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UNIVERSITY OF CAPE TOWN

Dissertation for Master of Economics

**Using foreign currencies to explain
the nominal exchange rate of Rand**

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Abstract:

The Rand-US Dollar exchange rate has been very volatile since the unification of the duo-exchange rate in 1995. Many researchers have successfully found some economic variables as the long-run determinants of Rand exchange rate. This paper tries to substitute those economic variables with some foreign currencies' exchange rates. In fact, it found that the Brazilian Real could well represent the investors' perception towards South Africa; the Australian Dollar could reflect the Terms of Trade's impact on Rand. After taking into account the structural break in the Rand exchange rate in 2002, the paper found the three currencies' exchange rates were actually cointegrated. In the final section, whether this cointegration relationship would sustain in the future is discussed.

Key words: Nominal exchange rate, Investor perception, Trade structure, Unit roots, Structural break, Perron test, Co-integration test

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1. Introduction

Most of economics is about finding equilibrium. However, equilibrium is not a state easy to observe in the real world. In the extremely fluid and volatile foreign exchange market, finding the fair value for a currency is not an easy task, although there is substantial literature about this topic. This paper follows the same theme. It attempts to explain the movement of South Africa Rand from the unification of the duo-exchange rate in 1995 until present time.

Past studies of exchange rate could generally be categorised into two approaches. The first one is on the theory and modelling. The classic examples are the purchasing power parity and the Dornbusch's overshooting model (1976). Both of them are backed by very solid reasoning. Unfortunately, theory is often not supported by empirical evidence as the foreign exchange market is driven by expectations based on available information. As Rogoff (1996, 2002) found, the purchasing power parity is not an appropriate model for determining equilibrium exchange rate, mainly because of the slow mean reversion of the rate. The Dornbusch model does not seem to capture all big exchange rate swings that regularly take place except the few instances, like "the Volcker deflation"¹ of the early 1980s in the US.

The second approach chooses various macro-economic variables which seem to move closely with the exchange rate. The authors then use cointegration techniques to establish the long-run relationship between them; like MacDonald & Stein (1999) and Hinkle & Montiel (1999). Various studies find some major explanatory variables for the developing country exchange rate which include the terms of trade, the real GDP per capita relative to trading partners, the interest differential, the fiscal balance of the government, and so on. The merit of this approach is that it explains fluctuations better and helps us understand and forecast the movement of the exchange rate. But as Meese (1990) pointed out, the intrinsic weakness of this empirical approach is that the exchange rates are far more volatile than those fundamental variables. Thus lots of variations of the exchange rate could not be explained by the explanatory variables.

One of the possible solutions of this problem is to replace those macro variables with others whose volatility could match the exchange rate. One natural

¹ It referred to an economic phenomenon in the 1980s when the US Federal Reserve chairman Paul Volcker raised interest rates very aggressively which later led to deflation.

solution of this problem is the exchange rates of other currencies. This paper would like to suggest that the movement of South African Rand could be mainly explained in relation to the Brazilian Real and Australian Dollar. Indeed, they may even cointegrate with each other.

This is worth some explanation. According to Granger's original paper (1986), if two markets are efficient, their spot prices shouldn't be cointegrated, because otherwise people could use one market price to forecast the other. His proposition is supported by MacDonald and Taylor study (1989; henceforth MT). MT used monthly data of nine currencies in the period between January 1973 and December 1985. They found no strong evidence of cointegration among the different spot rates in pairwise tests. However, both Granger and MT papers were dealing with the bivariate cointegration. When it is with a multi-variable equation, the relationship will be more complicated, and it is highly possible that there exists a cointegration between multi-prices.

Take the three-variable case as an example. If prices A and B are cointegrated you could predict one according to the other; but for the three-variable case, knowing B is not enough to predict A, because unless you make sure that the direction of change of the price C would be the same as B, it is highly possible that the price C would cancel out the movement of the price B. Since it is extremely difficult to know the two prices correctly together in advance, it would be very hard to forecast the price A even if we are well aware of trivariate cointegration. So if several currencies cointegrated, it does not necessarily mean that the foreign exchange markets are inefficient because agents may not be able to exploit the underlying relationship.

Additionally, if the three currencies are truly cointegrated, using bivariate tests of cointegration as in the MT study would be inappropriate, because it will have the problem of the omitted variable. For example, suppose that x , y , and z are three $I(1)$ variables, they are cointegrated to form the relationship $x = \alpha + \beta^*y + \delta^*z + \varepsilon$, where ε is $I(0)$. If we run the regression $x = \alpha + \beta^*y + u$, since $u = \delta^*z + \varepsilon$ is $I(1)$, the test would indicate x and y are not cointegrated. This could mean that part of the MT conclusions might be reversed.

In fact, some authors have already tried to test the cointegration between different currencies. For example, Baillie and Bollerslev (henceforth BB;1989) examined the daily exchange rates for seven currencies (British Pound, German Mark, French Franc, Italian Lira, Swiss Franc, Japanese Yen and Canadian Dollar)

for the period March 1, 1980 to January 28, 1985. They found that both Engle-Granger two-step approach and the Johansen test confirmed the cointegration relationship between those currencies during the sample period.

However, for the volatile time series such as exchange rates, testing of cointegration is always vulnerable to some pitfalls. The first is the sampling period. As Sephton and Larson (1991) convincingly showed in BB study, whether or not a set of spot rates are cointegrated largely depends on the time period selected. The sample period for this study is based on the earliest available market data, which is the period following the abolishment of the dual exchange rate regime. In most of the 1980's South Africa employed a dual-exchange rate system: Commercial Rand and Financial Rand. The Financial Rand is the rate applied to foreign investors who want to take their money out of the country. Indeed, it punished people to do that. The system largely distorted the market price of foreign exchange. The duo-exchange rates were unified on March 12th, 1995. To eliminate its effect, the time period from March 1995 to July 2006 is used in this paper.

The second one is the structural break. The foreign exchange market is full of external shocks. Some of the biggest ones in recent years include the 1998 East Asia financial crisis, 2001 September 11 terrorists' attack, and 2002 Argentina's default. These shocks do not only increase the volatility of the market, but also sometimes cause 'structural breaks'. There is no exact definition of structural breaks in the literature, but they are generally interpreted as being those shocks which cause drastic changes of either regression parameters or the underlying data generation process. One tricky thing of structural breaks is that the traditional Augmented Dicky-Fuller (ADF) test could give misleading signals. Usually we use ADF to decide whether the time series are integrated of the same order before we test the cointegration. However, as Perron (1989) pointed out, for a trend stationary time series but with a structural break, the ADF test tends to underreject the unit root null hypothesis. In other words, it leads to the wrong conclusion that the series is nonstationary. In Perron's seminal paper, he found that due to the structural break of 1920s' great depression and 1970s' oil price crisis, most US macroeconomic series thought to be $I(1)$ before were actually trend stationary. To prevent this problem, Perron's methods are adopted to test the unit root of the currency series, and for the cointegration, the Gregory and Hansen (1996) procedure is used to incorporate the possibility of structural breaks into the test.

The rest of the paper is ordered as follows: Section 2 is an overview of the three countries and lists the possible reasons why they could be correlated. Section 3 describes the data source and the reasons for the frequency chosen. Section 4 outlines the testing procedures employed, and reports the empirical results. Finally, section 5 draws some conclusions, and attempts to project the future robustness of this statistical relationship.

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2. An overview of the three countries

If it is theoretically possible for several currencies to be cointegrated, practically which currencies should be selected into the equation is still a problem. Several early studies of the Rand exchange rate shed some light on this question. An early attempt to estimate the equilibrium for Rand by Aron, Elbadawi and Kahn (1997) found the long-run determinants of real exchange rate are the terms of trade, the gold price, amount of official reserves, long-run capital inflows, and government expenditure. Similarly, MacDonald and Ricci (2004) used the vector error correction methods to establish the long-run relationship between the exchange rate of Rand and a set of fundamental variables, such as the commodity prices, real interest differential, GDP growth differential, the size of the fiscal balance, the extent of trade openness and the net foreign assets.

In short, there are two general common factors standing out from these variables. The first is the commodity price. South Africa is a big exporter of natural resources. Unfortunately, prices are determined by the international market. Furthermore, commodity prices have not been stable over the years. There appears to be a cycle of around 10 to 15 years, and its average level has a huge impact on Rand. The second factor is investors' perception. Variables such as capital inflows, interest differential, the fiscal balance, and the official reserve either influence or reflect the perception of risk towards investing in a country. Like other public opinions, perceptions are not stable over time. Sometimes they are biased, and other times overreacting. Indeed the change in investor perception is the main driver of the fluctuation of the exchange rates for developing countries. One interesting thing here is that foreign investors do not consider countries separately; more often they perceive a group of countries together. They could be in the same region or share some similarities in economic structure. This is where the contagion effect comes in. A case in point is the East Asian financial crisis. When Thailand had an investor run, it quickly spread to other countries in the region - even the well governed South Korea was caught in the crisis.

