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STATE BANK OF PAKISTAN

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Abstract

The aim of this study is to assess and analyze exchange rate risk related to three currencies i.e. Euro, American Dollar and Japanese yen on Public Debt Portfolio of Pakistan (PDPP) through Value-at-risk (VAR) methodology from year 2001 to 2006. Annual returns series of exchange rates show better convergence to normal distribution than for the whole period from 2001-2006. Moreover VAR through Monte Carlo (MC) and Historical Simulation (HS) also produce results in line with Delta-Normal Method, convergence of VAR results is more evident in the case of Delta-Normal and MC, validating that the assumption of Normality is not unreasonable. VAR obtained through three methods exhibit considerable decline of maximum potential loss over the years, thus signs of improvements in managing exchange risk. Our study reveals that Pakistan's Public debt policy management with respect to exchange rate exposure lacks hedging Strategy. This is evident from the fact that none of the currencies constituting PDPP has negative Beta or negative component VAR. Only Dollar has Beta less than unity for all the six years. Beta and Marginal VAR analysis reveal that individually Dollar is the least risky and Japanese yen as the most risky currency constituting PDPP. Throughout the period marginal VAR associated to Dollar never exceeds to those of Euro and Jyen. While Jyen has the highest Beta throughout the period and we obtain the same result through marginal VAR analysis too. Dollar, despite being individually least risky currency throughout the period is found to be contributing highest risk as component VAR in certain years that is mainly due to its positive Beta which declines considerably over the years and large weight structure in the PDPP. Lower component VAR of Dollar in certain years is mainly attributed to its exceptional decline in Beta values. Not only Beta and component VAR analysis reveal lack of hedging strategy but this is also confirmed by the Best Hedge analysis, where also all the results exhibit negative signs for all the years throughout the period, suggesting for lower exposure in all currencies including Dollar.

JEL Codes: G18, H63.

Keywords: - Value-at-Risk, Public Debt Management, Exchange Rate Risk.

1. Introduction

Prudent public debt management plays a crucial role in the economic growth and development of the country. There is general consensus among the academicians that prudent Public debt management reduces borrowing cost, controls financial risk exposure and helps the countries to develop their own debt domestic market. In this context it is important that developing countries understand and adopt a framework to assess and analyze the cost and risk associated to their public debt. A sound public debt management can not only reduce borrowing cost but also help the countries to contain the associated risks. One of the important corner stone of public debt management is sound risk management of the financial risk; such risk exposure may range from currency risk, interest rate risk, liquidity risk and refinancing risk to credit risk.

Lessons from financial crisis and sovereign default clearly suggest that in developing a debt strategy, risk reduction should get priority over cost reduction (see World Bank 2007). For such a strategy, proper identification and quantification of both risk and cost become prerequisite.

Debt management in context of developing countries should not stop at general understanding of risk and cost facing public debt portfolio but should go beyond to form comprehensive as well as specific strategies to understand the intricacies and complexities of the role of each risk factor in the debt portfolio. For example, world Bank (2007) states "At the diagnostic phase, none of the pilot countries had a medium term, comprehensive debt management strategy based on a systematic analysis of cost and risk, and agreed on at the ministerial level"[1]. For instance the division between external and domestic debt should be based on rational and conscious strategy rather than being a residual outcome.

Keeping in view the importance of Public debt management, World Bank and IMF jointly prepared "Guidelines for Public Debt Management" in November 2002 to help the countries establish institutional framework for managing public debt along with new risk management applications. Introduction of such guidelines were important because the size and complexity of government debt portfolio can generate substantial risks to economic stability of the country and make it vulnerable to domestic and international financial shocks. Probability of

[1]Experiences and summary analysis of World Bank and IMF when a joint pilot program was initiated, in year 2002 to extend their assistance by helping countries improve their public debt management and domestic debt market. The 12 countries participating in the program were Pakistan, Bulgaria, Colombia, Costa Rica, Croatia, Indonesia, Kenya, Lebanon, Nicaragua, Sri Lanka, Tunisia, and Zambia.

such vulnerabilities increases for smaller and emerging markets due to their less diversified and less developed financial system (See World Bank and IMF 2002). Lack of proper data system, research and absence of modern risk management techniques and approaches can be some other factors for high vulnerability to financial crisis.

Application of latest risk management techniques such Value-at-risk (VAR) and CaR (cost-at-risk) and others with respect to public debt portfolio, in context of developed country is not uncommon. For instance Danish financial authorities identify interest rate risk, exchange rate risk and credit risk as the main risk for the government debt portfolio. CaR model and its variants such as relative CaR, absolute CaR and conditional CaR are used to manage and quantify the degree of risk[2]. Ireland and Italy use VAR techniques to manage the risk exposed to their debt portfolios. While New Zeeland uses both VAR and stop-loss-limits approaches for foreign exchange rate risk exposures. Such an analysis is used for daily, monthly and annual time horizon at 95% confidence level[3].

