TIME SERIES STUDIES ON INDONESIAN RUPIAH/USD RATE 1995 – 2005

ISBN 978 90 5170 033 9

Cover design: Crasborn Graphic Designers bno, Valkenburg a.d. Geul

This book is no. **390** of the Tinbergen Institute Research Series, established through cooperation between Thela Thesis and the Tinbergen Institute. A list of books which already appeared in the series can be found in the back.

TIME SERIES STUDIES
ON
INDONESIAN RUPIAH/USD RATE 1995 – 2005

Tijdreeksanalyse van de Indonesische Rupiah/VS Dollar Wisselkoers
1995-2005

THESIS

to obtain the degree of Doctor from the
Erasmus University Rotterdam
by command of the rector magnificus

Prof.dr. S.W.J. Lamberts

and in accordance with the decision of the Doctorate Board

The public defense shall be held on
Thursday, 11th of January 2007 at 13.30 hrs.

by
Antonius Viva Hardiyanto
born in Surabaya, Indonesia

Doctoral Committee

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To His Kingdom enlargement on earth,
To Indonesian people, and the down-trodden
and
To my wife Hanna, my son Ariel,
To my parents, Goni and Titiek

Acknowledgements

When I started my Ph.D. study in 2000, I knew that it would be very hard and difficult. But, upfront, what I did not comprehend at full was that the ensuing struggle during the study period 2000 – 2005, could be full of great lessons that shape my life into what I am today. Challenges came from several fronts, and I learned how the help from Lord Jesus, friends, supervisor, and family was so comforting.

A special remark must be attributed to my supervisor, Prof. Dr. J.-M.A.R.G. Viaene. With a great patience, he supervised the work of my dissertation. He raised a high standard which in many cases I struggled very hard to fulfill. In the middle of the thesis work I faced difficulties but he always assured me that the more important thing is the process of which I can discover ways to overcome them, by working harder and harder. Many times did I make mistakes, and apologized to him. But, to my big confusion, Professor Viaene never replied back to my apologies. Much later on, I learned that he indeed wanted to say that I did not need to apologize to him, because all of the mistakes I made were actually not affecting him, but I myself. That was more than enough to convince me that I should not make mistakes again. One day, in the middle of our meeting, he showed me an old working paper with a pencil hand-writing in it. When I scrutinized the paper, I realized that the hand-writing was a "fatherly-encouraging" comment made by someone who praised his work. And that was Professor Tinbergen's comment. I am still amazed by Professor Viaene's passion for correctness and excellence that he has been maintaining since his younger years.

Related to the study itself, I faced tough times. However, when I took the courses, I enjoyed great help from great and endearing friends like: Reza Anglingkusumo, Andrea Galeotti, Stefano Ficco, Ton Wrasai, Felix Eisenbach, Stefan Schuller. I remember how they helped me without reserve while they themselves were very busy with their own study. What they showed to me as friends really re-shaped my understanding on the meaning of a true friendship. But the greatest encouragement came from Lord Jesus Himself. I found that He keeps His promise when He said: "Come to Me, all you who labor and are burdened, and I will give you rest." I just put my trust and belief on His words, and enjoyed the celestial respite in many occasions.

The main financial support for the entire Ph.D. study came from Bank Indonesia, and I am greatly thankful for the scholarship. Meanwhile, the support of the Foundation

"Vereniging Trustfonds Erasmus University Rotterdam" in the Netherlands is also gratefully acknowledged. Hence, I am very grateful to my superior, Dr. Hartadi Sarwono who supported me to pursue the Ph.D. study, back in 2000. I am also thankful to Dr. Miranda S. Goeltom for her help to find sponsors for the Ox package – STAMP software which I needed very much to run the Unobserved Component Model in my dissertation. She also arranged for a partial sponsorship for my trip back to Indonesia in December 2004, when I presented my research in the 1st National Academic Seminar in Jakarta.

In February 2001, my wife, Hanna, and my son Ariel joined me in Holland. They arrived in the middle of the winter and especially for my son, who was still a little bit older than 1 year old, that was the very first experience for him with cool air and snow. Looking at his expressions with all of the new experience was really a strong boost for my morale. Meanwhile the support that I enjoyed very greatly during my study came from Hanna. She understood my situation and in so many occasions did she encourage me to do important changes in my approach in finishing the Ph.D. study. I will never forget how she patiently helped me find typos and anomalies in my dissertation. I learned that a solid family front was so important for my study, as they supported me without any reserve. I thank God for my very lovely Hanna and Ariel, for it has become very apparent that I am now only one third of what I used to be after I have them in my life.

I want to thank the help of my lovely parents and my parent in-laws for their ceaseless supports. They supported my work with their love and prayers that I never forget. During our stay in Holland, my mother in law and my mother sent Indonesian foods many times, and that cured our longing for the typical spicy Indonesian food taste. I also have extended families and lovely friends in Holland: Pak Losir Taihuttu, Tante Esther, Sara, Johnny, Bati, Leslie, Verena, Teddy Löw and family, Om Jimmy and Zus Jane, Dodo, Sandra, Sandra Fousert, Gian, Rita, Johanna, Andres Nolten, Chyntia Nolten, Om Bob, Tante Arie, Kak Rita, Kak Tony, and still so many more from the BIC Rotterdam. They made my life, together with Hanna and Ariel, in Holland a very beautiful experience. In Indonesia I have great pastors: Pak Steven and Ibu Elly. They supported me in prayers and encouraging words which inspired me even more to finish what He allowed for me to start in 2000.

Maybe I will not be able to mention all of my other colleagues but I thank you all for the attention and the supports. Especially the Tinbergen Institute staffs: Ine, Carine, Dave,

and Nora, I thank you very much for your kind support. While Bank Indonesia friends: Wahyu Agung Nugroho, Pandri Hanandya Rama, and others, supported me when I work my thesis in Jakarta. I thank them for their encouragement.

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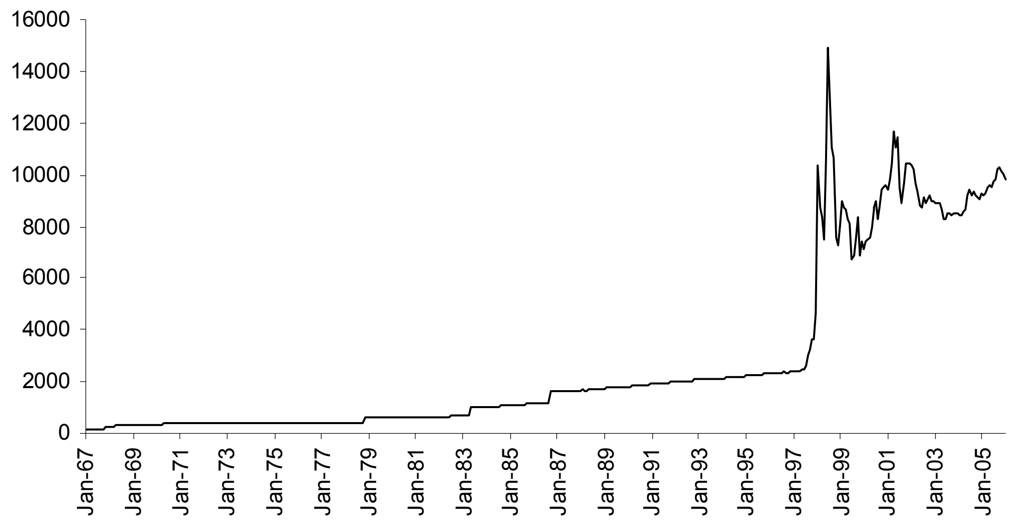
Chapter 1

The History of Rupiah and the Macroeconomic of Indonesia

1.1. Introduction

The optimal management of the exchange rate is very important for a small open economy because it determines how the import prices may affect the domestic economy. The import prices reflect the general prices through the price of the final goods produced by using imported intermediate goods. In the context of macroeconomics, general prices determine the level of interest rate and the interest rate theoretically determines the output of the economy through the aggregate demand changes in the short run.

Fig 1.1: Monthly Rp/USD, Jan 1967 - Dec 2005



During the long period of observation on the Indonesia economy, 1967-2005, there were three Rp/USD exchange rate regimes: Fixed, Managed Float, and Float. In the period of fixed exchange rate regime alone, there were eight devaluations – six of them took place during the period of 1967-1978. Why and how these changes occur would be an interesting topic to analyze in order to understand the gravity of the Rupiah's behavior. The analysis will discuss the macroeconomic situation that caused or preceded such exchange rate regime changes.

However, the study on Rupiah can be enriched if the perspective on the political atmosphere surrounding its history is also explored. After the independence of the Republic of Indonesia in 1945 until the 1997 crisis, only two presidents had successively ruled Indonesia. This initial political setting where the center of power switched between the two presidents and their different political machineries, was not conducive for a healthy institutional development. As the result, the seed of the problem that occurred much later in 1997 had actually been put in place by the political choices made by these two early presidents.

The first president curtailed the democratic mechanism in 1959 for the sake of the unity. Subsequently, the second president controlled the democracy for the sake of economic development and stability. These in effect curtailed the progress of the economic, social, and political institutions. Aggravating the situation, the law was subjected to the taste and interpretation of these leaders thus greatly reducing the certainty for the justice seekers, as well as the certainty for the business deals and contracts. What had flourished were the rent seeking, corruption, nepotism, and collusion activities, which completely hampered further the normal and healthy institutional development.

When all of these negative factors were working without hindrance nation-wide, the economic, social, and political agents then often failed to understand and abide by the common international practices in economic deals, contracts, and so forth. The property rights were often not respected and it was common that the ruling elite expropriated the rights of the parties outside it. This extended to the unequal opportunities for the access to the economic resources, which only the closest to the inner political circle would get the privilege. These deficient settings produced inflexible economic institutions, and when the ability to adjust was needed to absorb sudden changes in the regional and international market, they failed.

The ensuing political experiment by President Sukarno during 1960's reached its declining point when the worsening economic situation took place. The main cause was the money printing to finance the wars with the Netherlands over West Papua in 1961, and subsequently with Malaysia over Kalimantan in 1965. Inflation reached 600% in 1966, the production process stopped, the economy was in the deep recession. Following this economic adversity, the transfer of power from the first to the second president in 1966-1967 took place with coercion, very much like a well orchestrated coup d'etat by the then General Suharto, providing an even grimmer picture that set a very bad example to the whole nation.

The first chapter in the economic development started right after the undemocratic power transfer from President Sukarno to President Suharto that occurred in 1966. The new economic team known as the "Berkeley Mafia", comprising technocrats – economics professors and PhDs, UC Berkeley graduates – from a prestigious University of Indonesia, brought the soaring hyperinflation of 600% into the halt in a matter of only one year in 1967. The ambitious five-yearly development plan was launched, started in 1969. The strategy went step by step, started with the thrust in the agriculture sector. Suharto also initially paid a great deal of attention to public basic needs, facilities, and services such as the people health centers throughout Indonesia. It seemed that a new impetus had taken place since then, however it was proven later that this was not the case.

Under the second president, the stability of the nation was the priority. However, the seed of the problem in the form of the deficient institutional development continued, and had even gotten worse with the pyramidal structure of the KKN practices (for Korupsi, Kolusi, Nepotisme – in Indonesian language meaning Corruption, Collusion, and Nepotism) by the new regime, which points up to the president himself.

Thereby, the historical and political settings cannot be neglected, this introduction provides the way for further discussion concerning the Rupiah. Previous studies about Rupiah rarely incorporated this aspect. The explanation strategy in this introduction will cover the span of time between 1967 until 2005. This explanation period will be divided into five parts:

a. Period I : January 1967 – December 1978
b. Period II : December 1978 – May 1983
c. Period III : April 1983 – October 1986
d. Period IV : October 1986 – August 1997
e. Period V : August 1997 – present

The division of period is based on the simple cut-off points that coincide with the timing of the Rp/USD devaluations or other occurrences that pertained to a big change in the Rupiah foreign exchange rate. That way we understand the economic situation surrounding such changes, and the following sub-sections will discuss the development of Indonesia's macroeconomic condition within each period.

1.1.1. Period I: January 1967 – December 1978

Indonesian economy experienced dramatic changes during the first 10 years since 1967, although it was predominantly agricultural economy. The main focus of the government economic policy was the push for economic development, led by the agricultural sector development. Meanwhile the economy started to work in a normal condition after the 1966 hyperinflation was contained, and followed by the drastic economic measures taken by the newly established "Berkeley mafia" economic technocrats. The IGGI (Inter-Governmental Group on Indonesia), a consortium of 14 donor countries and 5 international organizations, held its first meeting in 1967. The U.S. and Japan each pledged $65 million in aid. Thus, 60 percent of the government's budget was funded by foreign aid through IGGI.

In 1969, the first Five Year Development Plan, the so-called REPELITA I, was launched. This was a very important initial momentum for the following success of the economic development in terms of economic growth. Its goals were to restore the economy, build the infrastructure, and make Indonesia self-sufficient in rice production. Meanwhile the earliest sign of serious international economic activity involving foreign direct investment took place in 1969, when Freeport-McMoran, a giant US mining company started to build a 63-mile road from the coast of Irian Jaya to its copper mining area in the interior.

Then the REPELITA I ignited bigger momentum in the economy. Although the dominant sector was agricultural sector at first, but the aim was to steadily stimulate the bigger role of manufacturing sectors. Data shows that between 1966-1970 agriculture share in GDP was 42.4% and the manufacturing share was mere 17.9%. The GDP share changed during the following decade, 1971-1981, to 33.8% for agriculture, and to 24.1% for industry sectors.

That meant more import of machines, tools, capital goods, and intermediate goods for the growing industry sectors, thus increasing international economic activities. It invoked new perception in the mind of the policy makers that exchange rate of Rupiah against strong currencies must be stable. At this earlier stage of development in the economy, the urgent need was stability. That translated to the fixed exchange rate of Rupiah against USD.

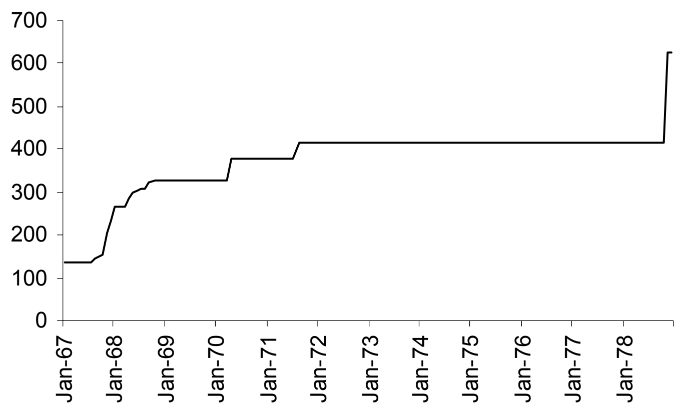
Table 1.1: Sectoral share (%) of GDP in Indonesia, 1966-1981*

	Agriculture	Industry
1966-1970	42.4	11.9
1971-1981	33.8	14.7

Notes:
- *) Industry sectors include: Manufacture, Mining, and Construction
- Source: Hayashi (2003)

Figure 1.2 shows that in the span of two years, 1970-1972, there were two devaluations of Rp/USD. The major devaluations during this period took place in August 23, 1971 and November 15, 1978. The span of time between these two latest devaluations was long and the Rp/USD was Rp 415 during 1971-1978, and devalued to Rp 625 in November 1978. However a careful study is needed to check whether this long period of stability was really supported by the macroeconomic fundamentals. Was the Rupiah actually overvalued or undervalued during that period?

Figure 1.2: Rp/USD monthly, Jan 1967 – Dec 1978



On the other hand, Figures 1.2 and 1.3 show that during the long period of fixed Rp 415/USD, January 1972 – December 1978, the rate stayed flat, while the CPI increased five-fold toward the end of the period of observation. The increasing inflation is reflected in the uptrend of the Real Effective Exchange Rate (REER),[1] which is trade weighted real exchange rate, shown in the Figure 1.4. It discloses the apparent overvaluation Rp/USD along the period, especially the uptrend movement of the REER index during 1973-1978.

Figure 1.3: Monthly average CPI Indonesia, 1995=100
Jan 1970 – Dec 1978

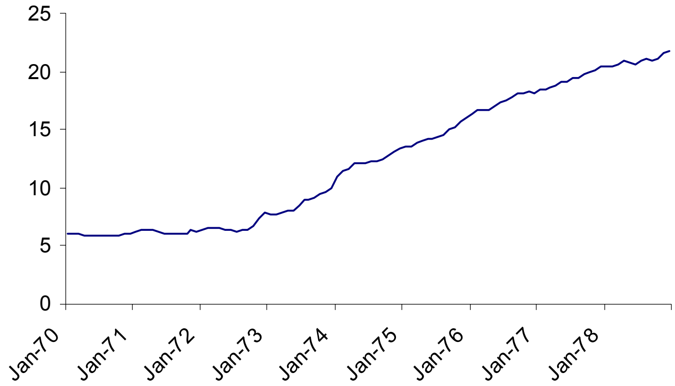
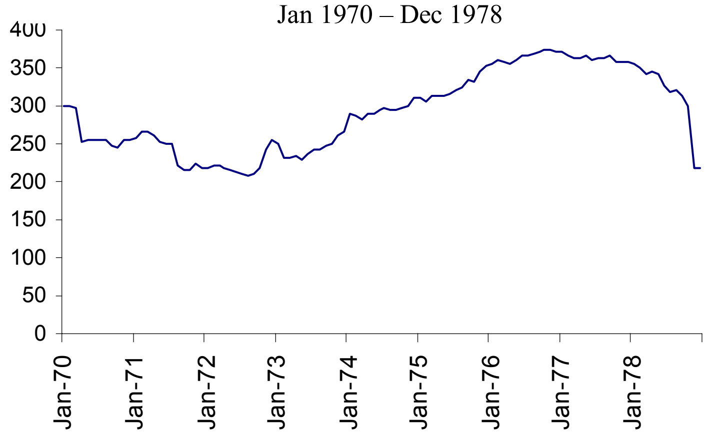


Figure 1.4: Trade weighted REER of Rupiah against
USD, Yen, SGD, and Won, 1995=100
Jan 1970 – Dec 1978



[1] The REER is calculated as the trade weighted real exchange rate. Trade partner countries are US, Japan, Singapore, and Korea. The nominal rate is based on the Rp/USD calculation. Thus the undervaluation (overvaluation) of the respected REER index is characterized by the downward (upward) movement in the REER plot. This applies to the whole discussion.

We then want to discuss the situation of the money supply (M1) and the domestic credit during the period. The money supply (M1) increased steeply during this period and the government heavily regulated the financial sector, which was indicated by the bank lending control and the various credit schemes with subsidized interest rate. These special credit schemes were channeled to the farmers, the needy poor in rural areas, and the special interest groups like the students and the consumers. But these all took the toll in the form of the deficient banking institution, corrupt practices based on favoritism, and unsustainable credit program. There was hardly any significant evidence that the banking sector introduced modern practices to its operation, not mentioning the so-called professionalism in this period of time. Nevertheless, spearheaded by the 'red-plate' banks, the reference made to the bulky state banks during that time, the financial sector contributed to the economic development in such a meager path.

During the 1970s, the state banks also benefited from the government policies, such as the requirement that the growing state enterprises bank solely with the state banks. The state banks were viewed as the agents of development rather than profitable enterprises, and most state bank lending was channeled to the government-mandated and subsidized programs designed to promote various economic activities, including the state enterprises and the small-scale *pribumi* (indigenous) businesses.

Meanwhile, the state bank lending was subsidized by Bank Indonesia's "liquidity credits" at very low interest rates to finance various programs. Figure 1.5 shows how the domestic credit increased steeply after 1973, and Figure 1.6 clearly shows that the interest rate during this period was fixed.[2]

On the other hand, the foreign exchange transaction by domestic residents had been unrestricted since the early 1970s. While many developing countries attempt to curb the capital flight, the government continued to permit Indonesian residents to invest in foreign financial assets and to acquire foreign exchange for investments through Bank Indonesia without limit.

[2] Bank Indonesia is the Central Bank of Indonesia. From this point on, the text will refer to Bank Indonesia with the acronym BI as well.

Figure 1.5: Domestic credit in billion USD,
Jan 1970 – Nov 1978

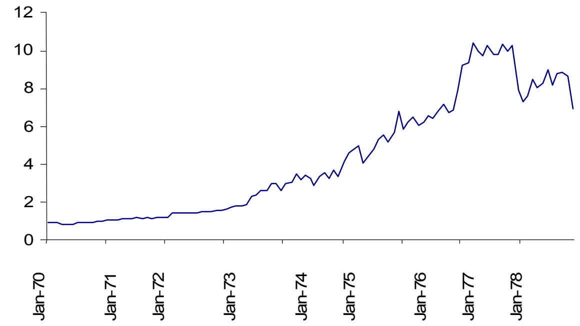
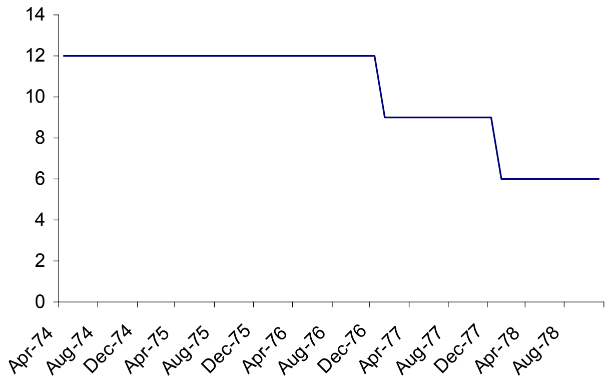


Figure 1.6: Nominal interest rate (3 month deposit),
April 1974 – Nov 1978

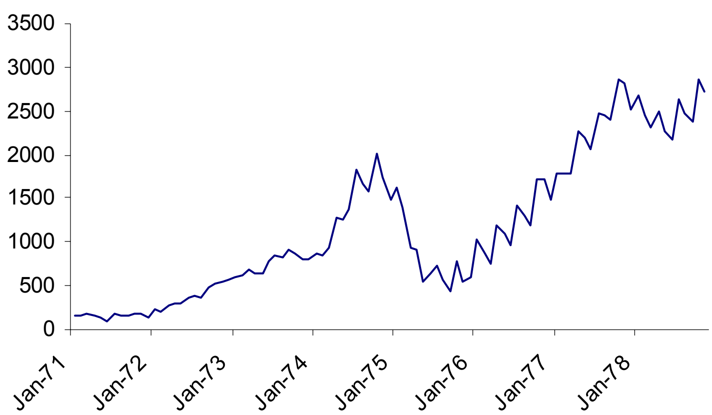


Since the late 1960s, commercial banks in Indonesia, including state banks, were permitted to offer foreign currency deposits (usually in USD), giving rise to the so-called Jakarta dollar market.

This freedom to invest in foreign currencies served the financial institutions well. During the 1970s, when banks' domestic credit activities were heavily restricted, most banks found it profitable to hold assets abroad, often well in excess of their foreign exchange deposits. When demand for domestic credit was high, banks often went for the international borrowing to finance the expanding domestic loans.

In conclusion, during this period, Indonesia had a repressed financial system, which did not show any significant influence to the gyration of Rp/USD. The interest was fixed, the exchange rate was fixed, but the CPI was rampant. The inflation was the cause of the overvaluation of the real exchange rate and the negative real interest rate. Meanwhile, the foreign reserve had two critical situations that explained why the devaluation took place in the end of 1978. We can see the foreign reserve gradually increased from 1971-1975, but dropped during 1975-1976, which posed the first alarm for the authority the necessity to safeguard the foreign reserve. As the result, the government established the standard for the safe duration of time of the imports that the foreign reserve can sustain for the economy. After the 1975-1976 dips, the reserve resumed to increase until the beginning of 1978 when the oil price began to show a downward trend. The oil price drop became the second alarm, which triggered the government to look at the devaluation option on November 15, 1978. Moreover, it was decided that the fixed exchange rate regime would be switched to the dirty managed float regime. From this point on, the Rupiah would start to behave differently as compared to its previous history.

Figure 1.7: Total reserve minus gold (monthly) in million USD, Jan 1971 – Nov 1978



1.1.2. Period II: December 1978 – May 1983

The main economic policy during this period was to focus on import substitution strategies that can support the export sectors. The government learned from the previous experience that it should maintain the Rp/USD real exchange rate, which supports the export-led growth with the modified fixed exchange rate strategy called the dirty managed floating exchange rate strategy. The central bank did not announce openly the Rp/USD "fixed rate", but on daily basis, indicatively revealed the fixed rate at the start of the market day, through the trade of the exchange rate with the economic agents.

However from Figure 1.8 we see that Rp/USD rate depreciated steadily from 1978 to 1981 and then depreciated steeper from 1981 until the next devaluation in March 29, 1983. In Figure 1.9, the CPI moved in a steady manner during this period and the point-to-point yearly inflation showed 5 percent inflation. Tradable goods comprised 60 percent of Indonesian CPI, thus inflationary pressure is linked to the exchange rate movements (Ramakrishnan and Vamvakidis, 2002).

Figure 1.8: Rp/USD monthly, Nov 1978 – Mar 1983

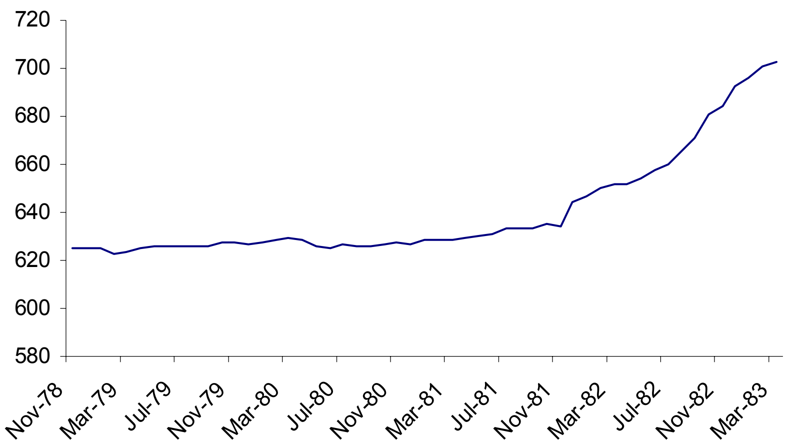
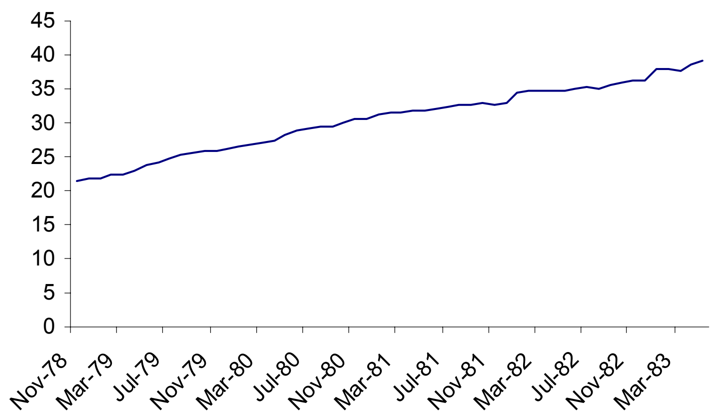


Figure 1.9: Monthly average CPI, 1995=100,
Nov 1978 – March 1983



It shows that during 1978-1981, the Rp/USD depreciation rate was comparable to the inflation rate, which resulted in the relatively steady REER in Figure 1.10. In this case, overvaluation is not preferable because it gives a wrong signal to the economy, such as lower price of imports in terms of domestic currency, while it is indeed not. On the other hand, it gives wrong signal also to the world market that Indonesia's tradable goods are expensive.

Then, what had caused the government to devalue the Rp/USD again in March 1983? During 1978-1981, the REER was held steady as the inflation rate was followed by the comparatively equal nominal depreciation rate. After 1981, the nominal Rp/USD was depreciating relatively steeper than the previous period. The cause of such depreciation was the widened Rp/USD intervention band in order to maintain the REER, in the face of the ever-increasing inflation. However, we must discuss further the movement of the other variables.

Figure 1.10: Trade weighted REER of Rupiah against USD, Yen, SGD, and Won, 1995=100, Nov 1978 – Mar 1983

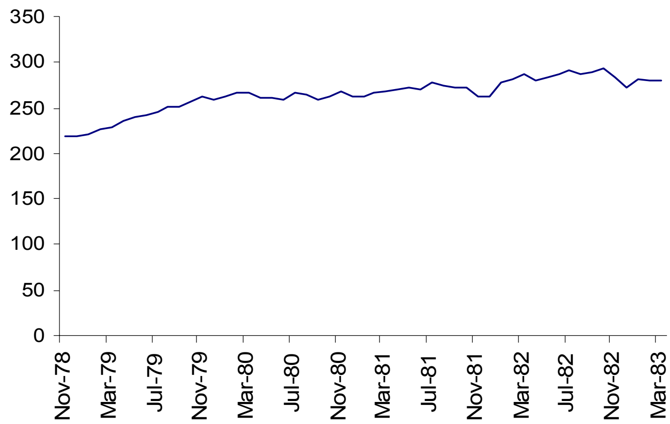


Figure 1.11 shows that the export was higher than the import during the 1978-1981. Then it shows that nearing to the end of this period, the export performed poorly, and even in March 1983 it was less than the import, thus creating the trade imbalance. As it happened, the foreign reserve also declined especially toward the end of the period, as shown in Figure 1.12.

Figure 1.11: Export and import of Indonesia in million USD,
Nov 1978 – Mar 1983

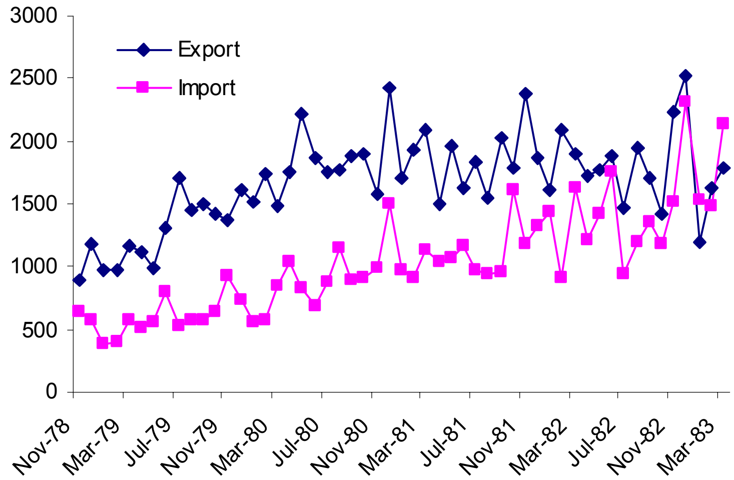
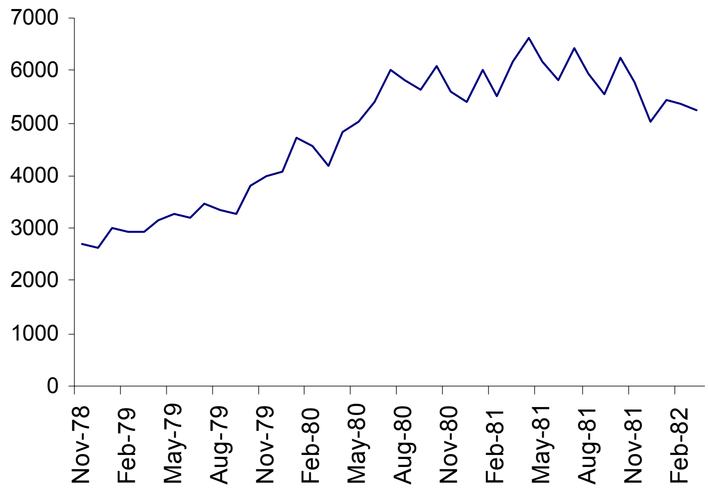
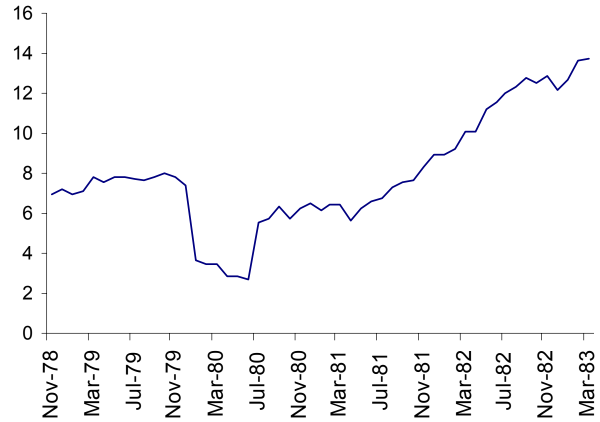


Figure 1.12: Total foreign reserve in million USD,
Nov 1978 – Mar 1983



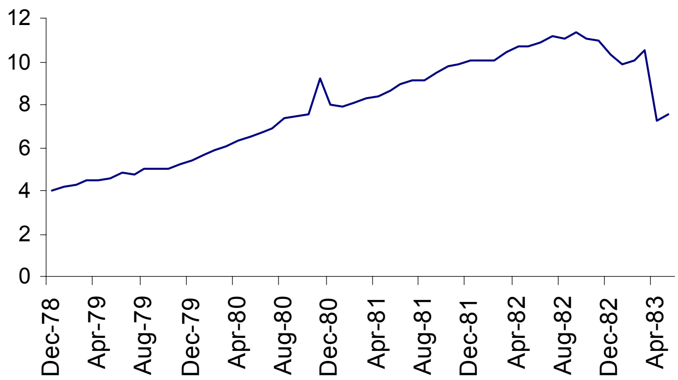
Then, it was decided by the government in March 1983 that devaluation was the right policy to impose the expenditure switch in the economy, thus curbing the import and boosting the export. On the other hand, the 3-month deposit rate was 6 percent flat throughout the period and the domestic credit was certainly not determined by the interest rate or by the actual demand and supply in the money market.

Figure 1.13: Domestic credit in billion USD,
Nov 1978 – Mar 1983



The financial repression still took place and the credit quota policy continued to exist. That was why during this period the financial sector was still vastly undeveloped. Meanwhile Figure 1.14 shows how the money supply (M1) continued to increase until March 1983, when it started to drop.

Figure 1.14: M1 in billion USD,
Dec 1978 – May 1983



1.1.3. Period III: April 1983 – October 1986

Early 1983, the economy experienced a heavy pressure when the oil price plunged in the world market and the world economic recession occurred. On the other hand, the overvalued real exchange rate eroded the competitiveness of the export sector. It threatened the sustainability of the economic growth and the deficit of the balance of payment was considerably large. Several monetary policies were then created to strengthen Indonesia's economic structure amid the difficult time. The June 1, 1983 deregulation package was created to allow for the market forces to work in the financial sector. The main points in the deregulation package were to let state banks to set the deposit rate, and to remove the credit quota.

Then on September 12, 1986 a 31 percent devaluation of Rp/USD, from Rp 1134/USD to Rp 1633/USD took place and the exchange rate regime still had not changed. The reason for this devaluation was to boost the export sector. Figures 1.15 and 1.16 show the similar direction of movement between nominal exchange rate and the CPI, while the REER movement is flat, as shown in Figure 1.17.

Figure 1.15: Rp/USD monthly, Mar 1983 – Sept 1986

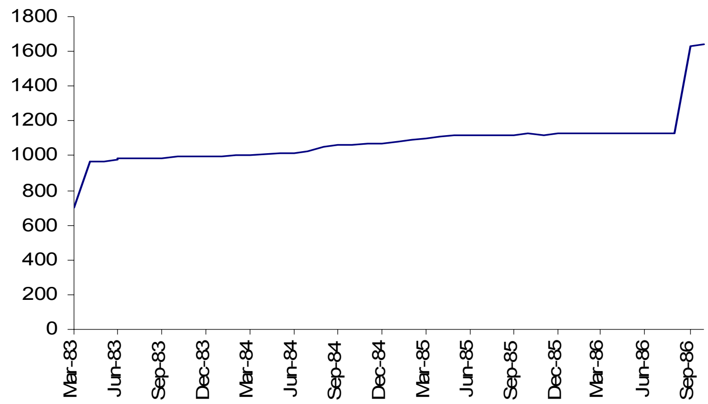
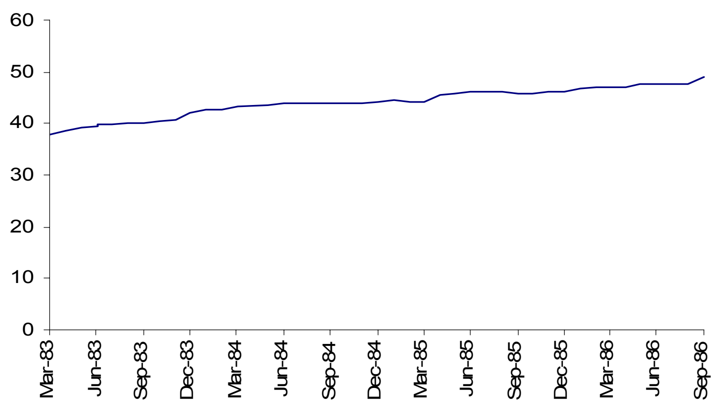
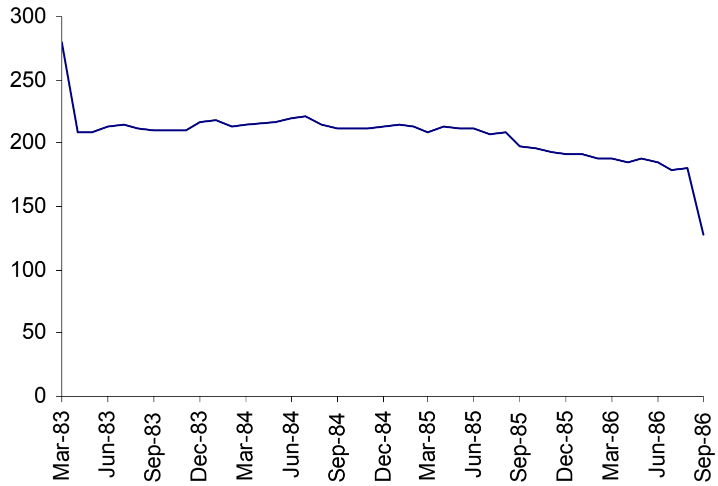


Figure 1.16: Monthly average CPI Indonesia, 1995=100
Mar 1983 – Sept 1986



These facts show a completely different view on the main reason of the September 1986 devaluation. Clearly the devaluation did not serve the purpose of restoring the REER equilibrium because the plots tell us different pictures as compared to the previous REER in the past devaluations. Comparing Rupiah's REER with four currencies of major trade partner reveals that during this period the index was relatively stable and there was no apparent indication of misalignment.

