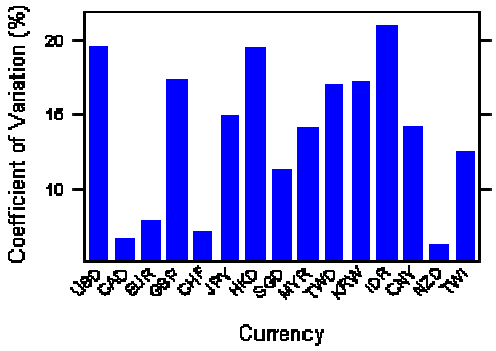
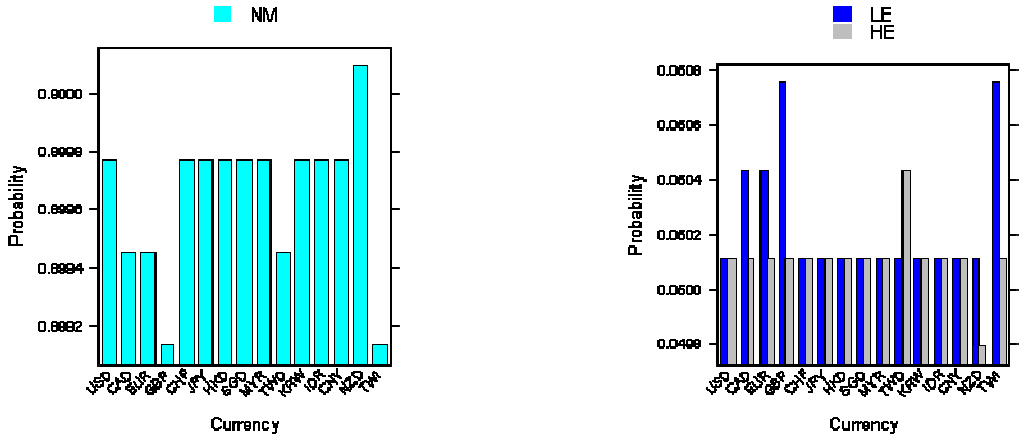
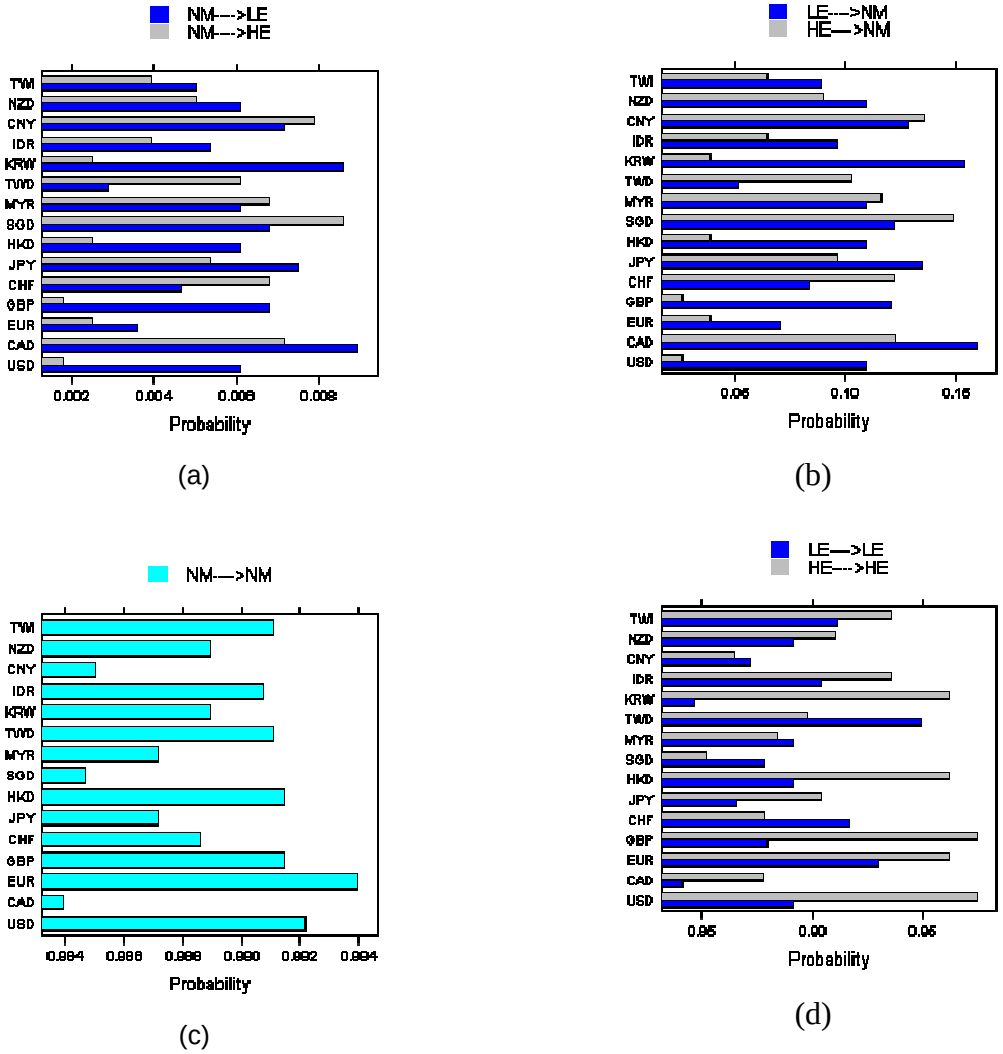