So if one can find two currencies which could represent those two influences on the Rand, the model should work reasonably well. In this section, it is argued that the Brazilian Real could generally work as proxy of the investors' perception towards South Africa, whereas the movement of Australian Dollar captures very well the commodity price effect on Rand.

Looking at them in order:

(1) Brazil and South Africa

Brazil and South Africa share many similarities. At first glance, both are big countries, located in the southern hemisphere. Both are endowed with huge natural resources, and could financially dominate their continents. In 2003, according to the Economist figure, South Africa accounted for nearly 45% of sub-Saharan GDP; while Brazil took around 43% of Latin America's.

Both are middle-income countries with a GDP per head about \$5000, depending on the market exchange rate. However, under that surface, the two countries share one ignominious resemblance: the super-high income inequality. In the 2003 World Development Indicators (WDI), Brazil and South Africa had the highest Gini coefficients of all countries, 0.61 and 0.65 respectively. Not coincidentally, this is largely blamed on two similar reasons.

The first is the highly unequal landholding. Brazil only abdicated its last emperor and became a republic in 1889. After a long history of colonialism and monarchy under Portuguese rule, the Brazilian land was carved up between a few big landlords. South Africa's land pattern was mainly shaped by its bitter racial history. In the colonial era, black people were dispossessed of the land to create a cheap labor force. This was further entrenched during the apartheid period. As a result, when apartheid ended in 1994, the whites, comprising 15% of its population, owned nearly 70% of the country, including its most desirable and fertile land. If the government-owned land was also counted, the proportion owned by whites would rise to 87%.²

The second reason is the neglect of education. According to Cristovam Buarque, Brazilian education minister, the problem is that Brazil has not taken education seriously enough. It has only got its first university in 1922. After almost four centuries of slavery, which was abolished in 1888, education is not a shared value by ordinary parents, especially the farming poor.³ In *Bolsa Familia*, the current income transfer program, the federal government has to attach some conditions, such as that the beneficiaries must keep their children in school and vaccinate their babies. In 2002, nearly two-thirds of Brazilian workers have not completed their basic education, including the current president Lula himself. South Africa's

² See "The bare necessities," *Economist*, February 24th 2001

³ See "Paradise lost," *Economist*, February 22nd 2003

case is even worse. Under the apartheid regime, the young black students were deprived of proper education opportunity in the name of "Bantu education". Post-apartheid in 1994, the adult illiteracy among blacks was about 46%, compared to 1% for the white. Despite the improvements in both countries in recent years, the 2000 census found that still 13% of Brazilian adults are totally illiterate, and for South Africa, according to 2004 WDI, it is about 18%.

Unsurprisingly, the inequality causes some staggering crime rates in both countries. According to Interpol in the period 2001 to 2002 the South African murder rate was about 47.8 per 100,000 people, almost six times higher than 8.3 murders per 100,000 in the United States. Brazilian rate is lower, about 28.4 per 100,000, but in the light of international comparisons, this is still terrifying and clearly among the top twenty in the world. Indeed, in their biggest cities, the situation is much worse. In 2003, Johannesburg had a murder rate of 73 per 100,000, while in Rio de Janeiro and Sao Paulo they are around 86 and 54, respectively. ⁴

Interesting enough, the two countries' manufacturing industries are also highly concentrated around these areas. In 2002, San Paulo state accounted for 35% of Brazilian GDP, while Gauteng, the industrial and mining center of South Africa, contributed 39% SA's GDP.⁵ This uneven distribution of the industrial capacity may also explain high social inequality.

Apart from the similar social conditions and high inequality, Brazil and South Africa also share extremely similar economic history in the last hundred years. At start of the 20th century, both Brazil and South Africa were newborn republics. Brazil abdicated its emperor in 1889, and the Union of South Africa was declared after the bloody Boer War in 1910. That was a golden age of globalization. Like many other countries, both countries experienced quick economic growth. Although the First World War ended this relatively prosperous period abruptly, it did some favors to both countries. Since both countries were located away from the major battle fields, they did not suffer war damages. Moreover, after external supply of manufactured goods was cut off, it gave the local production a great incentive and opportunity to expand.

⁴ These murder rates are from several websites.

Available on <http://www.benbest.com/lifeext/murder.html>
<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5308a1.htm>
<http://www.usaid.gov/sa/progobject1.html>

⁵ See Country Profile of Brazil and South Africa 2003, EIU

After the First World War trade protectionism became widespread. It was not long before the Great Depression started. However, between 1920s and 1930s, one of the most successful economies in the world was the Soviet Union. Its quick and consistent growth attracted a lot of attention. At the time of great depression when the market mechanism apparently failed to self-correct and utilize all production capacities, state intervention and government-led growth obviously had a strong appeal. Generally, Brazil and South Africa adopted an import substitution policy.

In the case of South Africa, the import substitution strategy was prompted after General Hertzog became the Prime Minister in 1924. Certain products' tariffs were increased so as to raise local prices until it became profitable to manufacture them inside South Africa. The state also participated directly in investment and created some heavy industries. For example, in 1924 the Hertzog government set up the Electricity Supply Commission (ESCOM) to supply electricity. Then in 1928, the Iron and Steel Corporation (ISCOR) was created to reduce the country's dependence on imported steels. There was a similar story in Brazil. In 1930, after several years of economic depression and some regional disputes, there was a military coup by Getulio Vargas. He became the new president, in reality, a dictator. He encouraged autarkic policy and import substitution. Under his reign, he created Petrobras, the state owned oil monopoly; he helped to build many hydroelectricity stations, a great legacy for Brazil - even today the country obtains around 90% of its electricity from hydropower. In early 1940s, Vargas brought Brazil into the steel industry by setting up *Companhia Vale do Rio Doce* (CVRD). CVRD has been influential since then, and it is still in place today. Last year it was the third largest iron ore producer in the world.

Although on the surface the local manufacturers were operating well in the two countries, they were heavily dependent on their foreign supplies, capital goods and a lot of semi-processed materials. For example in 1938/39, for every Dollar export South Africa manufacturers spent almost \$12 on imported materials.⁶ This created a big hole in the current account. Economic growth only became possible because of firstly, the large foreign capital inflows during and after World War II; and secondly, the huge amount of commodity export from the two countries - gold for South Africa, and coffee for Brazil.⁷ Thanks to the postwar global boom, both countries enjoyed quick economic growth in the two decades

⁶ See Feinstein, C. (2005) p131

⁷ Even today. South Africa and Brazil are still the biggest exporters of gold and coffee in the world, respectively. In 1930s, gold export accounted for about 70% of South Africa export revenue, and coffee export accounted for nearly the same percentage of Brazil total export.

after World War II. Between 1948 and 1973, Brazil achieved average annual growth of 7.9 per cent, and South Africa averaged around 5%. However, this could not fully disguise the problems inherent within the import substitution system.

The first is the small market size of both countries. Despite the relatively large population of two countries, their market size was severely limited by the high income inequality. The demand for durable goods was restricted to a small portion of the population. This made many industries unable to operate with economies of scale. The second problem is the uncompetitive productivity of local producers. In the short run, the high tariff used for import substitution helped the expansion of local industry; however in the long run it backfired, because it deprived companies of the vital incentives to improve their efficiency. This is particularly significant in a not so large market such as Brazil or South Africa, where most products were dominated by two or three big producers. Without any foreign competition and realistic domestic threat, those big producers could simply pass on the cost of inefficiency to consumers. These two problems caused one inevitable constraint: the vulnerability in the balance of payments.

The situation worsened after 1973 when OPEC raised the oil price and the global economy started to slow down. At the same time, the high energy price led to an increase in inflation worldwide. This hurt both countries' economic performance. Firstly, it reduced the demand for their exports. Secondly since the two countries relied heavily on oil imports, the import bill ballooned. This shifted the direction of the overall balance. For Brazil, it changed from 545 million US\$ surplus in 1970 to 950 million US\$ deficit in 1975, and -3,472 million in 1980.⁸ The Brazilian government adopted a policy of borrowing abroad, using the foreign loan to cover the current account deficit and keep the economy growing. Thanks to the cheap petro-dollars from the oil-exporting countries, this made sense at the beginning, because at that time the world interest rate was lower than the inflation in US and UK. In other words, the real interest rate was negative. However, the situation changed after 1980. Led by former Federal Reserve President Paul Volcker, monetary policy started to tighten and the repo interest rate was increased spectacularly. Since the Brazilian foreign loans were linked with the market rate, they started to have trouble repaying the debt and in the end headed towards a debt crisis in 1982.