Figure 1.17: Trade Weighted REER of Rupiah against
USD, Yen, SGD, Won, 1995=100,
March 1983 – Sept 1986



Then, why had the devaluation taken place? Again, it was carried out to remedy the external imbalance situation. Figure 1.18 shows the downtrend of export and import during this period. The explanation is that the major component, the crude oil export, was decreasing due to the dip in the world oil market that plunged further to USD 10/barrel in 1986. Figure 1.19 confirms the case. And as the main source of foreign reserve decreased so did the reserve itself. It decreased on the last 9 months in this period and is clearly shown in Figure 1.20.

Figure 1.18: Export and import of Indonesia in million USD,
Mar 1983 – Sept 1986

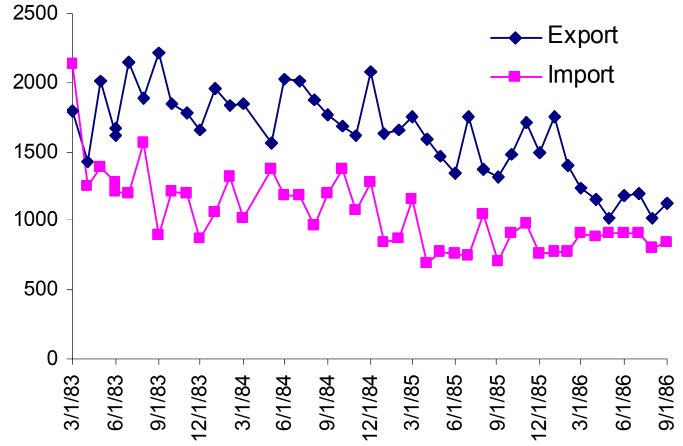
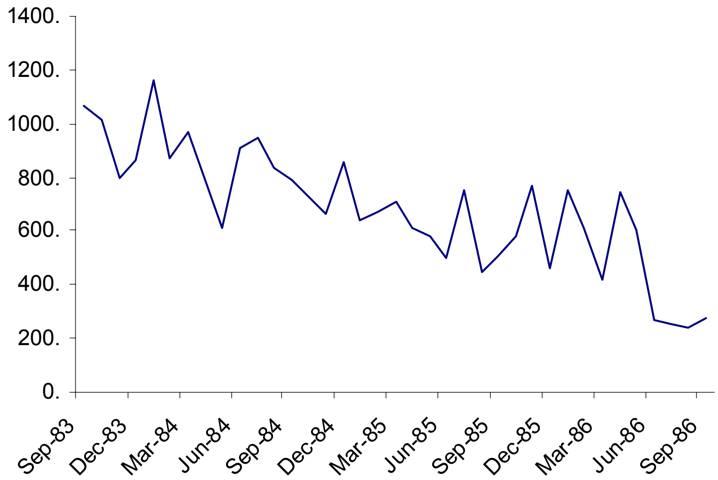


Figure 1.19: Crude oil export value in million USD,
Mar 1983 – Sept 1986

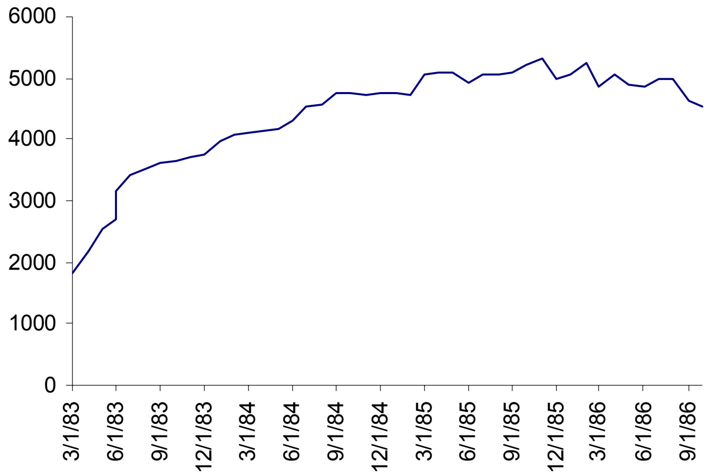


So far, several past devaluations were carried out to boost export and to curb import, thus improving the balance of payment. Export was expected to lead economic growth, however during this period, export would only literally mean crude oil. And nonetheless, these devaluations began to produce drawbacks. The economic agents grew weary to the term of devaluation. What the economic agents experienced was the shock in the economy that was caused by the devaluation that had been going on once at a time, would always literally mean a big shock to their daily economic activities and to their life. They would wake up the next day finding out that their money would buy less import goods. The devaluation's other aspect, is that it was like the ruling class expropriated the rights of the people. All of sudden, some luxuries have gone out of the life of the people, because their money would only buy less than what they had initially knew it could. Thus, the government became aware that the fixed exchange rate was socially less optimal than the managed float exchange rate, whenever the adjustments needed to be done.

Big Change in Financial Sector

Using a package of policy that was called Pakjun 1983 (June 1983 Package), the government reformed the financial sector. This economic reform package initially focused on the establishment of the financial markets, financial institutions and financial instruments, towards a more market-based system.

Figure 1.20: Total foreign reserve in million USD,
Mar 1983 – Sept 1986

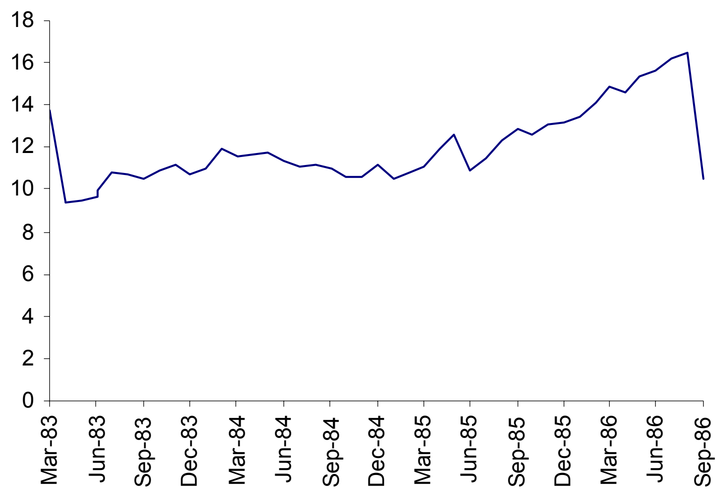


This package included a big transformation of the government-controlled financial sector into a competitive source of credit based on the market-determined interest rates, with a much greater role for the private banks and the stock exchange. The interest rate was then market-based, and the direct credit controls on the banking system were abolished, eventhough several heavily subsidized credit programs for farmers still continued.

A greater degree of competition was introduced by this reform, although the number of domestic non-state banks was only seventy at that time and there were only eleven foreign or joint-venture banks at the same time. Credit quotas were lifted and state banks were permitted to offer market-determined interest rates on deposits. Many of the subsidized lending programs were phased out, although several specific credits continued to receive subsidized refinancing from Bank Indonesia. By 1983 these special credits represented over 50 percent of the total state bank credit. The total state bank lending in turn represented about 75 percent of all commercial bank lending.

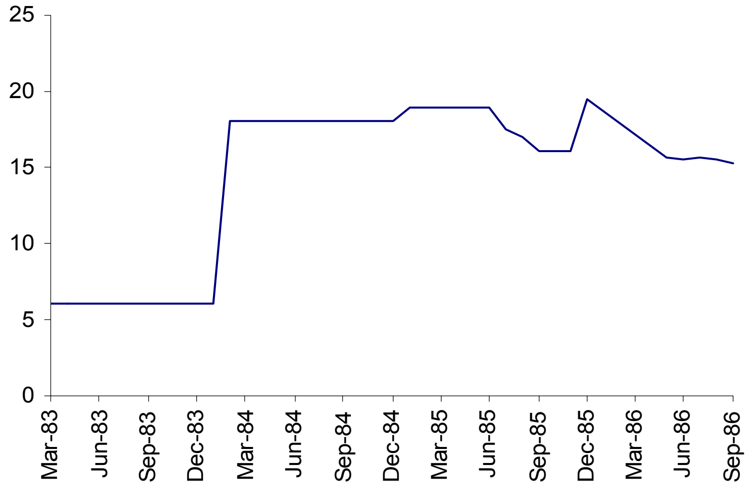
However, important restrictions remained, including the requirement that the state enterprises bank with the state banks and the limitation on the number of private banks. The overall result was an upsurge of the domestic credit until around August 1986 as shown in Figure 1.21.

Figure 1.21: Domestic credit in billion USD, Mar 1983 – Sept 1986



Meanwhile as soon as the government lifted the interest rate peg, the interest rate surged up to offset the negative real interest rate. One of the aims of this financial deregulation package was to introduce a little degree of competition so it could manifest into a movement of market force in the financial sector. The behavior of the nominal interest rate of 3-month deposit is shown in Figure 1.22.

Figure 1.22: Nominal interest rate (3 month deposit),
Mar 1983 – Sept 1986



Thus, it was apparent that the government tried to initiate the economic reform in the financial sector amid the difficult economic situation due to the international economic recession and the uncertainty from the world oil market, in order to help establish a stronger economic institution.

1.1.4. Period IV: October 1986 – August 1997

Up until this period, there were already eight devaluations since the new regime of Suharto took power in 1966. Each time, right before devaluation took place, the economy had always experienced difficult situation in the external balance, due to the deteriorating export performance. We have already discussed that such poor export performance in the past, was mainly caused by the typical high inflation that eroded the competitiveness.

However, each time after a Rp/USD devaluation takes place, the non-oil export was temporarily boosted up to a point until it becomes down again due to the eroded competitiveness. Then the government finally realized that maintaining the REER without being able to control the inflation would make such exchange rate policy ineffective. The option of devaluation becomes less preferable politically and socially because the economic agents and the Indonesian people were already traumatized by past sudden devaluation shocks, and the ruling regime was well aware about such discontent that could be destabilizing.

After the September 1986 devaluation, the government decided to switch the exchange rate regime to the managed float exchange rate. This involves the strategy of floating the Rupiah exchange rate against several foreign currencies of the trade partner countries. The government set an indicative rate and allowed it to gyrate inside a band of intervention. With this strategy the stability of the Rupiah exchange rate was expected to improve compared to the fixed rate strategy.

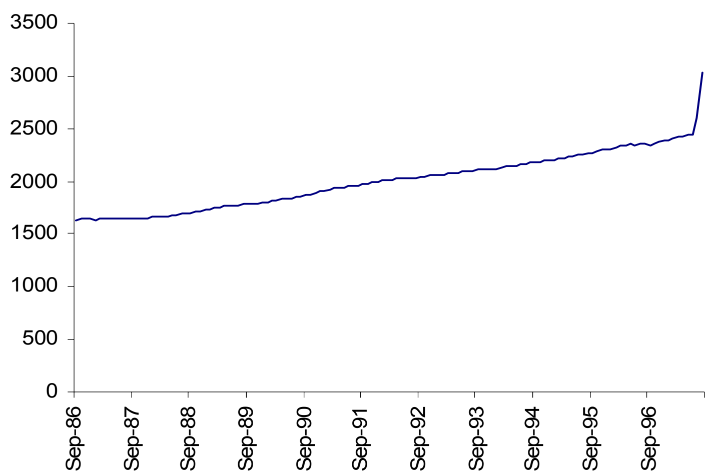
Entering 1987, the economy still faced pressures in the external balance because of firstly, the persistent volatility in the world oil market, and secondly, the downward trend of the traditional exports goods of Indonesia. Meanwhile, the new exchange rate regime was put to the test in the early 1987, the foreign exchange market began to speculate on the Rp/USD.

The response of the authority took place on June 1987, when Bank Indonesia acting under the command of the Minister of Finance, tightened the money supply by increasing the Bank Indonesia Certificate's interest rate and the discount window facility. Furthermore, the Ministry of Finance forced the state-owned enterprises to buy the Bank Indonesia Certificate at a set rate. At that time, this package was very famous because of what such dramatic shock brought to the economy, and was later named, the "Sumarlin Shock," after the then Minister of Finance, Mr. Sumarlin. This resulted in the drastic monetary contraction, which could help to curb the inflation.

However, the urge to further liberalize the economy emboldened. The government had then created the successive economic reform packages: First, the infamous monetary, finance, and banking deregulation package on October 1988, then the March 1989 deregulation package, and the latest, was the January 1990 package. These reform packages were aimed at the liberalization of the banking and finance sector and the main goal were to allow the market forces to work even further. However, it was proven that these reform packages were carried out hastily. It turned out that there was barely any incentive to the economic agents to establish improvements in the governance aspects. On the other hand, the banking supervision efforts were also not carried out according to the good governance principles. Many economists nowadays conclude that these packages greatly contributed to the economic crisis that happened later in 1997, because since then the banking sector had grown extremely rapid, without the accompanying prudence in the overall operation. This matter will later be discussed.

It is apparent that during this period, the exchange rate regime of Rp/USD was subjected to the greater international market influence in the economy. The managed floating strategy was carried out with an initial success for the coming years. The Rp/USD rate was stable and predictable, which allowed the economic agents to enjoy temporary certainty. International trade could proceed without much concern about the future Rp/USD rate, because depreciation was predictable. Foreign loan borrowers also enjoyed this stable Rp/USD rate. They did not need to include the exchange rate risk calculation, because they were certain about the yearly depreciation rate of the Rp/USD. The need to hedge the financial exposure to the future exchange rate risk was practically non-existent.

Figure 1.23: Rp/USD monthly, Sept 1986 – Aug 1997



However during the period from early 1990 until mid 1997, the Rp/USD volatility grew stronger as the financial sector became more open to the international market. During this time, Bank Indonesia widened the band several times to achieve safe nominal rate for the REER as well as for the monetary policy, while maintaining stability. Table 1.2 shows the band imposed by the monetary authority, which crawled slowly.

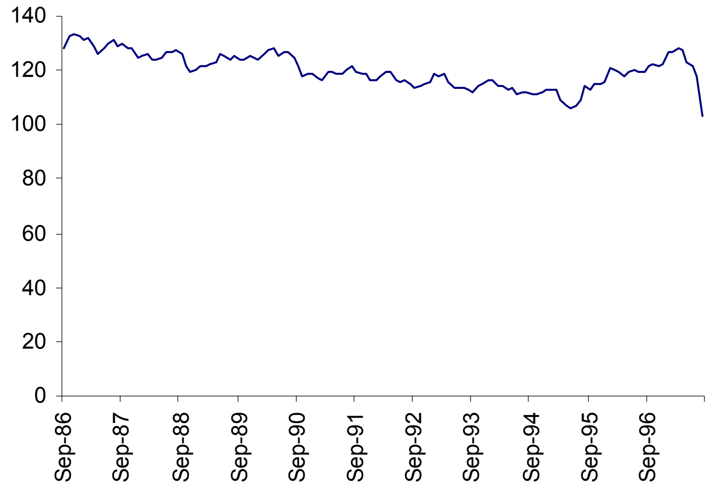
The early managed float period with a 0.25 percent to 0.50 percent spread from upper and lower intervention rate, coincided with the period of the insignificant fluctuations of the Rp/USD, shown in the Figure 1.23.

Table 1.2: Exchange rate band in the period of managed floating

Period	Band	
	Δ (Upper–Lower band in Rp)	Percentage
Jan 1, 1988 – Sept 15, 1992	6	0.25
Sept 16, 1992 – Dec 31, 1993	10	0.50
Jan 3, 1994 – Aug 31, 1994	20	1.00
Sept 2, 1994 – May 29, 1995	30	1.10
May 30, 1995 – Dec 28, 1995	44	2.00
Dec 29, 1995 – June 12, 1996	66	3.00
June 13, 1996 – Sept 10, 1996	118	5.00
Sept 11, 1996 – July 10, 1997	192	8.00
July 11, 1997 – Aug 13, 1997	304	12.00
Aug 14, 1997 – present	No band	-

Source: Bank Indonesia, Directorate of Reserve Management

Figure 1.24: Trade weighted REER of Rupiah against
USD, Yen, SGD, Won, 1995=100
Sept 1986 – Aug 1997



However, the exchange rate band was significantly widened from 1 percent in January 1994 to 8 percent in September 1996, which then increased to 12 percent in the wake of the heavy speculation on the region's currency. When the band was abandoned on August 13, 1997, the market suddenly faced the new Rp/USD trading situation where the economic agents did not have any indication or information about the right exchange rate, thus setting the roller-coaster Rp/USD rate movements from that point on.

The Genesis of Crisis

The 1988, 1989 and 1990 deregulations made it possible for the financial institution to channel credits in Rupiah even more aggressively. However, the bank officers did not carry out the expansion of credit with prudent assessment. Meanwhile the economy that had continuously been experiencing inflationary pressures in the past, continued to show the over-heating phenomenon, due to this aggressive domestic credit expansion.

The other direct result of these three major reforms was the liberalization of portfolio capital flows by the elimination of the quantitative limits on banks' borrowing from non-residents. Foreigners were permitted to invest in the stock market, and are allowed to acquire up to 49 percent of the ownership of listed companies. The foreign capital inflow was mainly in the form of commercial bank borrowing, which was then converted to the domestic currency using the central bank's swap facility, thus contributing the increasing growth of the money supply. Unaware of the potential problem, the government had further eased the restrictions on the direct investment inflows and allowed the foreign direct investors to sell foreign exchange directly to commercial banks instead of going through Bank Indonesia.

Figure 1.25 shows that the credit by the financial institutions went almost five-fold since the beginning of 1990 until August 1997. The government then issued the second monetary contraction policy known as the "Sumarlin Shock II." This sudden contraction succeeded in curbing the inflation rate in 1992, but the deposit rate went up to 27 percent. With this latest situation, the demand growth for domestic credit saturated for a while and the economic agents began to look abroad for cheaper funds. This was the start of a dramatic growth of private foreign borrowings, which exploited the large difference between the foreign and domestic interest rate and the fact that the Rp/USD depreciation rate was predictable at around 3-5 percent per year, making all of the future repayments burden seemed to be easily handled.

Figure 1.25: Domestic credit in billion USD,
Jan 1990 – Aug 1997

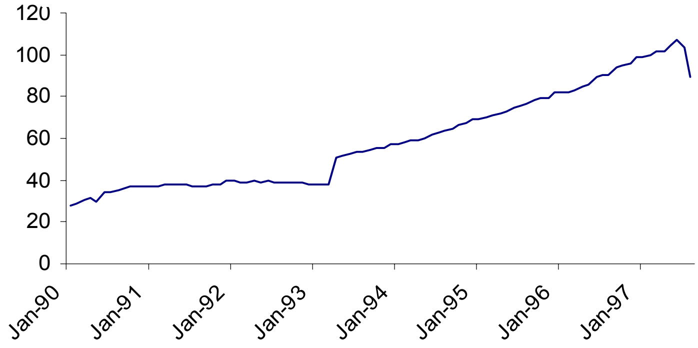
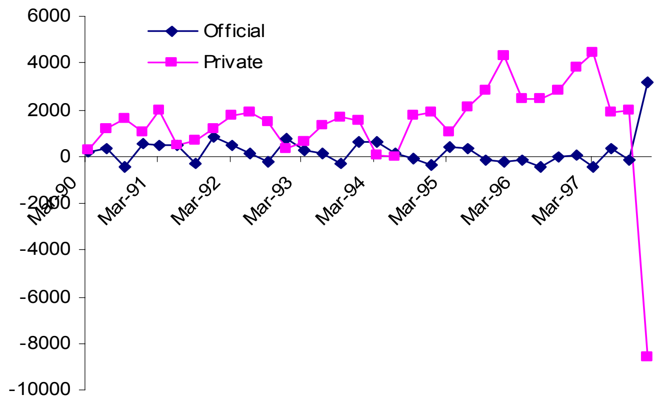


Figure 1.26: Official and private net capital flow
in million USD, Mar 1990 – Sept 1997



However, although the "Sumarlin Shock II" brought down the inflation in 1992, the impact was temporary. The high domestic interest rate, as the result of such shock drove away the fund borrowers to the cheaper foreign borrowings, and with it, brought the new problems for the central bank, because at the end of the day the inflow of the foreign funds had to be converted to the Rupiah. Meanwhile banks began to tap the foreign sources of funds with the lower cost of funds. When banks channeled these foreign borrowings for domestic lending (either in the Rupiah or in the foreign currencies), then the expansionary domestic credit took place. That explains why Figure 1.25 shows the steep increase of the domestic credit since 1992, right after the "Sumarlin Shock II" impact had died down. Meanwhile, in 1995, the economy started to enjoy the inflows of the foreign investment even more, and the aggregate consumption also drove up the economic growth. The industry and the construction sectors were the sectors that experienced the positive impact of the upsurge of the consumption. The inflation began to reach the alarming rate of 8.9% in 1996 and the current account deficit widened while total net private capital flows registered a surplus in 1990 for the first time since 1985, and it continued until August 1997.

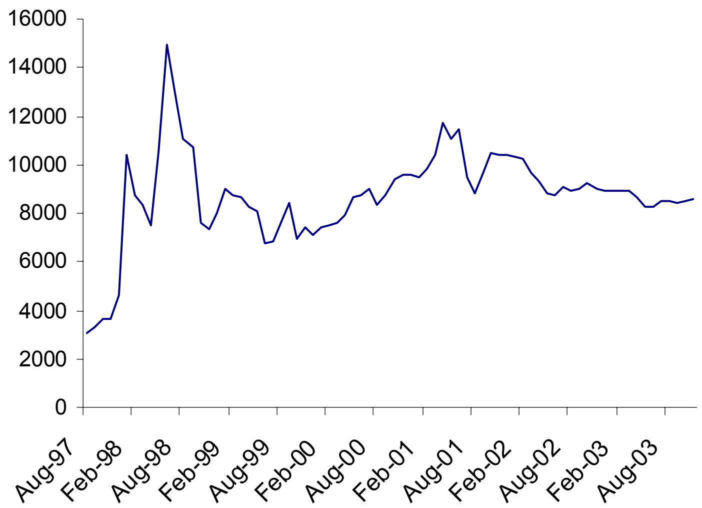
Moreover, Takagi (1999) finds that during the capital inflow episode of 1987-1997, the monetary authorities of East Asia (i.e., Indonesia, Korea, Malaysia, the Philippines and Thailand) took various measures to sterilize the expansionary effect of the foreign fund inflows on the growth of monetary aggregates. His econometric tests based on the quarterly data suggest that the set of various sterilization measures pursued were effective in limiting the growth of the narrow and broad money. This may have promoted the additional capital inflows by keeping the domestic interest rates level high or may have caused the disintermediation and expanded the volume of assets in a poorly supervised non-bank financial sector. In either case, the potential risk of the capital inflows in East Asia was likely magnified by the active policy of sterilization.

Since 1996, the private sectors including banks, made more external debt than what the government had done. But it is important to note that at that time, the figure only represented the tip of the iceberg, because, as uncovered post crisis, the private debts were much more than what the official data reported. The foreign debt regulation required none of the private enterprise to report its external borrowings except for the banks. The monitoring of the foreign borrowings was the big hole that skipped the attention of the government. When the Rp/USD rate plummeted in the subsequent years, 1997-1998, these unreported foreign borrowing activities suddenly became a monstrous problem to the whole economy. The repayment burden unexpectedly became almost six-fold heavier and this made it impossible for the foreign capital borrowers to meet their scheduled obligation. The repayment of the foreign borrowings was suddenly disrupted in the massive scale, bringing down the overall credit ratings in the eye of the world financial market. The sudden stop of the foreign capital inflow took place as the access to the international financial resources was completely closed.

1.1.5. Period V: August 1997 – Present

Indonesia was the last nation in Asia in 1997 to take the hit from the currency crisis. Reflecting to the period of the 1997-1998 crises, initially Indonesia withstood the period of trouble better than Malaysia and Thailand. This was attributed to the seemingly stronger fundamentals, including the relatively smaller external current account deficit as compared to Thailand. However, on July 11, 1997, barely four weeks before the switch to the free float regime took place, the monetary authority widened the trading band for the Rp/USD rate to 12 percent from its previous band 8 percent. Then the intervention band of the Rp/USD rate was officially replaced by the free float regime on August 14, 1997.

Figure 1.27: Rp/USD monthly, Aug 1997 – Mar 2004



The banking sector stability stumbled systematically, and the Rp/USD continued to be speculated heavily. The authorities took other measures like administrative sanction, to counteract the pressure on the exchange rate. Nonresidents' transactions in the forward market were restricted to USD 5 million per customer, and each bank's net open position in the forward market was limited to USD 5 million. In September 1997, the authorities also lifted the 49 percent limit on foreign ownership on new initial public offerings in the stock market. These measures turned out to be all too late. Figure 1.27 shows how Rp/USD was moving in the free float era. The turbulence was apparent in the first half of the period, and then eased up towards the end of the observation period. The 70 percent inflation rate in 1998 has been decreasing since then.

However, the Rp/USD rate began to show more volatile movement since the floating rate regime started. Figure 1.30 shows the stark difference in the daily Rp/USD before and after the floating rate regime was officially started. The higher Rp/USD volatility creates opportunities for the foreign exchange traders to speculate and reap gains.

Figure 1.28: Monthly average CPI Indonesia, 1995=100
Sept 1997 – Mar 2004

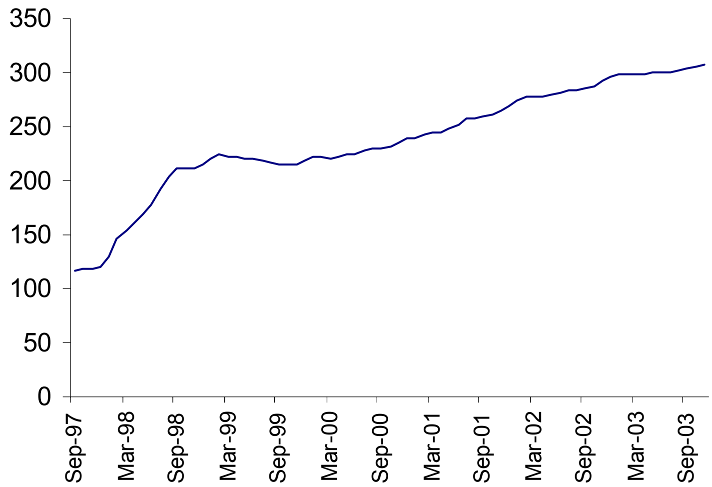
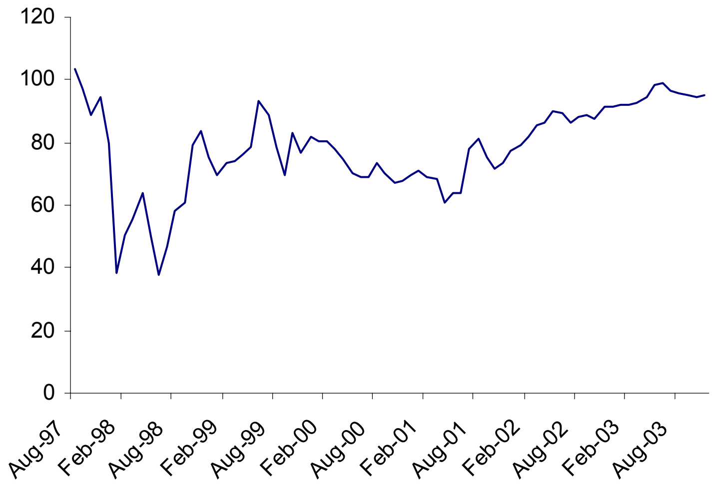
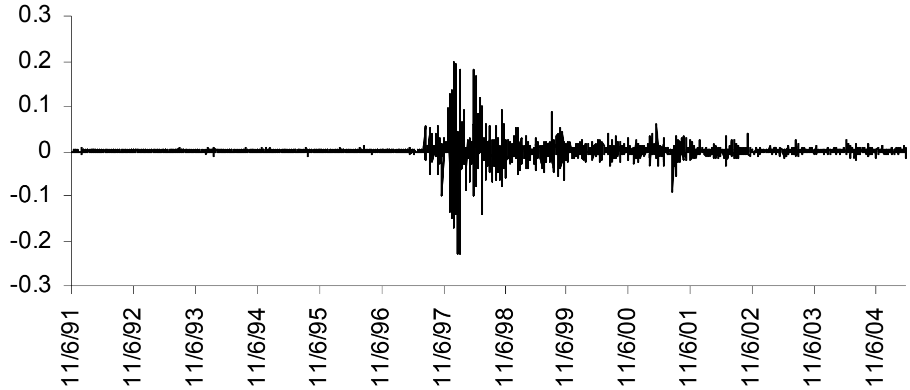


Figure 1.29: Trade weighted REER of Rupiah against
USD, Yen, SGD, Won, 1995=100
Sept 1997 – Mar 2004



It also produces new challenges to economic agents whose assets and wealth are exposed to the movement of the Rp/USD rate. They have to contain the exchange rate risks in the financial deals. Meanwhile the international market influences the economy with a new dimension. Now, the market can be punishing the economy whenever the government policies are deemed non-optimal or not market friendly. Moreover, the Rp/USD market does not only show the demand versus supply forces originating from underlying economic transactions, but reflects the expectation under uncertainty condition.

Figure 1.30: Daily Rp/USD in log returns, 1991 - 2005



All of these only make the prediction of the Rp/USD become more difficult, except when the government makes policy mistakes. In such case, the Rp/USD will be predictably depreciating fast.

In this light, it is now very important for the policy makers to understand the behavior of Rp/USD and the underlying volatility in order to establish support for sound monetary policy. The ability to predict the future rate of Rp/USD is also important. Studies by Alba *et al.* (1998) and Gosh and Pangestu (1999) for the case of Rp/USD are mainly on what happened in 1997-1998 crises and the cause, and are related to the macroeconomic framework. Meanwhile, Kurniati and Hardiyanto (1999) concentrate on the model of Behavioral Equilibrium Exchange Rate for Rp/USD, which basically used the real exchange rate approach to predict the movement of the nominal exchange rate. The problem with this approach is the strong assumptions made in order to get the predicted result. Meanwhile, Hernandez and Montiel (2002) focus on the post crisis exchange rate policy in five Asian Countries including Indonesia. Nevertheless, the number of Rp/USD studies is still limited compared to studies of the other currencies in the region.

1.2. The Plan and the Goal of the Research

Principally, this is a preliminary study on Indonesian Rupiah against US Dollar that can open the door for further research. Chapter 1 is the introduction. Chapter 2 will discuss various exchange rate theories. This chapter will function as the exchange rate theoretical review to refresh the reader. Chapter 3 will discuss the Efficient Market Hypothesis (EMH) for the case of Indonesian Rupiah. The study about the EMH for the Rp/USD has previously never been carried out, thus we want to determine whether EMH holds. The methodology used is Vector Error Correction Model. The result from the chapter 3 will be important for the next chapter because the proven condition of EMH in the case of Indonesian Rupiah, is the basis for the Markov Switching – Vector Error Correction Model analysis in chapter 4. Chapter 4 will show how Markov Switching is applied to investigate the regimes in the Rp/USD. We will show how the prediction of the future transition probability can give us insights on the probable Rp/USD movements in the future. Chapter 5 will investigate the stochastic volatility of five major regional currencies in Asia: Rp/USD, Yen/USD, SGD/USD, Baht/USD, and Peso/USD. Estimation will be done by the univariate and multivariate stochastic volatility models.

Thus, this work is intended to be a rigorous time series study of the Rp/USD exchange rate with the following research questions:

- Is the term structure of Rupiah's forward rate a good predictor of its spot rate?
- Do they have long run relationship? What is the best approach to predict Rp/USD?
- Does the Efficient Market Hypothesis (and hence, Uncovered Interest Parity) hold?
- How do currencies in the Asian region correlate through their stochastic volatilities?

Chapter 2

A Review on the Exchange Rate Determination Theory

This chapter as a whole presents a review of the theory of exchange rate determination. The discussion sequence of the review is as follow: the Mundell-Fleming model, the Monetary model, the Sticky Price model and the Portfolio Balance Approach. We start with the discussion of fixed price model of Mundell-Fleming with its comparative static analysis on the effects of fiscal, monetary, and external shocks. Then, the review goes on with the assumption of price stickiness and rational expectation, based on the Dornbusch monumental works. The purpose is to make it as close to reality as possible in an economy where sticky price takes place. The portfolio balance approach will close the discussion of the structural models of exchange rate determination. Moreover, a brief discussion about the volatility of the exchange rate will also be done.

The empirical chapters will refer this theoretical chapter and no explicit repeat of theoretical reviews will be shown after. Thus, the aim of this chapter is to demonstrate the variety of processes which exchange rate can be understood in the view of theory.

2.1. Mundell-Fleming Model

The Mundell-Fleming theory has been widely used in exchange rate research since its foundation. From the first introduction in the 1960s, the approaches applied by many researchers have also been continuously developing. The Mundell-Fleming theory was originally under the static expectations and fixed prices. In addition, the assumption was that the economy is not in full employment. The sources of the following review are from Mark (2001) and Gartner (1993). Mundell-Fleming model is based on the following equations:

$$i = i^* \tag{2.1}$$

$$m - p = \phi y - \lambda i \tag{2.2}$$

$$y = \delta\left(s + p^* - p\right) + \gamma y - \sigma i + g \,, \tag{2.3}$$

where

s = the nominal exchange rate,

p and p^* = domestic and foreign price level,

i and i^* = domestic and international interest rate,

m = level of the money supply,

y = domestic income,

g = exogenous variable (fiscal policy),

all but interest rate are in logarithms,

and parameters, δ, γ and σ are positive, and $0 < \gamma < 1$.

This is a Keynesian model where goods prices are fixed and home country is a small open economy. The equilibrium in the goods market is given by an open economy version of the IS curve. The determinants are: (i) Expenditure depends on own income, *y*, positively through the absorption channel. An increase in income leads to higher consumption, mostly spent on domestic market; (ii) The domestic demand for goods depends on the interest rate, *i*, negatively through the investment-saving mechanism. Thus, higher *i* reduce investment spending, increases saving, and could result in a lower consumption; (iii) The domestic demand for goods depends on the exchange rate. Higher (means depreciation) real exchange rate will make foreigner and domestic buyers switch the consumption to the domestic goods. This is the expenditure-switching effect of the exchange rate fluctuations. Thus, (2.3) is the equilibrium of output equals expenditures, which is the heart of the IS curve.

In (2.2), the setting for monetary model shows that logs real money demand, $m^d - p$, depends positively on log income y and negatively on the nominal interest rate *i,* which is the measurement of the opportunity cost of holding money. Hence (2.1) shows the uncovered interest parity condition with the assumption that the perfect foresight prevails in the economy. It is about a small open economy so i^* is fixed, thus i is fixed to the world interest rate. The capital moves freely across countries throughout the world and thus (2.3) is the equilibrium condition.

Now if we substitute (2.1) into (2.2) and (2.3), then we get the IS curve:

$$y=\delta\left(s+p^{*}-p\right)+\gamma y-\sigma i^{*}+g\,. \tag{2.4}$$

Assume p and p^{*} equal to zero for simplicity, which is derived from the fixity of price level, thus (2.4) becomes:

$$\begin{aligned}y&=\delta\left(s+p^{*}-p\right)+\gamma y-\sigma i^{*}+g\\&=\delta s+\gamma y-\sigma i^{*}+g\\y&=\frac{\delta s-\sigma i^{*}+g}{1-\gamma},\end{aligned} \tag{2.5}$$

and for the LM curve:

$$\begin{aligned}m&=\phi\left(\frac{\delta s-\sigma i^{*}+g}{1-\gamma}\right)-\lambda i^{*}\\&=\frac{\phi\delta s-\phi\sigma i^{*}+\phi g}{1-\gamma}-\left(\frac{1-\gamma}{1-\gamma}\right)\lambda i^{*}\\&=\frac{\phi\delta s-\phi\sigma i^{*}+\phi g}{1-\gamma}-\left(\frac{\lambda-\lambda\gamma}{1-\gamma}\right)i^{*}\\&=\frac{\phi\delta s}{1-\gamma}-\frac{\phi\sigma i^{*}}{1-\gamma}+\frac{\phi g}{1-\gamma}-\left(\frac{\lambda-\lambda\gamma}{1-\gamma}\right)i^{*}.\end{aligned} \tag{2.6}$$

Total differentiation of (2.5) and (2.6) gives the results:

$$\mathrm{d}y=\frac{\delta}{1-\gamma}\mathrm{d}s-\frac{\sigma}{1-\gamma}\mathrm{d}i^{*}+\frac{\mathrm{d}g}{1-\gamma} \tag{2.7}$$

$$\mathrm{d}m=\frac{\phi\delta}{1-\gamma}\mathrm{d}s-\left(\lambda+\frac{\phi\sigma}{1-\gamma}\right)\mathrm{d}i^{*}+\frac{\phi}{1-\gamma}\mathrm{d}g\,. \tag{2.8}$$

In the following discussions, the results of comparative static originate from (2.7) and (2.8). Under this setting, the exchange rate is free float, thus no government intervention would be in effect. In (2.7) and (2.8), *s* and *y* become endogenous variables in the system. The government controls money supply, *m*. Meanwhile, in the free float regime the exchange rate movement is almost always associated with the volatility of the exchange rate. Thereby, the market exchange rate quotation changes from time to time, reflecting the volatility.