Figure 4. Probability of the currencies and TWI being in (a) NM state, (b) LE and HE states



(a) (b)

Figure 5. Probability of transition from - (a) normal to anomalous state, (b) anomalous to normal state, (c) normal to normal state, (d) anomalous to anomalous state



(a) (b)

(c) (d)

Table 2. Data for the Agglomerative Hierarchical Clustering step

Information Considered	USD	CAD	EUR
R_{1-3}: Rank in terms of being in (*LE*, *NM*, *HE*) state	(3, 2, 2)	(2, 3, 2)	(2, 3, 2)
B_1 : Is Prob.(*LE*) > Prob.(*HE*)	No	Yes	Yes
B_2 : Is Prob.(*NM* –> *LE*) > Prob.(*NM* –> *HE*)	Yes	Yes	Yes
B_3 : Is Prob.(*LE* –> *NM*) > Prob.(*HE* –> *NM*)	Yes	Yes	Yes
B_4 : Is Prob.(*LE* –> *LE*) > Prob.(*HE* –> *HE*)	No	No	No
	GBP	**CHF**	**JPY**
R_{1-3}: Rank in terms of being in (*LE*, *NM*, *HE*) state	(1, 4, 2)	(3, 2, 2)	(3, 2, 2)
B_1 : Is Prob.(*LE*) > Prob.(*HE*)	Yes	No	No
B_2 : Is Prob.(*NM* –> *LE*) > Prob.(*NM* –> *HE*)	Yes	No	Yes
B_3 : Is Prob.(*LE* –> *NM*) > Prob.(*HE* –> *NM*)	Yes	No	Yes
B_4 : Is Prob.(*LE* –> *LE*) > Prob.(*HE* –> *HE*)	No	Yes	No
	HKD	**SGD**	**MYR**
R_{1-3}: Rank in terms of being in (*LE*, *NM*, *HE*) state	(3, 2, 2)	(3, 2, 2)	(3, 2, 2)
B_1 : Is Prob.(*LE*) > Prob.(*HE*)	No	No	No
B_2 : Is Prob.(*NM* –> *LE*) > Prob.(*NM* –> *HE*)	Yes	No	No
B_3 : Is Prob.(*LE* –> *NM*) > Prob.(*HE* –> *NM*)	Yes	No	No
B_4 : Is Prob.(*LE* –> *LE*) > Prob.(*HE* –> *HE*)	No	Yes	Yes
	TWD	**KRW**	**IDR**
R_{1-3}: Rank in terms of being in (*LE*, *NM*, *HE*) state	(3, 3, 1)	(3, 2, 2)	(3, 2, 2)
B_1 : Is Prob.(*LE*) > Prob.(*HE*)	No	No	No
B_2 : Is Prob.(*NM* –> *LE*) > Prob.(*NM* –> *HE*)	No	Yes	Yes
B_3 : Is Prob.(*LE* –> *NM*) > Prob.(*HE* –> *NM*)	No	Yes	Yes
B_4 : Is Prob.(*LE* –> *LE*) > Prob.(*HE* –> *HE*)	Yes	No	No
	CNY	**NZD**	
R_{1-3}: Rank in terms of being in (*LE*, *NM*, *HE*) state	(3, 2, 2)	(3, 1, 3)	
B_1 : Is Prob.(*LE*) > Prob.(*HE*)	No	Yes	
B_2 : Is Prob.(*NM* –> *LE*) > Prob.(*NM* –> *HE*)	No	Yes	
B_3 : Is Prob.(*LE* –> *NM*) > Prob.(*HE* –> *NM*)	No	Yes	
B_4 : Is Prob.(*LE* –> *LE*) > Prob.(*HE* –> *HE*)	Yes	No	