⁸ See Skidmore (1999). p180

South Africa had an average of 5.4% GDP current account deficit between 1974 and 1976.⁹ The gold boom gave it a bit of relief by the end of 1970s. However, from 1980, there were growing international campaigns against apartheid, which led to bans and restrictions on investment in South Africa. The fatal moment came in August 1985 when international banks refused to renew South African's substantial short-term foreign debts. It forced the government to announce a unilateral moratorium on debt repayments. Indeed, this largely closed for South Africa the opportunities to borrow in the international market until apartheid ended. Although loans were renegotiated later, economic growth was slowed down because the government had to maintain a current account surplus in order to repay the debt. For the period between 1981 and 1992, the Brazil economy's growth rate averaged only 1.4%. During the same period, South Africa only had 1% yearly growth. The dawn for the two economies came only after 1990. After the release of Mr. Mandela and the first all-race elections in 1994, political stability was gradually restored in South Africa. For international trade, the economic sanction was automatically lifted after apartheid. The tariff regime was reformed and cut about one third after 1995 to meet World Trade Organization requirements. Moreover, South Africa joined SADC in 1994 and reached a free trade agreement with EU in 1999.

Brazil followed a similar route. It helped form MERCOSUR, the South American regional free trade union¹⁰ in 1991, and started a four-stage tariff reduction in the same year. By 1993, the effective tariff rate for industrial products was cut massively from 45% to 18.38%. More importantly, inflation was finally brought down by the *Plano Real* (Real Plan). The plan cut down government expenditure and introduced a new currency, the Real, on July 1st 1994. The Real successfully broke the price indexation from the old currency *Cruzeiro Real*. The result for the Real Plan was wonderful at the year end; the monthly inflation rate dropped from 50% in June to about 2% per month in the fourth quarter.¹¹

After the lost decade in 1980s, the two countries have achieved some economic success in the last ten years. Between 1993 and 2005, Brazil and South Africa grew at 2.86% and 3.08%, respectively. As the numbers show, after integration into the world market, the economic fortune of the two countries became even more closely related. Both of them slowed down after the East

⁹ See Feinstein (2005), p227

¹⁰ Its members consist of Brazil, Argentina, Paraguay, Uruguay, Chile and Bolivia.

¹¹ See Brazil Country Profile, (1996) EIU, p13

Asian financial crisis, and picked up in recent years from the lower interest rate worldwide and quick growth in Asia.

Table 1: Brazil and South Africa GDP growth performance 1948-2005

	Brazil	South Africa
Post-War Boom 1948-1973	7.9%	5%
Slower Seventies 1974-1980	6.4%	2.9%
The Lost Decade 1981-1992	1.2%	1%
Back in the World 1993-2005	2.86% (2.70%)*	3.08% (3.24%)

Source: Michael Spicer (1996) and World Development Indicators Database

*The numbers in brackets are between 1994 and 2005.

In summary, the two countries' similar social conditions and parallel economic history causes foreign investors to maintain closely related perceptions towards them. This does not necessarily mean that the Brazilian Real would be the best proxy for the investor's perception towards South Africa, but generally the Real could well catch the major shifts of the investor sentiment towards emerging markets such as South Africa. This has been shown in the recent history on many major occasions. Both currencies have suffered big depreciation during the 1998 East Asia financial crisis, 2001 September 11 terrorist attack, and 2002 Argentina's default; although the extent was not the same for the two currencies. Even in some not so serious sell-off in the emerging markets, such as the middle of 2006, both currencies were weakened accordingly, which is why it could be argued that Brazilian Real could well reflect the international sentiment towards developing countries in general, and South Africa in particular.

(2) Australia and South Africa

From investors' eyes, Australia is surely not among the same group as South Africa. With the GDP per person around US\$ 35,000, it is a well-deserved member of the OECD. This however helps this thesis' premises, because the Australian Dollar will not reflect the investor sentiment towards South Africa, which would have posed an econometric problem in the analyses.

Australia's affluence is partly due to its rich natural endowments, and partly to its bravery in reform. In terms of income per person at purchasing power parity, Australia was the richest country in the world in 1901. But its economy deteriorated since the mid-1960s. By the 1990s, it had dropped down to the 18th. In terms of former Singapore's Prime Minister Lee Kuan Yew's words, Australia was running the risk of becoming "the white trash of Asia". However, after the Labor party came to office in 1983, the Australians started to rebuild the economy. It floated the Australian Dollar in the same year. Over the next few years the government deregulated the financial sector, introduced tougher competition laws, and privatized many state-owned industries. The trade tariffs were cut from 1988. After several phases of reduction, by 1996 the general tariff was only 5%. It also reached Free Trade Agreement with Singapore, Thailand and United States. The economy has been flourishing. In the last fifteen years, it has had an average growth over 3 per cent. For much of the 1990s, the multifactor productivity has increased at more than 2% a year, more than twice over the OECD average.¹² Its economy even shrugged off the major crisis of its trading partners: Japan's decade of stagnation, Asia's financial meltdown and America's tech-stocks crash. Last year, in the world rich list, Australia has climbed back to 8th.

In some senses then, Australia and South Africa are not two countries in the same class. However, the two indeed have a lot in common. Firstly, both of them were former British colonies and the British rule has left considerable influence over the local socio-cultural landscape. Secondly, both countries are rich in mineral resources and are leading exporters of many commodities. In 2005, Australia became the world biggest exporter of diamond, lead, black coal and iron ore. Additionally, it is ranked third in gold¹³, zinc and aluminum; whereas South Africa is the largest producer of gold, manganese, and platinum group metals, fifth in diamonds and sixth in coal. It is not surprising that the two countries'

¹² See "Miracle cure," *Economist*, September 9th 2000

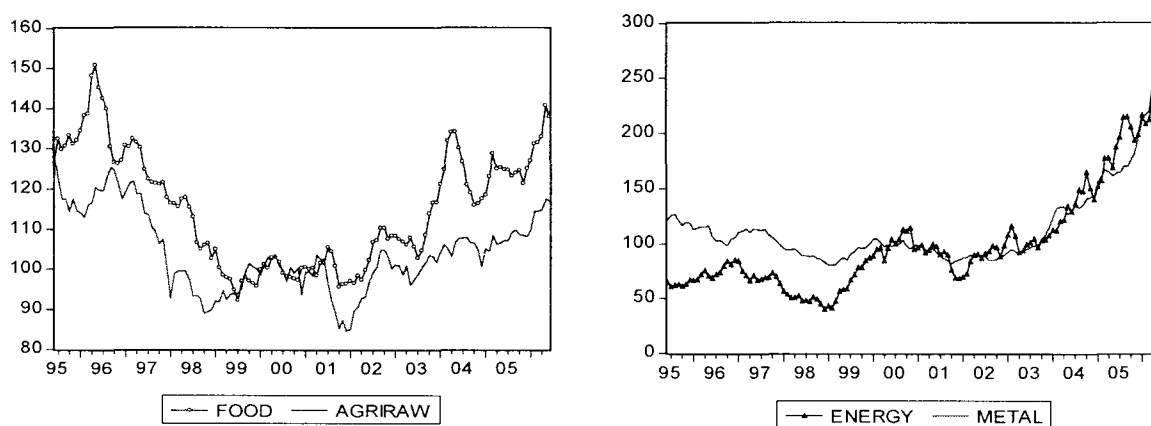
¹³ Considering the production, Australia is the second. It mined 263 tons gold in 2005. 10% of world total. South Africa produced 296 tons, 12% of world total.

economic fortunes are closely related to commodity prices. Both were hit hard by the economic downturns in Asia during the late 1990s, and in the last few years have been enjoying the buoyant demand from China and India.

If we want to understand better the two countries' relationship through commodity prices, we have to study their trade structures. The UN Comtrade Data was used to do the analysis. Because a country's trade structure does not change too much from year to year, it was decided to choose a sample comprising of 1996, 2000 and 2005 - three years' trade to reflect the testing period 1995-2006. The data of Brazil was compiled for comparison purposes.