Monetary Policy

An expansion in credit will result in an incipient of capital inflow, which leads to a depreciation of national currency. It is expressed as:

$$\mathrm{d}s = \frac{1-\gamma}{\phi\delta}\mathrm{d}m > 0 . \tag{2.9}$$

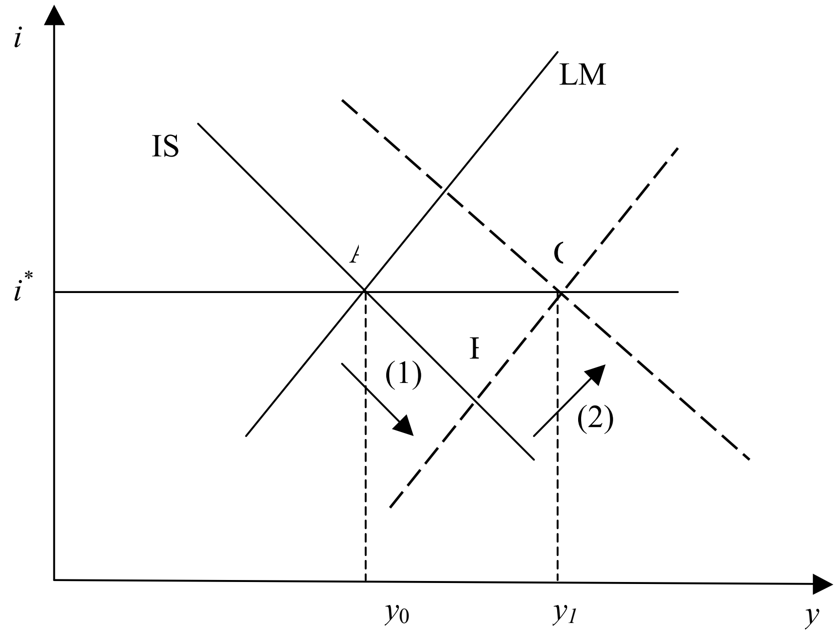
The expenditure-switching effect of the depreciation increases expenditures on the home goods and has an expansionary effect on output:

$$\mathrm{d}y = \frac{1}{\phi}\mathrm{d}m > 0 . \tag{2.10}$$

The graphical comparative statics explain more, as in Figure 2.1. Point A is the initial static equilibrium. Expansion of credit will result in the shift out of the LM curve (1). In a small open economy with perfect capital movement, it will result in the lower interest rate and induce capital outflow, the quasi equilibrium in the economy is thus B. The outflow of capital will depreciate the domestic currency against major currencies of the world. This will determine IS curve to shift out, setting new static equilibrium after the credit expansion (2). The overall result of the expansionary monetary policy is clear, that is the increase of output, y.

Thus, while in this case the increase of the output takes place, however the process of which the output increases would also involve the volatility of the exchange rate, through the depreciation of the exchange rate.

Figure 2.1: Comparative statics of monetary policy in
Mundell-Fleming framework of exchange rate under flexible rate



Fiscal Policy

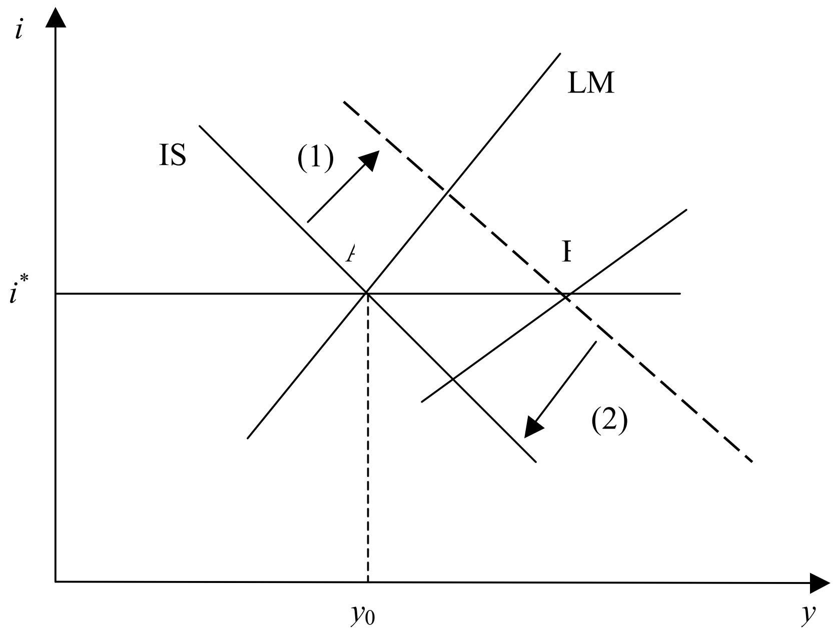
The fiscal policy is ineffective as a stabilization tool under flexible exchange rate regime and perfect capital mobility. Figure 2.2 explains why.

The expansionary fiscal policy will initially result in a shift out of the IS curve. But the supposedly new equilibrium B, will not take place. The shift out of the IS curve will induce capital inflow because of a higher domestic interest rate, and the appreciation of domestic currency would then be:

$$\mathrm{d}s = -\left(1/\delta\right)\mathrm{d}g < 0\,. \tag{2.11}$$

However, the resulting expenditure switching process will offset the initial expansionary effect, thus leaving output to stay at y_0.

Figure 2.2: Comparative statics of fiscal policy in
Mundel-Flemming framework of exchange rate under flexible rate



Interest Rate Shocks

A small open economy integrates with the world economy. An increase in world's interest rate results in a capital outflow, and a depreciation of local currency:

$$\mathrm{d}s = \left[\left(\lambda(1-\gamma)+\sigma\phi\right)/\phi\delta\right]\mathrm{d}i^* > 0\,. \tag{2.12}$$

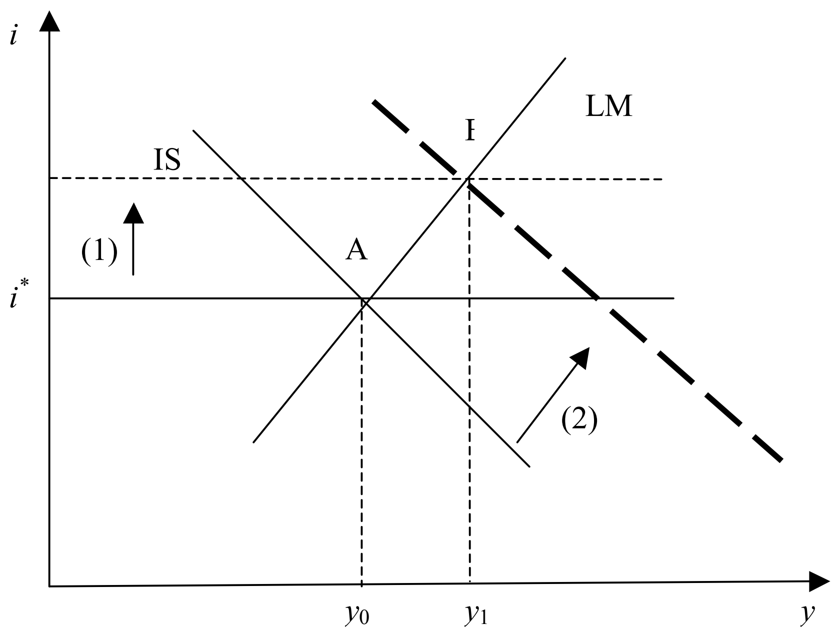
Figure 2.3 will explain further more. The expenditure switching effect of the depreciation causes the IS curve to shift out. The expansionary effect of the depreciation offsets the contraction effect of the higher interest rate, resulting in an expansion of the output:

$$\mathrm{d}y = \left(\lambda/\phi\right)\mathrm{d}i^* > 0\,. \tag{2.13}$$

Conclusion

Basic Mundell-Fleming model is based on the assumption that the price is fixed, the exchange rate is floating, and the monetary policy is exogenous. Hence, monetary policy is effective in increasing the output. When international interest rate rises, domestic demand is pushed so output increases.

Figure 2.3: Comparative statics of interest rate shock in Mundell-Fleming framework of exchange rate under flexible rate



2.2. Monetary Model

This model consists of two money demand functions, a continuous stock equilibrium in the money market, the uncovered interest parity, and the purchasing power parity (PPP). Under the flexible exchange rate, money stock is exogenous. The review of this model follows the explanation in Mark (2001).

We start with the equilibrium condition of domestic and foreign money demand:

$$m_t - p_t = \phi y_t - \lambda i_t \tag{2.14}$$

$$m_t^* - p_t^* = \phi y_t^* - \lambda i_t^* , \tag{2.15}$$

where $0 < \phi < 1$ is the income elasticity of money demand and $\lambda > 0$ is the interest rate semi-elasticity of money demand.

International capital market equilibrium is set by the uncovered interest parity:

$$i_t - i_t^* = \mathrm{E}_t s_{t+1} - s_t, \tag{2.16}$$

where $\mathrm{E}_t s_{t+1} \equiv \mathrm{E}_t\left(s_{t+1} \mid I_t\right)$ is the expectation of the exchange rate at date $t + 1$, conditioned on all public information, I_t, available to economic agents at date t.

Price levels and the exchange rate are related through the purchasing-power parity:

$$s_t = p_t - p_t^*. \tag{2.17}$$

If we substitute (2.14), (2.15) and (2.16) into(2.17), then the result will be:

$$s_t = \left(m_t - \phi y_t + \lambda i_t\right) - \left(m_t^* - \phi y_t^* + \lambda i_t^*\right)$$
$$s_t = \left(m_t - m_t^*\right) - \phi\left(y_t - y_t^*\right) + \lambda\left(\mathrm{E}_t s_{t+1} - s_t\right).$$

To simplify notations, let us use the following expression: $f_t \equiv \left(m_t - m_t^*\right) - \phi\left(y_t - y_t^*\right)$:

$$s_t = f_t + \lambda\left(\mathrm{E}_t s_{t+1} - s_t\right), \tag{2.18}$$

and solve for s_t:

$$s_t = \gamma f_t + \psi \mathrm{E}_t s_{t+1}, \tag{2.19}$$

where $\gamma \equiv 1/(1+\lambda)$, and $\psi \equiv \lambda\gamma = \lambda/(1+\lambda)$.

Equation (2.19) is the basic first order stochastic difference equation of the monetary model and serves the same function as an "Euler equation" in the optimization models. It indeed explains that expectations of future values of the exchange rate are intrinsic in the current exchange rate. A high relative monetary growth at home leads to a depreciation of the domestic currency, while a high relative income growth leads to an appreciation of the domestic currency.

Next, we advance time by one period in (2.19), to get $s_{t+1} = \gamma f_t + \psi \mathrm{E}_{t+1} s_{t+2}$. Then, take expectations conditional on time *t* information, and, by law of iterated expectations to get $\mathrm{E}_t s_{t+1} = \gamma \mathrm{E}_t f_{t+1} + \psi \mathrm{E}_t s_{t+2}$, we plug it to (2.19), and do it again for s_{t+2}, s_{t+3}, …, s_{t+k}, to get:

$$s_t = \gamma \sum_{j=0}^{k} (\psi)^j \mathrm{E}_t f_{t+j} + (\psi)^{k+1} \mathrm{E}_t s_{t+k+1} . \qquad (2.20)$$

Conclusion

A high relative money growth at home leads to a depreciation of the domestic currency, and a high relative income growth leads to an appreciation of the domestic currency.

2.3. Sticky Price Monetary Model

It is very obvious that the exchange rate movement is more volatile than the macroeconomic fundamentals. Dornbusch (1976) addresses this issue in a dynamic version of the Mundell-Fleming model. The main idea is to allow for the asset market to adjust faster than what the goods market does and to assume that the price is sticky. The goods market shall have disequilibrium as assumed, thus we have the actual output, *y*, and demand for domestic output, y^d. This review follows the explanation in Mark (2001) and Frankel *et al*. (2003).

Then, let us re-use the LM curve as in (2.2):

$$m - p = \phi y - \lambda i,$$

and re-use IS curve as in (2.3):

$$y = \delta\left(s + p^* - p\right) + \gamma y - \sigma i + g.$$

However, we recall that $p^* = 0$ in this setting. Price dynamics is determined by:

$$\dot{p} = \pi\left(y^d - y\right), \tag{2.21}$$

where $0 < \pi < \infty$, and, again, a dot over a variable denotes the time derivative.

A low π indicates a slow adjustment of prices, while for $\pi \to \infty$, the goods prices adjust instantaneously. If the latter takes place, then the goods market is always in the continuous equilibrium. Hence, (2.21) states that the rate of inflation is proportional to the excess demand for goods. Because the excess demand is always finite, the rate of change in goods prices is always finite, so there are no instantaneous price level hikes. If this is so, thus, price level is fixed, and over time it will steadily move. Dornbusch model captures this phenomenon into its body.

Meanwhile, international capital market equilibrium is given by the uncovered interest parity condition:

$$i = i^* + \dot{s}^e, \tag{2.22}$$

where $\dot{s}^e$ is the expected instantaneous depreciation rate.

To observe $\dot{s}^e$, we let $\overline{s}$ to be the steady state nominal exchange rate and form the forward-looking expectation:

$$\dot{s}^e = \theta\left(\overline{s} - s\right). \tag{2.23}$$

We note that (2.23) explains that the instantaneous depreciation is proportional to the difference between the current exchange rate and its long run value. But in reality, that belief must be guaranteed by a perfect foresight ability among the market player. With perfect-foresightedness, it is safe to assume the availability of consistent θ to set:

$$\dot{s}^e = \dot{s} . \tag{2.24}$$

Before we discuss the exchange rate dynamics, it is important to check the steady state equilibrium conditions. Let $\overline{p}$, $\overline{i}$, and $\overline{s}$ represent the steady state values of the variables, and $\dot{s} = \dot{p} = 0$. The steady state condition is:

$$\overline{i} = i^* \tag{2.25}$$

$$\overline{p} = m - \phi y + \lambda \overline{i} \tag{2.26}$$

$$y = \delta\left(\overline{s} - \overline{p}\right) + \gamma y - \sigma i + g . \tag{2.27}$$

If we re-write (2.27) into:

$$\begin{aligned} 0 &= \delta\left(\overline{s} - \overline{p}\right) + \gamma y - y - \sigma i + g \\ &= \delta\overline{s} - \delta\overline{p} + \gamma y - y - \sigma i + g \\ \delta\overline{s} &= \delta\overline{p} + (1-\gamma)\, y + \sigma i - g \end{aligned}$$

$$\overline{s} = \overline{p} + \frac{1}{\delta}\left[(1-\gamma)\, y + \sigma i - g\right], \tag{2.28}$$

and then, differentiate (2.26) and (2.27) with respect to *m*:

$$\mathrm{d}\overline{p}/\mathrm{d}m = 1 \tag{2.29}$$

$$\mathrm{d}\overline{s}/\mathrm{d}m = 1 , \tag{2.30}$$

we show that the money is neutral in the long run.

Now, a very appealing idea of this model is the interesting dynamics of the exchange rate, following a shock in the economy, say, a monetary expansion. Totally differentiating (2.2), noting p and y as fixed, results in:

$$\mathrm{d}i = -\frac{1}{\lambda}\mathrm{d}m < 0\,. \tag{2.31}$$

Hence, plug (2.23) into (2.22), then take the differentiation of it while holding $i^* = 0$ (constant) will result in:

$$\mathrm{d}i = \mathrm{d}i^* + \left[\theta\left(\mathrm{d}\bar{s} - \mathrm{d}s\right)\right]$$

$$\mathrm{d}i = \theta\left(\mathrm{d}\bar{s} - \mathrm{d}s\right). \tag{2.32}$$

Then, if we re-write (2.30):

$$\mathrm{d}\bar{s} = \mathrm{d}m\,, \tag{2.33}$$

use it into (2.32):

$$\mathrm{d}i = \theta\left(\mathrm{d}m - \mathrm{d}s\right), \tag{2.34}$$

after that, use (2.34) to expression (2.31) and solve it for $\mathrm{d}s$:

$$\theta\left(\mathrm{d}m - \mathrm{d}s\right) = -\frac{1}{\lambda}\mathrm{d}m$$

$$\theta\mathrm{d}m - \theta\mathrm{d}s = -\frac{1}{\lambda}\mathrm{d}m$$

$$\theta\mathrm{d}s = \theta\mathrm{d}m + \frac{1}{\lambda}\mathrm{d}m$$

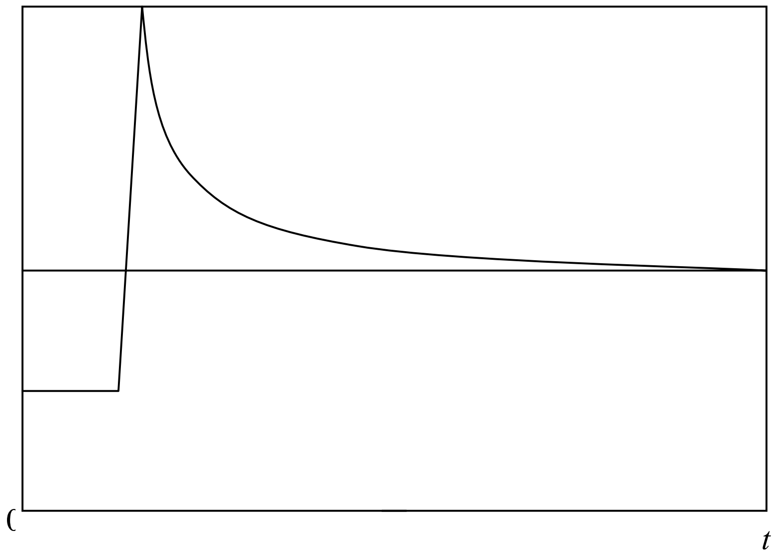
$$\mathrm{d}s = \left(1 + \frac{1}{\theta\lambda}\right)\mathrm{d}m > \mathrm{d}\bar{s}\,, \tag{2.35}$$

then, we can show that (2.35) is the expression of the nominal exchange rate overshoot right after depreciation.

Conclusion

When a shock takes place, instantaneously the depreciation overshoots exceeding the long run depreciation. In the transition period, when $i_t < i_t^*$, and the rational expectation on the exchange rate in the future operates through (2.24), then people will certainly expect appreciation of the domestic currency in the long run. In the case of long run depreciation, or when $i_t > i_t^*$, the rational expectation takes place, which allows the domestic currency depreciation to overshoot in the immediate short run and exceeds its long run depreciation.

Figure 2.4: The overshoot in Dornbusch model



This result is so obvious, as one can easily find in the empirical world that the exchange rate movements are more volatile than other macroeconomic variables. The dynamic is easily depicted and explained in Figure 2.4.

2.4. The Portfolio Balance Approach

This approach assumes that the portfolio composition held by individuals in the economy comprises domestic bonds (*B*) and foreign bonds (*F*), both of which are less than perfect substitutes since each has different risk exposure and money (*M*). For risk averse individuals, it is desirable to hold a combination of portfolio, which consists of the risk-free *B* and the risky but with higher expected profit *F*.

Short Run setting

The model setting in the short run is as follow:

$$W = M + B + sF \tag{2.36}$$

$$M = m\left[i, i^* + E(\dot{s}), W\right] \quad m_i < 0, m_{i+E(\dot{s})} < 0, m_W > 0 \tag{2.37}$$

$$B = b\left[i, i^* + E(\dot{s}), W\right] \quad b_i > 0, b_{i+E(\dot{s})} < 0, b_W > 0 \tag{2.38}$$

$$sF = \left[i, i^* + E(\dot{s}), W\right] \quad f_i < 0, f_{i+E(\dot{s})} > 0, f_W > 0 \tag{2.39}$$

$$m_i + b_i + f_i = 0$$

$$m_{i+E(\dot{s})} + b_{i+E(\dot{s})} + f_{i+E(\dot{s})} = 0,$$

where:

M = domestic money supply

B = supply of domestic bonds

F = supply of foreign bonds (in foreign currency) on the domestic market

s = exchange rate

W = domestic wealth

i = interest rate

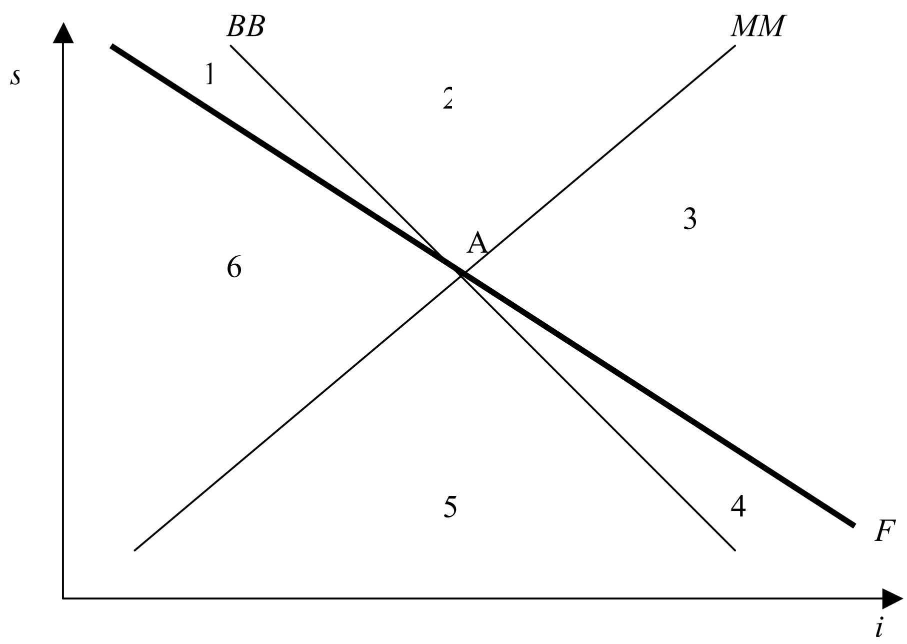
i^* = foreign interest rate

$E(\dot{s})$ = expected depreciation

m, b, f = the derivative of each, *M*, *B*, and *F*

We see that (2.36) identifies the wealth as the total holdings of money, domestic and foreign bonds by individuals. Hence, (2.37) is the demand for money by individuals, which depends on the domestic and foreign interest rates and wealth. It falls if expected yields of the two-interest bearing assets increase. Expected yields of the domestic bonds equal the interest rate *i*, while for foreign bonds, they equal the sum of the foreign interest rate i^* and expected depreciation $E(\dot{s})$. In (2.38) we understand how the demand for domestic bonds, *B*, behaves. It increases when wealth, *W*, and domestic interest rate, *i*, increase. If the expected returns for the competing foreign bonds increase, the demand for *B* falls. Meanwhile, (2.39) describes the demand for foreign bonds. It is reciprocal in any way to the domestic bonds.

Figure 2.5: Equilibrium conditions set in the Portfolio Balance Model



It must be noted that domestic and foreign bonds are substitutes. The supply of foreign bonds in the home country is only fixed in foreign currency. The value of this physical supply in domestic currency, which must equal the domestic demand, increases with the depreciation of the home currency. Thus a depreciation increases domestic wealth, since foreign bonds held by domestic residents increase in value. The equilibrium conditions in these three markets set in this model can be shown in Figure 2.5.

Conditions around the equilibrium point A as shown in the Figure 2.5 are:

Area 1: $M^d > M^s$, $B^d < B^s$, $F^d < F^s$

Area 2: $M^d > M^s$, $B^d > B^s$, $F^d < F^s$

Area 3: $M^d < M^s$, $B^d > B^s$, $F^d < F^s$

Area 4: $M^d < M^s$, $B^d > B^s$, $F^d > F^s$

Area 5: $M^d < M^s$, $B^d < B^s$, $F^d > F^s$

Area 6: $M^d > M^s$, $B^d < B^s$, $F^d > F^s$.

Hence, (2.37), (2.38) and (2.39) show equilibrium conditions for the three markets while the mathematical way to understand further the equilibrium conditions is as follow. Applying the implicit function rule, we get the slopes of each equilibrium condition, represented each by curves *BB*, *MM*, and *FF* in the figure. Re-writing the equilibrium conditions, and using (2.36), we have these results:

$$m\left[i, i^* + E(\dot{s}), M + B + sF\right] - M$$
$$\equiv \Phi\left[i, i^* + E(\dot{s}), M + B + sF, M\right] = 0 \tag{2.40}$$

$$b\left[i, i^* + E(\dot{s}), M + B + sF\right] - B$$
$$\equiv \Psi\left[i, i^* + E(\dot{s}), M + B + sF, B\right] = 0 \tag{2.41}$$

$$f\left[i, i^* + E(\dot{s}), M + B + sF\right] - sF$$
$$\equiv \Omega\left[i, i^* + E(\dot{s}), M + B + sF, sF\right] = 0 . \tag{2.42}$$

From (2.40), $\Phi_s = m_w F$ is positive by assumption, so we postulate that the exchange rate is an implicit function of the interest rate, *i*. Let us apply the implicit function rule to find the slope of the *MM* curve:

$$\frac{\partial s}{\partial i} = \frac{-\Phi_i}{\Phi_E} = \frac{-m_i}{m_w F} > 0 , \tag{2.43}$$

apply the implicit function rule to find the slope of BB curve:

$$\frac{\partial s}{\partial i} = \frac{-\Psi_i}{\Psi_E} = \frac{-b_i}{b_w F} < 0 , \tag{2.44}$$

and apply the implicit function rule to find the slope of FF curve:

$$\frac{\partial s}{\partial i} = \frac{-\Omega_i}{\Omega_E} = \frac{-f_i}{(1-f_w)F} < 0 . \tag{2.45}$$

It is important to point out that the model above is over-determined because there are three endogenous variables: i, W, and s, determined by means of four equations. By Walras' Law, only n-1 out of n markets is independent in general equilibrium, given a budget restriction. Thus, we reduce the model to the following setting:

$$b(i,W) = B \tag{2.46}$$

$$f(i,W) = sF \tag{2.47}$$

$$W - b(i,W) - f(i,W) = M . \tag{2.48}$$

We note that (2.48) is the money market equilibrium condition which is resulted from (2.46) and (2.47). Then, let us simplify that $\left[i^* + E(\dot{s})\right] = 0$, which means that the expected yields of F is constant, in order to make the following steps, which involves comparative statics exercises, easier. The comparative statics effects of various policy measures are obtained after complete differentiations of (2.46), (2.47), and (2.48), which produce the following set of equations:

$$b_i \mathrm{d}i + b_w \mathrm{d}W = \mathrm{d}B \tag{2.49}$$

$$f_i \mathrm{d}i + f_w \mathrm{d}W - F\mathrm{d}s = s\mathrm{d}F \tag{2.50}$$

$$-(b_i + f_i)\mathrm{d}i + (1 - b_w - f_w)\mathrm{d}W = \mathrm{d}M . \tag{2.51}$$

Let us now express (2.49), (2.50) and (2.51) in matrix $Ax = d$:

$$\begin{bmatrix} b_i & b_w & 0 \\ f_i & f_w & -F \\ -b_i - f_i & 1 - b_w - f_w & 0 \end{bmatrix} \begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \begin{bmatrix} \mathrm{d}W \\ s\mathrm{d}F \\ \mathrm{d}M \end{bmatrix}, \tag{2.52}$$

and solve for x, that is $\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix}$:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} (1 - b_w - f_w)F & 0 & -b_w F \\ (-b_i - f_i)F & 0 & b_i F \\ (1 - b_w - f_w) f_i - (-b_i - f_i) f_w & b_w(-b_i - f_i) - b_i(1 - b_w - f_w) & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} \mathrm{d}B \\ s\mathrm{d}F \\ \mathrm{d}M \end{bmatrix}, \tag{2.53}$$

where $|A| = F\left(b_i(1 - b_w - f_w) - b_w(-b_i - f_i)\right)$.

Now, let us simplify it, using $m_w = 1 - b_w - f_w$ and $m_i = -b_i - f_i$:

$$|A| = F\left(b_i m_w - b_w m_i\right). \tag{2.54}$$

By the rule set in (2.44) – (2.46), $|A|$>0, therefore:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} \mathrm{d}B \\ s\mathrm{d}F \\ \mathrm{d}M \end{bmatrix}. \tag{2.55}$$

Finally, we are ready to see the results of the comparative statics of the model and investigate changes made by exogenous variables to *i*, *W*, and *s*.

The open market purchases by the government create money, and result in the asset substitutions. Refer to the setting of (2.55), creating money by market operations, such as purchasing bonds from public, increases the domestic money supply. Thus, foreign bonds remain unaffected. In this case, the transposed vector of exogenous changes is $d^T = (-\mathrm{d}M, 0, \mathrm{d}M)$. Multiplying the coefficient matrix by the vector of changes *d*:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} \text{-d}M \\ 0 \\ \mathrm{d}M \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{\mathrm{d}M} = \frac{-F(m_w + b_w)}{|A|} < 0$$

$$\frac{\mathrm{d}W}{\mathrm{d}M} = \frac{F(m_i + b_i)}{|A|} > 0$$

$$\frac{\mathrm{d}s}{\mathrm{d}M} = \frac{-f_i(m_w + b_w) + f_w(m_i + b_i)}{|A|} > 0\,.$$

Now, we investigate the effect of changes from intervention in the foreign exchange market without sterilization, by buying foreign bonds (money creation). The money supply increases as much as the foreign bonds bought by the authority, while domestic bonds remain unchanged. Therefore, the transposed vector of exogenous changes is: $d^T = (0, -\mathrm{d}M, \mathrm{d}M)$. Multiplying the coefficient matrix by the vector of changes *d*:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} 0 \\ -\mathrm{d}M \\ \mathrm{d}M \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{\mathrm{d}M} = \frac{-Fb_w}{|A|} < 0$$

$$\frac{\mathrm{d}W}{\mathrm{d}M} = \frac{Fb_i}{|A|} > 0$$

$$\frac{\mathrm{d}s}{\mathrm{d}M} = \frac{b_i\left(m_w + f_w\right) - b_w\left(m_i + f_i\right)}{|A|} > 0 .$$

For the changes from sterilization of foreign exchange intervention, we refer to the setting of (2.55), which shows that the changes take place when the foreign exchange intervention from buying foreign bonds is sterilized by selling domestic bonds in the same amount. In this case, the vector of exogenous changes is $d^T = \left(\mathrm{d}B, -\mathrm{d}B, 0\right)$. Multiplying the coefficient matrix by the vector of changes d:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|}\begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix}\begin{bmatrix} \mathrm{d}B \\ -\mathrm{d}B \\ 0 \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{\mathrm{d}B} = \frac{Fm_w}{|A|} > 0$$

$$\frac{\mathrm{d}W}{\mathrm{d}B} = \frac{Fm_i}{|A|} < 0$$

$$\frac{\mathrm{d}s}{\mathrm{d}B} = \frac{m_w\left(f_i + b_i\right) - m_i\left(b_w + f_w\right)}{|A|} > 0 .$$

These changes affect the interest rate and exchange rate because the domestic and foreign bonds are not perfect substitutes.

For the case of changes from fiscal policy by debt financing that will affect money supply, we refer to the setting of (2.55). Since domestic bonds are sold, then, $d^T = \left(\mathrm{d}B, 0, 0\right)$. Multiplying the coefficient matrix by the vector of changes d:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} \mathrm{d}B \\ 0 \\ 0 \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{\mathrm{d}B} = \frac{Fm_w}{|A|} > 0$$

$$\frac{\mathrm{d}W}{\mathrm{d}B} = \frac{Fm_i}{|A|} < 0$$

$$\frac{\mathrm{d}s}{\mathrm{d}B} = \frac{m_w f_i - m_i f_w}{|A|} \lesseqgtr 0 .$$

It shows that the interest rate and wealth respond in the similar way with the sterilization policy result. However, the result in the foreign exchange changes is undetermined.

Now, we investigate the effect of changes from fiscal policy by printing money, that is asset creation. We refer to the setting of (2.55), where debt financing by printing money obviously affects money supply. Thus, while $d^T = (0, 0, \mathrm{d}M)$, multiplying the coefficient matrix by the vector of changes d:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ \mathrm{d}M \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{\mathrm{d}M} = \frac{-Fb_w}{|A|} < 0$$

$$\frac{\mathrm{d}W}{\mathrm{d}M} = \frac{Fb_i}{|A|} > 0$$

$$\frac{\mathrm{d}s}{\mathrm{d}M} = \frac{b_i f_w - b_w f_i}{|A|} > 0.$$

It shows that the interest rate decreases and the exchange rate depreciates as printing money finances fiscal deficit.

For changes from a current account surplus, we refer to the setting of (2.55), which shows that the current account surplus does not affect money supply, but the supply of the foreign bonds in the domestic market. Thus, while $d^T = (0, s\mathrm{d}F, 0)$, multiplying the coefficient matrix by the vector of changes d:

$$\begin{bmatrix} \mathrm{d}_i \\ \mathrm{d}W \\ \mathrm{d}s \end{bmatrix} = \frac{1}{|A|} \begin{bmatrix} m_w F & 0 & -b_w F \\ m_i F & 0 & b_i F \\ m_w f_i - m_i f_w & b_w m_i - b_i m_w & b_i f_w - b_w f_i \end{bmatrix} \begin{bmatrix} 0 \\ s\mathrm{d}F \\ 0 \end{bmatrix},$$

will result in the following expressions:

$$\frac{\mathrm{d}i}{s\mathrm{d}F} = 0$$

$$\frac{\mathrm{d}W}{s\mathrm{d}F} = 0$$

$$\frac{\mathrm{d}s}{s\mathrm{d}F} = \frac{b_w m_i - b_i m_w}{|A|} < 0.$$

It is shown that the interest rate and wealth are not affected by the current account surplus, but by the exchange rate.

Let us expand the third expression by dF and recall (2.54):

$$\frac{\mathrm{d}s}{s} = \frac{\text{-d}F\left(b_i m_w - b_w m_i\right)}{F\left(b_i m_w - b_w m_i\right)} = \frac{\text{-d}F}{F}. \tag{2.56}$$

Then, we can conclude that the exchange rate appreciates as the surplus in the current account increases the domestic bonds supply measured in domestic currency.

Conclusion

In the short run, the current account disequilibrium affects the exchange rate. Monetary and fiscal policies also affect the exchange rate. However, we should investigate how in the long run these changes, which produce disequilibria in the short run, will affect the whole system. Table 2.1 shows the effects of short run changes in the framework of Portfolio Balance Approach.

Table 2.1: The summary of the effects of short run changes in the portfolio balance approach

	Interest Rate	Wealth	Exchange Rate
Expansionary monetary policy			
Open market operation	falls	decreases	rises
Foreign Exchange Market Intervention	falls	decreases	rises
Foreign exchange market intervention			
Sterilized	rises	falls	rises
Expansionary fiscal policy			
Financed by issuing debt	rises	Falls	rises/falls
Financed by creating money	falls	Rises	rises
Current account surplus			
Exogenous	unchanged	Unchanged	falls

Long Run setting

The long run model of Portfolio Balance Approach will include the previous system of equations with the following expression of current account:

$$CA = T\left(s/p\right) + i^{*}F \ , \tag{2.57}$$

where CA = current account, and $T(\cdot)$ = the trade balance. $T(\cdot)$ is the function of competitiveness and it improves if the exchange rate gets more competitive, that is, when s rises or when p falls.

Whatever the source of the shock, if the wealth is affected through the mechanism explained in Portfolio Balance Approach model, the feedback of the process will finally affect the asset market, thus, affecting the exchange rate during the adjustment to long-run equilibrium (Mark, 2001):

$$CA = 0 = T\left(s/p\right) + i^{*}F \ . \tag{2.58}$$

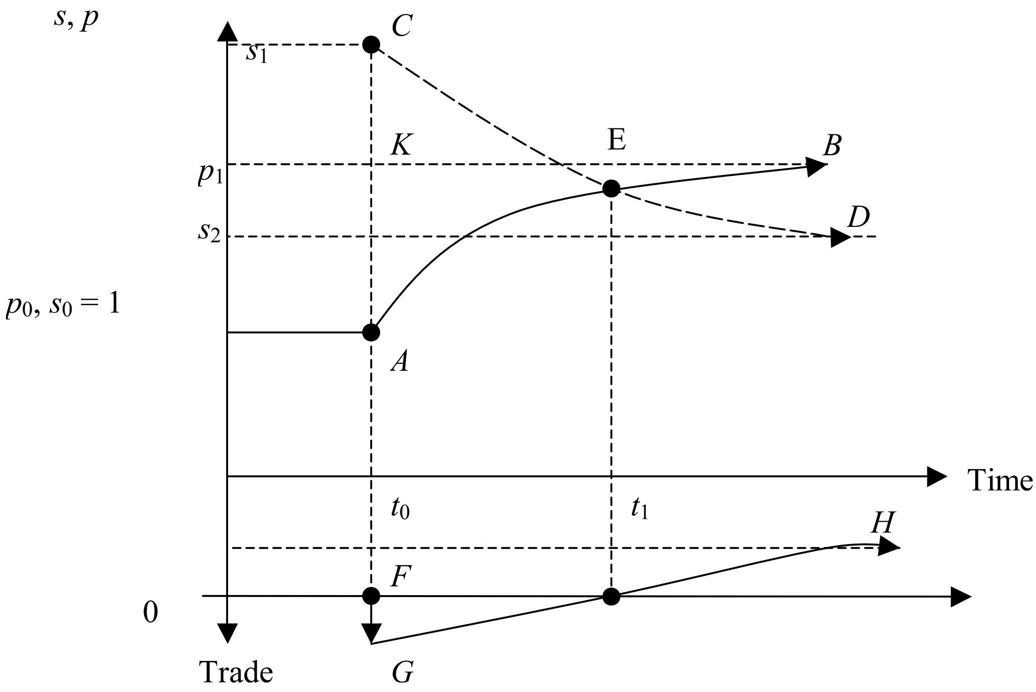
The condition set in (2.58) shows the balance on the current account. This implies that a deficit (surplus) on the trade balance is required if the country is a net exporter (importer) in capital. Meanwhile, a non-zero current account will constitute changes in B^{*} and hence in wealth, a trade deficit is required in long-run equilibrium.