Figure 6. Dendogram based upon executing AHC on exchange rate characteristics for the currencies

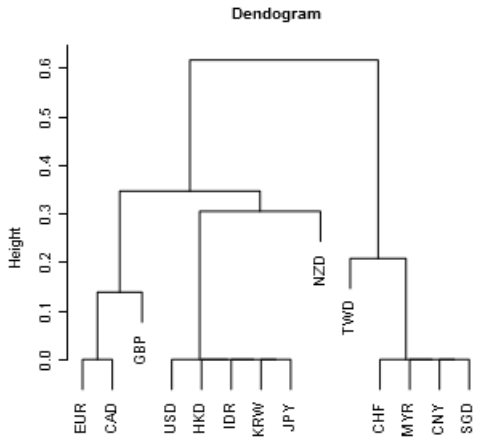
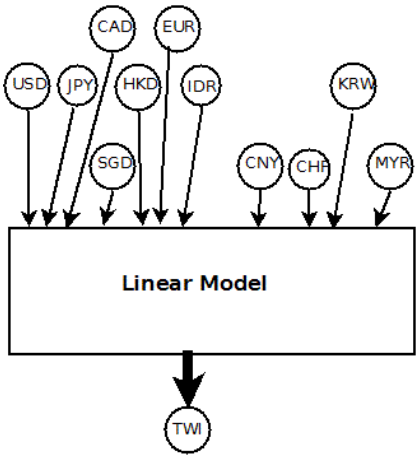
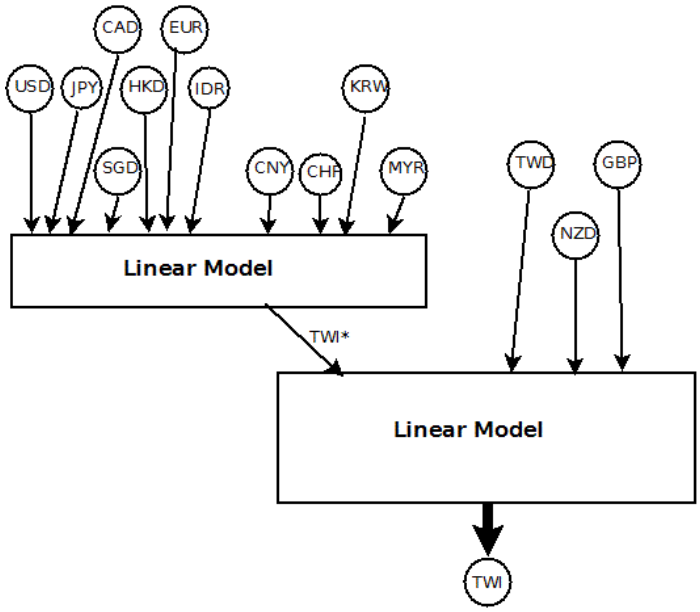


Figure 7. Models relating TWI to the exchange rates of the currencies: (a) Model M_1 considers all the currencies in a single stage; (b) Model M_2 relates exchange rates for all the currencies to TWI in two stages



(a) Model: M_1



(b) Model: M_2

Figure 8. *RMSE* for the Models: M_1 and M_2 over 100 trials