The Harmonized System 1996 (HS1996) trade reporting system is employed for the data collection. Since there are thousands of different traded products, data has been aggregated for this analysis. Using general knowledge, the data was firstly compiled into five groups: agricultural raw material, food, energy, metal and manufactured goods. (See details in appendix) Of interest here is that some of these prices are highly correlated. IMF has constructed a set of price index for different groups of commodity prices. These indices are calculated according to the commodities' weight of the world export. Using these series a strong positive correlation is found between prices of food and agricultural raw materials, as well as energy and metal. (See figure 1) To some extent this is not surprising at all, because both the food and agricultural material prices are influenced by the same rainfall and climatic conditions; likewise the demand for energy and metal are affected by the industrial growth in the world. The correlation coefficients of the two pairs are both over 0.8. (See table 2)

Figure1: the graphs of 4 commodity price indexes



2000=100

Table 2: Correlation coefficients of four commodity price series

	AGRIRAW	ENERGY	METAL	FOOD
AGRIRAW	1			
ENERGY	0.247	1		
METAL	0.480	0.864	1	
FOOD	0.836	0.284	0.569	1

Source: IMF Primary Commodity Prices

Because of the strong correlation between two pairs the trade data is further simplified into four categories: agricultural products, mineral resources, manufactured goods and others. The import and export data of the three countries have thus been compiled in table3 and table 4, respectively.

Table 3: Three countries' import data in 1996, 2000 and 2005
(Value in US\$ bn)

1996	Australia		Brazil		South Africa	
	Value	Proportion	Value	Proportion	Value	Proportion
Agricultural Products	7.86	12.8%	10.4	18.3%	3.42	12.7%
Mineral resources	7.32	11.9%	10.1	17.9%	4.09	15.2%
Manufactured Products	46.1	75.0%	35.9	63.4%	17.1	63.8%
others, not elsewhere specified	0.16	0.3%	0.27	0.5%	2.24	8.3%
Total	61.4	100%	56.7	100%	26.9	100%
2000						
Agricultural Products	8.38	11.8%	7.15	12.1%	2.62	9.8%
Mineral resources	10.6	14.9%	12.0	20.4%	5.36	20.0%
Manufactured Products	52.1	73.2%	39.7	67.3%	16.4	61.4%
others, not elsewhere specified	0.12	0.2%	0.1	0.2%	2.36	8.8%
Total	71.2	100%	58.9	100%	26.79	100%
2005						
Agricultural Products	12.1	10.2%	6.78	8.9%	4.94	9.0%
Mineral resources	22.4	18.8%	19.7	25.7%	11.44	20.8%
Manufactured Products	84.1	70.8%	49.9	65.3%	33.82	61.5%
others, not elsewhere specified	0.25	0.2%	0.11	0.1%	4.83	8.8%
Total	119	100%	76.4	100%	55.03	100%

Table 4: Three countries' export data in 1996, 2000 and 2005
(Value in US\$ bn)

1996	Australia		Brazil		South Africa	
	Value	Proportion	Value	Proportion	Value	Proportion
Agricultural Products	19.0	31.6%	19.5	40.8%	4.5	19.3%
Mineral resources	25.3	42.0%	10.8	22.5%	12.7	54.0%
Manufactured Products	14.6	24.2%	16.9	35.4%	5.95	25.3%
others, not elsewhere specified	1.3	2.2%	0.64	1.3%	0.33	1.4%
Total	60.2	100%	47.7	100%	23.5	100%
2000						
Agricultural Products	17.6	28.4%	19.0	34.3%	4.26	14.1%
Mineral resources	28.2	45.6%	11.3	20.4%	17.9	59.1%
Manufactured Products	15.0	24.2%	23.9	43.4%	7.96	26.3%
others, not elsewhere specified	1.09	1.8%	1.08	1.9%	0.14	0.5%
Total	61.9	100%	55.3	100%	30.26	100%
2005						
Agricultural Products	22.7	21.5%	41.7	35.9%	6.63	14.1%
Mineral resources	54.5	51.5%	29.9	25.7%	25.0	53.3%
Manufactured Products	22.0	20.8%	44.5	38.3%	15.3	32.5%
others, not elsewhere specified	6.6	6.2%	0.05	0.00%	0.33	0.07%
Total	105.8	100%	116.15	100%	47.26	100%

Source: UN Comtrade

Firstly, from the import side, all three countries are basically self-sufficient in food production; hence the agricultural products only account for around 10% of total imports. On the mineral resources row, although Australia and South Africa are net energy exporters due to coal export, they need to import oil to meet the domestic fuel demand. This is particularly true of South Africa, where over 90% of its oil is imported. This accounts for between 10-15% of the total import bill. When the oil price is high, this portion of import will increase substantially. Brazil is partially dependent on the energy imports. Although most of its electricity demand is met by hydroelectricity, it needs to import substantial oil, gas and coal to meet fuel and industrial demand. Overall, one third of its energy consumption is imported. For manufactured goods, all three countries have between 60% and 70%, although Australia has some higher proportion on this category. In general,

the three countries' import structures are quite similar, although there are some differences in certain sections.

From the export side, one can see a big difference between South Africa and the other two. South Africa's agricultural sector is much smaller. It accounts for around 15% of the export, while Brazil is over 35% and Australia is always over 20%. This is mainly due to geographical conditions. Brazil has around 8.5 million sq km, and about 44% of it is suitable for agricultural uses, not mentioning its large areas of forest around Amazon region. Last year, Brazil became the world's largest exporter of beef, coffee, orange juice and sugar; and it is the second (and closing fast on the export leaders) in soya, poultry and pork. Australia has around 7.7 million sq km, and about 60% of the land is suitable for agriculture. Australia has been famous for its exports of beef, wool and wheat. In contrast, South Africa is not only smaller, with around 1.2 million sq km, but also has less suitable land for intensive cultivation, only about 15%, in three areas: coastal areas of southwestern Cape, the Natal coast and the northern Free State. This has undoubtedly resulted in the small portion of agricultural products in SA export. However, the strength of South Africa lies in the energy & metal sectors. Despite SA's successful efforts at diversifying its exports in recent years, mineral resources still take the lion's share of its export performance.

Looking back at the three countries' export structure, Brazil is thus very different to SA. The strength of Brazil is in agricultural and manufactured products, rather than the mineral resources.

Australian exports display a similar pattern to those of SA. Its mineral resources always comprise the largest proportion of its exports, and the trend in recent years is that its agriculture is becoming less important and the proportion of mineral resources is rising due to the skyrocketing energy and metal prices. This makes the Australian export structure look more like SA. In fact, if one adds the first two rows - agricultural and mineral goods - the two countries are very similar. Both of them export about 70% primary products. Although their compositions are not the same, as the Table 2 shows, the agricultural and mineral prices are still positively correlated, with the correlation coefficient between them being about 0.3. This could partly offset the two countries' differences in agriculture.

However, there is still one problem remaining. Even if Australia has a similar trade structure to SA, and experiences similar trade terms, how closely would it

be related to the Australian Dollar? This has been well answered by David Gruen and Tro Korian (1996). In an Australian reserve bank research paper, they found that, using the terms of trade as the sole explanatory variable, the real exchange rate of Australian Dollar could be well predicted over a one to two year horizon. In other words, the Australian Dollar can reflect well the changes in commodity prices and its terms of trade.

In summary, in view of the similarity of the trade structure of two countries, the Australian Dollar could work well as the proxy for the terms of trade for South Africa.

(3) What else?

After some discussion of the Brazilian Real and the Australian Dollar, it is natural to ask one question: are there any other currencies which could be included in the equation?

Although one naturally could examine other currencies, it is pointless trying to refer to too many currencies with respect to exchange rate movements; one should rather focus on countries that exhibit significant parallels.

It is important to query, if one breaks down the exchange rate movement, which factors might be influencing it. There are of course numerous factors, but in general there would appear to be 4 major components:

The first is the terms of trade. First of all, the foreign exchange market is serving the international trade. When a big proportion of either import or export prices change sharply, it will have a direct impact on the exchange rate. Of course, the terms of trade is a very dynamic issue - not only can external demand change dramatically for some domestic goods, but a country might also change the products it produces over time. Thus it is important to find some countries with similar trade structure. Fortunately, Australia does not differ too much from SA.

The second is the investor perception. For a developing country, the foreign investor perception is a big driving force for short-term capital movement. For South Africa, generally there are two kinds of perceptions. The first one puts SA into a group of middle-income countries, which export large amounts of resources,

but which have some social problems. This is very similar to Brazil. The other one is more regional, more related to Africa. Investors always tend to take the countries in the same region as a whole. For example, when Argentina defaulted in 2002, all other Latin America currencies took a knock as well. This regional bias could also partly explain the Rand slump at the end of 2001, although this is naturally a very complex issue. Even the Myburgh (2002) Commission employed by SA's president didn't find any definite causes. It is certain however that factors such as Zimbabwe's chaos situation of land-reform play an important role in investors' minds.

Possibly one should then use an African currency to represent this regional bias. One possible candidate is Botswana. Botswana has been a very successful economic story of Africa in the last two decades. Unfortunately, its currency, Pula, is pegged to a basket of currencies, and, because Botswana's economy is deeply related with SA, the Rand takes about roughly 60% weight in that basket. This is absolutely too high to qualify as an explanatory variable. Due to this reason, the Pula was abandoned as a variable.