Now, let us simply recall the effects shown in table 2.1 of the money creation by the government, where s rises and i falls. We then use Figure 2.6 to show the causes and effects, which go along with the Portfolio Balance Approach in the long run. Suppose that the economy is initially in an equilibrium with $T\left(\cdot\right) = 0$ and net foreign assets equals to zero, or simply, $CA = 0$. Figure 2.6 shows this initial condition at time t_0. Initial value at t_0 is normalized to unity. When Marshall-Lerner condition holds, the improvement in competitiveness will make the trade balance surplus (the distance of points *F*-*G* in Figure 2.6), ignoring all of the J-curve effects.

At this point, at t_0, the current account is surplus and net foreign asset takes place in domestic holdings. Then the holdings are liquidated to reposition the portfolios, thus making s to decline (appreciate), moving along *CD* (from point *C* to *D*) in figure 2.6.

After s declines, competitiveness erodes, thus making trade balance deteriorates along *GH* (from point *G* to *H*). Meanwhile, the increase of money supply causes the price level to rise along the *AB* path towards a new equilibrium price level p_1, which further adds the weight for competitiveness deterioration, hurting further the current account.

Figure 2.6: The dynamics of an open-market purchase of domestic bonds
in the Portfolio Balance Approach



Now at time t_1, the s and p are equal in value and hence the ratio is unity as in point A at t_0. Assuming that the foreign price level stays the same, the real exchange rate situation like in E would bring back the trade balance to zero. However, if (2.58) is restated to show the condition in E, where $T(s/p)=0$, then it is clear that the following expression shows the net foreign assets holding in the economy:

$$CA = 0 + i^* F \ . \tag{2.59}$$

The current account condition as stated in (2.59) means that domestic residents have a positive level of net foreign assets and will be receiving a stream of interest income i^*F from abroad. Thus, the income stream from abroad means injections of foreign exchange into the economy, which would in turn push s further down. Meanwhile, agents still try to rebalance the holdings and composition between the foreign and domestic interest bearing assets, precipitating further appreciation of s. The condition (2.58) states current account balance with following expression:

$$-T\left(s/p\right)=i^{*}F\ , \qquad (2.60)$$

which clearly shows the trade imbalance (deficit). This condition can be achieved only if s appreciates and p level to increase, both toward their long run equilibrium levels, s_2 and p_1, so there is no further net accumulation of foreign assets.

Conclusion

The long run effect of the intervention to the exchange rate by the government is the long run depreciation from s_0 to s_2 with the initial overshooting s_1- s_2. This long run process is precluded by the temporary negative trade imbalance, which would improve along the long run movement of the depreciation of the exchange rate toward its equilibrium.

Chapter 3

The Rp/USD and The Efficient Market Hypothesis Puzzle

3.1. Introduction

Fama (1970) states that in general terms the theory of efficient markets concerns with whether prices (of financial assets) at any point in time "fully reflect" available information. He continues that the theory only has an empirical content, however, within the context of a more specific model of market equilibrium, that is, a model that specifies the nature of market equilibrium when prices "fully reflect" available information.

Fama (1970) categorizes the efficient market hypothesis into three forms, based on the tests of the *strong form*, *semi-strong form* and *weak form*. Strong form tests concern with whether individual investors or groups have a monopolistic access to any information relevant to price formation. Being less restrictive, the semi strong form tests include all obvious publicly available information in the information subset of interest. In the weak form tests the information subset is simply historical price or return sequences.

Based on Fama (1970), this chapter focuses on the weak form test category. In line with the spirit in the Fama's efficient market hypothesis (EMH) tests, this chapter investigates whether the information set in the forward rate of Rp/USD reflects the corresponding spot rate in the future. In addition, this chapter will provide an explanation on how the Rp/USD rate behaves in the market, which would eventually enrich the policy insights for the authority. This chapter begins with the discussion about the theoretical review of the efficient market hypothesis root that is the uncovered interest parity and its micro foundation. The discussion continues with empirical works, which attempts to prove whether the efficient market hypothesis would hold for the Rp/USD.

Concepts and Theory of the Efficient Market Hypothesis

In this section, we want to approach the theoretical review of the efficient market hypothesis using the micro foundation of the uncovered interest parity. Let i_t denote the domestic interest rate, i_t^* denote the international interest rate, f_t denote the forward exchange rate, and s_t denote the spot rate, all at time *t*. We start off with the covered interest parity:

$$1+i_t=\left(1+i_t^*\right)\frac{f_t}{s_t}. \tag{3.1}$$

Since f_t refers to a future period, would this have any implications for the expected future spot rate? According to the uncovered interest parity, there is a relation. Let $E_t\left(X_{t+1} \mid I_t\right)$ denote the mathematical expectation of the random variable X_{t+1} conditioned on the date-*t*. Thus, f_t-s_t is the swap premium or the profit from taking a position in the forward foreign exchange. Moreover, under risk neutrality, the expected forward speculation profits are driven to zero, and the forward exchange rate must, in equilibrium, be market participants' expected future spot exchange rate. Then, the uncovered interest parity condition states that:

$$f_t=E\left(s_{t+1}\right). \tag{3.2}$$

The wealth, *W*, is spread into the domestic or foreign investments. Let θ be the proportion of *W* invested in the domestic bond, and the payoff is:

$$\left(1+i_t\right)\theta W_t.$$

Let $\left(1-\theta\right)$ be the proportion of *W* invested in the foreign asset, and the payoff is thus:

$$\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{s_{t+1}}{s_t}\right)W_t .$$

The next period total nominal wealth is the future payoff of bond holdings:

$$W_{t+1}=\left[\left(1+i_t\right)\theta+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{s_{t+1}}{s_t}\right)\right]W_t . \tag{3.3}$$

Domestic wealth holders define their constant absolute risk aversion utility function over wealth as follows:

$$U\left(W\right)=-e^{-\gamma W_{t+1}} . \tag{3.4}$$

Here, $\gamma \geq 0$ is the risk aversion coefficient and $\gamma = 0$ means risk averse.

The domestic agents' problem is to maximize the expected utility function by choosing the optimal investment share θ:

$$\underset{\theta}{Max} \quad E\left[U\left(W_{t+1}\right)\right]=-E_t\left(e^{-\gamma W_{t+1}}\right), \tag{3.5}$$

while $e^{-\gamma W_{t+1}}$ is the moment generating function.

If we believe that W_{t+1} has a normal distribution, then the moment generating process of $e^{-\gamma W_{t+1}}$ is just the special case of the moment generating function for the normally distributed random variable $X \sim \mathrm{N}\left(\mu,\sigma^2\right)$:

$$M_X\left(t\right)=E\left(e^{tX}\right)=E\left(e^{\mu t}e^{\sigma^2 t^2/2}\right). \tag{3.6}$$

By substituting $t=-\gamma$, $X=W_{t+1}$, $\mu=E_t\left(W_{t+1}\right)$, $\sigma^2=\mathrm{Var}\left(W_{t+1}\right)$ to (3.6) and taking logs:

$$E_t\left(W_{t+1}\right)-\frac{\gamma \text{Var}\left(W_{t+1}\right)}{2}. \tag{3.7}$$

From (3.7) we can see that the wealth owners maximize mean and variance, however wealth owners are keen on having a high mean and are not in favor with variance in the wealth.

To solve (3.5), we maximize the simpler (3.7) with respect to θ. Thus, we must first find the mean, $E_t(W_{t+1})$, from (3.3), and variance $\text{Var}(W_{t+1})$, of which the derivations are shown in the appendix of this chapter. The results for $E_t(W_{t+1})$ and $\text{Var}(W_{t+1})$ are as follow:

$$E_t\left(W_{t+1}\right)=\left[(1+i_t)\theta+\left(1+i_t^*\right)(1-\theta)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)\right]W_t, \tag{3.8}$$

$$\text{Var}\left(W_{t+1}\right)=\left[W_{t+1}-E_t\left(W_{t+1}\right)\right]^2=\frac{(1-\theta)^2\left(1+i_t^*\right)^2\text{Var}\left(s_{t+1}\right)W_t^2}{s_t^2}. \tag{3.9}$$

Thus, maximizing (3.7) with respect to θ results in the following expression which implicitly determines the optimal investment share θ:

$$(1+i_t)+\left(1+i_t^*\right)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)=\frac{-\gamma(1-\theta)\left(1+i_t^*\right)^2\text{Var}\left(s_{t+1}\right)W_t}{s_t^2}. \tag{3.10}$$

From (3.10) the underlying theoretical explanation for uncovered interest parity (UIP) is straightforward. Even if the market situation permits the materialization of expected uncovered profit, the position size taken by investors will be limited by the risk aversion perception, represented by γ:

- If $\gamma=0$, investors are risk averse, thus UIP holds.
- If $\gamma>0$, UIP does not hold, thus forward rate is a biased predictor of the future spot rate and investors need a premium to cover the foreign currency risk

– However, regardless of how risk averse investors are, UIP will still hold if $\theta = 1$, the means that the whole portion of wealth is invested domestically.

The basic theorems to start with are the uncovered interest parity theorem by Fisher (1930), the covered interest parity theorem by Keynes (1923) and the efficient markets hypothesis. With these theoretical basis, some economists try to conclude that the equilibrium forward exchange at date *t*+n, $f_{n,t}$, should be the best available predictor of the level of the spot exchange rate realized at date *t*+n, s_{t+n} (Clarida and Taylor, 1993).

Earlier research on this issue by Frenkel (1981) investigates the question by the following econometric model:

$$s_{t+1} = \alpha + \beta f_{1,t} + \gamma z_t + \varepsilon_{t+n}, \tag{3.11}$$

where the lower case letters denote log form of variables: spot rate s_{t+1} and forward rate $f_{1,t}$. His findings show that the hypothesis of $\beta = 1$ and $\gamma = 0$ could not be rejected. This result supports the efficient market hypothesis:

$$E_t\left(s_{t+1}\right) = f_t. \tag{3.12}$$

Meanwhile, Hansen and Hodrick (1980), Cumby and Obstfeld (1980, 1984), Meese and Singleton (1982), Fama (1984), Huang (1984) and Meese (1986) show that the approach like the econometric model (3.11) will face a problem that is caused by the non-stationarity of variables involved. The main critic is that the spot rate and forward rate show the non-stationarity problem, which has to be addressed carefully in the empirical research. Then, following these findings, researchers in 1980s and early 1990s began to model the information contained in the forward exchange rate by investigating the empirical result of this straightforward econometric model:

$$s_{t+n} - s_t = \alpha + \beta\left(f_{n,t} - s_t\right) + \varepsilon_{t+n}. \tag{3.13}$$

We understand (3.13) shows that the forward premium does not predict the direction of the subsequent change in the spot rate, thus, deviates from the covered interest arbitrage condition. The conclusions by Dornbusch (1980), Mussa (1979) and Frenkel (1981) are that the exchange rate changes over the recent period of floating seem to have been largely unanticipated, and were also in line with of Cumby and Obstfeld (1984). Model (3.13) also corresponds to the interest rate parity theorem:

$$i_{n,t} - i_{n,t}^{*} = f_{n,t} - s_t \,. \tag{3.14}$$

Meanwhile, Clarida *et al*. (1993, 1997, 2001) conducted several series of research on the exact same issue, with different views. These successive works on the related issue evolve over a span of 8 years, and each of them challenges the previous conclusions made by other exchange rate economists, which conclude that the forward rate is not a good predictor of the spot rate in the case of several strong currencies against the USD. Clarida and Taylor (1993, 1997) show that the forward premia contains information regarding the subsequent spot rate movements. They used weekly USD/DEM and USD/GBP data, and discovered that the spot and exchange rates together are well represented by a vector error correction model (VECM), since there exists the exact number of cointegrating relationships predicted by a simple theoretical framework and that the basis for this cointegrating space is the vector of forward premia. Their dynamic forecasts indicate that the information in the forward premia can be used to reduce the root mean squared forecast error for the spot rate (relative to a random walk forecast) by at least 33 percent at a 6-month-horizon and by some 50 to 90 percent at a 1-year-horizon.

Clarida and Taylor (1993, 1997) lay the theoretical framework as follow. Consider a vector y_t comprised of the log of the spot exchange rate s_t and the log of j forward exchange rate at horizons h(1), …, h(j):

$$y_t = \left[s_t, f_{h(1),t}, f_{h(2),t}, \ldots, f_{h(j),t} \right]' \,. \tag{3.15}$$

The spot exchange rate has a unit root and evolves according to:

$$s_t = z_t + v_t, \tag{3.16}$$

where v_t is a zero – mean stationary stochastic process and z_t is a random walk:

$$z_t = \mu + z_{t-1} + e_t. \tag{3.17}$$

Now, using (3.15), (3.16) and (3.17), and if we define the deviation from the interest rate parity at horizon *h*(*j*):

$$\tau_{h(j),t} = f_{h(j),t} - E\left(s_{t+h(j)}\right), \tag{3.18}$$

then an expression for forward exchange rate is:

$$f_{h(j),t} = h(j)\mu + z_t + E\left(v_{t+j}\right) + \xi_{h(j),t}. \tag{3.19}$$

From (3.19), since $\xi_{h(j),t}$ is a stationary stochastic process, the forward exchange rate at horizon *h*(*j*) and the spot rate share a common stochastic trend z_t and are cointegrated such that the forward premium at horizon *h*(*j*) is a stationary stochastic process:

$$f_{h(j),t} - s_t = h(j)\mu + E\left(v_{t+j} - v_t\right) + \xi_{h(j),t}. \tag{3.20}$$

Moreover, among the *j* forward rates and the spot exchange rate contained in y_t, there exists at least *j* cointegrating vectors that are defined by the *j* forward premia:

$$f_{h(1),t} - s_t, f_{h(2),t} - s_t, \ldots\ldots f_{h(j),t} - s_t. \tag{3.21}$$

Clarida *et al*. (2001), in correspondence with Clarida and Taylor (1993), finds the evidence of the forward premia term structure, which contains valuable information for forecasting future spot exchange rates. However, they conclude that exchange rate dynamics display nonlinearities. Their works propose a term-structure forecasting model of exchange rates based on a regime-switching VECM. They claim that the model significantly outperforms both the random walk and the linear term-structure VECM for four major currencies as against the USD, across a range of horizons. Apart from the prediction techniques, their basic underlying theoretical framework is similar to Clarida and Taylor (1993).

The rapid development of computers and the new findings in econometrics and quantitative techniques help the progress of the exchange rate economics. Studies with better exchange rate forecast result, lead to the new understandings. Engel and Hamilton (1990) use Markov-switching process introduced by Hamilton (1989) to achieve a strong evidence of nonlinear serial dependence in the data characteristics of the USD and find that the new approach to time series analysis produces an exchange rate forecast which beats the random walk. However, determined to sharpen his previous finding with Hamilton (1990), Engel (1994, p. 151) writes that:

> *A Markov-switching model is fit for 18 exchange rates at quarterly frequencies. The model fits well in-sample for many exchange rates. By the mean-squared-error criterion, the Markov model does not generate superior forecasts to a random walk or the forward rate. There appears to be some evidence that the forecasts of the Markov model are superior at predicting the direction of change of the exchange rate.*

Marsh and Power (1994) have investigated the ability of 22 currency forecasters to predict movements in three major exchange rates against USD within a portfolio framework. With a direct approach, they collected raw survey results from exchange rate forecasters working in the commercial and investment banks, industrial corporations, chambers of commerce, and forecasting agencies, both in private and public sectors. The survey took place between September 1989 until August 1992, and the collection of the raw data was done on the first Monday of each month. They matched the forecasts with the contemporaneous middle market spot and three-month forward rates prevailing at a time between 3:30 PM and 4:00 PM in the London market, taken from the Barclays Bank International pages on Datastream. As the result, they found that the majority of currency analysts have little ability to predict the future, only one among them consistently outperformed the others.

Meanwhile Clarida *et al*. (2003) claim that their out of sample forecast of the several spot exchange rates beat the random walk's. They use Markov-switching process for the VECM. The model itself is non-linear which allows regime shifts in both the intercept and the variance-covariance matrix and is governed by three different regimes. The striking result shows that their model outperforms random walk and linear VECM model prediction. Using the mean absolute error (MAE) and the root mean square error (RMSE) criteria for forecast accuracy, the evidence is clear in favor of the predictive superiority of their model against the naïve random walk, and to a lesser extent, against linear VECM models.

However, the studies regarding the Rp/USD exchange rate behavior and its prediction are unfortunately not that many. The ability to understand its behavior would help the economic agents who are exposed to the Rp/USD exchange rate to understand the risk in an improved manner. On the other hand, for the central bank, Bank Indonesia, the implementation of the inflation targeting policy in its monetary policy, requires that additionally it must possess an exceptional understanding of the Rp/USD behavior.

Thus, this study seeks to fulfill the gap. This work specifically investigates whether the efficient market hypothesis could hold in the case of the Rp/USD. The intuition is that the Rp/USD forward rate is a decent predictor for the movement of Rp/USD spot rate. Although studies on exchange rate show big progress, minor currencies like the Indonesian Rupiah catches little attention. This gap leaves an opportunity to test the case of the Rupiah with the latest approaches developed by these studies.

Thus the following work tries to investigate answers of following questions:

1. Refer to the efficient market hypothesis, and assuming that the wealth owners are risk averse, does the efficient market hypothesis (and hence, uncovered interest parity) hold in the case of Rp/USD?
2. Is the term structure of Rp/USD forward rates a good predictor for the Rp/USD spot rate?

3. Do they have a long run relationship?

This work starts off with the introduction in section 3.1. Section 3.2 continues with the discussion about the efficient market hypothesis for the Rp/USD case and the cointegration process. Section 3.3 will discuss the empirical result and also the test, which will answer whether the efficient market hypothesis will be able to hold the Rp/USD case, while section 3.4 concludes the whole discussion.

3.2. Prediction of Nominal Rp/USD with Forward Rate: Answering the Puzzle

3.2.1. The Efficient Market Hypothesis to the Cointegration Process

From (3.20), since $\xi_{h(j),t}$ is a stationary stochastic process, the forward exchange rate at horizon *h*(*j*) and the spot rate share a common stochastic trend z_t and are cointegrated such that the forward premium at horizon *h*(*j*) is a stationary stochastic process.

Recalling (3.20), one can see that the forward and spot rates exhibit a common stochastic trend and theoretically are cointegrated with cointegrating vector: [1,-1]. Note that the representation of cointegrating vector: [1,-1] in our case of Rp/USD, will be written in the following form: [-1,1] to simplify the representation in the matrix form. And if we consider the column vector of forward rates of tenor 1, 3, 6, and 12 months together with spot rate:

$$y_t = \begin{pmatrix} lspot_t \\ lfwd_t^1 \\ lfwd_t^3 \\ lfwd_t^6 \\ fwdf_t^{12} \end{pmatrix}, \qquad (3.22)$$

which theoretically is cointegrated with following unique cointegrating space:

$$\beta' = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix}. \qquad (3.23)$$

Theoretically, the cointegration estimation will follow the departure of the uncovered interest parity (UIP), which imposes condition of the cointegrating vector: [1,-1] following (3.21). However we rewrite this condition as noted earlier, as follows:

$$\beta' y_t = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} \beta_{lspot} \\ \beta_{lfwd1} \\ \beta_{lfwd3} \\ \beta_{lfwd6} \\ \beta_{lfwd12} \end{pmatrix}. \qquad (3.24)$$

The parameters which are going to be tested against the restriction of $f_{h(1),t} - s_t, f_{h(2),t} - s_t, \ldots\ldots f_{h(j),t} - s_t$ with their cointegrating vector [1,-1] is rewritten as follows:

$$\beta' y_t = \begin{bmatrix} -1 & \phi & 0 & 0 & 0 \\ -1 & 0 & \phi & 0 & 0 \\ -1 & 0 & 0 & \phi & 0 \\ -1 & 0 & 0 & 0 & \phi \end{bmatrix} \begin{pmatrix} \beta_{lspot} \\ \beta_{lfwd1} \\ \beta_{lfwd3} \\ \beta_{lfwd6} \\ \beta_{lfwd12} \end{pmatrix}. \qquad (3.25)$$

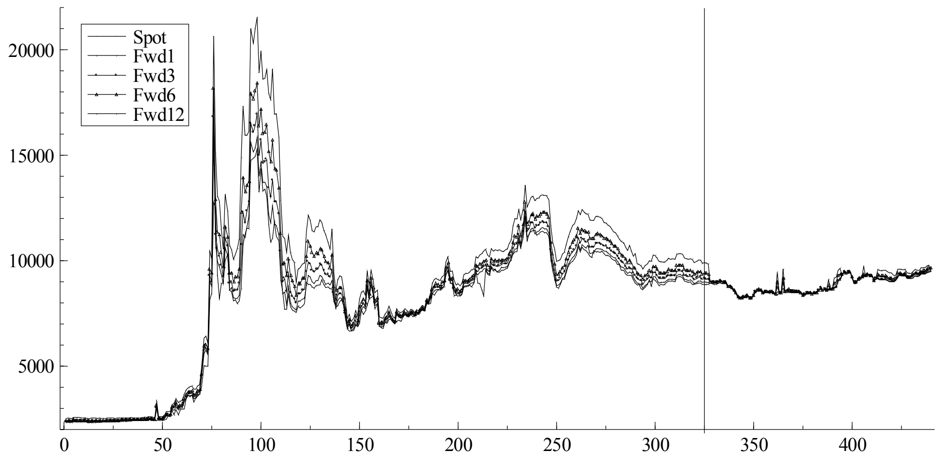
These parameters are not yet restricted in the cointegration test. Later we will investigate whether the restriction of these parameters are supported by the data in explaining the efficient market hypothesis for the case of Rp/USD.

3.2.2. Cointegration and VECM Process for the Rp/USD Spot and Forward Rate

We use weekly Rp/USD spot and forward 1, 3, 6, and 12-month rates data from January 1997 until April 2005. The data source is from the Bloomberg Market Database & the Foreign Exchange Directorate – Bank Indonesia.

The area on the left of the vertical line shows the crisis period, inundated by the political, economic, and social turbulence, from August 1997 – September 2002. The period includes the 1998 Jakarta riot, the political power shifts amongst the four presidents, the bombings in Bali and Jakarta's Marriott Hotel, and other social unrest events. This period shows no sign of "mean reversion" in Rp/USD gyration and Figure 3.1 shows the sharp turns of Rp/USD post-crisis, in the last seven years before 2005.

Figure 3.1: Weekly Rp/USD spot and 1, 3, 6, and 12-month forward rates, Jan 1997 – April 2005, n = 415



Thus, variables are assumed to be $\ln(y_t) \sim I(1)$, and the series are then generated in the log form. The rest of the empirical work estimates them in the log form. Suppose that a set of g variables which are $I(1)$ (in our case, $g = 5$), are under the investigation for the long run relationships, thus the vector auto-regressive (VAR) with k-lag system is:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ \ldots \ + \beta_k y_{t-k} + \mu_t \,, \qquad (3.26)$$

where, in matrices structures and dimensions, y and μ are of dimension (g x 1) and β is of dimension (g x g).

In the cointegration test procedure, the above VAR setting shall be transformed into a VECM in the form of:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \ldots + \Gamma_{k-1} \Delta y_{t-(k-1)} + \mu_t , \tag{3.27}$$

where $\Pi = \left(\sum_{j=1}^{k} \beta_i \right) - I_g = \alpha\beta'$ and $\Gamma_i = \left(\sum_{j=1}^{i} \beta_j \right) - I_g$.

VECM in (3.27) is indeed another form of VAR, which contains g variables in the first differenced form on the left hand side, and k-1 lags of the dependent variables (in differences) on the right hand side. Γ is a coefficient matrix and Π is the long run coefficient matrix. The formal structure of the VECM(k-1) system for the EMH test of Rp/USD looks as follow:

$$\begin{pmatrix} \Delta lspot_t \\ \Delta lfwd1_t \\ \Delta lfwd3_t \\ \Delta lfwd6_t \\ \Delta lfwd12_t \end{pmatrix} = \mu + \Pi \begin{pmatrix} lspot_{t-k} \\ lfwd1_{t-k} \\ lfwd3_{t-k} \\ lfwd6_{t-k} \\ lfwd12_{t-k} \end{pmatrix} + \sum_{j=1}^{\tau} \Gamma_\tau \begin{pmatrix} \Delta lspot_{t-\tau} \\ \Delta lfwd1_{t-\tau} \\ \Delta lfwd3_{t-\tau} \\ \Delta lfwd6_{t-\tau} \\ \Delta lfwd12_{t-\tau} \end{pmatrix} + \varepsilon_t , \tag{3.28}$$

where, $\Pi = \left(\sum_{j=1}^{k} \beta_i \right) - I_g = \alpha\beta'$, and $\tau = k - 1$.

We are interested in analyzing the matrix Π. The matrix Π is the product of two matrices: α and β' of dimensions (g x r) and (r x g). The matrix β' contains the cointegrating vectors, while the matrix α gives the weight of each cointegrating vector entering each equation of the VECM and also known as the "adjustment parameters".

The test of cointegration in this form will be done by looking at the rank of the $\Pi'\Pi$ matrix through its eigenvalue. Indeed the rank of the matrix is equal to the number of its characteristic roots (eigenvalues) which are different from zero. We then do the hypotheses test for the matrix rank to investigate the presence of the long run cointegration relationships as shown in Table 3.1.

How we proceed with the empirical work is basically standard. We must firstly investigate the VAR structure and establish the VAR residual correlation test (the LM test). We then want to search the right lag length for the VAR, based on the lag length criteria. The cointegration test will be implemented once the right VAR lag length is established.

Table 3.1: Cointegration test

H0: $r = 0$	against H1: $0 < r \leq g$	which looks for the confirmation of no cointegration
H0: $r = 1$	against H1: $1 < r \leq g$	which looks for the confirmation of at least there is 1 cointegration relationship
H0: $r = 2$	against H1: $2 < r \leq g$	which looks for the confirmation of at least there are 2 cointegration relationships
H0: $r = g$ -1	against H1: r = g	which looks for the confirmation of at least there are r = (g-1) cointegration relationship

Note: Based on Johanssen (1995)

Only after the cointegration relationship is found that we would proceed the investigation regarding the vector error correction, by estimating a VECM representation of the established VAR system, we then make a number of restrictions on the matrix Π and execute the weak exogeneity test, prior to making a conclusion for the EMH in the Rp/USD case.

3.3. Empirical Test and Result

3.3.1. Rp/USD Forward Rate with the 1, 3, 6, and 12 Month Terms Structure

We firstly want to investigate whether the efficient market hypothesis holds for the term structure of the 1, 3, 6, and 12-month Rp/USD forward rates, and whether the Rp/USD forward rates are the predictor of the spot rate. In this approach, the empirical test tries to investigate whether the term structure of the forward premia contain the information about the future Rp/USD spot rate. We start by the discussion about the lag length criteria for the Rp/USD spot-forward rate VAR model.

Lag Length Criteria

We use the Rp/USD spot and forward 1, 3, 6, and 12-month rates weekly data, while the observation period is from January 1997 until April 2005. We start the VAR analysis by searching for the right lag length. The VAR lag length criteria selection adheres to Lütkepohl (1991) and Johansen (1995). At this point, we do not know the VAR order, *k*, for the Rp/USD data generating process. Choosing *k* unnecessarily large will reduce the forecast precision of the corresponding estimated VAR (*k*) model, as clearly stated in Lütkepohl (1991). Moreover, it is important to avoid too many lags, since the number of parameters grows rapidly with the lag length. Johansen (1995) suggests that the information criteria strike a compromise between the lag length and the number of parameters, by minimizing a linear combination of the residual sum of squares and the number of parameters. Furthermore, Johansen (1995) describes that if a long lag length is required to acquire white noise residuals, then it often pays to reconsider the choice of variables and search for other important explanatory variables to include in the information set. He continues by explaining that rather than automatically increasing the lag length, it is more fruitful in a multivariate context to increase the information set.

However, in the case of the EMH with the term structure Rp/USD forward rate, there is no luxury of increasing the information set, say, by increasing the number of variables. To address this, we refer to Lütkepohl (1991, p. 128):

> *If forecasting is the objective it makes sense to choose the order such that a measure of forecast precision is minimized.*

Although our work is not mainly aimed to produce a forecast, it is on the other hand intended as a preparation to forecast spot Rp/USD with other econometric techniques such as VECM or Markov-switching VECM. It is then crucial to look for the VAR lag length according to Lütkepohl (1991). There are without doubt many widely used and well-known VAR order selection criteria, such as: Akaike's Information Criterion (AIC), Final Prediction Error (FPE), Likelihood Ratio Test Statistic (LR), Hannan & Quinn (HQ), and Schwarz Criterion (SC). However, this work does not discuss VAR order selection criteria in a great length, but the criteria being searched for are the ones that help minimizing the forecast quality measurement. Lütkepohl (1991) mentions that in small samples AIC and FPE choose the correct order more often than HQ and SC.

However, the former two criteria were designed to minimize the forecast error variance. Thus, in a small and large sample, models based on the AIC and the FPE may produce superior forecasts, despite the fact that it might not estimate the orders accurately. With all these considerations in hand, supported by a large number of available data, we chose the lag length criterion that is based on the HQ criteria.

From VAR to VECM: Results and Findings

Up until now, the right order of VAR for Rp/USD case, k, has not yet been identified. The search for the right VAR (k) begins methodically from the lowest order of the VAR process fitted to the data and goes on to the next order, for k = 2, 3, 4, …, and look for the minimum HQ result. Table 3.2 shows that at k = 3, HQ shows the lowest number and thus the VAR is of order k = 3.

Table 3.2: VAR lag length criteria selection

Lag 4			
AIC	-29.9236	SC	-28.8856
HQ	-29.5128	FPE	1.02233E-13
Lag 3			
AIC	-29.8591	SC	-29.0682
HQ	-29.5460	FPE	1.08305E-013
Lag 2			
AIC	-29.7586	SC	-29.2149
HQ	-29.5434	FPE	1.19326E-013
Lag 1			
AIC	-29.4709	SC	-29.1743
HQ	-29.3535	FPE	1.58886e-013

Note: The calculation is based on the sample, Jan 1997 – April 2005

Meanwhile, Table 3.3 contains the information about the residual serial correlation. Johansen (1995) warns us against the danger of misspecification of the unrestricted VAR. In order to avoid misspecification, we must first of all check whether the estimated residuals $\hat{\varepsilon}_t$ have no serial correlation, no conditional heteroskedasticity, and does not deviate too much from Gaussian white noise.

The unrestricted VAR residuals serial correlation test specifies H_0: no serial correlation at lag order k against the alternative H_1 of the existence of serial correlation. Table 3.3 shows that the H_0: no serial correlation at lag order k is rejected for $k = 3$ at 1%, as the p-value is less than 0.01.

Table 3.3: VAR residual serial correlation LM tests
H0: no serial correlation at lag order *k*, n: 415

Lags	LM-Stat	*p*-value
1	40.81288	0.0240
2	44.22314	0.0102
3	49.82354	0.0022
4	40.97690	0.0231

Note: The test is AR(4)

Johansen (1995) stresses the importance of estimated VAR residuals, $\hat{\varepsilon}_t$, having no serial correlation. However we refer back to Lütkepohl (1991) to address this estimated VAR white noise issue. The procedures taken for unrestricted VAR specification so far may be interpreted as methods for determining a filter that transforms the given data into a white noise series. In this context, the criteria for model choice may be regarded as the criteria for deciding whether the residuals are close enough to white noise to satisfy the investigator. However, he continues that if forecasting is the objective, it may not be important whether the residuals are actually white noise or not, as long as the model forecasts well. Moreover, according Johansen (1995) and Lütkepohl (1991), no excessive lag order is allowed because it will deteriorate the forecast power of the VAR model. On top of that, EMH framework does not provide room for the additional variables that can contain more information to be introduced in the VAR system to establish white noise in the residuals.

Cointegration, Weak Exogeneity and Long Run Restriction Test Results

By taking into account all of the VAR quality specification, the cointegration test can safely follow. The cointegration properties of the vector of variables $y_t = [lspot_t, lfwd1_t, lfwd3_t, lfwd6_t, lfwd12_t]$ use the VECM representation of (3.28).

Table 3.5 contains the columns of hypothesis test statements, trace statistic, critical value, and the estimated VAR residual diagnostics. The interpretation is standard and straightforward. At this early stage the deterministic element, that is also the trend, must be investigated to figure out whether it has to be restricted in the cointegration space by testing its significance, following the discussion by Doornik *et al*. (1998) and Johansen (1995), using the likelihood ratio test statistics. The test for the deterministic trend significance is carried out by estimating the cointegrated VAR with and without trend, and the number of rank equals to 3. Table 3.4 shows the χ^2 test result, which strongly accepted the drop of the trend from the cointegration space.

Table 3.4: Likelihood ratio test for
the deterministic trend of the cointegrated VAR

Model	Obs.	Log Likelihood
VAR with trend	406	6139.7625
VAR w.o. trend	406	6137.0262
$\chi^2(3)$ = 5.4725 [0.1403]		

Notes:
- Sample: Jan 1997 – April 2005
- VAR is of order k=3
- [.] = p value

After we opt out the inclusion of the trend, the cointegration test is thus carried out. Table 3.5 reports that there are three cointegrating equations at the 5% and 1% levels. The trace statistics for r ≤ 0, r ≤ 1, r ≤ 2, successively 247.25, 131.87, and 41.69, exceed the corresponding 5% and 1% critical values, thus reject H_0: r ≤ 0, H_0: r ≤ 1, and H_0: r ≤ 2. Meanwhile the trace statistic for r ≤ 3 and r ≤ 4, 13.477 and 3.5823, are lower than the 5% and 1% critical value of 29.65 and 35.65.

Table 3.5 presents the estimated VAR residual diagnostic tests as well. The vector autocorrelation p-value is 0.00, which shows that the estimated unrestricted VAR (k=3) is clean from autocorrelation.

Table 3.5: Cointegration rank test* (Johansen 1991, 1995) for VAR (*k=3, g=5*)

H_0:	Tr (LR)		5 %	1%	VAR Residuals Test
					Vector Autocorrelation (7)
r ≤ 0	247.25	[0.000]	68.52	76.07	(Johansen, 1995, p. 22)
r ≤ 1	131.87	[0.000]	47.21	54.46	χ^2 /p-value = 2.3053 / 0.00
r ≤ 2	41.469	[0.001]	29.68	35.65	Vector heteroschedasticity
r ≤ 3	13.477	[0.098]	15.41	20.04	
r ≤ 4	3.5823	[0.058]	3.76	6.65	χ^2 /p-value = 1381.4/0.00

Notes:
- Trace test indicates 3 cointegrating equations at the 5% and 1% level
- The cointegration test following Johansen (1991, 1995)
- [.] = p-value

The cointegrated VAR (*k=3*, *g*=5, *r=3*) estimates results in the following decomposition of the $\Pi = \alpha\beta'$, the long run cointegrating matrix:

$$\begin{array}{c} \alpha \\ \begin{array}{c} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{array} \begin{bmatrix} -0.43 & 2.22 & -0.17 \\ -0.07 & 0.90 & -0.20 \\ -0.05 & 0.90 & -0.23 \\ -0.14 & 0.59 & -0.24 \\ -0.20 & 0.59 & -020 \end{bmatrix} \end{array} \ \mathrm{X} \ \begin{array}{c} \beta' \\ \begin{bmatrix} 1.00 & 1.66 & -6.67 & 4.96 & -0.95 \\ -0.25 & 1.00 & -1.55 & 1.00 & -0.20 \\ 0.05 & -2.39 & 1.00 & 3.35 & -2.01 \end{bmatrix} \end{array} = \begin{array}{c} \Pi \\ \begin{array}{ccccc} lspot & lfwd1 & lfwd3 & lfwd6 & lfwd12 \end{array} \\ \begin{bmatrix} -0.98 & 1.91 & -0.77 & -0.45 & 0.30 \\ -0.30 & 1.26 & -1.15 & -0.09 & 0.28 \\ -0.28 & 1.38 & -1.32 & -0.11 & 0.33 \\ -0.30 & 0.94 & -0.20 & -0.95 & 0.51 \\ -0.35 & 0.73 & 0.20 & -1.06 & 0.47 \end{bmatrix} \end{array}.$$

Table 3.6 reports the cointegrated VAR (*k*=2, *g*=5, *r*=3) estimation result (the insignificance is omitted in the short run dynamics report).

Table 3.6: VECM (*k*=2, *g*=5, *r*=3) estimation result, unrestricted, unconstrained, (Sample: Jan 1997 – April 2005, weekly Rp/USD spot and 1, 3, 6, and 12-month forward rate)

$dlspot = 0.27dlspot_{t-2} - 0.98lspot_{t-1} - 0.30lfwd1_{t-1} - 0.28lfwd3_{t-1} - 0.30lfwd6_{t-1} - 0.35lfwd12_{t-1}$
(0.16) (0.16) (0.19) (0.19) (0.20) (0.22)

$dlfwd1 = 0.46dlspot_{t-1} + 0.48dlspot_{t-2} + 1.91lspot_{t-1} + 1.26llfwd1_{t-1} + 1.38lfwd3_{t-1}$
(0.19) (0.16) (0.59) (0.69) (0.72)
$+0.94lfwd6_{t-1} + 0.73\ lfwd12_{t-1}$
(0.75) (0.82)

$dlfwd3 = 0.49\ dlspot_{t-1} + 0.53dlspot_{t-2} - 0.77lspot_{t-1} - 1.15lfwd1_{t-1} - 1.32\ lfwd3_{t-1}$
(0.20) (0.21) (1.04) (1.23) (1.27)
$-0.20\ lfwd6_{t-1} + 0.20\ lfwd12_{t-1}$
(1.32) (1.44)

$dlfwd6 = 0.51\ dlspot_{t-1} + 0.55dlspot_{t-2} - 1.16\ dlfwd12_{t-1} - 0.45\ lspot_{t-1} - 0.09\ lfwd1_{t-1}$
(0.21) (0.17) (0.52) (0.83) (0.98)
$-0.11\ lfwd3_{t-1} - 0.95\ lfwd6_{t-1} - 1.06\ lfwd12_{t-1}$
(1.02) (1.06) (1.16)

$dlfwd12 = 0.58\ dlspot_{t-1} + 0.63dlspot_{t-2} + 2.91\ dlfwd6_{t-1} - 1.90\ dlfwd12_{t-1} + 0.30\ lspot_{t-1}$
(0.22) (0.19) (1.31) (0.57) (0.29)
$+0.28\ lfwd1_{t-1} + 0.33\ lfwd3_{t-1} + 0.51\ lfwd6_{t-1} + 0.47\ lfwd12_{t-1}$
(0.34) (0.35) (0.37) (0.40)

Notes:
- (.) denote standard error
- The insignificants are omitted in the short run dynamics report

When the log forms of spot, forward rate of 1, 3, 6, and 12 month are all $I(1)$ and the linear combination of $lspot - \beta_{lfwd1} lfwd1 - \beta_{lfwd3} lfwd3 - \beta_{lfwd6} lfwd6 - \beta_{lfwd12} lfwd12 = \varepsilon_t$ is stationary, then these variables are cointegrated of order (1,1). The vector of variables is $y_t = [lspot, lfwd1, lfwd3, lfwd6, lfwd12]$ and the cointegrating vector is β = $[-1, \beta_{lfwd1}, \beta_{lfwd3}, \beta_{lfwd6}, \beta_{lfwd12}]$.