The third factor is the country specific risk. In terms of the studies on determinants of exchange rate, these are the variables such as GDP growth, size of the fiscal balance, trade openness and inflation differential. They reflect economic and political conditions of a country. It will be extremely difficult to find some foreign country currency to represent a country's own risk. However, in some respects this is still possible. The Brazilian Real to some extent can reflect the economic growth in South Africa. During the testing period 1995 to 2005, the correlation coefficient between the two countries' GDP growth rate is as high as 0.648. It somehow reveals a fact that in the globalization era, most developing countries economic performances are not totally in their own hands. Especially after trade liberalization, many countries' growth has become more export oriented, and this has exposed them to the same global economic events, such as interest rate changes, commodity booms and the financial crises. As a result, many countries' economic performances have become bound together. For Brazil and South Africa, which are two countries with similar development stages and economic history, it is not surprising that their growth rates are so correlated in the last decade (see table 5). Since economic growth is one determinant of exchange rates, this helps raise the Real explanatory power on the Rand.

Table 5: GDP annual growth rate of Brazil and South Africa 1995 - 2005

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Brazil	4.2	2.7	3.3	0.1	0.8	4.4	1.3	1.9	0.5	4.9	2.3
SA	3.1	4.3	2.6	0.5	2.4	4.2	2.7	3.5	2.8	4.5	4.9

Source: World Development Indicators Database

Finally, another influential factor on the Rand exchange rate is the relative strength of its counterpart currency, in this case, the US Dollar. The volatility of the US Dollar has been a major cause of the movement of Rand exchange rate. According to general consensus, the US Dollar was very strong by the end of 1990s, partly due to IT booms, stocks boom, and partly because after the Asian financial crisis America was viewed as a safe haven. Many investors moved their money into America. However, in the last three years the US Dollar became significantly weaker owing to its twin deficits. Presumably this strongly contributes to the pattern of Rand exchange rate over the last decade. If we want to use one currency to reflect Dollar strength, possibly the best choice is Euro, because the European Union (EU) has a similar economic size to the US, and does not suffer from swings in investors' sentiment towards developing countries. In fact, the South African foreign exchange market believes the Rand tracks the Euro, because EU is the biggest trading partner of SA, accounting for about 36% the value of SA's international trade. However, in this paper the real question is whether the inclusion of the Euro would significantly improve the results. The answer is not so conclusive. It is true that the EU only consists of about 17.5% and 23% of Australia and Brazil trade respectively in 2005, but it is hard to believe the trade partner effect will give a currency long-term support. In the end, the exchange rate should reflect the productivity of two economies. More likely, the Rand follows the Euro because the Euro gives the reflection of short-term Dollar strength. However, as a developed country currency, the Australian Dollar can mainly provide the same function. In addition, there is a technical problem with Euro. The Euro only started to work from January 1st, 1999, making its time span incompatible with other currencies.

In summary: the Australian Dollar and Brazilian Real should work well in explaining the Rand exchange rate. It is not necessary to include more currencies.

3. Data and Empirical testing

3.1 Empirical methodology

In this section, a simple model of the Rand exchange rate is presented, consisting of two foreign currencies: Brazil Real and Australian Dollar. It seems that this model could capture most of Rand movements. The nature of the data is carefully investigated, testing each series individually for its stationarity, and then implement the necessary tests for cointegration.

3.2 Data

The data of all the currency series are from Thomson Datastream. The exchange rates are all expressed as domestic currency per US Dollar. Their time spans are from March 1995 to July 2006. The data are originally on daily basis, but the monthly averages have been used, as there are some distinct advantages in using the monthly data.

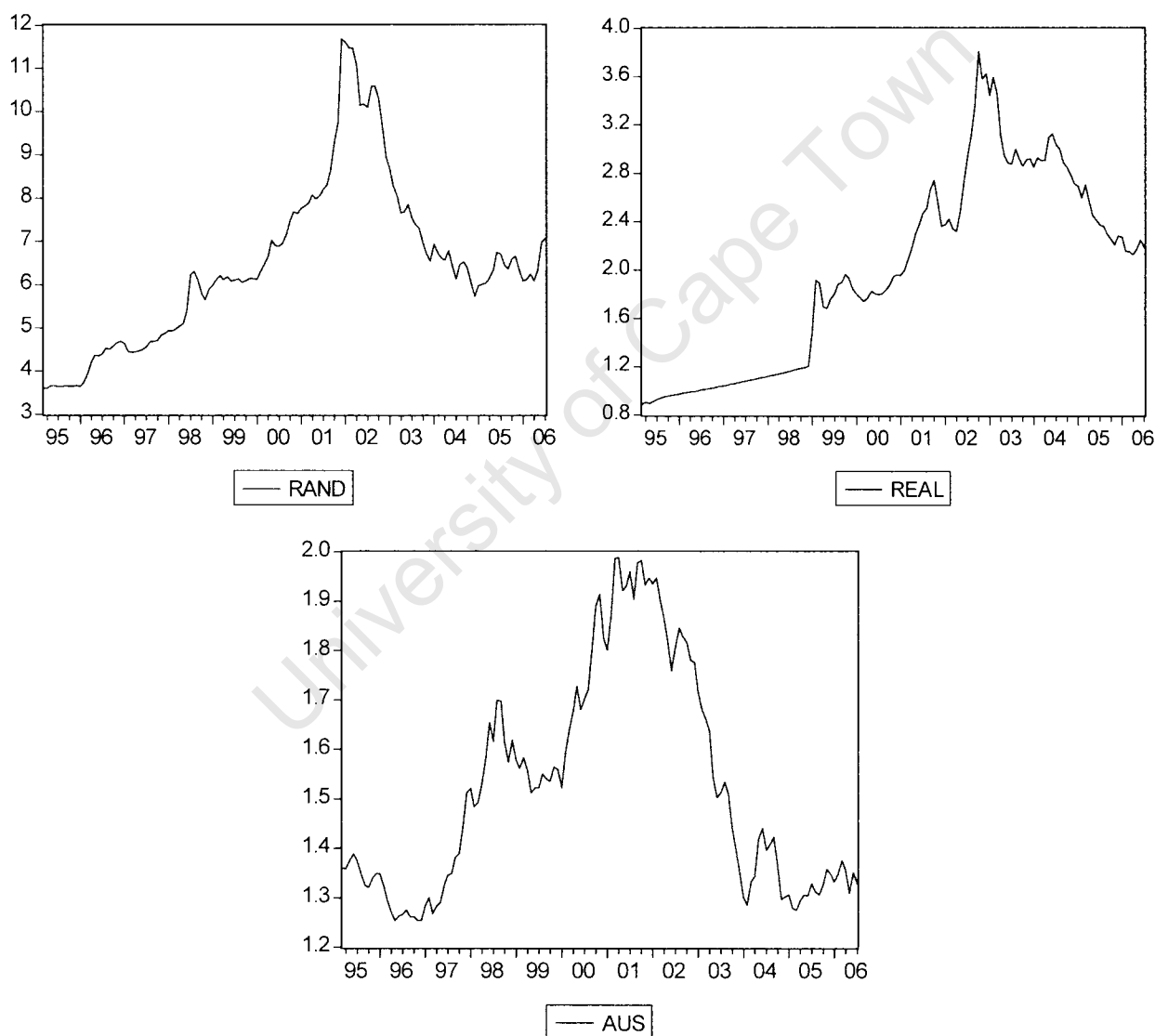
First of all according to Shiller and Perron (1985) and Perron (1991), the power of unit root test depends more on the span of data rather than the frequency of observations. In other words, using the monthly data with the same span will not change the validity of all the tests results. The second reason to use monthly data is that all the currencies involve testing for structural break. It is possible to know which month a certain currency had a big depreciation, but the choice of the exact day is very arbitrary. Using monthly data makes this task much easier. Furthermore, if the daily data is used, there are more observations. For example, the size of daily data is over 3000 observations, whereas the monthly observations are 137. The 5 percent significance level is used for the test regardless of sample size, since the null hypothesis of no cointegration is more likely to be rejected if the number of observation is large. Finally, the monthly average is used rather than the first or last day of the month, because the three countries have different macro-economic data release schedules. Exchange rates are very sensitive to these data, say, GDP growth or inflation rate. Using the first or last day data can include some unnecessary volatility into the data.

A summary of the descriptive statistics and the graphs of all currencies are attached below.

Table 6: Descriptive Statistics of the Four Currencies

Currency	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Observations
Rand	6.460403	11.6874	3.598165	1.907385	0.75085	3.394205	137
Real	1.984226	3.810348	0.889304	0.798815	0.188931	1.893216	137
Aus\$	1.523299	1.989153	1.254352	0.223494	0.630531	2.113693	137

Figure2: the graphs of 3 currencies' exchange rates



X axis: the time line in years
Y axis: the exchange rate to US Dollar

3.3 The test results

As described in the introduction, the intention of this paper is trying to use some other currencies to explain Rand exchange rate. The model is a general stationary representation of a VAR process.

3.3.1 The unit-root testing

First of all, it is conventional to use the Augmented Dicky-Fuller (ADF) test to see whether the time series is stationary. The test is specified as in equation (1). The null hypothesis of non-stationarity attests the parameter restrictive $\rho=0$.

$$\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{i=1}^k \theta_i \Delta Y_{t-i} + \epsilon_t \quad (1)$$

In practice, there is an argument about how to choose the lag length. Here the Schwarz Bayesian information criterion (BIC) was used to decide the lag length. Since the ADF test assumes the errors are independently and identically distributed (id), which may not always apply to the financial time series, it results in the low power of ADF in detecting unit roots. Therefore the Phillips-Perron (1988) Z_t test is also used to check the results. The Phillips-Perron test is a non-parametric method, and it allows for conditional heteroscedasticity and non-normality. Both results are presented in Table 7. None of the test result is significant at 10% level, but after first differencing, all the t-statistics become significant at 1%. Thus the tests confirmed all the currencies are I(1) process.

Table 7: Unit root testing results

currency	ADF			Z_t	
	t-stats	p-value	Lags k	t-stats	p-value
Rand	-1.703	0.43	1	-1.625	0.47
Aus\$	-1.206	0.67	1	-1.08	0.72
Real	-1.467	0.55	1	-1.44	0.56

T = 137

The critical value for ADF and Z_t test is -2.88 at 5%, -2.58 at 10%.

Normally, the rejection of the null hypothesis will be taken as strong evidence of stationarity, while non-rejection is inferred as non-stationary. However, there is a major problem of the conventional unit-root test. As Perron (1989) pointed out, the power of the test is much lower in the presence of a structural break. This may mislead one to conclude the series have a unit root, while in fact, they are trend stationary.

Perron (1989) proposed three models for testing. One of the models which incorporates both intercept and slope change after the structural break was used here. The test equation is expressed as:

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t + \hat{\beta}^C t + \hat{\gamma}^C DT_t + \hat{d}^C D(TB)_t + \hat{\alpha}^C y_{t-1} + \sum_{i=1}^k \hat{c}_i \Delta y_{t-i} + \hat{\varepsilon}_t \quad (2)$$

where TB is referred to as the time of structural break. The definitions of three dummies are: $DU_t = 1$ if $t > TB$, and 0 otherwise. $DT_t = t$ if $t > TB$, and 0 otherwise. $D(TB)_t = 1$ if $t = TB + 1$, and 0 otherwise. To put them into words, DU_t stands for the intercept change after the structural change. DT_t represents the slope change, and $D(TB)_t$ is a step dummy which embodies a once-of-all change in intercept at the time of break.

Under the null hypothesis of the Perron test, the time series is a unit root process with a shock. The parameter restriction attests $(\alpha, \beta, \gamma, \theta) = (1, 0, 0, 0)$ and $d \neq 0$. While under the alternative hypothesis, the series is a trend stationary with intercept and slope change after the structural break. It is expected that $\alpha < 1$, $\beta, \gamma, \theta \neq 0$, and d should be close to zero. One tricky thing of all the tests including structural break is that of choosing the time of break. The Perron test is one with the break already known. The assumption of a known break date sometimes raises the problem of data-mining regarding the choice of date, but as Maddala and Kim (1998) pointed out, it also does not make sense to search for a break over the entire period ignoring the prior information. Here the month when the Rand and the Real had their biggest depreciation was used as the break date. December 2001 is chosen for the Rand when at one stage it reached R13.85/US\$1, the lowest ever against the US Dollar. According to the Myburgh commission report, that was a combination of the worsening of current account, contagion from Zimbabwe, and bad luck that in the same month Argentina declared the debt default. For the Real, the break occurred in October 2002 when the left Worker's Party candidate Lula seemed to win the election. Because

Brazil's debt amounted to about 60% of GDP, investors worried about the populist Lula turning Brazil into another bankrupt Argentina. A capital flight started. The Real plummeted to R4/\$1 in middle of October in 2002. It's hard to say whether the Australian Dollar had structural breaks. The exchange rate had about 50% depreciation between 2000 and 2001 September 11th, but it was not as phenomenal as Brazil or SA, whose exchange rates nearly doubled when they were hit by the break. However, to make sure it is not trend stationary, September 2001 is chosen as the break time.

One special feature of the Perron test is that its critical value depends on the parameter $\lambda = T_B / T$, the ratio of the pre-break sample size to total sample size. The Perron test results are presented in table 8 and 9. The test statistic for the null hypothesis focuses on the value for α whether it is equal to 1, and the rest by inspection.

Table8: The Perron model regression results

$$Y_t = \mu + \theta * DU_t + \beta * t + \gamma * DT_t + d * D(TB)_t + \alpha * Y_{t-1} + \sum_{i=1}^k C_i * \Delta Y_{t-i} + \varepsilon_t$$

Currencies	k	μ	t_μ	θ	t_θ	γ	t_γ	d	t_d	α	t_α	S(e)
Rand	1	-0.03	-0.28	-0.49	-0.80	0.001	0.23	-0.56	-1.58	0.996	28.15	0.035
Real	1	0.01	0.32	0.23	0.84	-0.003	-1.19	-0.37	-3.55	0.955	23.18	0.041
Aus\$	2	0.07	1.85	0.058	0.859	-0.001	-1.62	0.007	0.183	0.933	28.07	0.033

Table9: The Perron test results and critical values

Currencies	λ	t-value for $\alpha=1$	5% critical value	10% critical value
Rand	0.6	-0.121	-4.24	-3.95
Real	0.7	-1.096	-4.18	-3.86
Aus\$	0.6	-2.025	-4.24	-3.95

From the tables above none of the currencies' α test value is significant at 10% level. The results assure us that all the currencies are unit root processes. Thus, we proceed with the cointegration test.

3.3.2 Cointegration test

First of all we use the standard Engle and Granger (EG; 1987) procedure to estimate the relationship between Rand, Real and Australian Dollar, given by:

$$\mathbf{Rand}_t = \mu + \mathbf{Real}_t + \mathbf{Aus}_t + \varepsilon_t \quad (3)$$

Nowadays most researchers prefer the Johansen method. This is partly because EG could not identify more cointegration relationships among variables. However, this should not be the case in this example, because there could only exist one cointegration relating the three currencies. Firstly, the trade structure is very different between Brazil and Australia, therefore Rand and Australian Dollar are not expected to explain Real. Similarly, since Australia is more developed than the other two countries, it is hard to believe that Rand and Real can explain the movement of the Australian Dollar. Therefore, a simpler method was chosen instead of the Johansen atheoretical approach.

With the estimated residuals, the ADF-type regression is employed to test its stationarity. The critical values are calculated from MacKinnon (1991) response surface.

Table10: The EG test results and critical values

$\Delta e_t = \alpha e_{t-1} + v_1 \Delta e_{t-1} + v_2 \Delta e_{t-2} + \dots + v_p \Delta e_{t-p} + \varepsilon_t$				
	1 lag	4 lag	5% critical value	10% critical value
Test value for α	-3.434	-3.942	-3.805	-3.497

As shown in the table above, the cointegrating relationship between the three currencies is not very robust. With Bayesian information criterion, one lag is chosen, but it is insignificant even at 10% level. When this is changed to the Hall method (1994) which proceeds from general to specific, from a starting point of 12 lags, 4 lags were chosen. This lag length was found to be significant at 5% level. All this ambiguity partly reflects the fact that the power of ADF test is very sensitive to the number of lag terms (k) used. Possibly this is because ADF is not good at dealing with structural breaks.

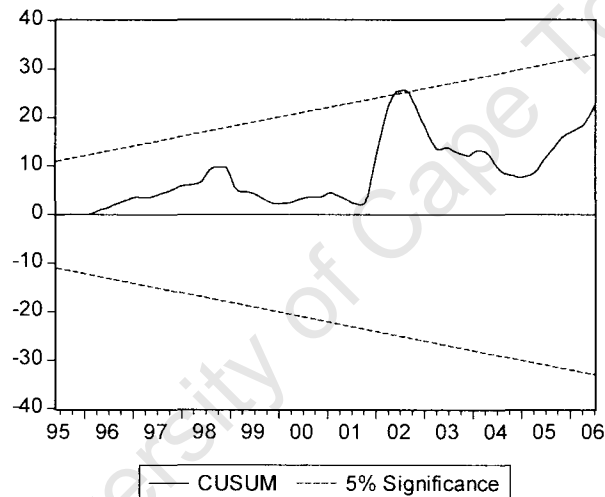
If the selection of structural break point in the unit root test is still considered a little arbitrary, one can use the CUSUM test to clearly display the existence of a structural break in the regression. Under CUSUM the structural change, if it

exists, will induce a systematic movement of parameters, thus it represents a complementary approach. The test suggested by Brown, Durbin and Evans (1975) is based on the cumulative sum of the recursive residuals to test parameter stability. It involves considering the plot of the quantity:

$$W_t = \sum_{r=k+1}^t w_r / \sigma, \quad t = t+1, \dots, T \quad (4)$$

where W_t is the recursive residual, σ is the standard error of regression. When the plots cross the 5% significance line, it suggests a systematic movement of coefficients. In other words, there is a structural change there.