Table 3.7 shows that the long run coefficients of $CI(1,1)_{r=3}$ are normalized with the identifying variable *lspot*, *lfwd1*, *lfwd3* with coefficients set to 1. Note that at this point, the approach is putting together the information set in the whole term structure of four forward premia in the four Rp/USD forward rates, into the VAR system. The idea was to exploit the entire information content that is intrinsic in this set of term structure forward rates, in an effort to explain and investigate whether the data support the efficient market hypothesis for the Rp/USD case.

Table 3.7: Identified cointegrating vectors estimates

$$\beta'$$

$$\begin{bmatrix} 1.00 & 0.00 & 0.00 & -2.45 & 1.41 \\ 0.00 & 1.00 & 0.00 & -2.14 & 1.14 \\ 0.00 & 0.00 & 1.00 & -1.64 & 0.64 \end{bmatrix} \begin{pmatrix} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{pmatrix}$$

Note: Sample from Jan 1997 – April 2005

Table 3.8 reports the VECM estimation result with restrictions on the long run vector β, as it is normalized. Up to this point, we have not yet identified whether variables $lfwd1$, $lfwd3$, $lfwd6$, and $lfwd12$ are weakly exogenous conditioning variables in the long run cointegration relationship, with the *lspot* as a normalizing variable. Restrictions to matrix α and further restriction to matrix β' will be carried out in order to test the weak exogeneity in the long run cointegration relationship.

However before the weak exogeneity test is carried out, let us recall the restriction condition in (3.24):

$$\beta' = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} \beta_{lspot} \\ \beta_{lfwd1} \\ \beta_{lfwd3} \\ \beta_{lfwd6} \\ \beta_{lfwd12} \end{pmatrix},$$

and, with $CI(1,1)$, $k=2$, $g = 5$, $r = 3$, β' is of (r x g) dimension:

$$\beta' = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{pmatrix} \beta_{lspot} \\ \beta_{lfwd1} \\ \beta_{lfwd3} \\ \beta_{lfwd6} \\ \beta_{lfwd12} \end{pmatrix}. \tag{3.29}$$

Thus, the term structure of the Rp/USD forward rate is tested by the EMH framework, through the system of $CI(1,1)$, k=2, g = 5, r = 3. We then carry out the following restrictions on the long run cointegration matrix $\alpha \cdot \beta'$:

Table 3.8: Restrictions in the long run adjustment matrix α and the cointegrating vectors β

Unrestricted

$$\begin{array}{l} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{array} \overset{\alpha}{\begin{bmatrix} -0.43 & 2.22 & -0.17 \\ -0.07 & 0.90 & -0.20 \\ -0.05 & 0.90 & -0.23 \\ -0.14 & 0.59 & -0.24 \\ -0.20 & 0.59 & -020 \end{bmatrix}} \begin{bmatrix} 1.00 & 1.66 & -6.67 & 4.96 & -0.95 \\ -0.25 & 1.00 & -1.55 & 1.00 & -0.20 \\ 0.05 & -2.39 & 1.00 & 3.35 & -2.01 \end{bmatrix} \overset{\beta'}{\begin{pmatrix} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{pmatrix}}$$

Restricted

$$\begin{array}{l} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{array} \overset{\alpha}{\begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ 0.00 & \alpha_{22} & \alpha_{23} \\ 0.00 & \alpha_{32} & \alpha_{33} \\ 0.00 & \alpha_{42} & \alpha_{43} \\ 0.00 & \alpha_{52} & \alpha_{53} \end{bmatrix}} \begin{bmatrix} -1.00 & 1.00 & 0.00 & 0.00 & 0.00 \\ -1.00 & 0.00 & 1.00 & 0.00 & 0.00 \\ -1.00 & 0.00 & 0.00 & 1.00 & 0.00 \end{bmatrix} \overset{\beta'}{\begin{pmatrix} lspot \\ lfwd1 \\ lfwd3 \\ lfwd6 \\ lfwd12 \end{pmatrix}}$$

The zeros in the first column of α indicate that variables *lfwd*1, *lfwd*3, *lfwd*6, and *lfwd*12 are weakly exogenous for the corresponding β coefficients in the long run cointegration relation. In a cointegrated system, if a variable does not respond to the discrepancy from the long run equilibrium relationship, then it is weakly exogenous. Engel *et al*. (1983) provide a comprehensive analysis of various types of exogeneity. In general, a variable x_{it} is weakly exogenous for the parameter set β if the marginal distribution of x_{it} contains no useful information for conducting inference on β.

Thus, if the speed of adjustment parameter of α_{it} is zero, that is to say that the long run speed of adjustment that comes together in the term structure of Rp/USD forward rates does not accommodate useful information about the future Rp/USD spot rate. We want to investigate whether the efficient market hypothesis is supported by the data. The efficient market hypothesis holds if the forward exchange rate predicts its future spot rate.

Table 3.9.A shows that the weak exogeneity hypothesis test for the Rp/USD forward rate term structure can be rejected (p-value = 0.09). Table 3.9.B contains the report on the hypothesis that the long run restriction of Rp/USD spot – forward rate in the term structure follows the theoretical setting (-1,1) within the VECM ($k=2$, $g=5$, $r=3$), which shows rejection at a high significance level (p-value = 0.00). Meanwhile, in Table 3.9.C, we see the test result of the joint restrictions on α and β' within the VECM:

$$\beta_{lspot,r1}=-1,\ \beta_{lfwd1,r1}=1,\ \beta_{lfwd3,r1}=0,\ \beta_{lfwd6,r1}=0,\ \beta_{lfwd12,r1}=0,$$

$$\beta_{lspot,r2}=-1,\ \beta_{lfwd1,r2}=0,\ \beta_{lfwd3,r2}=1,\ \beta_{lfwd6,r2}=0,\ \beta_{lfwd12,r2}=0,$$

$$\beta_{lspot,r3}=-1,\ \beta_{lfwd1,r3}=0,\ \beta_{lfwd3,r3}=1,\ \beta_{lfwd6,r3}=0,\ \beta_{lfwd12,r3}=0,$$

and

$$\alpha_{lfwd1,r1}=\alpha_{lfwd3,r1}=\alpha_{lfwd6,r1}=\alpha_{lfwd12,r1}=0.$$

The statistical result of the test in Table 3.9.C also shows a rejection to the restriction (p-value = 0.00). This means that the term structures of Rp/USD forward rates are not weakly exogenous. The result also entails that the market deems the premia in a term structure of 1, 3, 6, and 12-month Rp/USD forward rate scheme does not reflect the future Rp/USD spot rate. The spot Rp/USD does not react to the forward rate term structure changes in the long run. Moreover, the theoretical condition that is set in (3.20) and (3.21), also finds rejection in the case of Rp/USD. It shows that the efficient market hypothesis does not hold. It simply says that for the case of Rp/USD, its term structure of forward rate does not contain useful information regarding the future nominal Rp/USD spot rate. In this situation, when the market is not certain about the future of Rp/USD, it then decides on introducing risk premia to offset the inherent risk, hence the departure of the efficient market hypothesis. However, the test implies an indication that the Rp/USD market looks for a less complex set of information, rather than the combined information that originated from the Rp/USD forward rate premia terms structure.

Table 3.9.A: Exogeneity test report of the VECM (*k=2*, *g=5*, *r=3*)

Restrictions:	$\alpha_{lfwd1,r1}=\alpha_{lfwd3,r1}=\alpha_{lfwd6,r1}=\alpha_{lfwd12,r1}=0$
Statistic	$\chi^2(2)/p-value=$ 4.77/ 0.09

Table 3.9.B: Long run restriction test report of the VECM (*k=2*, *g=5*, *r=3*)

Restrictions:	$\beta_{lspot,r1}$=-1, $\beta_{lfwd1,r1}$=1, $\beta_{lfwd3,r1}$=0, $\beta_{lfwd6,r1}$=0, $\beta_{lfwd12,r1}$=0, $\beta_{lspot,r2}$=-1, $\beta_{lfwd1,r2}$=0, $\beta_{lfwd3,r2}$=1, $\beta_{lfwd6,r2}$=0, $\beta_{lfwd12,r2}$=0, $\beta_{lspot,r3}$=-1, $\beta_{lfwd1,r3}$=0, $\beta_{lfwd3,r3}$=0, $\beta_{lfwd6,r3}$=1, $\beta_{lfwd12,r3}$=0
Statistic	$\chi^2(2)/p-value=$ 42.67/ 0.00

Table 3.9.C: Joint exogeneity and long run restriction test report of the VECM (*k=2*, *g=5*, *r=3*)

Restrictions:	$\beta_{lspot,r1}$=-1, $\beta_{lfwd1,r1}$=1, $\beta_{lfwd3,r1}$=0, $\beta_{lfwd6,r1}$=0, $\beta_{lfwd12,r1}$=0, $\beta_{lspot,r2}$=-1, $\beta_{lfwd1,r2}$=0, $\beta_{lfwd3,r2}$=1, $\beta_{lfwd6,r2}$=0, $\beta_{lfwd12,r2}$=0, $\beta_{lspot,r3}$=-1, $\beta_{lfwd1,r3}$=0, $\beta_{lfwd3,r3}$=0, $\beta_{lfwd6,r3}$=1, $\beta_{lfwd12,r3}$=0 $\alpha_{lfwd1,r1}=\alpha_{lfwd3,r1}=\alpha_{lfwd6,r1}=\alpha_{lfwd12,r1}=0$
Statistic	$\chi^2(2)/p-value=$ 119.98/ 0.00

Note: Sample estimated: weekly Rp/USD lspot, lfwd1, lfwd3, lfwd6, lfwd12, Jan 1997 – April 2005

We decide to do the next investigation to answer the question whether the non-term structure approach can explain differently to the application of the efficient market hypothesis for the Rp/USD case, which is to do a simpler VAR and VECM system with smaller vector variables.

3.3.2. The Non Term Structure Rp/USD Forward Rate

Previous result with the term structure forward rates shows that the efficient market hypothesis does not hold in the case of Rp/USD. In this part, the same sample period of January 1997– April 2005 is observed, and data is weekly.

The sole difference now is the manner on how the relationship between variables involved is treated. The efficient market hypothesis expression will be treated individually for each Rp/USD forward rate term. The vector variable is now $y_{\tau} = \left[lspot, lfwd\left(m\right) \right]$; where τ refers to the term of the forward rate being observed, which in our case *m* = 1, 3, 6, and 12. The cointegrating vector is now $\beta_{\kappa} = \left[-1, \beta_{lfwd(\kappa)} \right]$, where by the efficient market hypothesis, $\beta_{lfwd(\kappa)} = 1$.

Studies by Clarida *et al*. (1993, 1997, 2003) use the term structure of forward rate for the case of four strong currencies, French Franc (FF), Deutsche Mark (DEM), Pound Sterling (GBP), and Yen, against the USD. Regarding the β coefficients, Clarida *et al*. (2003) claim that the departure of the efficient market hypothesis in their research is due to the tiny data imperfections, therefore the theoretical parameter value of 1 is indeed achieved for countries that were observed, except for Franc and DEM. However, this is not the case for Rp/USD under the term structure forward rate approach, as was proven in the previous section.

Cointegration, Weak Exogeneity and Long Run Restriction Test Results

Table 3.10 shows the result of the cointegration rank test. Note that the lag length criteria selection is completely similar to such process in sub-section 3.3.1. The VAR (*k* = 3, *g* = 2) system applies to all *m* = 1, 3, 6, and 12. The cointegration test report in Table 3.4 shows that the $y_6 = \left[lspot, lfwd6 \right]$ and $y_{12} = \left[lspot, lfwd12 \right]$ do not have the cointegration relationship. Only $y_1 = [lspot, lfwd1]$ and $y_3 = [lspot, lfwd3]$ show the existence of cointegration.

Using the information from the cointegration rank test, we can now estimate the vector error correction of the VAR, and later implement the restriction imposition to the parameter. However, we focus the following empirical test solely on the Rp/USD 1 month forward rate.

When the log forms of spot and forward rate 1 month are $I(1)$, and the linear combination of $lspot - \beta_{lfwd1} lfwd1 = \varepsilon_t$ (3.30) is stationary, these variables are cointegrated of order (1,1).

Table 3.11 reports the vector error correction estimate and the long run coefficient component of the long run cointegration matrix, $\Pi = \alpha\beta'$. The decomposition of matrix Π is also shown in the Table 3.12 (the unrestricted), which clearly tells us that the long run coefficient vector $\beta = [1, -1]$ conforms to the efficient market hypothesis' cointegrating vector $\beta = [1, -\beta_{lfwd1}]$.

Table 3.10: Cointegration rank test (Johansen 1991, 1995)
for vector $y_\tau = [lspot, lfwd(m)]$, n = 415

m	Ho	Trace Stat.	Critical Value		Est. VAR Residual Diagnostic		
			5%	1%	1	2	3
1	$r \leq 0$	56.08	15.41	20.04	100.38/(0.00)	788.14/(0.00)	301.20/(0.00)
	$r \leq 1$	10.43	3.76	6.65			
3	$r \leq 0$	24.59	15.41	20.04	114.00/(0.00)	983.77/(0.00)	254.90/(0.00)
	$r \leq 1$	9.97	3.76	6.65			
6	$r \leq 0$	17.98	15.41	20.04	73.94/(0.00)	842.80/(0.00)	218.81/(0.00)
	$r \leq 1$	7.80	3.76	6.65			
12	$r \leq 0$	15.34	25.32	30.45	93.71/(0.00)	756.92/(0.00)	203.41/(0.00)
	$r \leq 1$	5.51	3.76	6.65			

Notes:

- The cointegration test following Johansen (1991, 1995)), at 1% and 5%. Critical Values column shows the (nonstandard) critical values are taken from Osterwald-Lenum (1992).
- Column (1): Vector autocorrelation test: $\chi^2_{(38)}$ / (p-value), following Johansen (1995, p. 22)
- Column (2): Vector Normality test: $\chi^2_{(4)}$ / (p-val), following Lütkepohl (1991, p.155-158)
- Column (3): Vector Heteroschedasticity test: $\chi^2_{(36)}$ / (p-value)

However, tiny departure from the efficient market hypothesis could take place because of the tiny data imperfection. On the other hand, in their cross sectional research about the forward premium puzzle among 28 developed and emerging economies, Bansal and Dahlquist (2000) finds that the tiny departure appears in countries where interest rate is lower than that of the US. However, this is not the case for Indonesia because the interest rate is higher than that of the US. The departure of the efficient market hypothesis in the case of Rp/USD definitely says that the Rp/USD forward rate does not predict the future spot rate.

Table 3.11: VECM
(k=2, g=2, r=1) estimation result, unconstrained, unrestricted

dlspot	$= 0.018 - 0.61 lspot_{t-1} - 0.14 lfwd1_{t-1}$
	(0.13) (0.15)
*dlfwd*1	$= -0.238471 + 0.61 lspot_{t-1} + 1.26 lfwd1_{t-1} + 0.34 dlspot_{t-1} + 0.47 dlspot_{t-2} - 0.46 dlfwd1_{t-1}$
	(0.13) (0.15) (0.17) (0.15) (0.17)

Notes:
- Sample: Jan 1997 – April 2005, weekly spot, forward 1, 3, 6, and 12 month rate of Rp/USD
- (.) denote standard error
- The insignificants are omitted in the short run dynamics report

Table 3.12: Restrictions in the long run adjustment matrix α and the cointegrating vectors β

Unrestricted

$$\begin{matrix} & \alpha & & \beta' \\ \begin{matrix} lspot \\ lfwd1 \end{matrix} & \begin{bmatrix} -0.61 \\ -0.14 \end{bmatrix} & \begin{bmatrix} 1.00 & -1.00 \end{bmatrix} & \begin{pmatrix} lspot \\ lfwd1 \end{pmatrix} \end{matrix}$$

Restricted

$$\begin{matrix} & \alpha & & \beta' \\ \begin{matrix} lspot \\ lfwd1 \end{matrix} & \begin{bmatrix} \alpha_{11} \\ 0.00 \end{bmatrix} & \begin{bmatrix} 1.00 & -1.00 \end{bmatrix} & \begin{pmatrix} lspot \\ lfwd1 \end{pmatrix} \end{matrix}$$

However, another test needs to be done in order to prove whether the efficient market hypothesis condition of $\beta_{lfwd(\kappa)} = 1$ is supported by the data. Referring to (3.20) and (3.21), the VECM parameter will be restricted for two reasons: first, to conform the efficient market hypothesis coefficient vector $\beta = [-1,1]$, and second, we want to do the exogeneity test.

Tables 3.13.A, 3.13.B, and 3.13.C show that the test within the VECM of vector $y_1 = [lspot, lfwd1]$ does not reject either the hypothesis of the weak exogeneity for the log of the 1-month Rp/USD forward rate nor the hypothesis of the long run restriction of $\beta = [-1,1]$ for the vector y_1. The statistic of the weak exogeneity test is $\chi^2(2)/p-value=$ 1.93/0.16, the statistic of the long run restriction test is $\chi^2(2)/p-value=$ 0.000798/0.98, and the statistic of the joint test is $\chi^2(2)/p-value=$ 2.52/0.28. All of these results show that the efficient market hypothesis is supported by the data, in the case of vector $y_1 = [lspot, lfwd1]$.

Table 3.13.A: Exogeneity test report of the VECM
(*k=2*, *g=5*, *r=3*)

Restrictions:	$\alpha_{lfwd1,r1}$=0
Statistic	$\chi^2(2)/p-value=$ 1.93/ 0.16

Table 3.13.B: Long Run Restriction Test Report of the VECM
(*k=2*, *g=5*, *r=3*)

Restrictions:	$\beta_{lspot,r1}$=-1, $\beta_{lfwd1,r1}$=1,
Statistic	$\chi^2(2)/p-value=$ 0.000798/ 0.98

Table 3.13.C: Joint exogeneity and long run restriction test report of the VECM (*k=2*, *g=5*, *r=3*)

Restrictions:	$\beta_{lspot,r1}$=-1, $\beta_{lfwd1,r1}$=1, $\alpha_{lfwd1,r1}$=0
Statistic	$\chi^2(2)/p-value=$ 2.52/ 0.28

Note: Sample estimated - weekly Rp/USD lspot, lfwd1, lfwd3, lfwd6, lfwd12, Jan 1997 – April 2005

3.4. Conclusion

We find that in the case of the full term structure of the Rp/USD forward rates, the efficient market hypothesis does not hold. The term structure includes the rate premia of 1, 3, 6, and 12-month in the Rp/USD forward rate, so it represents the perception about the complex future risks. With this result, we conclude that the market players who seek profits by trading Rp/USD, do not base their calculation on the combined information set from the 1, 3, 6, and 12-month Rp/USD forward rates premia altogether. Moreover, the asset holders who are exposed to the exchange rate risk, also do not base their risk minimization criteria on the combined information set from the 1, 3, 6, and 12-month Rp/USD forward rates premia. The results also imply that when the economic agents want to seek profits from their investment that involve the Rp/USD rate, their investments are surely exposed to the Rp/USD rate risks. If the whole bunch of investors uses the term structure Rp/USD forward rates information set in their decisions, they produce an inefficient Rp/USD market.

However, we also find that with the non term-structure approach, we can isolate and group market information into different time horizon and test how it influences the predictability of the forward rate. It turns out that for the Rp/USD market, the efficient market hypothesis holds for the 1-month time horizon. The efficient market hypothesis asserts that the foreign exchange market efficiency requires a particular forward exchange rate to equal the expectation of the spot rate in the next corresponding period. The 1-month Rp/USD forward rate is meant to perfectly predict the Rp/USD spot rate, 1 month ahead. If this condition does not hold, thus theoretically economic agents can make a pure profit (or loss) on their speculations in the foreign exchange market. If the efficient market hypothesis does not hold, or even if the departure of the efficient market hypothesis in the long run entails the speculation on the future Rp/USD rate, we can suggest that the domestic economic agents who hold non-Rupiah denominated assets both in the domestic or in the international market, or those domestic economic agents who have USD denominated liabilities and will have to repay in USD, must hedge and pay the risk premia to secure their long term position.

The cointegration test for the Rp/USD forward rate terms structure with its corresponding spot rate shows that there are only three cointegration equations in the cointegrated VAR ($k=2$, $g=5$, $r=3$). It simply shows that one of the variables in the 1, 3, 6, and 12-month Rp/USD forward rate term structures, completely does not have any relation with its corresponding spot rate. However, the term structures Rp/USD forward rates are not weakly exogenous, as our test shows. This fact simply explains that the term structure Rp/USD forward rates does not reflect the future Rp/USD spot rate. The joint forward rate premia term structure information set in the forward rates does not contain any information concerning the future Rp/USD nominal rate. The market players do not base their prediction on the future Rp/USD nominal rate on the forward rates combined information, but as we have proved in the test, they focus on the 1-month Rp/USD forward rate to predict the one month ahead Rp/USD spot rate. Moreover, it is well known that the Rp/USD market is very sensitive to the set of information that comes from the domestic socio-political issues, as well as to the non-market friendly government policies. Thus, the Rp/USD prediction based on the available market information is hard to predict, especially for more than 3 months ahead of time. However, speculators will always have incentive to speculate on Rp/USD to reap gain, as suggested by the departure of efficient market hypothesis in its market, especially for long term positions.

Appendix

Derivations:

- From (3.3):

$$W_{t+1}=\left[\left(1+i_t\right)\theta+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{s_{t+1}}{s_t}\right)\right]W_t$$

Then to get $E_t\left(W_{t+1}\right)$ is easy:

$$E_t\left(W_{t+1}\right)=\left[\left(1+i_t\right)\theta+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)\right]W_t$$

- $\mathrm{Var}\left(W_{t+1}\right)=\left[W_{t+1}-E_t\left(W_{t+1}\right)\right]^2=$

$$\left[\left[\left(1+i_t\right)\theta+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{s_{t+1}}{s_t}\right)-\left(1+i_t\right)\theta+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)\right]W_t\right]^2=$$

$$\left[\left[\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{s_{t+1}-E\left(s_{t+1}\right)}{s_t}\right)\right]W_t\right]^2=\left(1+i_t^*\right)^2\left(1-\theta\right)^2\frac{\mathrm{Var}\ \left(s_{t+1}\right)}{s_t^2}W_t^2$$

- Maximization of equation (3.7) with respect to θ, find FOC:

$$\underset{\theta}{Max}\ \ E_t\left(W_{t+1}\right)-\frac{\gamma\mathrm{Var}\left(W_{t+1}\right)}{2}=$$

$$\left[\left(1+i_t\right)\alpha+\left(1+i_t^*\right)\left(1-\theta\right)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)W_t\right]-\gamma\frac{\left(1+i_t^*\right)^2\left(1-\theta\right)^2\frac{\mathrm{Var}\ \left(s_{t+1}\right)}{s_t^2}W_t^2}{2}=0$$

$$\left(1+i_t\right)-\left(1+i_t^*\right)\left(\frac{E\left(s_{t+1}\right)}{s_t}\right)W_t+\gamma\left(1+i_t^*\right)^2\left(1-\theta\right)\frac{\mathrm{Var}\ \left(s_{t+1}\right)}{s_t^2}W_t^2=0$$

Chapter 4

The Rp/USD Prediction: An Approach with the Markov Switching – Vector Error Correction Model

4.1. Introduction

In chapter 3, we already discussed about Meese and Rogoff (1983), Hansen and Hodrick (1980), Frankel (1980), and Bilson (1981), which all focus on the exchange rate predictions. The new impetus in this field emerged when Engel and Hamilton (1990) use Markov switching process introduced by Hamilton (1989). However, Engel (1994) corrects Engel and Hamilton (1990) previous finding and claims that the exchange rate prediction with Markov switching does not result in a better forecast, compared to the random walk, as previously found. On the other hand, Marsh and Power (1994) produce a research with a direct approach, on the ability of 22 currency forecasters of three major currencies against USD within a portfolio framework. Meanwhile, Wu and Chen (2001) and Clarida *et al*. (2003) conclude that the exchange behavior is non-linear. Both works claim that with non-linear approach, the nominal exchange rate prediction is superior to a range of alternative forecasts, such as the random walks, the conventional time-invariant and the time variant parameters model.

However, Clarida *et al*. (2003) do the out of sample forecast of the several major currencies against the USD and claim that it beats the random walk. They use Markov switching – vector error correction model (MS-VECM) framework to forecast the exchange rate of several strong currencies against the USD. Their model is non-linear which allows regime shifts in both the intercept and the variance-covariance matrix, and is governed by three different regimes

In line with Clarida *et al*. (2003), this chapter tries to establish the Rp/USD prediction model with the MS-VECM. Using the result of the preceding chapter 3, we will apply the MS-VECM framework for the case of the Rp/USD spot and 1-month forward rate. The main aim is to study the behavior of the Rp/USD rate, and beside that, by the help of the MS-VECM, we will be able to establish the Rp/USD rate regime classification. The model will classify the Rp/USD behavior into two regimes: the stable and the unstable. It will help us recognizing the cut off periods of the stable and unstable movements. The other appealing product of this approach is the transition probabilities between the Rp/USD rate regimes, which will enable us to recognize the likelihood of a particular Rp/USD behavior to remain in a regime, or to switch to another regime because of the behavioral changes which take place as the result of the economic agents perceptions changes.

This work starts with the introduction part in section 4.1. The following section 4.2 will discuss the methodology and the Markov switching framework. We will discuss about the VECM structure and the MS-VECM concept. Meanwhile section 4.3 will discuss about the data, and report the estimation results. The focus in section 4.3 is the discussion about the Rp/USD behavior regime classification. We want to investigate the period when a particular regime classification starts and ends, and analyze the Rp/USD behavior in that particular regime as well as the regime switching probabilities. Moreover, it is our interest to know whether a particular regime is characterized by the unstable or stable Rp/USD rate movement. The estimation of the MS-VECM will also show the estimated parameters for each regime, and we want to study how these parameters and equations can be used to predict the Rp/USD. Section 4.4 discusses the Rp/USD forward looking prediction which is based on the future transition probability of the exchange rate regime. The prediction about the future exchange rate regime transition probabilities, will enable us to explain the likelihood of a particular Rp/USD behavior in the future. The intuition on the transition probability prediction is that in the long run the Rp/USD will likely to move in the stable regime. However, that will have to be proven later. Finally, section 4.5 concludes the whole discussion.

4.2. Methodology

4.2.1. The Vector Error Correction Model Structure

In chapter 3, we started the discussion about the long run relationship of variables and the error correction representation. Based on the effective market hypothesis framework in the previous chapter, the long run equilibrium of spot and the term structure of forward rate is investigated in this chapter with the following VECM structure:

$$\Delta y_t = \mu_t + \Pi y_{t-1} + \sum_{j=1}^{\tau} \Gamma_\tau \Delta y_{t-\tau}$$

$$\begin{pmatrix} \Delta lspot_t \\ \Delta lfwd1_t \end{pmatrix} = \Pi \begin{pmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{pmatrix} + \sum_{k=1}^{\tau} \Gamma_\tau \begin{pmatrix} \Delta lspot_\tau \\ \Delta lfwd1_\tau \end{pmatrix} + \mu_t , \quad (4.1)$$

where $\Pi = \left(\sum_{i=1}^{k} \beta_i \right) - I_g = \alpha\beta'$, $\Gamma_\tau = \left(\sum_{j=1}^{\tau} \beta_j \right) - I_g$, and $\tau = k - 1$. Meanwhile $lspot_t$ and $lfwd1_t$ are the Rp/USD spot rate and the 1-month Rp/USD forward rate in logarithm form at time t, and all other denotations are completely similar to those of (3.28) in chapter 3.

The $I(1)$ and $CI(1,1)$ condition for variables *lspot* and *lfwd*1 must exist, which guarantee the existence of an error correction representation in the form of :

$$\Delta lspot_t = \mu_t + \alpha\beta' \begin{bmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{bmatrix} + \sum_{k=1}^{\tau} \Gamma_\tau \begin{bmatrix} \Delta lspot_{t-\tau} \\ \Delta lfwd1_{t-\tau} \end{bmatrix} . \quad (4.2)$$

From the result in the chapter 3, $\tau = (k - 1) = 3 - 1 = 2$. Matrix β is the cointegrating vector which contains the long run coefficients. Matrix α is called the loading matrix which contains the weights attached to the cointegrating relations in the individual equations of the model. From (4.2), we want to focus on the following expression:

$$\alpha\beta' \begin{bmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \begin{bmatrix} \beta_{lspot} & \beta_{lfwd} \end{bmatrix} \begin{bmatrix} lspot(-1) \\ lfwd1(-1) \end{bmatrix} . \quad (4.3)$$

Hence, (4.3) shows one long run (cointegrated) relationship, $r = 1$, from the VECM estimation in chapter 3, between the Rp/USD spot and forward rate 1-month.

Prior to working on the MS-VECM, we must prove the existence of the cointegration relation and the weak exogeneity in (4.3). Table 3.13.A in chapter 3 showed that the Rp/USD spot and 1-month forward rate possess a long run relationship and show the weak exogeneity. Therefore we concluded in chapter 3 that the efficient market hypothesis holds in that case. Meanwhile, we have a system of VECM(2), with r = 1. And when $lspot_t$ and $lfwd1$ are cointegrated then coefficient β in (4.3) is the cointegrating coefficient which defines the long run relationship between the variables involved. We understand that (4.2) indeed shows that if $lspot_t$ is to change between time t-1 and t as a result of the changes in the values of the explanatory variable, then the cause is the change of $lfwd1$ between t-1 and t, and also in part to correct for any disequilibrium that existed during the previous period. This expression has a lag, t-1, because otherwise, it is completely nonsensical to say that the changes in $lspot_t$ between t and t-1 are in response to a disequilibrium at time t. More discussion about the VECM, can be read in chapter 3.

4.2.2. Markov Switching –VECM (MS-VECM)

The methodology splits the possible occurrences in variables involved into m states of the world, denoted $z_t \in \{1,...,M\}$, corresponding to M regimes. In our case of Rp/USD spot and forward 1-month, it is assumed that they switch regime according to some unobserved variable z_t which takes integer values. Following less technical explanation by Brooks (2002), then, when z_t = 1, the process is in regime 1 at time t, and if z_t = 2, the process is in regime 2 at time t, and if z_t = 3, the process is in regime 3 at time t. Movements of the state variable between regimes are governed by a Markov process, with following property:

$$\Pr\left[z_t = z \mid z_t ..., z_{t-1}\right] = \Pr\left[z_t = z \mid z_{t-1}\right]. \qquad (4.4)$$

Expression (4.4) means that the probability distribution of the state z_t depends only on the state of z_{t-1}, and not on the states before that. Thus Markovian processes do not follow path-dependent process. The strength of MS models thus lies in its flexibility, being capable of capturing changes in the variance between state processes, as well as changes in the mean.

Following Hamilton's (1989) explanation, assume $M = 2$, thus $z_t = 1$ or 2, denote the unobserved state of the system, that is the unobserved state variable. Then, it is assumed that the Markov model be governed by a first-order Markov process:

$$\text{Prob}\ [z_t = 1 \mid z_{t-1} = 1] = p_{11}, \qquad (4.5)$$

$$\text{Prob}\ [z_t = 2 \mid z_{t-1} = 1] = 1 - p_{11}, \qquad (4.6)$$

$$\text{Prob}\ [z_t = 2 \mid z_{t-1} = 2] = p_{22}, \qquad (4.7)$$

$$\text{Prob}\ [z_t = 1 \mid z_{t-1} = 2] = 1 - p_{22}, \qquad (4.8)$$

where p_{11} denote the probability of state variable being in regime 1, given that the system was in regime one during the previous period, and where p_{22} the probability of being in regime 2, given that the system was in regime 2 during the previous period, respectively. Thus 1 – p_{11} defines the probability that y_t will change from state 1 in period *t*-1 to state 2 in period *t*, and 1 – p_{22} defines the probability of a shift from state 2 to state 1 between times $t - 1$ and *t*.

Technical discussions in greater length is unfortunately not the main focus of this work, but good reference for that are from Hamilton (1989), Engel and Hamilton (1990), and Krolzig (1999).

However, the estimation of MS model uses the expectation-maximization algorithm and each iteration process of this algorithm consists of two steps:

- The expectation step. The unobserved states are estimated by their smoothed probabilities, Prob $[z_t \mid y_t, \theta]$, by the MS filter and smoother. By this step, probabilistic inference can be drawn about the unobserved z_t given observations on y_t and the joint conditional density distribution of both states is estimated by the maximum likelihood estimation (MLE) as explained by Hamilton (1989).

- Maximization step. Let $y \equiv (y,...,y_t)'$, $z_t \equiv (z_1,...,z_t)'$, and θ is the population parameter. Then the filter evaluates $f(y \mid \theta, y_{1-k},..., y_0)$ and maximizes with respect to θ. The MLE $\hat{\theta}$ is then used in a final pass through the filter to draw the probabilistic inference about z_t (Hamilton, 1989). The parameters estimated, θ, are based on the smoothed probabilities of the last expectation step.

Technically, the basic model in focus of this work is based on a finite order VAR process with MS intercepts:

$$y_t = v(z_t) + \sum_{i=1}^{k} \Pi_i y_{t-i} + \varepsilon_t \text{ ; } \varepsilon_t \sim NID\ (\mathbf{0}, \Sigma), \tag{4.9}$$

where:

- y_t is a $K-$dimensional observed time series vector, $y_t = [y_{1t}, y_{2t}, y_{3t},..., y_{Kt}]$
- $v(z_t) = [v_1(z_t), v_2(z_t),...., v_K(z_t)]$ is a K-dimensional column vector of regime-dependent intercept terms
- The Π_i's are $K \times K$ matrices of parameters
- $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t},..., \varepsilon_{Kt}]$' is K-dimensional vector of Gaussian white noise processes with covariance matrix Σ, $\varepsilon_t \sim NID\ (\mathbf{0}, \Sigma)$.

As previously described in general, the regime-generating process is assumed to be an ergodic Markov chain with a finite number of states $z_t \in \{1,..., M\}$ governed by the transition probabilities $p_{ij} = \Pr(z_{t+1} = j \mid z_t = i)$ and $\sum_{j=1}^{M} p_{ij} = 1\ \forall i, j \in \{1,..., M\}$.

In economic data such as *lspot* and *lfwd*1, it is common to find them as first difference stationary, *I*(1). Thus there may be cointegrating relationships which represent the long term relationships (equilibrium) of the system, and also the equilibrium error (the deviation from the long run equilibrium) is measured by the stationary stochastic process as stated in (4.2). If cointegration exists, the cointegrated MS-VAR becomes a Markov switching vector equilibrium correction model (MS-VECM):

$$\Delta y_t = v(z_t) + \Pi y_{t-1} + \sum_{j=1}^{\tau} \Gamma_\tau \Delta y_{t-\tau}; \ \ \varepsilon_t \sim NID\,(\mathbf{0},\, \Sigma), \tag{4.10}$$

Where $\Gamma_\tau = \left(\sum_{j=1}^{\tau} \beta_j \right) - I_g$, and $\tau = k - 1$, while $\Pi = \left(\sum_{i=1}^{k} \beta_i \right) - I_g = \alpha\beta'$ is the long run impact matrix whose rank r determines the number of cointegrating vectors as discussed by Johansen (1995) and Krolzig (1999).

The MS(1) with regime-dependent intercept expression for (4.10) in the case of *lspot* and *lfwd*1 with VECM(2), r = 1, g = 2, shall look like:

$$\Delta lspot_t = v(z_t) + \alpha\beta' \begin{bmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{bmatrix} + \sum_{k=1}^{\tau} \Gamma_\tau \begin{bmatrix} \Delta lspot_{t-\tau} \\ \Delta lfwd1_{t-\tau} \end{bmatrix}, \tag{4.11}$$

where $\tau = 3 - 1 = 2$.

In this chapter, the MS-VECM representation of variables *lspot* and *lfwd*1 is:

$$\begin{aligned} &\Delta lspot_t - \mu(z_t) = \\ &\mu_t + \alpha\beta'(z_t) \left[\begin{bmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{bmatrix} - \left[\mu(z_{t-1}) \right] \right] + \sum_{k=1}^{\tau} \Gamma_\tau \left[\begin{bmatrix} \Delta lspot_{t-\tau} \\ \Delta lfwd1_{t-\tau} \end{bmatrix} - \left[\mu(z_{t-\tau}) \right] \right], \end{aligned} \tag{4.12}$$

where $\mu_t \sim$ NID $(0, \Sigma(z_t))$, $\mu_t(z_t)$, $\alpha\beta'(z_t)$, and $\Sigma(z_t)$ are parameter shift functions of the Markovian regime switching process, describing the dependence of the parameters μ, $\alpha\beta'$, and Σ.

Hence, this research tries to provide a synthesis of the dynamic factor of VECM process and the non-linear Markov switching process for the exchange rate fluctuations. After the VECM procedure identifies the presence of cointegration relationship, then the following step is to implement the non-linear approach with MS-VECM by Krolzig (1996, 1997, 1998), and Hamilton (1989, 1990) pioneering work. Discussion in the following part will be more related to the case of Rp/USD spot and 1-month forward rate and its MS-VECM estimation results.