Figure3: the plot graph of CUSUM test



From the graph, one can clearly see a break at the beginning of 2002. This, to some extent, justifies the choice of December 2001 as the Rand's structural break. Since cointegration tests the long-run stability of the coefficients, the structural break clearly stands in its way. This is why traditional cointegration tests are weak at dealing with the structural break. In fact, Gregory, Nason and Watt (1994) showed that the power of EG approach and conventional ADF test fell sharply in the presence of a structural break.

Therefore, the Gregory and Hansen (GH; 1996) testing procedure is adopted, which allows for a break in the mean. Similar to the Perron's test, GH also has several models. The model which includes the intercept and slope change after the structural break is chosen and presented as follows:

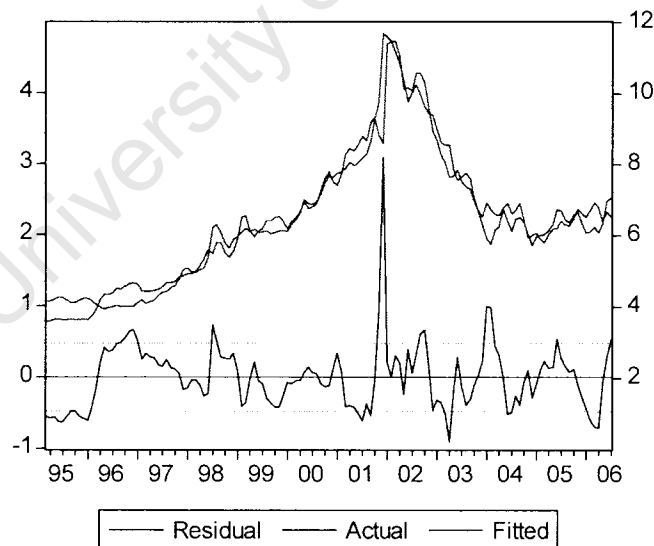
$$Y_{1t} = \mu_1 + \mu_2\Psi_t + \alpha_1Y_{2t} + \alpha_2Y_{2t} \Psi_t + \varepsilon_t \quad (5)$$

where $t = 1, \dots, n$, $\Psi = 1$ if $t > \lambda T$ and 0 otherwise. The null hypothesis of GH test is no cointegration. It uses the estimated residuals ε_t to run the ADF test. However, the beauty of GH procedure is that it has endogenized the structural break- one no longer needs to choose the date of structural break. This avoids the accusation of data-mining. However, the procedure has to be run across all the observation dates, i.e. for values of $\lambda \in [0,1]$, and then the smallest, most negative value from the associated ADF t-statistics has to be selected and then compared with the critical values reported in GH (1996).

Table11: The GH cointegration test results

ADF t-value	Break date	5% critical value	10% critical value
-6.09	Jan 2002	-5.50	-5.23

Figure4: the graph of regression actual, fitted and residual series with the break date chosen by GH procedure



After testing, the break date chosen by GH is January 2002. This is just a month later than the date chosen in the unit root testing. With this date, the t-statistics in ADF test is significant at 5%. In addition, the graph of regression actual, fitted and residual series is reported in figure 4. From the graph, it can be seen that apart from the date of break, the residual series is generally stationary.

These confirm that if one takes the structural break into consideration, the three currencies have a cointegration relationship.

5. Conclusion and discussion

This paper follows the approach of looking for the determinants of the exchange rates. The main point of difference is that some foreign currencies are used to explain the Rand exchange rate after its unification in 1995.

There are some advantages in using foreign currencies rather than some local macro-variables. First of all, exchange rates are more volatile than fundamental variables. Using currencies could explain those variations much better. Secondly, a shift of sentiment is always one big cause of the exchange rate movement in developing countries. It is very difficult for fundamental variables to reflect this change of sentiment. Using other currency's exchange rates could incorporate this factor much better. Finally, most macro-economic variables are only published monthly or quarterly, and the value for a particular month is not available until several months later. This makes it very difficult to judge the current situation of an exchange rate. In contrast, the foreign exchange rate is available at any time and by any frequencies. Therefore, if this approach proves feasible, it would be quicker to spot mispricing in the foreign exchange market.

In this paper, it was found that using the Brazilian Real and the Australian Dollar as explanatory variables could work quite well in explaining the Rand. Indeed, if one takes the structural break(s) into account, the three currencies are cointegrated during the test period. Of course, cointegration is only a purely statistical concept and the existence of cointegration does not necessarily mean any economic relationship. However, in this paper it is argued that there are some structural reasons which guide the three currencies into cointegration. Generally, Australia and SA have very similar trade structure; Brazil and SA share very similar economic history and social conditions.

In the final analysis, one problem still remains- the robustness of this cointegration. Can this relationship sustain in the future? To answer this question, it is worthless to look at test statistics, because the future would not necessarily imitate the past. The answer has to be based on some reasoning.

There are some factors which may cause divergence between these three countries. The first is the difference in natural endowments. As has been mentioned earlier, South Africa's export is largely dependent on mineral resources, while the other two countries produce more agricultural goods. The key is that agriculture is possible to keep up in the long-run, but the mineral resources are not renewable by any means. At the moment SA mining is doing fairly well, but some of the minerals have already shown signs of decline. A case in point is gold. After mining for over 100 years, the economically viable gold ore is depleting in SA. Coupled with declining grades and increased depth of mining, gold production has been steadily falling in the last decade. In 1995, the output was 520 tons, 430 tons in 2000, and has declined to only 296 tons in 2005. Australia is not facing this strain. The agriculture sector keeps expanding its output, (although it is currently becoming less important in total exports). In addition, Australia continues to find new gold mines in the west. Its gold production is expected to overtake SA in 2009.

Brazil, according to the Brazilian Agribusiness Association, is now the third largest exporter of agricultural products. Unlike its competitors, Brazil is not running out of land. Agriculture occupies 60m hectares now; it could stretch out to another 90 million hectares without touching the Amazon rainforest.¹⁴ This might have profound social impacts in Brazil. Because agriculture is a labor-intensive business, the future expansion can create thousands of jobs. That in turn will reduce the income inequality in Brazil -indeed, the inequality situation has already been improving, thanks to the strong economic growth and sensible policies of the government. According to Marcelo Neri of *Fundacao Getulio Vargas*, a business school, the inequality is "now at its lowest level in the past 30 years, and still falling."¹⁵ In contrast, it is hard to see any real signs of reducing inequality in SA. The Gini coefficient has actually risen from 0.60 in 1996 to 0.65 in 2005.

Secondly, a serious problem now in SA is AIDS. According to recent data from SSA, the adult HIV prevalence rate (15-64 years) is estimated to have increased from 14.4% in 2001 to 16.2% in 2005. In contrast, due to the well managed health program, 600,000 Brazilians were estimated HIV infected in 2005, only

¹⁴ See "The harnessing of nature's bounty," *Economist*, November 5th 2005

¹⁵ See "Lula's leap," *Economist*, March 4th 2006

0.52% of the adult population.¹⁶ This huge difference may change the social conditions and growth path of two countries.

Thirdly, the risks involved with SA and Brazil are a little different. South Africans tend to consume a lot. The household saving is nearly non-existent in SA -last year, it only accounted for 0.5% of the household disposable income. This has caused the continuous problem in balance of payments. Every time the economy grows fast, the current account deficit starts to build up, reaching over 5% GDP in 2006. Brazilians' tendency towards consumption is curbed by their high interest rate, and they are running a surplus in the current account in recent years, about 5.6% GDP in 2005. However, the problem of Brazil is its huge pile of external debt. At the end of 2005, it had US\$187bn external debt, about 28% of GDP, depending on the market exchange rate. In contrast, by the end of 2004 SA's external debt/GDP ratio was only 13.3%. This big difference sometimes causes the different risk perceptions towards two countries. For example, during the rising phase of an interest cycle, foreign investors firstly tend to shy away from the countries with big current account deficit. This could mainly explain why the Rand suffered a big depreciation in the middle of 2006, while it did not hurt the Real too much. However, if the international interest rate keeps rising, it will cause big problems for countries with huge debts to serve. In the event of default by any countries, the Brazilian Real will surely experience a heavy slump. Therefore, the two countries' different risk profiles might occasionally cause the divergence of their exchange rates.

Finally, the skills development in SA and Australia could make a difference on their trade structure in the future. We know the commodity prices are not stable, and the mineral resources will not last forever. It is important and necessary for commodity export countries to diversify their products and make more manufactured goods. However, this diversification needs enough skilled workers, and skills shortage is one apparent constraint of the South African economy. One widely quoted number from Standard Bank chief economist Iraj Abedian is that there are about 500,000 skilled vacancies right now in SA. This could partly be blamed on the poor education system in SA. The government has actually spent a lot on education, about 20% of national budget, but, in terms of quality, SA still compares badly with other countries. In the Trends in International Mathematics and Science Study (TIMSS) in 2003, which tested the teenagers' proficiency in mathematics and science, South Africa came at the bottom of 45 countries, even

¹⁶ See "Roll out. roll out." Economist, July 30th 2005

worse than its African neighbors Botswana and Ghana. In comparison, the performance of Australian students was much better. For mathematics, Australia was comparable with Belgium and Sweden, all of which were above the OECD average. For science, only seven countries ranked higher than Australia. This education deficit may have long-run impact on SA growth. To make things worse, SA is also experiencing severe "brain drain" in recent years. According to Institute of Race Relations, it is estimated about 840,000 whites emigrated from SA between 1995 and 2005. Many of them, the heads of families, are highly skilled professionals.¹⁷ Australia is in a completely opposite situation. It has succeeded in attracting about 100,000 migrants every year in the last decade¹⁸. Around two-thirds of them are admitted on the basis of their skills, using a points system to pick the most needed skills. Considering the whole population of the country is just over 20 million, Australia is very receptive to the foreigners. In contrast, South Africa is not such an open society. Indeed, there is a strong bias of xenophobia. The SA government tends to protect the jobs from foreigners. In the new Immigration Act, there is a quota for annual intake of the skilled foreigners, and the locals detest competition from other countries. Last year, about 10 shopkeepers from Somali were shot dead in Cape Town.¹⁹ So in the long run, this skills difference will surely have an effect on two countries' trade structure. Australia should be able to produce more value-added products, and SA will face great difficulty in doing the same.

Within the present model, it is difficult to predict the future of the underlying relationship analyzed here, but it presents an obviously interesting extension of this research. And whether the approach outlined in this thesis can apply to other currencies still needs further research; but it appears to offer much promise.

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¹⁷ See "SA's woes spark another exodus," *Pretoria News*, October 6th 2006, p6

¹⁸ It varies with the economic climate. It was about 121.000 in 1990. 93.000 in 2000 and 123.000 in 2005.

¹⁹ See "City Somalis hunted down and executed," *Cape Times*. August 23rd 2006

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Appendix

The Aggregate level 2 (Ag2) data from the HS96 is used for the trade analysis. Although Ag2 is already quite brief, it still consists of a hundred categories. To make it more obvious, they are firstly simplified into fourteen big categories.

1. Animal meat and its related products:

- Live animals.
- Meat and edible meat offal
- Fish, crustaceans, mollusks, aquatic invertebrates nes
- Dairy products, eggs, honey, edible animal product nes
- Products of animal origin, nes
- Animal, vegetable fats and oils, cleavage products, etc
- Meat, fish and seafood food preparations nes

2. Agricultural food, drink and tobacco

- Live trees, plants, bulbs, roots, cut flowers etc
- Edible vegetables and certain roots and tubers
- Edible fruit, nuts, peel of citrus fruit, melons
- Coffee, tea, mate and spices
- Cereals
- Milling products, malt, starches, inulin, wheat gluten
- Oil seed, oleagic fruits, grain, seed, fruit, etc, nes
- Lac, gums, resins, vegetable saps and extracts nes
- Vegetable plaiting materials, vegetable products nes
- Sugars and sugar confectionery
- Cocoa and cocoa preparations
- Cereal, flour, starch, milk preparations and products
- Vegetable, fruit, nut, etc food preparations
- Miscellaneous edible preparations
- Beverages, spirits and vinegar
- Residues, wastes of food industry, animal fodder
- Tobacco and manufactured tobacco substitutes

3. Various crude materials (wools, leather, etc)

- Rubber and articles thereof
- Raw hides and skins (other than furskins) and leather
- Articles of leather, animal gut, harness, travel goods
- Furskins and artificial fur, manufactures thereof
- Silk
- Wool, animal hair, horsehair yarn and fabric thereof
- Cotton
- Bird skin, feathers, artificial flowers, human hair

4. Wood, paper and their related products

- Wood and articles of wood, wood charcoal
- Cork and articles of cork
- Manufactures of plaiting material, basketwork, etc.
- Pulp of wood, fibrous cellulosic material, waste etc
- Paper & paperboard, articles of pulp, paper and board
- Printed books, newspapers, pictures etc

5. Mineral ores

- Salt, sulphur, earth, stone, plaster, lime and cement
- Ores, slag and ash
- Stone, plaster, cement, asbestos, mica, etc articles

6. Mineral fuel

Mineral fuels, oils, distillation products, etc

7. Precious stones and metals

Pearls, precious stones, metals, coins, etc

8. Iron & steel

Iron and steel

Articles of iron or steel

9. Other metals and articles thereof (copper, lead, etc)

Copper and articles thereof

Nickel and articles thereof

Aluminium and articles thereof

Lead and articles thereof

Zinc and articles thereof

Tin and articles thereof

Other base metals, cermets, articles thereof

10. Chemicals

Inorganic chemicals, precious metal compound, isotopes

Organic chemicals

Pharmaceutical products

Fertilizers

Tanning, dyeing extracts, tannins, derivs, pigments etc

Essential oils, perfumes, cosmetics, toileteries

Soaps, lubricants, waxes, candles, modelling pastes

Albuminoids, modified starches, glues, enzymes

Explosives, pyrotechnics, matches, pyrophorics, etc

Photographic or cinematographic goods

Miscellaneous chemical products

Plastics and articles thereof

11. Textile, fiber, clothing & footwear

Vegetable textile fibres nes, paper yarn, woven fabric

Manmade filaments

Manmade staple fibres

Wadding, felt, nonwovens, yarns, twine, cordage, etc

Carpets and other textile floor coverings

Special woven or tufted fabric, lace, tapestry etc

Impregnated, coated or laminated textile fabric

Knitted or crocheted fabric

Articles of apparel, accessories, knit or crochet

Articles of apparel, accessories, not knit or crochet

Other made textile articles, sets, worn clothing etc

Footwear, gaiters and the like, parts thereof

12. Electronics, tools & machinery

Headgear and parts thereof

Umbrellas, walking-sticks, seat-sticks, whips, etc

Ceramic products

Glass and glassware

Tools, implements, cutlery, etc of base metal

Miscellaneous articles of base metal

Nuclear reactors, boilers, machinery, etc

Electrical, electronic equipment

Optical, photo, technical, medical, etc apparatus

Clocks and watches and parts thereof

Musical instruments, parts and accessories

Furniture, lighting, signs, prefabricated buildings
Toys, games, sports requisites
Miscellaneous manufactured articles

13. Transport equipment (vehicles, aircraft & ships)

Railway, tramway locomotives, rolling stock, equipment
Vehicles other than railway, tramway
Aircraft, spacecraft, and parts thereof
Ships, boats and other floating structures

14. Others, not elsewhere specified or can be included

Works of art, collectors pieces and antiques
Commodities not elsewhere specified

Next from these 14 big categories, they are combined into 6 groups: agricultural raw material, food, energy, metal and manufactured goods and others.

I. Agricultural raw material:

Various crude materials (wools, leather, etc)
Wood, paper and their related products

II. Food:

Animal meat and its related products
Agricultural food, drink and tobacco

III. Energy:

Mineral fuel

IV. Metal & other minerals:

Precious stones and metals
Iron & steel
Other metals and articles thereof (copper, lead, etc)
Mineral ores

V. Manufactured goods

Chemicals
Textile, fiber, clothing & footwear
Electronics, tools & machinery
Transport equipment (vehicles, aircraft & ships)

VI. Others

Others, not elsewhere specified or can be included

Finally, as described in the paper, they are simplified into four big groups: agricultural products, mineral resources, manufactured goods and others.

This classification is based on general knowledge. It may not be strict and accurate enough for professionals. However, since the methods of classification are consistent with all three countries, it shouldn't affect the comparison of their trade structure.