4.3. Estimation Result for Rp/USD Spot and Forward Rate

4.3.1. Data

The sample, frequency, and period of observation are exactly the same with chapter 3. Descriptive statistics of Rp/USD spot and 1-month forward (at log returns level) in Table 4.1 shows that 231 and 219 out of 415 data observation center around the range of 0 – 0.2 value of log returns.

From January 1997until April 2005, the highest weekly Rp/USD spot and 1-month forward rate reached Rp 15300 and Rp 15850, which took place on July 1998. Meanwhile, the pre-crisis spot and forward rate 1-month was around Rp 2000 and the average Rp/USD rate during the sample period is circa Rp 8000. The gyration of such magnitude in only 2 years, is very rare among the other currency in the world.

Table 4.1: Descriptive statistics for weekly Rp/USD *dlspot* and *dlfwd1* 1-month (level), sample: Jan 1997 – March 2005 (n = 415)

Range	Mean		Standard Deviation		Observation	
	(1)	(2)	(1)	(2)	(1)	(2)
[-0.4 to -0.2)	-0.295714	-0.293642	NA	0.130242	1	2
[-0.2 to 0)	-0.022229	-0.021239	0.033232	0.030417	177	188
[0 to 0.2)	0.017464	0.019176	0.026123	0.028869	231	219
[0.2 to 0.4)	0.229290	0.231230	0.018729	0.027072	3	3
[0.4 to 0.6)	0.449473	0.537924	0.053893	0.068640	2	2
All	0.003360	0.003355	0.052938	0.059255	414	414

Note: (1) and (2) refer to *lspot* and *lfwd1*, both in first-difference

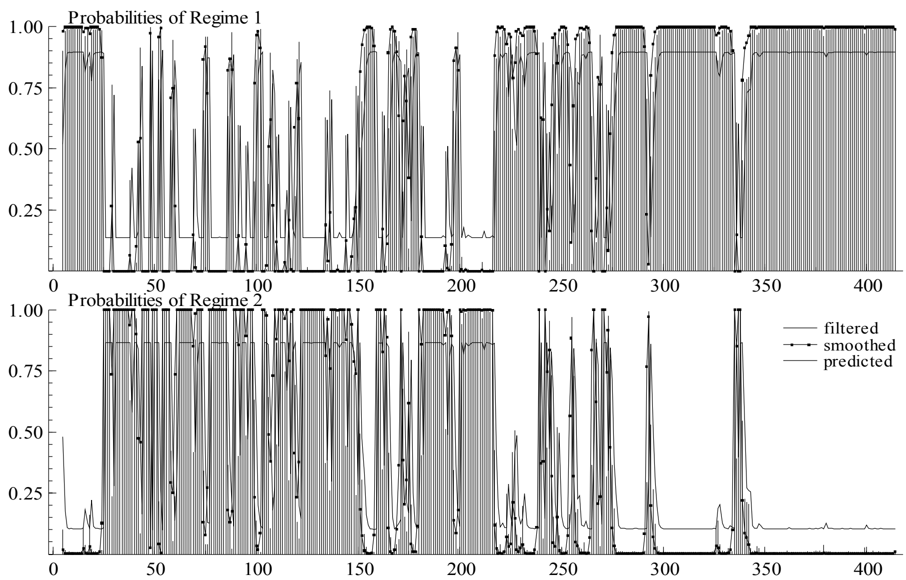
4.3.2. From VECM to MS-VECM: Empirical Results

Hence, (4.12) is the MS-VECM representation of our case:

$$\Delta lspot_t - \mu(z_t) =$$
$$\mu_t + \alpha\beta'(z_t)\left[\begin{bmatrix} lspot_{t-1} \\ lfwd1_{t-1} \end{bmatrix} - \left[\mu(z_{t-1})\right]\right] + \sum_{k=1}^{\tau}\Gamma_\tau\left[\begin{bmatrix} \Delta lspot_{t-\tau} \\ \Delta lfwd1_{t-\tau} \end{bmatrix} - \left[\mu(z_{t-\tau})\right]\right].$$

Prior to the estimation, we transform first the data into log form. Then we estimate VECM with variables *lspot* (log spot) and *lfwd1* (log 1-month forward) which results in the empirical proof that efficient market hypothesis holds for the case of Rp/USD spot and 1-month forward rate. Moreover, it is proven too that the relation between variables is that *lfwd1* determines *lspot*, which is proven by the result of the weak exogeneity test.

Figure 4.1: MS (2)-VECM(2) Estimation results: regime probabilities
Jan 1997 - March 2005



Thus, we employ MS(2) –VECM(2) with 2 regimes and 2 lags model, with shifts in the intercept, the error variance, and the autoregressive parameters. Three lags is the outcome of the HQ model selection procedure of the lag length for the VAR model which is carried out in the preceding chapter 3, and becomes two lags in its VECM representation. While the number of regimes, 2, is chosen to represent the occurrences of the appreciation dominance period and the depreciation dominance period.

The MS(2)-VECM(2) empirical run result is shown in the Table 4.2. We find that the parameter signs of the log returns spot rate are all negative in both Regime 1 and 2, all positive for the log returns forward rate 1-month in both Regime 1 and 2, and all negative for the long run dynamics in both Regimes 1 and 2.

Table 4.2: MS(2)-VECM(2) Estimation results

Variable	**Regime 1**	**Regime 2**
C	0.0063* (0.0008)	-0.0061 (0.0027)
Short-run dynamics		
$dlspot_{t-1}$	-0.1989* (0.1016)	-0.1904 (0.1030)
$dlspot_{t-2}$	-0.1653* (0.0191)	0.0486 (0. 0839)
$dlfwd_t$	0.8473* (0.0293)	0.8119* (0.0307)
$dlfwd_{t-1}$	0.4022* (0.0862)	0.1893 (0.1070)
$dlfwd_{t-2}$	0.1793* (0.0433)	-0.0583 (0.0881)
Long-run dynamics		
CI1	-0.7525* (0.0923)	-0.5662 (0.1127)

	Non-linear	Linear
Log Likelihood	1272.0997	1021.6901
LR Test	2*{1373.5863-1023.3659} = 500.8192	
	χ^2 (8) = [0.00], χ^2 (10) = [0.00]	
AIC	-6.1176	-4.9448
HQ	-6.0478	-4.9138
SC	-5.9412	-4.8665

Notes:

- Numbers (.) denote the standard error, except for χ^2 (.) denote degrees of freedom
- [.] shows the *p*-value
- * denote significance of parameter
- CI1 = Long run cointegration equation
- Sample n = 415, weekly spot and 1-month Forward Rate Rp/USD

Regime 1

We estimate that the parameters of $dlspot_{t-k}$ for k = 1, 2, are successively: -0.1989, -0.1653 while the parameters of $dlfwd1_{t-k}$ for k = 0, 1, 2, are successively: 0.8473, 0.4022, 0.1793. The long run dynamics parameter is -0.7525. All of these parameters show significance. We find that when the *k*, the time lag denotation, gets bigger, the estimated parameter gets smaller, both in the case of the log returns spot rate and log returns 1-month forward rate. Meanwhile, Table 4.3 shows that the transition probability of regime change from Regime 1 to Regime 2 is only 5.26%. However, once Rp/USD movements enter the classification of behavior that matches the Regime 1, the probability that it will stay is 94.74% (Table 4.3) with the duration of 19 weeks

(Table 4.4). The first graph in Figure 4.1 exhibits probabilities of Rp/USD movements being in Regime 1.

Next we want to investigate the characteristics of Rp/USD movements in Regime 1, whether they are tranquil and dominated by the occurrence of the Rp/USD appreciation more than the depreciation or not. The estimation report shows that along the periods of Rp/USD movements which are categorized into Regime 1, the highest appreciation was 25.6% in February 20, 1998 when the rate was Rp9300/USD, down from the previous week's rate of Rp12500/USD.

Table 4.3: Matrix of transition probabilities

	Regime 1	Regime 2
Regime 1	0.9474	0.0526
Regime 2	0.0825	0.9175

Table 4.4: Duration of regimes

	Obs.	Probability	Duration*
Regime 1	250	0.6104	19
Regime 2	160	0.3896	12.13

Notes:
- * denote the length of week(s)
- No of Obs. denote the number of week(s) observed

The largest Rp/USD depreciation was 17.04% which took place in August 10, 1998. What confirms Regime 1 as the tranquil regime is the fact that the average Rp/USD appreciation and depreciation were 1.35% and 1.42%. We find also that toward the end of the sample period, the Rp/USD rate is stable, since the last 140 weeks of observation are categorized into Regime 1 with even lower appreciation and depreciation average of 0.72% and 0.64%. However, presently the domestic economic agents always feel more insecure when the Rp/USD rate depreciates rather than when it appreciates. Moreover, the perception among the domestic economic agents about the instability of the Rp/USD rate continues.

However, contrary to such belief, we find that the Rp/USD rate has been relatively stable in the long period of time. We can show that Regime 1 also covers three big events that shocked Indonesia, they are the October 12, 2002 Kuta-Bali bomb, the August 5, 2003 Marriott Hotel-Jakarta bomb, and the September 9, 2004 Australian Embassy- Jakarta bomb. The MS(2)-VECM(2) model detects these three occurrences and categorized them into Regime 1, which means that the weekly Rp/USD rate movements around those dates are considered stable by the model.

On the other hand, from the MS(2)-VECM(2) regime classification output, we can report that there are 250 weeks out of the estimated total of 410 weeks which fall into the classification of Regime 1, with the characteristics of the stable Rp/USD movements. However, despite the 19 weeks average duration of mild depreciation/appreciation in Regime 1, as shown in Table 4.4, there are 3 set of periods when depreciation/appreciation takes place consecutively for more than 19 weeks, as shown in Table 4.5.

We conclude that Regime 1 detects and classifies the Rp/USD rate movements well because it can precisely show the tranquil and stable periods of the rate. It does not fail in detecting the events when the mild Rp/USD appreciation and depreciation takes place.

Table 4.5: The periods of major consecutive mild appreciation / depreciation of Rp/USD rate in Regime 1 ($\geq$ 10 weeks)

Length of time	Period	Avg. Appr (%)	Avg. Depr (%)
20 weeks	Feb 7, 1997 – July 10, 1997	0.21	0.30
26 weeks	Dec 28, 2001 – June 21, 2002	0.90	1.20
76 weeks	Nov 11, 2003 – Apr 15, 2005	0.72	0.64

Note: Length of time shows consecutive weeks

Regime 1 also detects the stability of the Rp/USD movements during the big non-market events that brought shocks to Indonesia such as the militant bombings, which can help us concluding that the Rp/USD has been stable, contrary to the general belief of the domestic economic agents.

Regime 2

We find that Regime 2 classifies the unstable Rp/USD movements with high occurrences of depreciations. The Regime 2 MS(2)-VECM(2) estimation results in Table 4.3 shows that only two parameters are significant, and they are the estimated, $dlfwd1_t$ and CI1, the long run dynamic parameter with successively following parameters: 0.8119, and -0.5662.

Table 4.3 shows that the transition probability of regime change from Regime 2 to Regime 1 is 8.25%. Comparing the transition probability of regime changes, we find that the transition probability from Regime 2 to Regime 1 is bigger than the other way around. However, once the Rp/USD movements enter the classification of behavior that matches the Regime 2, the probability that it will stay is 91.75% (Table 4.3) with the stay duration of 12 weeks (Table 4.4). The second graph in Figure 4.1 exhibits probabilities of Rp/USD movements being in Regime 2.

Next we must investigate the Rp/USD rate movement behavior in order to understand Regime 2 better. From the estimation result, we find that the highest Rp/USD rate appreciation and depreciation which are detected by Regime 2 are 17.35% and 62.84%. The highest Rp/USD rate appreciation took place in October 23, 1998 when the rate moved from the previous week's Rp 10950/USD to Rp 9050/USD, while the highest Rp/USD rate depreciation took place in January 16, 1998 when it moved from Rp 5005/USD to Rp 8150/USD. Regime 2 also detects 160 weeks when the Rp/USD rate movements are considered to be instable. We find that the average appreciation and depreciation during these weeks are 3.65% and 5.05%, which considerably higher than the average in Regime 1. It is apparent that the identified periods in this regime are associated with the time of high turbulence of the Rp/USD rate. However the MS(2)-VECM(2) model detects that the time of high turbulence of the Rp/USD rate is already far behind, and the latest week that is classified into this period is the fourth week of October 2003. As mentioned earlier, the domestic economic agents still have the perception that the Rp/USD rate is unstable. However, our finding can explain that the period of the unstable Rp/USD has ended in July 2002.

Meanwhile from the MS(2)-VECM(2) regime classification output, we can report that there are 160 weeks out of the estimated total of 410 weeks which fall into the classification of Regime 2, with the characteristics of the unstable Rp/USD movements. However, despite the 12 weeks average duration of the unstable Rp/USD rate depreciation/appreciation in Regime 2, as shown in Table 4.4, there are 5 set of periods when the depreciation and the appreciation takes place consecutively for more than 12 weeks, as shown in Table 4.6.

Table 4.6: The periods of major consecutive unstable appreciation / depreciation of Rp/USD rate in Regime 2 (≥ 12 weeks)

Length of time	Period	Avg. Appr (%)	Avg. Depr (%)
13 weeks	Oct 17, 1997 – Jan 16, 1998	3.89	13.28
63 weeks	Feb 27, 1998 – Jun 25, 1999	4.68	5.01
25 weeks	July 23, 1999 – Jan 14, 2000	3.90	3.53
13 weeks	Sept 22, 2000 – Dec 29, 2000	1.64	4.03
13 weeks	Feb 23, 2001 – May 18, 2001	3.40	2.86

Note: Length of time shows consecutive weeks

We conclude that Regime 2 detects and classifies the unstable Rp/USD rate movements well because it can precisely show the turbulent periods in the observed sample. In particular, Regime 2 detects the relatively large Rp/USD rate appreciation and depreciation as can be inferred in the last two columns in Table 4.6. Definitely, it is characterized by the time of the abnormal Rp/USD rate movements, driven by anxiety and speculations in the market. Looking at the date of the occurrences, these depreciations represented the reaction from the market players more to the turbulence in the socio-political situation in Indonesia, rather than to the general macro-economic situation. The most succinct example is the 62.84% depreciation in January 16, 1998 which coincided with the food shortage panic and the social unrest, three days prior to that date. However we conclude that the regime 2 classification brings the good news for the domestic economic agents and the policy makers, that the period of the Rp/USD heavy turbulent is already far behind, as confirmed by the MS(2)-VECM(2). The last week that experienced heavy Rp/USD turbulent was in July 2002.

4.4. Transition Matrix that Predicts the Future of Rp/USD state

Other foresight which we can get from the model is the future Rp/USD transition probability, which inform us whether the rate will be behaving like it did in the regime 1 or 2 in the future. The less technical question is how likely will the Rp/USD rate movements be? Will it have the high probability to move up and down with stability or will it go unstable? This question is important for the policy makers to put forward, because they are interested in the set of information that can be used to guarantee their present policy's success in the future. For example, there are assumptions in the yearly planned Indonesian fiscal budget on the Rp/USD rate and the oil price. The Rp/USD rate assumption is made by the policy makers in the fiscal budget purpose because in their expenditure items, there are planned imports expenditures and the scheduled official debts repayments. A credible prediction on the Rp/USD's probable future behavior regime will surely help the policy makers in setting the Rp/USD rate assumption, thus eliminating the chances of the uneducated guess.

We are interested to investigate the h-steps prediction of the transition probability. What we are going to do next is to exploit the information set which is contained in the transition probability matrix, as shown in Table 4.3. What we know about this matrix is that it is a stochastic matrix because the row's total is equal to 1, and this main character will be used in the prediction. The matrix will be powered by itself over and over until we find the point when the convergence takes place, which means that the powered matrix' component does not change anymore from that point on, no matter how many times more it is powered. This convergence shows the long run predicted future of the Rp/USD's transition probability and we find it to take place in 140 weeks ahead after the last observation, April 2005. Next we will have the discussion on the theorem and the finding.

Theorem

Let **P** be the transition probability matrix of a Markov Chain, and let **u** be the probability vector which represents the regime changes possibility. Then the probability that the chain is in state s_i after h steps is the ith entry in the vector:

$$\mathbf{u}^{(h)} = \mathbf{u}\mathbf{P}^{h}$$

A primitive rows stochastic matrix **P** has the property that lim P^h has identical columns, and since the product of stochastic matrices is stochastic and the limit of powers of a stochastic matrix, all of whose elements are positive, is a matrix with identical columns, multiplying this limiting matrix on the right by any stochastic matrix leaves the former invariant.

Below is the h-steps ahead (h-weeks ahead) process of the MS(2)-VECM(2) transition matrix which goes from h = 1 to h = 140. As explained, the process involves powers of the matrix according to the *h*-steps ahead. The results show that after 140 steps ahead (which is equivalent to say 140 weeks ahead), our regime transition matrix predictions are independent of the initial start. That means, the probabilities of the regime transition will finally not change from Regime 1 to Regime 2, after 140 weeks ahead: 0.61, 0.39. And from the analytical point of view, this result confirms that in the long run, the spot rate of Rp/USD will have 61% probability to stay stable, and 39% probability to be unstable.

It is interesting to see that whatever the state of Rp/USD is in, the model always predicts that in the future, its rate will enter the regime of stability with higher probability than other Regime. Thus we can provide another fact that is contrary to the general domestic economic agents perception that the Rp/USD rate is unstable.

Meanwhile Figure 4.2 shows the interesting foresight on how the Rp/USD rate might behave in the future. Each graph below represents the transition probability in the *h* steps ahead.

Table 4.10: Transition matrix *h*-steps forecast

	h = 1	
	Regime 1	Regime 2
Regime 1	0.9474	0.0526
Regime 2	0.0825	0.9175

h = 4		*h = 10*	
Regime 1	Regime 2	Regime 1	Regime 2
0.8285	0.1715	0.7516	0.2484
0.2689	0.7311	0.3896	0.6104

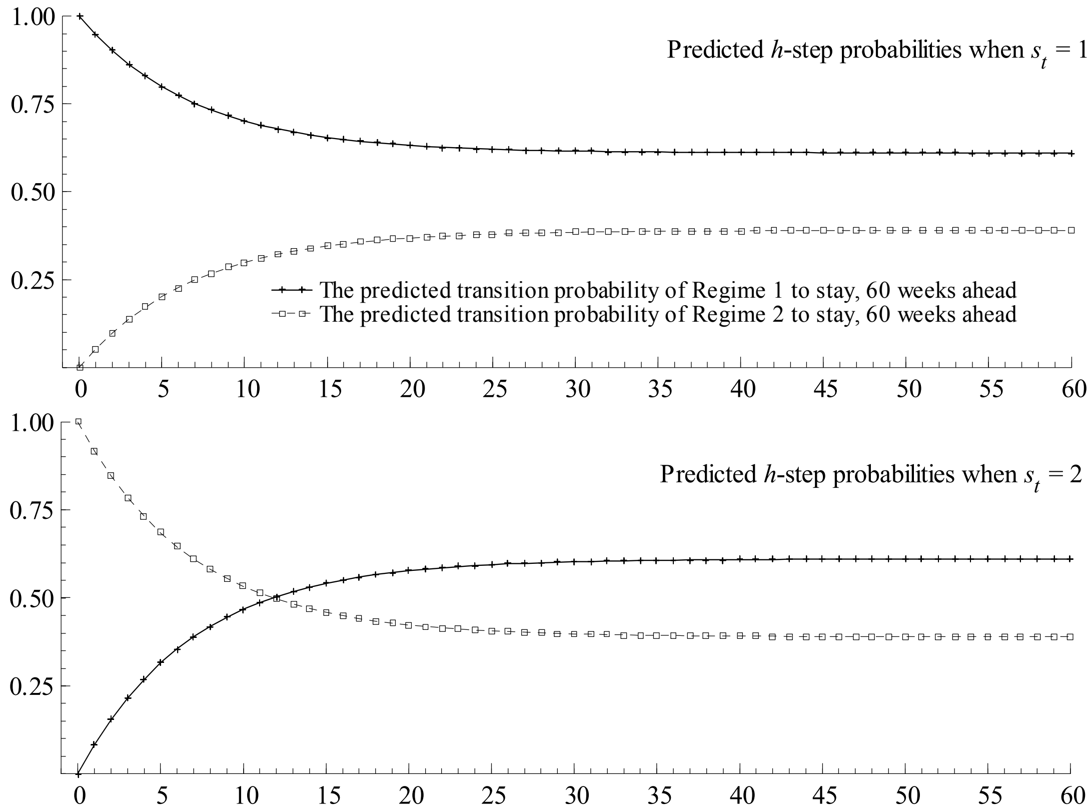
h = 20		*h = 40*	
Regime 1	Regime 2	Regime 1	Regime 2
0.7161	0.2839	0.6895	0.3105
0.4453	0.5547	0.4869	0.5131

h = 50		*h = 42*	
Regime 1	Regime 2	Regime 1	Regime 2
0.6392	0.3608	0.6320	0.3680
0.5659	0.4341	0.5772	0.4228

h = 60		*h = 140*	
Regime 1	Regime 2	Regime 1	Regime 2
0.6210	0.3790	0.6107	0.3893
0.5944	0.4056	0.6107	0.3893

The vertical axis represents the predicted probability value of the occurrence of a particular state in a particular regime while the horizontal axis represents the number of weeks ahead.

Figure 4.2: The *h*-steps predicted transition probability



Note:
- The vertical axis shows the probability
- The horizontal axis shows the number of weeks

The s_t refers to the regime, where $s_t = 1$ represents the regime of stable period, while $s_t = 2$ denote the regime of unstable period. The *h*-steps transition probability prediction is derived from the unique characteristics of the transition matrix in Table 4.3 where the total of the row is all 1. Here we have an intuition that the powers of the transition matrix will give us interesting information about the process as it evolves, that is the prediction on the future transition probability.

4.5. Conclusion

We find that MS(2)-VECM(2) detects and classifies Regime 1 and 2 reliably. We already investigate and prove that Regime 1 covers the period when the Rp/USD rate movements are relatively stable. Contrary to the ongoing perception that the Rp/USD is not stable, the model helps us understand that the exchange rate has been in the stable period, as the estimation shows that the last 140 weeks are categorized in Regime 1. This finding can be used to assure the domestic economic agents as well as the policy makers that the response to the Rp/USD latest movements does not need to be panicky. We can suggest that the domestic economic agents hedge their economic activities which are exposed to the Rp/USD exchange rate risk. With the relative calm Rp/USD movements like what we find from our model, the risk premium as indicated in the 1-month Rp/USD forward rate will be worth paying as they can be a good insurance for each international economic activity involving the Rp/USD exchange rate. On the other hand, the results in this chapter, together with the preceding chapter 3, also show that the 1-month Rp/USD forward rate is a reliable predictor of its spot rate, thus we can also suggest that the Rp/USD movement is very predictable in the short run.

Meanwhile in Regime 2, we find that the Rp/USD unstable movements are detected precisely. In Regime 2, the average Rp/USD appreciation and depreciation rate are 3.65% and 5.05%, while the highest appreciation and depreciation rate reach 17.35% and 62.84%. We find that Regime 2 detects the periods of high Rp/USD turbulence during the currency crisis in 1997 – 1999. What we can learn from Regime 2 is that the unstable Rp/USD rate period has already been in the past, even long time ago. The last year that Regime 2 detects the major unstable Rp/USD movements is in 2002 which already far behind. It is well known in Indonesia that after the 1997 crisis until at least the end of the observation period, April 2005, the economic agents, the asset holders, the policy makers, the press, the housewives, the petty traders, and many more respond very sensitively to the Rp/USD depreciation news by very often taking the illogical economic actions based on the fear and anxiety. Upon hearing the news of Rp/USD depreciation, the asset holders can suddenly ask the fund managers to withdraw their previously sound financial positions. Meanwhile the policy and law makers start to make comments and counter-comments in the press regarding the latest Rp/USD depreciation behavior, merely based on what they think they know, not on what the facts say. The long memory of the 1997 currency crisis still lingers very strongly and only with the consistent and credible policy stance regarding the Rp/USD, then the education about the new exchange rate behavior can be invested in the mind of the economic agents with a positive result. We see that our finding can help by showing that the unstable Rp/USD rate period is already the thing of the past, even long time ago.

On the other hand, we predict that the future Rp/USD movements, at least 140 weeks ahead, will have a 61% probability that it will go on stable. Meanwhile the transition probability shows that once the Rp/USD rate enters the stable period, like the last 140 weeks in our observation sample, then the chance that it will transition to the period of unstable movements is only 5.26%. That explains why we find in Regime 1 that even during the last 140 weeks in our observation sample, the Rp/USD rate has been going very stable with only 0.72% and 0.64% average appreciation and depreciation. It is almost impossible that the Rp/USD will suddenly become jumpy after this very long period of stability. Thus, we find no evidence that the Rp/USD is in the unstable regime, and there is no evidence that the exchange rate will depart from the stable to unstable regime since the probability of such transition is very little as shown in Table 4.3.

Chapter 5

Stochastic Volatility Model for Daily Rupiah, Yen, Singapore Dollar, Baht, and Peso, All Against US Dollar

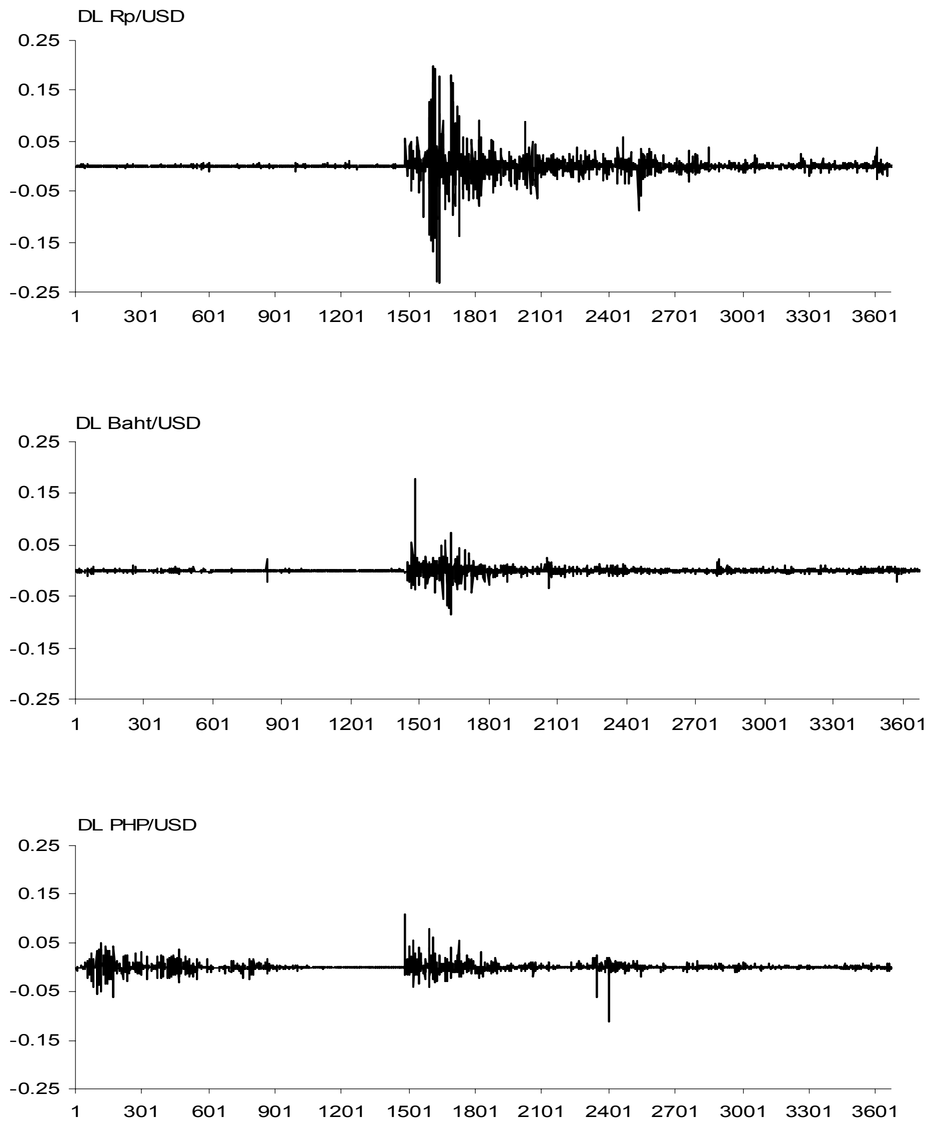
5.1. Introduction

The volatility of exchange rates has been related to the speculative motives in the international financial transaction. A study by Wei and Kim (1997) shows that the market participants' position taking is likely to have contributed to an increase in the exchange rate volatility. However, exchange rate volatility can increase because of the central bank interventions (Dominguez, 1998). Surprisingly, such interventions need not be publicly known in order to increase volatility. This result provides evidence to support the hypothesis that the more ambiguous non-market signals from such interventions, the more likely they are to increase volatility. On the other hand, Melvin and Yin (2000) found that higher than normal public information brings more than the normal quoting activity and volatility. They suggest that their results have implications for the debate over the regulation of the foreign exchange market and also that the foreign exchange trade activity is not largely self-generating.

Meanwhile, an abnormal volatility can introduce the element of uncertainty to the economy. Viaene and de Vries (1992) show how changes in the first and second moments of the exchange rate theoretically affect trade flows. Other study by Berger *et al*. (2000) shows different perspective on how countries that deviate from their model's predicted regime by choosing fixed instead of floating exchange rates will generally suffer higher exchange rate volatility compared to countries that chooses a fixed exchange rate regime.

For a small open economy which already adopts the free-float exchange rate system, experiencing volatility in a foreign exchange rate is in fact normal. The abnormal exchange rate volatility introduces uncertainties in various aspects in the production planning, debt repayments, planned expenditures, and even the assumption made by governments on their fiscal budget. Although the modern financial market provides means to prevent or deter the adverse effect of the uncertainty in the international transaction, involving foreign exchange. However, a less volatile environment or predictable and anticipated exchange rate volatility is most surely preferable.

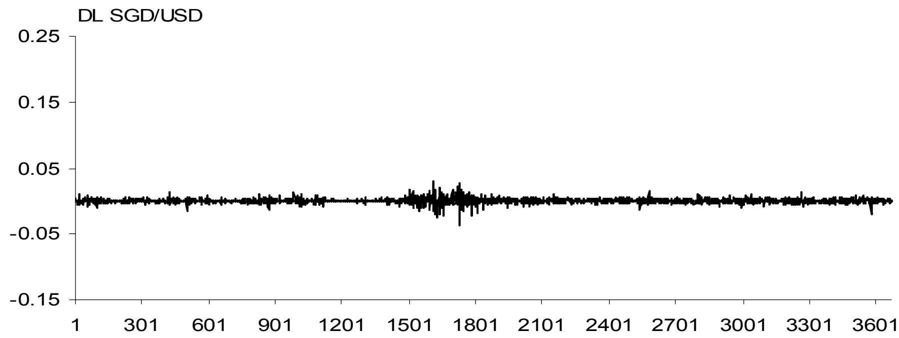
Figure 5.1.A: The log returns of daily Rupiah, Baht, and Peso against USD, 1991-2005

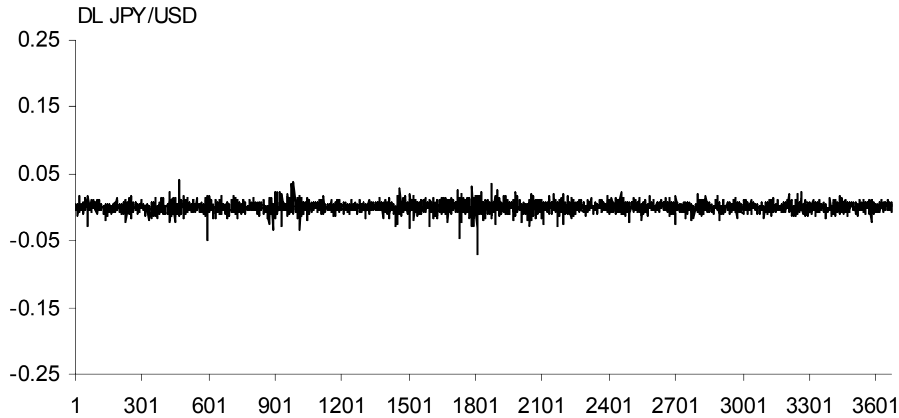


Notes:

- DL: differenced logarithm, calculated from the daily data
- Period is June 1991 – Nov 2005
- Data source: Bloomberg

Figure 5.1.B: The log returns of daily Singapore Dollar and Japanese Yen against USD, 1991-2005





Notes:

- DL: Differenced Logarithm, calculated from the daily data
- Period is June 1991 – Nov 2005
- Data source: Bloomberg

In regards to this chapter, it is found from the literature study that most of the research on Rp/USD focuses on the structural studies or the study on its nominal rate behavior and time series. Referring to the latter, in the mathematical statistics term they are studies about the first moment of the time series data of Rp/USD. Meanwhile there are four moments in the statistical study of time series: mean (the first moment), variance/volatility (the second moment), skewness (the third moment), and kurtosis (the fourth moment). Based on the study on statistical moments, a research focusing on the second moment, that is, the volatility of the Rp/USD nominal rate, would enrich the understanding of its behavior, and moreover has policy implications.

In the case of Indonesia, after the free float exchange rate regime was implemented on August 14, 1997, the Rp/USD volatility had completely changed. In the mean time, in approximately the same period in 1997, other South East Asian currencies also showed the same increasing volatility, as shown in Figure 5.1.A and 5.1.B.

It is interesting to investigate whether these currencies' volatility co-move, or else, whether one currency's volatility triggers other regional currencies volatility movement. In fact, the 1997 currency speculative attack contagion took place right after the Thai Baht crisis started. It was as if the upsurge of the volatility in one currency diffused and had spread the tensions all throughout the South East Asian economies through the high degree of openness, and through the intra-regional trade. Therefore, investigating the volatility of the regional currencies movement would be a necessity, especially for the cases dealing with the Rupiah, Yen, Singapore Dollar (SGD), Baht, and Peso, all against the USD. These currencies are from countries with very close proximity in terms of location, regional financial market, and also in terms of the regional trade activity. And as the crisis came about in 1997-1998, Baht succumbed to the speculative attack first, followed by a great pressure to the entire regional market, even as far-flung as Korean Won, Hong Kong Dollar and also to the Australian Dollar.

This work concentrates on the volatility of the exchange rates of the following countries: Indonesia, Japan, Singapore, Thailand, and Philippines. The aim of this work is to investigate how the stochastic volatility (or stochastic variance; both terminologies will be used interchangeably from this point on) of four major Asia Pacific regional currencies: Yen, SGD, Baht, and Peso, can be related to the volatility of Rupiah, all against the USD. Principally the focus of investigation in this chapter is the second moment of the data of those currencies. The importance of this study lies with the fact that the exchange volatility may have a big policy implication, especially for Indonesia, which adopts the free float exchange rate system and also the inflation-targeting framework in the monetary policy. With the free-floating exchange rate system in one hand and the inflation targeting framework on the other hand, the authority cannot target the rate but only the volatility, in order to contain the excess volatility. The excessive volatility of the exchange rate can disrupt the expectation about the import prices, making it difficult for the economic agents to make plans for imports.

Thus, the prime focus is indeed to investigate Rp/USD's stochastic volatility and the policy implication for the central bank. The univariate model is estimated to draw statistical summary of each currency's time series and to better understand ways to approach the multivariate stochastic volatility model. Meanwhile, the multivariate model will be estimated to investigate the exchange rates volatility correlation.

There are at least three exchange rate stochastic volatility papers that can be insightful starters for our own investigation. Nakatsuma (2000) investigated the structural changes in the Asian foreign exchange rates volatility after the Asian financial crisis. He estimated the break points and the changes in volatility of daily returns for the six Asian currencies. He finds that the break point of Baht, the trigger of the greater scale currency crisis in the region, indeed took place 2 months before July 2, 1997, the date when speculative attack on the currency started. Meanwhile, Lee (2000) investigates how volatility in the Won/USD daily rate changed before and after the currency crisis. His approach is with the ARMA-Stochastic Volatility model. His study confirms that the daily Won/USD rate volatility increased after the crisis. The other work by Harvey *et al*. (1994) is most important. Although this work was made earlier than the previous two that we have just discussed, we deliberately mention it last in order to stress its importance. The study sets the standard on how the multivariate stochastic volatility model can be developed to explain unobserved components of high frequency exchange rate time series of 4 major currencies in the world, and draw robust conclusions on the volatility and common factors that determines it.

This chapter approaches the investigation using the stochastic volatility model and will make a special reference to Harvey *et al*. (1994). The stochastic volatility model contains the unobserved variance component in the time series being investigated. Following Harvey *et al*. (1994), the logarithm of the unobserved variance component is modeled in a linear stochastic process, in the form of autoregression. This approach applies to both univariate and multivariate case.

Thus, section 5.1 introduces the issues being investigated. Section 5.2 will discuss the system of the methodology, the univariate as well as the multivariate stochastic volatility models, and also provide a brief description of the data. Section 5.3 discusses results of the empirical work, where the estimation result of univariate and multivariate stochastic volatility models will be reported. We want to investigate the exchange rate volatility correlation by also focusing on the covariance and correlation matrices. In section 5.4, we will discuss the salient analysis about the Rp/USD volatility. And finally in section 5.5, the conclusion of the whole work will be discussed.

5.2. Univariate and Multivariate Stochastic Volatility Model Set Up, Methodology, and Data

5.2.1. Univariate Model

Let y_t be the return of a particular exchange rate in concern, made up by components:

$$y_t = \psi \exp\left(h_t/2\right)\varepsilon_t \sim NID\,(0,1), \tag{5.1}$$

$$h_t = \log\left(\sigma_t^2\right) = \phi_0 + \phi_1 h_{t-1} + \eta_t \sim NID\left(0, \sigma_\eta^2\right), \tag{5.2}$$

where $\psi \exp\left(h_t/2\right) \equiv \varsigma_t$ is the variance in time t. Thus h_t represents the unobserved volatility of the process y_t. If $|\phi_1|<1$, by standard theory, then h_t is strictly stationary.

Several studies by Harvey *et al*. (1994), Mahieu and Schotman (1998), Gallant *et al*. (1994), Kim *et al*. (1998), and Jacquier *et al*. (2003), discuss about the fat-tailedness and the non-normality of exchange rate error diffusions. In Harvey *et al*. (1994), the assumption of normality for ε_t is relaxed by letting it have the student t-distribution. Normality of ε_t is assumed in this work because the number of observation is very large. Student t-distribution approaches normal distribution when the number of observation is large. Meanwhile, Kim *et al*. (1998) found that the departure of normality condition is primarily due to a few outliers, and is not severe in the case of daily Poundsterling/USD in their study. However it is found in Mahieu and Schotman (1998) that the estimation results on the exchange rates volatility persistence vary systematically with the estimation methods. They found that the differences are due to the auxiliary assumption about the normality of the exchange rates' innovations conditional on the volatility. It also was explained how ignoring the occurrence of outliers, and thus not modeling the deviations from normality, leads to the biased low estimates of the persistence in the volatility process. However, this chapter leaves the discussion and investigation of the relaxation of normality assumption of these five regional Asian currencies for the future research.

In the time series process of Rp/USD, the volatility is investigated. In the estimation of the stochastic volatility model, the likelihood for the probability density function follows this integral equation:

$$L(Y_t;\theta) \equiv \int f(Y_t \mid H_t;\theta) f(H_t \mid \theta)\,\mathrm{d}H_T, \tag{5.3}$$

where:

Y_t = data observed with T length of time,

$H_T \equiv (h_1,\ldots,h_T)'$, is the latent volatility vector,

$\theta = (\phi,\sigma,\psi)$ is the estimated stochastic volatility model parameters.

In the integral (5.3) we can recognize three hierarchical structures of the conditional distribution function in the SV model: $f(Y_t \mid H_t;\theta), f(H_t \mid \theta),\ f(\theta)$. The likelihood principle in (5.3) works as follow: *given* the estimated θ, the conditional probability $P(H \mid \theta)$ in the $f(H_t \mid \theta)$ is used to estimate and explain the variance *H*, and *given* the estimated *H*, thus the likelihood function $f(H_t \mid \theta)$ and $f(Y_t \mid H_t;\theta)$ are used to reason about θ and Y_t. Given Y_t, the likelihood function $f(Y_t \mid H_t;\theta)$ is used to reason about H_t.

The parameter in the SV model will be estimated by using the quasi maximum likelihood. It requires that (5.1) and (5.2) should be rewritten:

$$y_t \equiv \sigma_{\phi 0}\varsigma_t\varepsilon_t, \tag{5.4}$$

where $\sigma_{\phi 0} = \exp(\phi_0/2)$ and $\psi\exp(h_t/2) \equiv \varsigma_t$.

In (5.4) another important process is to express the stochastic volatility in h_t by modeling it as an AR(1) stochastic process:

$$h_t = \phi_1 h_{t-1} + \eta_t \sim NID\left(0, \sigma_\eta^2\right). \tag{5.5}$$

If $\phi_1 = 1$, the process is *random walk*, and if $|\phi| < 1$, h_t is stationary.

Subsequently, the estimation of SV model with quasi maximum likelihood requires the linearization and the rewriting of (5.4):

$$\log\left(y_t^2\right) = \kappa + h_t + u_t, \tag{5.6}$$

$$h_t = \phi h_{t-1} + \eta_t,$$

where,

$$u_t = \log\left(\psi_t^2\right) - E\left(\log\left(\psi_t^2\right)\right), \quad (5.7)^3$$

$$\kappa = \log\left(\sigma_{\phi 0}^2\right) + E\left(\log\left(\psi_t^2\right)\right). \tag{5.8}$$

Hence, the estimation of the stochastic volatility model for the exchange rates being investigated will result in the stochastic volatility of each of the exchange rate. The estimated parameters are ϕ, σ, and ψ. This will enable us to acquire h_t, the stochastic volatility of the exchange rate.

5.2.2. Multivariate Model

The multivariate stochastic volatility model follows easily from the univariate settings. Let y_t be a (N x 1) vector with components:

$$y_{it} = \psi \exp\left(h_{it}/2\right)\varepsilon_{it}, \; i = 1, ..., N, \; t = 1, ..., T, \tag{5.9}$$

[3] Note: $u_t = \sigma^2_{\log\psi,t} = E\left[\log(\psi) - E(\log(\psi))\right]^2 = \log\left(\psi^2\right) - E\left(\log\left(\psi^2\right)\right)$

where y_{it} denote the observed variable at time t of series I and $\varepsilon_{it} = (\varepsilon_{1t}, .., \varepsilon_{Nt})'$ is a multivariate normal vector with zero mean and a covariance matrix, Σ_ε, in which the off-diagonal elements are the estimated correlations.

Meanwhile the AR(1) of (5.6) in the multivariate framework becomes:

$$h_{it} = \phi_i h_{it-1} + \eta_{it}, \tag{5.10}$$

where i = 1, …, N, and $\eta_{it} = (\eta_{1t}, ..., \eta_{Nt})'$ is multivariate normal with zero mean and covariance matrix Σ_η. As in the univariate stochastic volatility model, ε_{it} and η_{it} are uncorrelated.

5.2.3. Methodology

The estimation of the univariate stochastic volatility model will be carried out in order to investigate the volatility component of each currency's time series. The univariate model report will include the diagnostic summary statistics and the discussion. Meanwhile the multivariate stochastic volatility model approach is similar to the univariate's, except that y_t is now an N X 1 vector of observations. The multivariate stochastic volatility model is estimated to investigate the principal components of matrix Σ_η, which is the variance matrix, which corresponds to the variance parameters of series being investigated. The upper-right triangle part of this N X N variance matrix reports the correlation of the disturbances driving the components. The link of the different series is thus established through the correlations of the disturbances in the variance matrix.

The multivariate stochastic volatility model allows us to place restrictions on the model, such as, the imposition of common trends. By reducing the rank of the covariance matrix, we can re-estimate and re-investigate the entire result. The parameters of both models will be estimated by using quasi maximum likelihood (QML) approach, following Nelson (1988) and Harvey *et al.* (1994). This approach has been widely supported by a number of researchers. Ruiz (1994) shows that quasi maximum likelihood estimator is consistent and asymptotically normal. Andersen and

Sørensen (1996) show that quasi maximum likelihood estimator dominates the generalized methods of moment (GMM) estimator for models with a high degree of persistence. Sandmann and Koopman (1998) as well as Breidt and Carriquiry (1996) also support the use of the approach in their research. Moreover, Hwang and Satchell (2000) and Yu (2002) also show that the quasi maximum likelihood procedure is extremely flexible and has been extensively implemented for the empirical analysis of financial returns. Broto and Ruiz (2005) use this approach by linearizing the stochastic volatility model and taking the logarithms of squares as explained in (5.6).

5.2.4. Data

The variables observed are the following currencies: Rupiah (Indonesia), Yen (Japan), Singapore Dollar (Singapore), Baht (Thailand), and Peso (Philippines), all against the USD. The frequency is daily and the observation period is from August 14, 1997 until the end of November, 2005, with number of observation: 2165.

5.3. Empirical Result

Five daily time series of Rp/USD, Yen/USD, SGD/USD, Baht/USD, and Peso/USD are investigated in this empirical part. The period of observation is chosen to include the day when Rp/USD was officially freely floated, August 14, 1997 until the end of November 2005.

5.3.1. Univariate Stochastic Volatility Model Result and Statistical Summary

We refer again to equation (5.1) and (5.2) for our univariate stochastic volatility model estimation. What we estimate is the stochastic volatility of series, y_t, of each currency in the returns form (first difference of the log y_t) as a dependent variable. However, before we estimate the univariate stochastic volatility model, an innovation must be done towards the stochastic volatility of y_t, since the model will _ run in the log form. A practical problem will arise if some of the observations are zeros or even negatives, where in such cases their logarithms cannot be taken. To treat these technicalities, we refer to Koopman *et al*. (2000), Fuller (1996) and Breidt and Carriquiry (1996), and use the stochastic volatility transformation as follows:

$$\log y_t^2 \cong \log\left(y_t^2 + cs_y^2\right) - cs_y^2 \big/ \left(y_t^2 + cs_y^2\right), \quad t = 1, \ldots, T, \qquad (5.11)$$

where $s_y^2 =$ the sample variance of the y_t and $c =$ is a small number, in our case 0.02.

The $\log y_t^2$ in (5.11) enters the univariate stochastic volatility model in (5.6), and then will be estimated to get the parameters of the unobserved components. Let $\log y_t^2$ denotes stochastic volatility of the series of each currency being investigated. As described earlier, we linearize the system of (5.1) and (5.2), and then estimate the parameters of the unobserved components of the series with the fixed trend level component (κ), the autoregression (of degree 1 – AR1), and the irregulars (ξ_t), as explicitly expressed in (5.6):

$$\log y_t^2 = \kappa + h_t + \xi_t .$$

Moreover, according to Durbin and Koopman (2001) the concept of state in time series analysis is important. Whittle (2004) suggests the simplest state-structured model in that line, that is, AR(1). Thus h_t in (5.6) denotes the volatility process of the series, which will be modeled as AR(1). We estimate the parameter using the STAMP 5.0 software.[4]

Preliminary Statistical Tests Report

First, we want to report the several statistic tests: normality test, heteroskedasticity test, Box-Ljung serial correlation test, based on Koopman *et al*. (2000). Such tests serve the purpose of understanding the nature of series being investigated. Normality test is the Doornik and Hansen statistic, which is the Bowman-Shenton statistic with the correction of Doornik and Hansen (1994). This normality test is distributed

[4] STAMP stands for The Structural Time Series Analyser, Modeller, and Predictor. This software is devoped by Siem Jan Koopman, Andrew C. Harvey, Jurgen A. Doornik, and Neil Shephard.

approximately as χ_2^2 under the null hypothesis. It basically tests the third and fourth moments of the residuals, with the said χ^2 distribution and 2 degrees of freedom. The 5% and 1% critical value of χ_2^2 are 5.99 and 9.21. High normality values show that there are outliers in the series.

By doing cumulative sum (CUSUM) graph we assess whether the first moment of the residuals process changes over time, as discussed by Koopman *et al.* (2000). CUSUM test which is carried out is defined by:

$$\text{CUSUM}(t) = \hat{\sigma}_y^{-1} \sum_{j=1}^{t} \left(y_j - \bar{y} \right), \quad t = 1, \ldots, T , \tag{5.12}$$

where $\bar{y} = \frac{1}{T} \Sigma_{j=1}^{T} y_j$ and $\sigma_y = \sqrt{\frac{1}{T} \Sigma_{j=1}^{T} \left(y_j - \bar{y} \right)}$. If the mean of the residuals changes through its standard, it will have runs of positive or negative observations.

Therefore, the CUSUM will drift up (or down), before going back to zero at CUSUM(T). A formal check on the CUSUM is given by up and below boundary lines based on a significance level of 10%, given by:

$$\text{CUSUM} = \pm \left[0.85\sqrt{T} + 1.7t / \sqrt{T} \right]. \tag{5.13}$$

Meanwhile, to investigate further the residuals, we also apply CUSUM of squares (will be referred as CUSUMSQ) which is indeed similar to the CUSUM, albeit it is to detect a change in variance over time:

$$\text{CUSUMSQ}(t) = \sum_{j=1}^{t} \left(y_j - \bar{y} \right)^2 \Big/ \sum_{j=1}^{T} \left(y_j - \bar{y} \right)^2, \quad t = 1, \ldots, T . \tag{5.14}$$

CUSUMSQ increases along the time, and if the model is homoskedastic, this increase shall be linear, up following a positively sloped straight line in the graph that is supposed to be 45°. A breach somewhere along this 45° line means the emergence of the heteroskedasticity. Thereby these two additional residual tests will be of interest for the continuation of this research since they _ propel questions on why and how the series behave in a particular way.

Figure 5.2: Normality, density, histogram of residuals currencies stochastic variance in returns

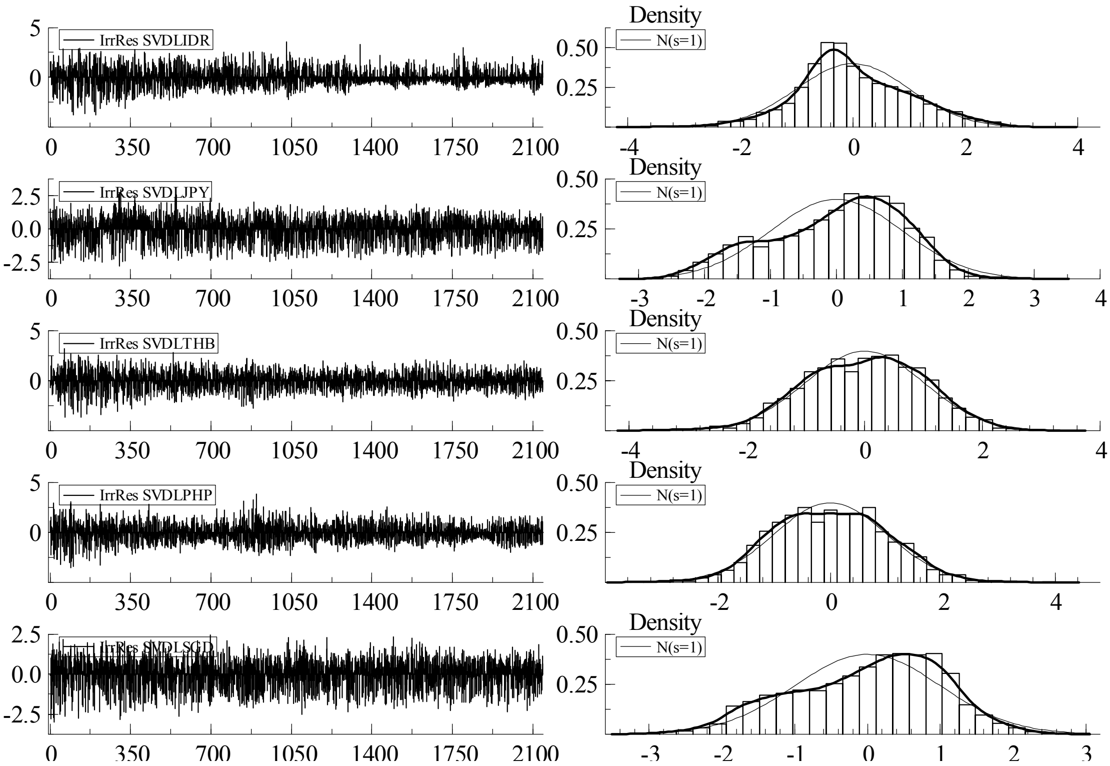
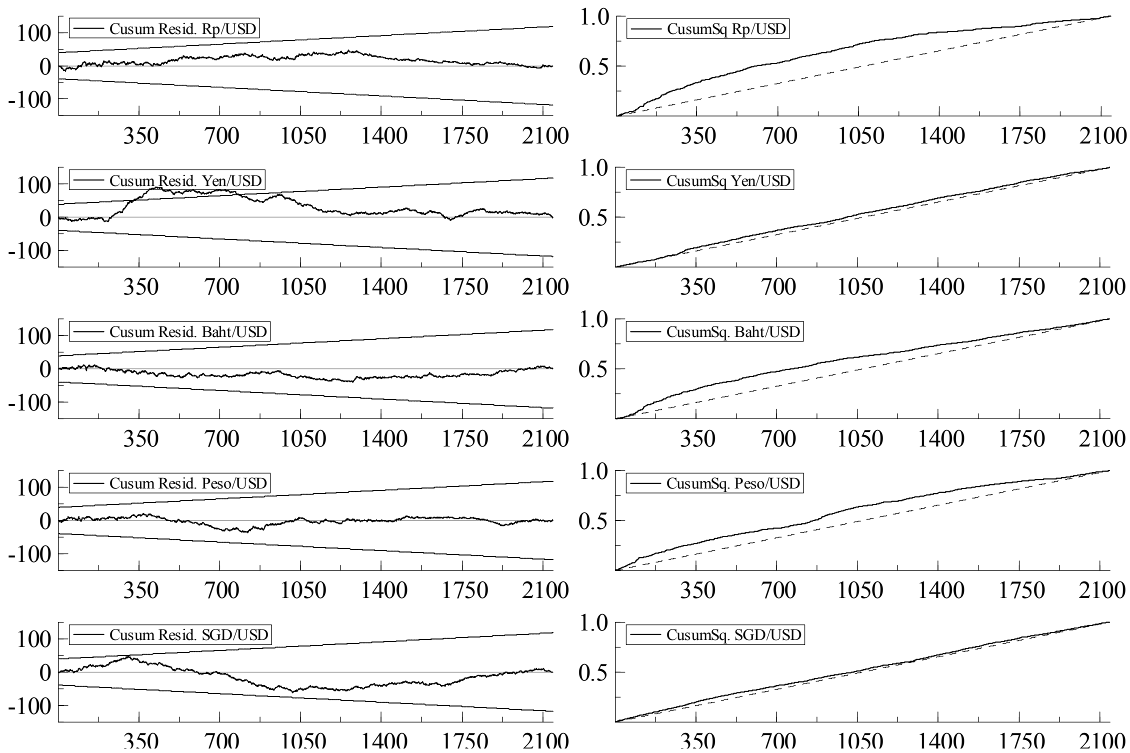


Figure 5.3 shows that the mean of variance changes during the sample period. It seems that Rp, Yen, SGD, Baht, and Peso variance means converge to close to zero line toward the end of sample period, which is in fact close to conformity with the condition stated in (5.2). On the other hand the CUSUMSQ graphs show that nearing to the end of the sample period, the variances converge to the 45 degree line, which means that variances become less heteroskedastic toward the end of the sample period. It is clearly visible by identifying the little hills and troughs around the positively sloped straight line. It is obvious that indeed lately each currency becomes less volatile as compared to 2-3 months before the end of sample period. From Figure 5.2 we easily recognize that once, Rp, Baht, and Peso volatility increased for a long period, approximately 2000 days since the beginning of the sample period.

Heteroskedasticity test statistic, $H_{(h)}$, is the ratio of the squares of the last h residuals to the squares of the first h residuals where h is set to the closest integer of the number of observations divided by 3. It is centered around unity and should be treated as having an F distribution with (h, h) degrees of freedom. A high (low) value indicates an increase (decrease) in the variance over time by Koopman *et al*. (2000).

Figure 5.3: CUSUM and CUSUMSQ tests for stochastic variance of currencies returns



Meanwhile Box-Ljung test, $Q(p, q)$, is the statistic report based on the first p autocorrelations, where it should be tested against at χ^2 distribution with q degrees of freedom. Notice that the loss in the degrees of freedom q of the Box-Ljung Q-statistic takes into account the number of relative parameters in the maximum likelihood estimation process.

Univariate Stochastic Volatility Model Estimation Report

In Table 5.1, the univariate stochastic volatility model estimation shows that AR(1) coefficients are all less than 1, conforming the condition set in equation (5.2). The AR(1) coefficient for Rp/USD, Yen/USD, SGD/USD, Baht/USD, and Peso/USD are successively 0.972, 0.993, 0.99, 0.989, and 0.978. Meanwhile, $\hat{\sigma}_\eta^2$ is the variance of the AR in (5.2) and has a straightforward interpretation. We get high normality statistics for the residuals of all series, Rp/USD, Yen/USD, SGD/USD, Baht/USD, and Peso/USD (and p-values inside the brackets): 53.78 [0.00], 114.93 [0.00], 77.81 [0.00], 0.23 [0.41], 6.92 [0.00]. Against 5% and 1%, all p-values of all series residuals indicate non-normality of the residuals except for the Baht/USD. The normality statistic is considerably high amongst these currencies due to outliers. However, future studies on these Asian currencies with more focus on the non-normal diffusions is indeed encouraged.

Table 5.1: Univariate stochastic volatility model estimation result of daily returns, Aug 14, 1997 – Nov 30, 2005

Parameter	Rp/USD	Yen/USD	SGD/USD	Baht/USD	Peso/USD
ϕ	0.971874	0.99266	0.990263	0.989046	0.978513
$\hat{\sigma}_\eta^2$	1.6115	0.016482	0.017802	0.22947	0.038473
Norm.	53.785	114.93	77.809	0.22947	6.9254
	[0.00]	[0.00]	[0.00]	[0.4093]	[0.00]
$H_{(713)}$	0.29916	0.80588	0.82841	0.52443	0.50260
	[1.00]	[0.9980]	[0.9940]	[1.00]	[1.00]
$Q_{(10,8)}$	53.978	10.911	5.9341	13.7	17.184
	[0.00]	[0.21]	[0.65]	[0.09]	[0.03]
Log L	-1024.34	-1244.1	-1169.27	-1035.16	-1055.79

Notes:

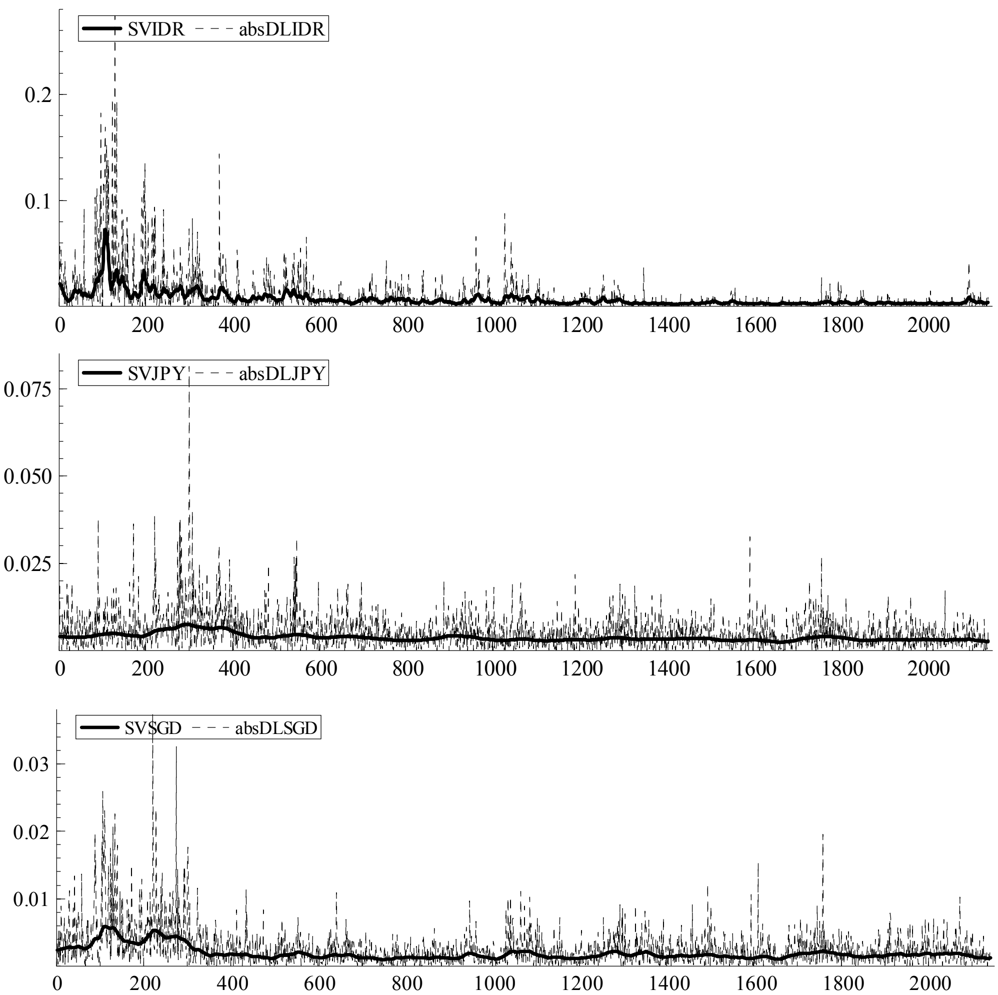
- ϕ = estimated AR(1) coefficient of equation (5.2)
- $\hat{\sigma}_\eta^2$ = variance
- Log L = Log likelihood
- Norm = the Doornik-Hansen statistic, which is the Bowman-Shenton statistic with the correction of Doornik and Hansen (1994), distributed approximately as χ_2^2 under the null hypothesis.
- $H_{(h)}$ = a test for heteroskedasticity, distributed approximately as $F_{(h,h)}$
- $Q_{(P,d)}$ = Box-Ljung Q-statistic, based on the 1st P residual autocorrelations & distributed approximately as χ_d^2
- number(s) inside [ ] denote p-value

The heteroskedasticity statistical reports of Yen/USD and SGD/USD show proximity to unity: 0.80 and 0.83, except for Rp/USD, Baht/USD and Peso/USD. We understand this as an indication that high increase of variance does not apply to the Yen/USD and SGD/USD, and it happens otherwise for the other three currencies.

However, Baht/USD and Peso/USD show decreasing variances toward the end of sample period. On the other hand, the Box-Ljung Q-test shows that for the first 10 lags of the residuals for Yen/USD and SGD/USD the null hypothesis of residual autocorrelation is strongly rejected, while for Rp/USD and Peso/USD is not. For Baht/USD test, it is rejected within 5% p-value.

The estimation of the univariate stochastic volatility model requires us to focus on (5.1), (5.2), (5.6), and (5.11). When we formulate the model, we set the time series components as follow: the level of trend is fixed with no slope while AR and irregular are allowed. Basically what we are looking for is the estimation of the stochastic variance of series that is being investigated, that is h_t in (5.2).

Figure 5.4.A: Absolute log returns of Rp/USD, Yen/USD, SGD/USD and the stochastic volatility



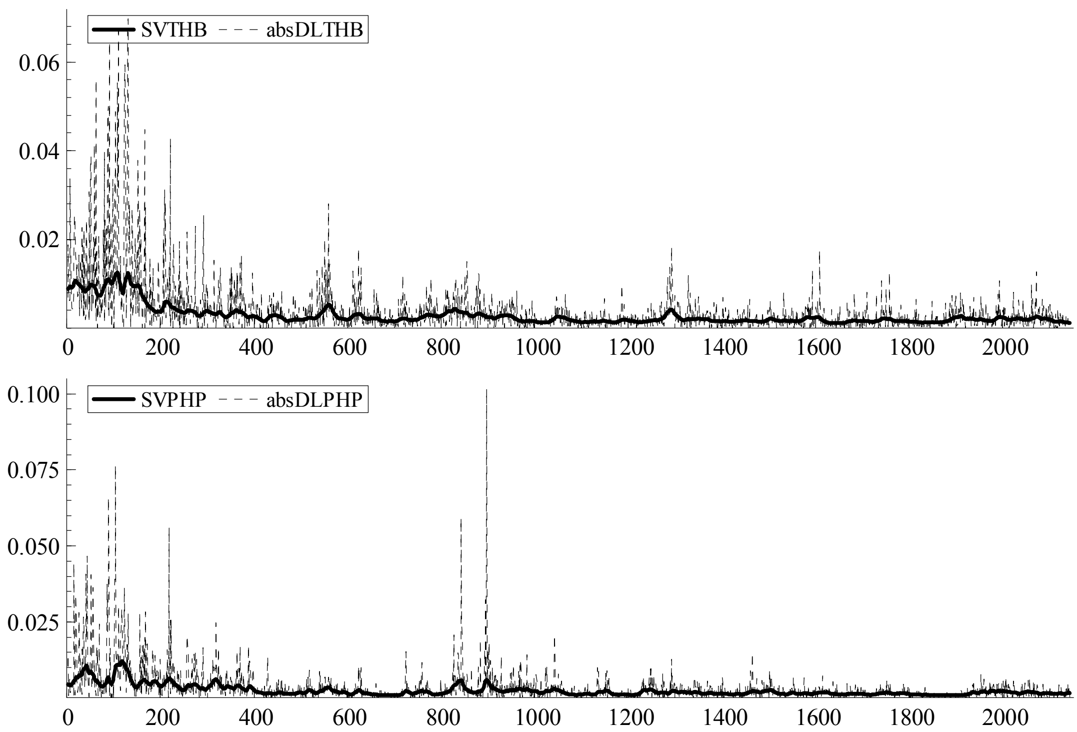
Notes:

a. SV refers to the Stochastic Volatility
b. absDL refers to the absolute term of the Differenced Logarithm (Returns)

The elements of unobserved components of trend plus AR, h_t, is the smoothed implied volatility in logarithm form. We want to calculate the anti-log of the trend plus AR to get the real σ_η^2. Taking the square root will make its standard deviation, that is the stochastic volatility. Its plot with the absolute value of returns of the currencies is shown in Figure 5.4.A and 5.4.B.

Thus, Figures 5.4.A and 5.4.B show the stochastic volatility of the exchange rates being investigated. All except for the Japanese Yen show high stochastic volatility in the early period of the sample that is from the start of the period, August 14, 1997 until approximately 400 days after, that is February 24, 1999.

Figure 5.4.B: Absolute log returns of Baht/USD, Peso/USD, and the stochastic volatility



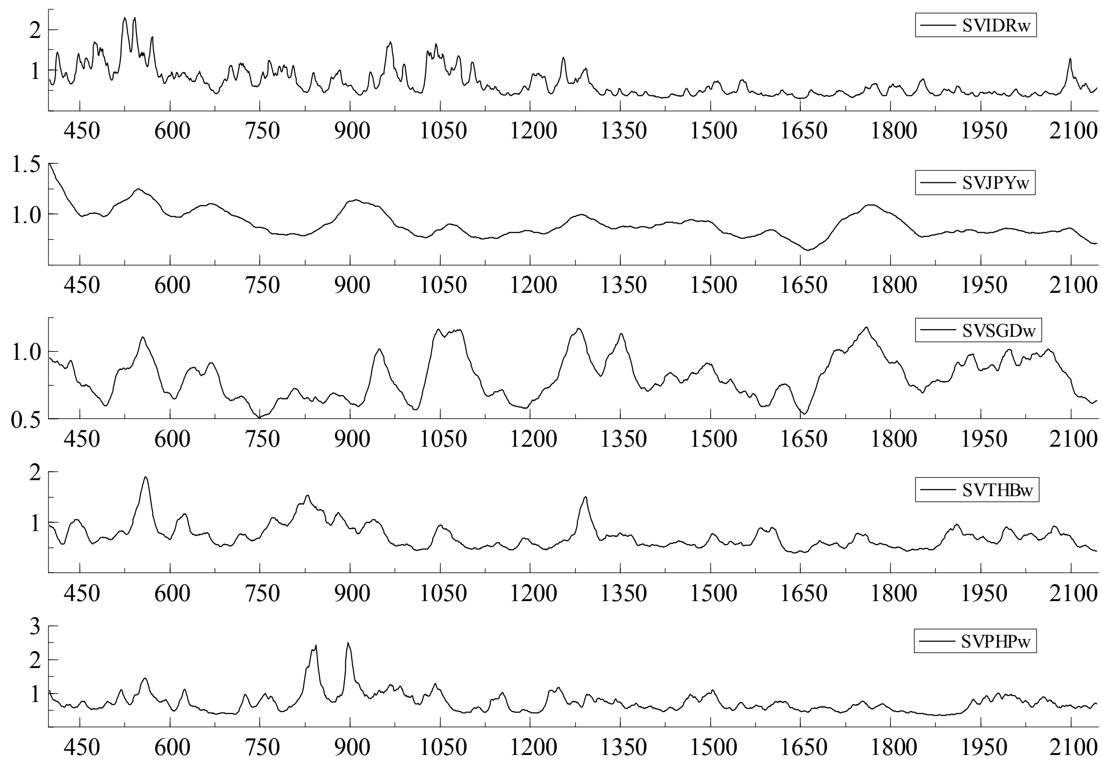
Notes:

- SV refers to the stochastic volatility
- absDL refers to the absolute term of the differenced logarithm (returns)

The stochastic volatility is shown by the thick line that is buried under the absolute value of the returns in logarithmic value of daily currencies. To really see what happened during this period, we need to zoom in the sample period, starting from February 24, 1999 until November 11, 2005 as can be seen in Figure 5.5.

Figure 5.5 shows that the Rp/USD stochastic volatility has rougher peaks and troughs, as compared to other currencies. This kind of behavior can be attributed to several factors. First, it can be that Rp/USD daily market was thin, so whenever big participants entered the market of Rp/USD then their position takings would induce other participants with speculative motives to anticipate the potential rise or decrease of volatility in the market. The rise and decrease of volatility inherently brought opportunity to reap gain. When the size of the market of Rp/USD was limited, such behavior of major participants would certainly contribute to the increases and decreases of the exchange rate volatility, more than those of other currencies which have larger market size.

Figure 5.5: Mean weighted stochastic volatility of Rp, Yen, SGD, Baht, and Peso, all against USD, observation # 400 - # 2143 (Feb 24, 1999 – Nov 11, 2005)



Notes:
- SV refers to the stochastic volatility, and “w” means weighted
- Stochastic volatility presented, is weighted by each stochastic volatility series’ mean

Second, other possible reason is that Rp/USD was actively being traded after the repeated mixed signal of intervention that came from Bank Indonesia, the central bank. As investigated by Dominguez (1998), such intervention by the central bank need not be publicly known in order to increase volatility which provides evidence in support of the hypothesis that the more ambiguous non-market signals from such intervention operation, the more likely they are to increase volatility. This explains that Bank Indonesia can always have reasons to intervene the Rp/USD market whenever it deems appropriate.

The closest to the Rp/USD volatility is the Peso/USD volatility, and then followed by the Baht/USD volatility. These currencies are from countries with approximately similar economic outlook and strength, thus the underlying economic activities behind the gyration of the currencies are more or less similar. Interesting questions can thus be put forward: does the stochastic volatility of a particular currency correlate with the other currencies' and even move the same way? Then the investigation must be carried out by the multivariate stochastic volatility model in the next part. We can also detect whether there are common factors among the series or whether there is any particular behavior, like cyclical.

However, particular patterns are obvious in Figure 5.5. For example, we can check that Rp/USD stochastic volatility looks very obviously cyclical. Meanwhile, Baht/USD and Peso/USD seem to have common movement.

5.3.2. Multivariate Stochastic Volatility Model Result, Common Factor and Volatility Correlation

We apply the same univariate stochastic volatility model estimation method, except that now all of the series are treated altogether as dependents. Now y_t is an N X 1 vector of observations, which depends on unobserved components vectors. Harvey *et al*. (1994) do the similar investigation for the USD/Pound, USD/DM, USD/Yen, and USD/Swiss Franc. They assume that each series' process follows (5.9) and each series' volatility is an AR(1) process of (5.16).

Next, we want to investigate how the different exchange rates disturbances are correlated with the variance matrices of the disturbance vectors, ε_{it} from (5.9) and η_{it} from (5.10), namely matrices $\sum_{\varepsilon}$ and $\sum_{\eta}$. In our case, the exchange rates volatility links through variance matrices via the correlation of disturbances that drive the components. Basically, we want to investigate how strong the disturbance of a particular exchange rate relates to the disturbance of the other exchange rates by checking the $\hat{\Sigma}_{\varepsilon}$ matrix. The number in $\hat{\Sigma}_{\varepsilon}$ shows the correlation of the disturbances between the exchange rates. On the other hand, we want to know how the volatility correlation among the exchange rates is being investigated, by checking the $\hat{\Sigma}_{\eta}$ matrix. The number in $\hat{\Sigma}_{\eta}$ shows the correlation of the volatility between the exchange rates.

The correlation of the disturbance vector, ε_{it}, as estimated following (5.9) is:

$$\begin{array}{ccccc} \text{Rp} & \text{JPY} & \text{THB} & \text{PHP} & \text{SGD} \end{array}$$
$$\hat{\Sigma}_{\varepsilon} = \begin{bmatrix} 1 & -0.03 & 0.14 & 0.04 & 0.06 \\ & 1 & 0.14 & 0.01 & 0.25 \\ & & 1 & 0.12 & 0.24 \\ & & & 1 & 0.05 \\ & & & & 1 \end{bmatrix} \begin{array}{l} \text{Rp} \\ \text{JPY} \\ \text{THB} \\ \text{PHP} \\ \text{SGD} \end{array}, \qquad (5.15)$$

and, the correlation of the volatility disturbance vector, η_{it}, as estimated following (5.10) is:

$$\begin{array}{ccccc} \text{Rp} & \text{JPY} & \text{THB} & \text{PHP} & \text{SGD} \end{array}$$
$$\hat{\Sigma}_{\eta} = \begin{bmatrix} 1 & 0.89 & 0.10 & 0.01 & 0.20 \\ & 1 & 0.15 & 0.15 & 0.49 \\ & & 1 & 0.21 & 0.39 \\ & & & 1 & 0.31 \\ & & & & 1 \end{bmatrix} \begin{array}{l} \text{Rp} \\ \text{JPY} \\ \text{THB} \\ \text{PHP} \\ \text{SGD} \end{array}. \qquad (5.16)$$

It is obvious that the correlations between currencies' disturbance as reported in matrix $\hat{\Sigma}_{\varepsilon}$ are in general smaller than the volatility correlation shown in matrix $\hat{\Sigma}_{\eta}$. Further interpretation of both matrices is straightforward. It is obvious that stochastic volatility correlations involving Rp/USD, Yen/USD, and SGD/USD are high.

If we look at the matrix (5.16), we see that the correlation involving the volatility of Rp/USD and Yen/USD is relatively the highest, although we cannot see that clearly in Figure 5.5. On second place is the exchange rate volatility correlation involving

SGD/USD and Yen/USD. On the other hand, in general, the exchange rate volatility correlation involving Peso/USD as against the other exchange rates, is the lowest.

Meanwhile, the total value of the log-likelihood for the multivariate estimation is -5296.97, which is far larger than the univariate's total, -5528.66.[5] The number of parameters in the multivariate model is 40 parameters more than the univariate's total, and the likelihood ratio test statistic is 231.69. With α= 5%, the χ^2_{40}= 55.76, the likelihood ratio test statistic significantly shows that multivariate stochastic volatility model fits the data better than the univariate stochastic volatility model.

However, we have shown in matrix (5.16), $\hat{\Sigma}_\eta$, the exchange rates volatility correlations among currencies involved. We are now interested in the plot of the stochastic volatility, and from Figure 5.6, we can preliminary conclude that Yen/USD, Baht/USD, and Peso/USD's volatility tend to co-move, while Rp/USD is cyclical. Rp/USD is separated from the others because we want to see whether in its cyclical characteristics there buried similar trend to the dominant Yen/USD.

Meanwhile, Figure 5.6 tells us that the volatility of Rp/USD has a cyclical behavior. Indeed, if the authority has the interest to reduce the volatility and make the rate more stable, further steps must be taken to model and investigate the amplitude of the cycle. Once the amplitude is discovered, then it can be used as the base for the timing of the intervention in the market, aiming at the second moment, not at the first moment of the Rp/USD rate.

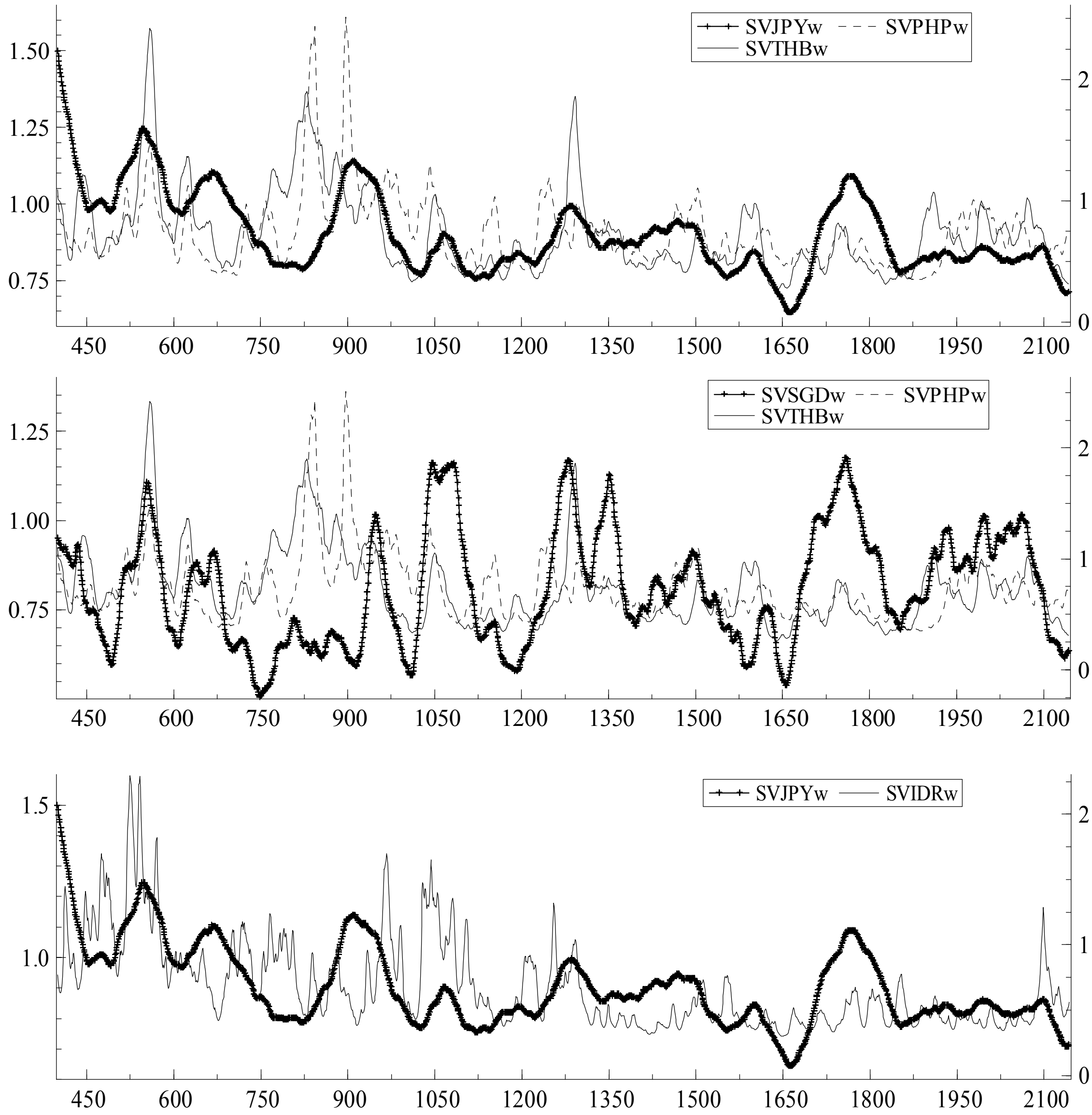
Evidently, Figure 5.6 shows that there exists common factor_ in stochastic volatility of Rp, Yen, Baht, Peso, and SGD, all against USD, which presumably move them together. However, at this point it is impossible to pinpoint exactly which "factors" are the unobserved components or how many "factors" which are common among the currencies. Future research based on what is found at this point can focus on the investigation of the common factors among second moments of these currencies.

Next research can investigate the co-movement of the volatility by the imposition of common factors or removal of explanatory variables from the equations. Next research can also implement the restrictions by reducing the rank of the variance matrices of the disturbances driving the stochastic components. The aim of such study is to investigate

[5] Calculated by adding up the log likelihood in Table 5.1.

the impact of the imposition of common factors to the variance matrices, especially to the elements in correlation matrices.

Figure 5.6: Co-movement of the stochastic volatility of Rp, Yen, Baht, Peso, and SGD, all against USD, observation # 400 - # 2143 (Feb 24, 1999 – Nov 11, 2005)



Notes:

- SV refers to the stochastic volatility, and “w” means weighted
- Stochastic volatility presented, is weighted by each stochastic volatility series’ mean
- Left Y-axis represents Yen and SGD

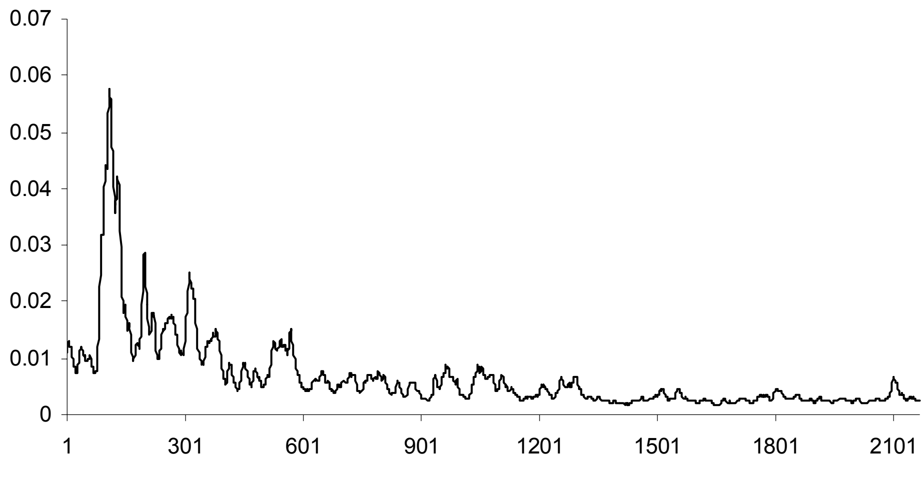
5.4. A Salient Analysis on the Rp/USD Stochastic Volatility and the Policy Implication Lessons

As we indicated earlier, the prime focus of this chapter is to study the Rp/USD stochastic volatility and the policy implication lessons. Figure 5.7 shows the stochastic volatility plot from August 14, 1997 until November 30, 2005.

Indeed, the division of the sub-period could have been done by several techniques, such as the Chow break-point or the one with the Markov-switching regime classification. However, we start the analysis by simply dividing the whole observation period into three sub-periods evenly since we want to simplify the analysis and concentrate more on the cyclical behavior of the Rp/USD stochastic volatility to draw policy implications. Therefore, we divide the whole observation into the following sub-periods:

a. Sub-period I : August 14, 1997 – May 19, 2000
b. Sub-period II : May 22, 2000 – February 25, 2003
c. Sub-period III : February 26, 2003 – Nov 30, 2005

Figure 5.7: The daily stochastic volatility of Rp/USD,
August 14, 1997 – November 30, 2005



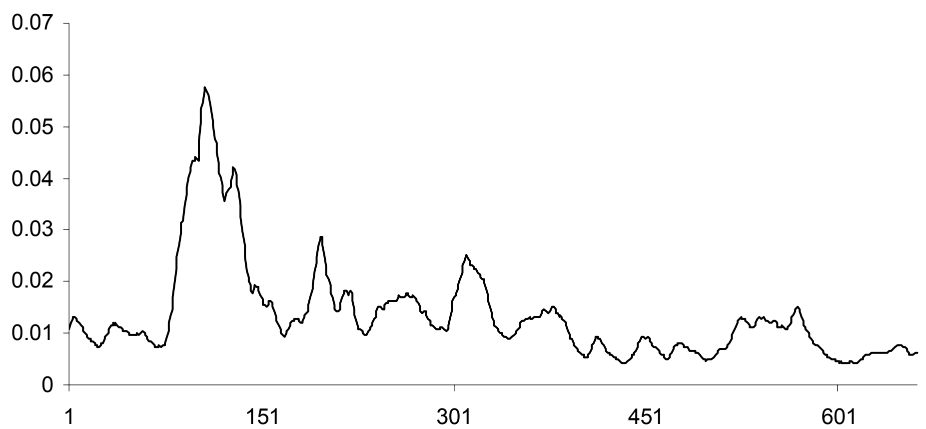
5.4.1. Sub-Period I: August 14, 1997 – May 19, 2000

In Indonesia, this period was inundated by the fluid economic, social, and political turbulences. However, one interesting fact is uncovered. There is a cyclical behavior of the Rp/USD stochastic volatility throughout this period. A cyclical behavior in economic data has also been the subject of research. It pertains to a particular pattern in the economic activities that could have economic or non-economic reasoning behind it. However we must keep aside at this point on what causes the Rp/USD stochastic volatility cyclical pattern for further research.

We can see from Figure 5.7 that the stochastic volatility of Rp/USD hits the highest points especially during the first 400 observations. The troughs and peaks are considerably rough. This is the result of very active trades of Rp/USD beyond the normal activity. Earlier we quoted research results on the exchange rate volatility, which show that position takings, mixed signals that come from un-optimal intervention policy, and even the improper exchange rate regime may all be the cause. However, we are also seeing abnormal volatility in Rp/USD during the abnormal time, that is in this first 400 observation.

We now investigate the sub period of August 14, 1997 – May 19, 2000 as shown in Figure 5.8.

Figure 5.8: The daily stochastic volatility of Rp/USD, Aug 14, 1997 – May 19, 2000



There are 12 highest peaks during this period. Surrounding these peaks' dates, we focus the discussions on the following aspects:

- The length of time between the immediate-preceding troughs to the major peaks.
- The immediate-preceding date of the volatility peaks.
- The length of time between major peaks. Major peaks in our definition are the ones which take place right after the deep troughs.

The attention on the distance between the immediate-preceding troughs to the peaks can give us preliminary information on whether the timing of such phenomenon is predictable. On the other hand, the immediate preceding date of a particular peak will bring about the information on whether Rp/USD volatility is exclusively characterized by a depreciation or appreciation phenomenon.

The length of time between peaks can help us understand the time horizon of the next potential major volatility peaks. All of these efforts will enrich the policy insight on how to tackle the main task of maintaining the stability of Rupiah. We find that the number of days between the preceding-immediate troughs and the major peaks varies between 6 to 34 days, with the average of 17 days during this period. Meanwhile, Table 5.2 shows the peaks of Rp/USD stochastic volatility, the dates, and the depreciation or appreciation of the rate.

Table 5.2: Peaks of the daily Rp/USD stochastic volatilities, the corresponding nominal rate, and the date, Aug 14, 1997 – May 19, 2000

Date	Rp/USD	Stochastic Volatilities
Jan 12, 1998	Rp 8150	0.0709*
Feb 16, 1998	Rp 9950	0.0339
March 5, 1998	Rp 10300	0.0280
May 14, 1998	Rp 11700	0.0330
June 11, 1998	Rp 13850	0.0200
July 16, 1998	Rp 13100	0.0168*
Sept 9, 1998	Rp 12150	0.0190
Nov 3, 1998	Rp 8475	0.0192
Jan 22, 1999	Rp 8900	0.0177
Aug 18, 1999	Rp 7360	0.0155*
Sept 10, 1999	Rp 8275	0.0154*
Oct 21, 1999	Rp 7025	0.0122*

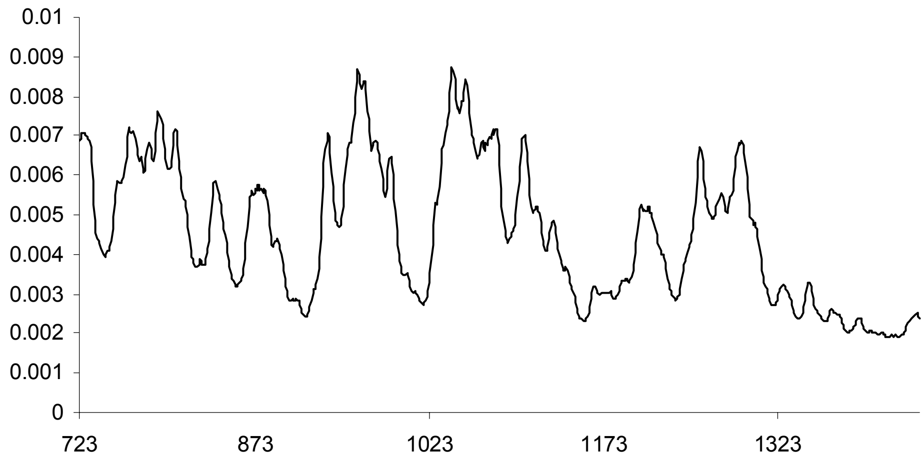
Note: * denote the date when Rp/USD appreciation takes place from the preceding trading day

The immediate-preceding date analysis of the Rp/USD major volatility peaks in this sub-period uncovers the fact that they are predominantly shadowed by the depreciation of the rate. We also find that among the 12 stochastic volatility peaks, 8 of them are major stochastic volatility peaks. There are only 5 major stochastic volatility peaks which are shadowed by such appreciation. The highest depreciation of Rp/USD in this particular observation is 21.3% that took place in February 16, 1998, which shadows the corresponding stochastic volatility of 0.0339. The highest appreciation is 15.5% in January 12, 1998, with the corresponding stochastic volatility is 0.0709. A new major volatility peak will materialize averagely 42 days after the previous peak took place and during this period.

5.4.2. Sub-Period II: May 22, 2000 – February 25, 2003

As we discussed before, Figure 5.7 shows that this sub-period is considerably less turbulent than the previous sub-period. However, we see again in Figure 5.9 that the gyration of the Rp/USD stochastic volatility is cyclical. There are 20 minor and major stochastic volatility peaks all throughout this period, and 12 of them are considered major. Major peaks in our definition are the ones which take place right after the deep troughs. We find that the number of days between the preceding-immediate troughs and the major peaks varies between 4 to 26 days, with the average of 14 days during this period. All of these indicate shorter volatility movement compared to the previous sub-period.

Figure 5.9: The daily stochastic volatility of Rp/USD, May 22, 2000 – Feb 25, 2003



Moreover, the Rp/USD volatility is predominantly an appreciation phenomenon, as 12 out of 22 volatility peaks are shadowed by its appreciations. The biggest appreciation of Rp/USD in this particular observation is 6.04% that took place on August 13, 2001, which shadows the corresponding stochastic volatility of 0.011. The biggest depreciation is 3.75% on October 14, 2002, with the corresponding stochastic volatility is 0.0036. We also find the shorter length of time for a new major volatility peak to materialize compared to the previous sub-period, with average of 34 days after the previous peak had taken place.

Table 5.3: Peaks of the daily Rp/USD underlying volatilities, the corresponding nominal rate, and the date, May 22, 2000 – Feb 25, 2003

Date	Rp/USD	Stochastic Volatilities
July 19, 2000	Rp 8993	0.0083*
Aug 23, 2000	Rp 8395	0.0076
Sept 13, 2000	Rp 8803	0.0074
Oct 13, 2000	Rp 9445	0.0063
Jan 1, 2001	Rp 9750	0.0067
March 13, 2001	Rp 10300	0.0168*
April 27, 2001	Rp 11700	0.0114*
May 31, 2001	Rp 11125	0.0077*
Aug 13, 2001	Rp 8560	0.0113*
Oct 4, 2001	Rp 9738	0.0091*
Nov 6, 2001	Rp 10815	0.0154*
March 6, 2002	Rp 7025	0.0122*
April 9, 2002	Rp 9665	0.0062
June 5, 2002	Rp 8913	0.0088
July 26, 2002	Rp 9150	0.0070
Sept 17, 2002	Rp 9060	0.0034*
Oct 14, 2002	Rp 9345	0.0036
Nov 13, 2002	Rp 9053	0.0031*
Dec 16, 2002	Rp 8815	0.0031*
Feb 13, 2003	Rp 8945	0.0028*

Note: * denote the date when Rp/USD appreciation takes place from the preceding trading day

5.4.3. Sub-period III: February 26, 2003 – Nov 30, 2005

At a glance, this sub-period is characterized by considerably lower turbulence than the previous sub-period as shown by Figure 5.7. However, we see again the cyclical gyration of the Rp/USD stochastic volatility in Figure 5.10. There are now 18 minor and major stochastic volatility peaks all throughout this sub-period and 16 of them are considered major. In this observation, the major peaks are also the ones, which took place right after deep troughs.

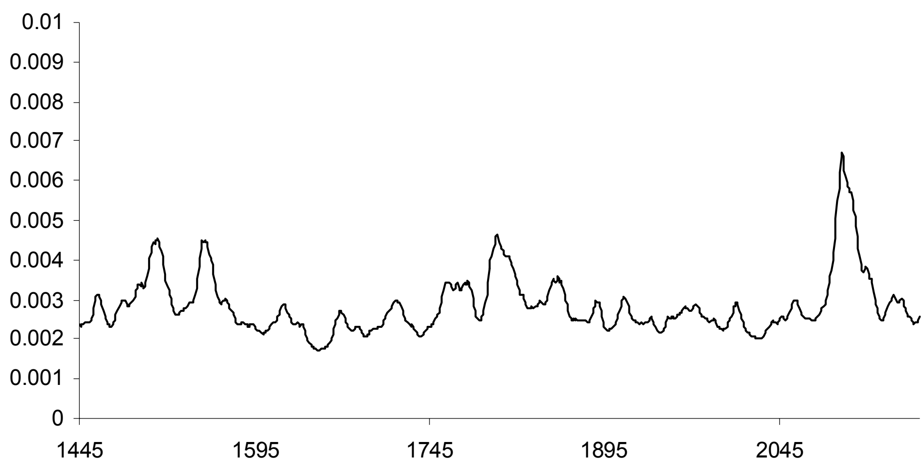
We find that the number of days between the immediate-preceding troughs and the major peaks varies between 5 to 38 days, with the average of 12 days during this period which shows an even shorter volatility movement compared to the previous two sub-periods.

Table 5.4: Peaks of the daily Rp/USD stochastic volatility, the corresponding nominal rate, and the date, Feb 26, 2003 – Nov 30, 2005

Date	Rp/USD	Stochastic Volatilities
March 21, 2003	Rp 8973	0.0031*
April 17, 2003	Rp 8722	0.0030*
May 30, 2003	Rp 8310	0.0045
July 25, 2003	Rp 8505	0.0045*
Oct 29, 2003	Rp 8530	0.0029*
Jan 6, 2004	Rp 8338	0.0027*
March 11, 2004	Rp 8628	0.0030
July 12, 2004	Rp 8800	0.0034*
Sept 16, 2004	Rp 9000	0.0047*
Nov 8, 2004	Rp 8939	0.0035*
Dec 10, 2004	Rp 9248	0.0030
Jan 12, 2005	Rp 9195	0.0031*
Feb 2, 2005	Rp 9178	0.0026*
April 26, 2005	Rp 9695	0.0031*
June 8, 2005	Rp 9595	0.0030
July 4, 2005	Rp 9865	0.0025
Aug 30, 2005	Rp 10550	0.0030*
Oct 5, 2005	Rp 10030	0.0045*
Oct 31, 2005	Rp 10123	0.0032

Note: * denote the date when Rp/USD appreciation takes place from the preceding trading day

Figure 5.10: The daily stochastic volatility of Rp/USD, Feb 26, 2003 – Nov 30, 2005



Meanwhile, this sub-period shows that the Rp/USD volatility is predominantly an appreciation phenomenon, as 13 out of 16 major volatility peaks are shadowed by its appreciations. The biggest appreciation of Rp/USD in this particular observation was

2.4% that took place on August 31, 2005, which shadows the corresponding stochastic volatility of 0.008.

The biggest depreciation was 3.75% on August 29, 2005, with the corresponding stochastic volatility is 0.004. We again found an even shorter length of time for a new major volatility peak to materialize, with average of 27 days after the previous peak took place compared to the previous sub-period I and II.

5.5. Conclusion

The stochastic volatility model for Rp/USD, Yen/USD, SGD/USD, Baht/USD, and Peso/USD shows intriguing results. From the univariate stochastic volatility model, we report that the stochastic volatility of major currencies in the Asian region shows a unique situation. Yen, Baht, Peso, and SGD all against USD seem to have common movement in volatility, while Rp/USD has a cyclical characteristic in its stochastic volatility. The trend component in its cyclical volatility is also driven by the volatility movement of Yen/USD. Modeling the cycle for Rp/USD will be quite an interesting issue and is left for future research. It will surely give the Indonesian authority a policy insight on the management of the exchange rate whenever they want to maintain the stability of Rp/USD.

Meanwhile, the multivariate stochastic volatility model estimation gives us a clear picture of the inter-volatility taking place amongst the currencies being investigated. We see that in general, a high correlation involving Yen/USD and SGD/USD is proven in the correlation matrices. However, we want to draw a special conclusion about the Rp/USD stochastic volatility and the policy implication lessons.

Rp/USD Stochastic Volatility and Its Policy Implication Lessons

Stochastic volatility model for Rp/USD shows intriguing results. First, we can report that the stochastic volatility Rp/USD has a cyclical characteristic in its gyration. Indeed modeling the cycle for Rp/USD, based on this finding will be quite an interesting issue and is left for future research. It will surely enrich the monetary authority's policy insight on the management of the exchange rate.

Second, it can be concluded that Rp/USD volatility has shorter average peak to peak movements towards the end of the observation, albeit subsequently with smaller magnitude.

Third, we conclude that the distance between the immediate-preceding troughs and the major peaks are getting shorter, at least along the observation. We will discuss the policy implication of this and the most important lessons that can be drawn around the major troughs and peaks behavior.

Fourth, against the perpetual image that Rp/USD volatility has always been the result of depreciation pressures that come from speculations, we can show from the investigation that it is not entirely the right case. It is true only for the first sub-period that covers August 14, 1997 – June 28, 2000, when the Rp/USD stochastic volatility major peaks are predominantly shadowed by depreciations. Even in this sub periods, out of 12 major peaks, 5 of them are not shadowed by the Rp/USD depreciation, but by appreciation. Even the strongest Rp/USD stochastic volatility takes place on January 12, 1998, that is the day when Rp/USD appreciates.

Policy Implications

The cyclical behavior of Rp/USD stochastic volatility that is uncovered by the stochastic volatility model brings about the following points of interest for the policy lesson. It is less cumbersome to predict the future movement of the Rp/USD stochastic volatility if the behavior is cyclical. However, the way to solidly understand is to model the cycle specifically, and provide an estimate in future research. The results of such research on the cyclicality are: the right knowledge about the timing of the volatility upswing, the amplitude of the cycles, the characteristics surrounding such volatility cycle, and a clearer picture on each major upswing and downswing in the past, so as to acquiring the knowledge on these volatile occurrences. Uncovering the past occurrences will show whether the past interventions dampened the volatility or not, and also whether the past interventions on Rp/USD were timely.

It is important to know whether the interventions policy in the past really sent clear signals to the market, by investigating whether the deflection points in the major troughs were followed by the right intervention signals from Bank Indonesia. It is important to understand the process of past intervention, in order to suggest a more optimal direction in the future, the timing, as well as the type of policy. That way, the policy can really aim at dampening the potential peaks after the major troughs. Our present study shows that by having solid lessons from all of these aspects and rearrange future policy strategy based on the comprehensive knowledge on the cyclicality of Rp/USD volatility, the future policy regarding the main task of Bank Indonesia as stated in BI Act no. 23, 1999, Chapter 3, Article 7, that is to maintain the stability of Rupiah, will be more optimal than ever. Bank Indonesia will be able to carry out the task by the BI Act no 23, by closely looking at the stability of the rate (that is related to the volatility), more than targeting the Rp/USD rate per se. That means, the main target is the second moment of the Rp/USD rate, which is the volatility. Thus, further research in the near future which specifically aims at this specific purpose will be necessary.

Meanwhile, the cyclicality of Rp/USD volatility shows the possibility of active cyclical actions by a particular type of market agent. By nature, these actions might represent the underlying needs of the foreign currencies in a time-structured manner, like the debt repayments, the repetitive import payments for the purpose of the production line schedule by the manufacturing industries, or others. Further research must carry out the investigation on what really took place around the occurrences of major troughs and peaks, which include the actions taken by Bank Indonesia's Treasury Directorate as well as the major players in the market. The real purpose is to uncover the source of such major volatility swings, so the future policy responses will have better focus on what to do to tame the potential volatility. This investigation can be incorporated into the future study of the Rp/USD stochastic volatility.

On the other hand, the cyclicality of Rp/USD volatility also implies that the market of Rp/USD is relatively thin. If the market volume is large, such cycles are surely gyrating beneath the overall volatility movements. This further suggests that indeed a relatively more stable Rp/USD can be attained if the market volume is large. The repatriation of export yielded in foreign currencies can improve the situation, and surely further research on this can enrich the policy insights.

The shorter distance between preceding-immediate troughs and their corresponding major peaks, as well as the shorter distance between major peaks of stochastic volatility suggests points of interest for the purpose of policy making. We suggest that a comprehensive study about deflection points in major troughs have to be carried out. There are four implications that can be learned from our investigation.

First, the shorter distance between major troughs and peaks of volatility along the observation suggests that Bank Indonesia has a shorter horizon to react for any sign of Rp/USD volatility that is picking up in pace, requiring swifter reactions based on the knowledge about the ensuing volatility movement.

Second, when a deflection point in a particular trough of Rp/USD stochastic volatility movement is recognized, the condition around it must be clearly uncovered and learned. This is important because a deflection point is the starting indication of the stochastic volatility picking up the pace. We recognize that the period within the first 4-5 days after a particular deflection point of a stochastic volatility trough are the most important time for swift and proper intervention. The element of timing in an intervention can dampen the ensuing stochastic volatility that is surely picking up. When the timing is right, then the magnitude of the intervention can be less than what will be when it is too late.

Third, if we incorporate our finding towards the end of observations the major peaks of Rp/USD stochastic volatility are predominantly triggered by appreciations, then the right and timely actions will be guaranteed further by understanding the market situation around such deflection points. It is thus very important to incorporate the market data analysis about the demand and supply of USD. If the Rp/USD market clearing situation is analyzed within the first 4-5 days after a particular deflection point, the authority can have clearer suggestion on what to carry out in order to flatten Rp/USD volatility's ensuing rise. When the market shows indications of over-demand (over-supply), then within the first 4-5 days after a deflection point, Bank Indonesia must prepare the package of intervention strategy that counters it, and within the right time, a solid action must be taken, such as flooding (buying) the market with USD.

Fourth, shorter peak to peak distance adds the weight to the whole analysis regarding the timing of proper short run policy responses. It gives a horizon on the rough forthcoming peaks when a particular major trough takes place.

We have already shown that the major Rp/USD volatility peaks are shadowed more by the Rp/USD exchange rate appreciations than depreciations. This is counterfactual to the seemingly perpetual belief that the volatility of Rp/USD has always been triggered by depreciation. It has been known that commotions from responses and comments by market analysts, high ranking government officials, press, and public in Indonesia are very prone to Rp/USD depreciation more than the appreciation. Such responses transmit the wave of anxiety throughout the market players and in the very short run can create a situation where policy response becomes less effective. There is one recent but good example. Let us look back to the period around April and August 2005, when Rp/USD depreciated and the market analysts produced gloomy analysis, but the stochastic volatility during this period does not show any change of behavior, indicating the unchanged underlying trading characteristics of Rp/USD. How did we come to this conclusion? The answer lies in the pattern of the Rp/USD stochastic volatility which does not show any break of behavior, as can be seen in Figure 5.10. If the depreciations are related to the speculative attack from speculators, especially foreign speculators, then, during and after the period of April and August 2005, the fact about the Rp/USD stochastic volatility poses as a counterfactual. We do not recognize any break of behavior in the stochastic volatility.

Thus, the policy implication of this finding is that the increasing Rp/USD stochastic volatility can be triggered by appreciation more than depreciation. Market jittery during the heavy pressures on the Rp/USD can be calmed in the very short run by the counter-comments from high ranking officials of Bank Indonesia disclosing the counterfactual empirics from the Rp/USD stochastic volatility estimation. This, together with the right timing and direction of intervention, can help fulfilling the main task of stabilizing the Rupiah.

Appendix

Data Source

Daily data for variables Indonesian Rp/USD, Japanese Yen/USD, Singapore Dollars/USD, Thai Baht/USD, and Philippines Peso/USD are taken from Bloomberg. The sample period for all of these variables is: August 14, 1997 – November 11, 2005, with the total of 2165 observations.

Chapter 6
Conclusion

There are lingering concerns about the Rp/USD rate movement, that this currency has been showing volatile characteristics. And the economic agents also have a memory about the shock of 1997 – 1998 which knocked Rp/USD. These all together are even aggravated more by the free float regime. The public and policy makers' reaction to the early gyration of the Rp/USD shows what it is called as the "fear of floating".

This study tries to build up a basis for further understanding about the new Rp/USD which is now free float. The old Rp/USD was the story of fixed and managed float regimes which the economic agents prefer due to its stability. However in the span of more than 30 years, Indonesia experienced a lot of problems with the previous exchange rate system. The real rate of Rp/USD was once so overvalued, and when combined with the disclosure of deficiency in the management of the economy at the micro and macro level, finally blew a stroke nobody could ever imagine before. The economic agents and the policy makers were so used to the unreal stability introduced to the economy by the slowly depreciating Rp/USD, or even the fixed Rp/USD in the past, whereas they were fed by wrong signal. Then, the economy was used to get seemingly cheap import, meanwhile the export of goods became relatively expensive for the foreigners. Short term external debt was thought to be repayable easily, with low interest rate and the certainty in the Rp/USD exchange rate. All of these happened, just because of the introduction of the deceiving stability which anchored from the stable Rp/USD during the fixed and the managed float exchange rate system era. However that was totally unreal.

Presently, Rp/USD freely floats. This is the consequence of the currency crisis which hit Indonesian very hard. Indonesian economy must learn about the new behavior of Rp/USD since then. Thus, this study tries to build a basis to such understanding, through the implementation of the econometric tools with the underlying exchange rate economics theories.

From the empirical investigation with VECM on the EMH, we conclude that 1-month Rp/USD forward rate predicts the future 1-month ahead Rp/USD rate. For Rp/USD market, the EMH holds when the perception about the future is framed into the short distance ahead, which is only 1 month ahead. Beyond that point, the market speculates on the Rp/USD. To refresh our understanding, the EMH asserts that foreign exchange market efficiency requires the 1-month forward exchange rate to equal the expectation of the spot rate in the next 1-month period. If this condition does not hold, thus theoretically speculators can make a pure profit on their trades in the foreign exchange market. Knowing this, and even if the departure of EMH in the long run entails the opportunity to speculate and thus exploit future profit from Rp/USD transactions, we can suggest that market player must hedge their long horizon financial position when they are denominated in non Rupiah.

Intervention to soften short run volatility is then justified, if the goal is to reintroduce stability quickly and not to bring the rate to a certain "wanted" level. The Rp/USD market will correct itself as EMH suggests for the 1-month period ahead.

On the other hand, we conclude also that the result of the MS(2)-VECM(2) shows highly reliable regime classification of Rp/USD. We can get also the transition probability of Rp/USD to move between Regimes. It is confirmed that until the end of sample period, April 2005, Rp/USD is in the stable period, with the probability to stay in such regime is 95%. However, the probability for Rp/USD to switch regime to the the unstable period, is below only 5.26%. Although there is a small probability that the Rp/USD can switch regime, however the authority can learn more on how to educate people that the Rp/USD will always be going up and down as dictated by the market, but stable. Moreover the h-steps (h = 60 weeks) forecast of the transition matrix also shows that in the long run, Rp/USD will have 62% chance to stay stable.

Another factor to understand about the "new" Rp/USD is to investigate its volatility. It is also useful to know how volatility of Rp/USD goes among the volatility of the surrounding economies' exchange rate, as against USD. Using univariate and multivariate stochastic model, we find that Rp/USD has a special form of volatility and it is cyclical. This finding has opened up a venue for the future study on Rp/USD, like how and why Rp/USD volatility has cycle, and what causes it. The policy makers need to comprehend more about the underlying truth about the cycle in the Rp/USD volatility. However, with our finding, we can preliminary provide information to the policy makers about the impending downward cycle of the Rp/USD volatility which will lead to its upswing. Whenever these Rp/USD volatility “deflection points” are about to be reached, we can advise the policy makers on the timing. The policy makers must decide on what to do next, based on the knowledge about the situation in the Rp/USD market. That way, our findings on the Rp/USD stochastic volatility can help establishing the pre-emptive policy stance on safeguarding the stability of Rp/USD. We find that through this mechanism, the intervention in the Rp/USD market will have smoother results than the “piss on the market” intervention strategy.

All of these preliminary findings will surely open up new door for further investigation of Rp/USD behavior. These findings also have policy implication that fortifies the continuance of the present free float regime. The authority shall understand more about stability and volatility of Rp/USD and how to convey the message to the whole nation that the currency is indeed behaving normally. And that the Rp/USD depreciations or appreciations are just part of its natural behavior.

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Nederlandse Samenvatting

(Summary in Dutch)

Dit onderzoek benadrukt de wisselkoersvoorspelling en volatiliteit van de Indonesische Rupiah (Rp) ten opzichte van de Amerikaanse Dollar (USD) – Rp/USD. Het begint met een overzicht van voorgaand onderzoek uit begin jaren '60 tot op de dag van vandaag. Het overzicht geeft u een historisch perspectief van 'hoe' en 'waarom' de Rp/USD aan de veranderingen van het wisselkoersregime werd onderworpen. Wij tonen aan dat, in de periode van 1966 tot aan het jaar 2005, de Rp/USD tot drie maal toe is veranderd, van vaste wisselkoers, naar de vuil-geleide vlotter en vervolgens het vrije vlotter-regime. In dezelfde periode, hebben wij ontdekt dat er maar liefst 8 devaluaties waren van de Rp/USD.

Reeds hebben wij getracht te onderzoeken of er een efficiënte grip is op de markthypothese in het geval van Rp/USD, voor de periode januari 1995 tot en met april 2005. Het onderzoek vindt dat de 1^e, 3^e, 6^e, en 12^e maand Rp/USD voorwaarts tariefterm de structuur niet voor de observatieperiode houden. Dat betekent dat de economische agenten zich niet op de reeks van informatie baseren die in de term van het voorwaartse tarief van de Rp/USD wordt samengesteld. Wij proberen dan te onderzoeken of de niet term structuurbenadering een verschillend resultaat geeft, en vinden dat de efficiënte markthypothese voor het geval van de 1^e en 3^e maand Rp/USD voorwaartse tarieven houdt.

Gebaseerd op het verkregen resultaat van de efficiënte markthypothese, zetten wij het onderzoek op Rp/USD voort met een focus op de voorspelling van Rp/USD, daarbij gebruikende de Markov Switching – VECM benadering. Uit onderzoek is bewezen dat de Markow Switching VECM model een betrouwbaar model is om de regimeveranderingen in de Rp/USD bewegingen te kunnen voorspellen. We krijgen een betrouwbaar Regime 1 en Regime 2 classificatie die overeenkomen met de karakteristieken van de Rp/USD bewegingen gedurende de observatieperiode.

Uit het Markov Switching VECM model verkrijgen we de overgangs-waarschijnlijkheden van de regimeomschakeling, die de waarschijnlijkheid verklaart om van een bepaalde regime over te gaan op een andere regime, veroorzaakt door de veranderingen in de karakteristieken van Rp/USD bewegingen. De matrix van de overgangswaarschijnlijkheden kan worden gebruikt om toekomstige Rp/USD van waarschijnlijke bewegingskenmerken betrouwbaar te kunnen voorspellen.

Het volgende onderzoek wordt uitgevoerd voor de stochastische volatiliteit van verscheidene Aziatische wisselkoersen. Één van het belangrijkste resultaten toont aan dat de wisselkoers van Rp/USD een cyclische beweging van stochastische volatiliteit heeft. Bovendien, hebben wij ontdekt dat de cyclisch stochastische volatiliteit van de Rp/USD in dezelfde richting bewegen als de Thaise Baht, de Filippijns Peso, de Singapore dollar (SGD) en de Japanse Yen. Echter, heeft de cyclische stochastische volatiliteit van Rp/USD beleidsimplicaties.

Het bestuderen van de volatiliteit van Rp/USD-cyclus kan het interventiebeleid optimaal helpen, in termen van timing en interventieomvang. Wij stellen voor dat dit onderzoek een weg opent voor toekomstig onderzoek naar Rp/USD's cyclisch stochastische volatiliteit, om de beleidsbepaler een meer optimaal wisselmarktinterventie te helpen vormen.

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