What is value- at- risk?

Value-at-risk signifies downside risk on a position. VAR conveys the risk associated to a position in a single and easy to understand number. Jorion (2007) defines VAR as "The worst loss over a target horizon such that there is a low, pre-specified probability that the actual loss will be larger". Dowd (1998) defines VAR as "a particular amount of money, the maximum amount we are likely to lose over some period at some specified confidence level". Holding period usually indicates one day but it could be a week, month, quarter or even a year. Decision of holding period has significant effect on final result of VAR. Longer the holding period, larger would be the VAR results. Confidence level is percentile of expected potential portfolio values, which will be used as cut-off point to determine the left-tail of the distribution of portfolio values. Usually confidence level is set at 95%, but it could be at 99% or even 99.5%, depending on task at hand. Confidence level of 95% means that for about 5% of the time, portfolio could be expected to lose more than the number given by the VAR (Best, 1998). Different VAR confidence levels are used for different purposes. A low confidence level is usually used for validation purpose, while high one for risk management and capital requirements. So no single confidence level is binding on the entities to follow. Role of confidence level, like holding period too depends on the task at hand (Dowd, 1998)

[2] http://www.nationalbanken.dk/C1256BE9004F6416/side/Danish_Government_borrowing_and_Debt_2004_pub/$file/index.html. Danish Government borrowings and debt(2004)

[3] IMF and World Bank "Guidelines for Public Debt Management: Accompanying Document" (November, 2002)

The main purpose for the development of VAR is to assess different kinds of risk to which the positions are exposed and provide guidelines for decision making in risk management arena (Jorion2007; Dowd 1998).

Attractions and limitations of VAR

Dowd (1998) outlines following attractions of VAR:

1. VAR provides more informed and better risk management opportunity to managing authorities.

2. VAR being better crisis signal measure than traditional measures is more preventive in approach towards financial crisis, fraud and human error.

3. VAR provide more consistent and integrated measure of risk , which leads to greater risk transparency and thus results in better management of risk.

4. VAR takes full account of risk implications of alternatives and measures a broad range of financial risks, thus provides better input for risk management decision.

Dow (1998) outlines three main limitations of VAR:

1. VAR is backward looking. Forecast through VAR is based on past data. It is not necessary that history may repeat itself. In this perspective, scenario analysis is always recommended methodology along with VAR models.

2. Critical assumptions which may not be realistic under certain conditions could be used for VAR. For example assumption of normal distribution of returns may not be valid under certain scenarios. The main point here is to be aware of limitations and act accordingly.

3. VAR is only tool for measuring and managing the risk. VAR system demands a through and in-depth understanding from the users.

4. Available numerical approaches to measuring financial risk related to debt portfolios:

Melecky (2007) categorizes the risk management techniques into three main groups to gauge the risk associated to government balance sheet as follows:

1. First group belongs to the techniques applied by Bank of Canada (see Bolder, 2002, 2003); Danmarks Nationalbank, (see Danmarks National Bank 2006); Korea, (Hahm and Kim, 2004); the UK DMO (UK DMO Annual Review 2006) and (Pick, 2005); Swedish DMO (see Bergstom and Holmlund, 2000); or Peruvian Ministry of Economy and Finance, (see Peru Ministry of Economy and Finance, 2005). Commonly VAR or CaR are calculated through simulating the financial/economic variables.

2. Second group belongs to the studies of Garcia and Rigobon (2004), or Xu and Ghezzi (2004). According to this approach; economic variables are simulated to produce different time paths of debt/GDP realizations. By simulating many times such paths and distribution at hand facilitates the task of finding threshold level of debt/GDP, at which point the un-sustainability of public debt can be realized. The main difference between the Garcia and Rigobon (2004), or Xu and Ghezzi (2004) is of path specification while executing for simulations.

3. Third group belongs to works related to Gaspen, Gray and Limand Xiao (2005) and Gray, Merton and Bodie (2005). Gaspen et al (2005) determine a distress barrier like default threshold level, by utilizing book value of external debt and interest on long term external debt, along with value of domestic currency liabilities. Once the distribution of assets values is determined, distance to distress is calculated which appears to follow EMBI closely.

Our study relates to first group. We use VAR technique to assess exchange rate risk exposure to Public debt portfolio of Pakistan for each year for one day holding period from year 2001 to year 2006. The purpose of this study is to assess the performance in terms of managing risk exposure and also identify the risky currencies in debt portfolio. Such an approach would help us to identify currencies which are generating more risk than others in Public Debt Portfolio of Pakistan (PDPP) or identify currencies which help to reduce the overall risk exposure of PDPP. Our wok is similar to Ajili (2008), but we extend the approach and also apply historical simulation and Monte Carlo simulation VAR methodology along with Delta-Normal VAR to assess the exchange risk exposure of PDPP. Basic calculation methodology for VAR has been adopted from Jorion (2007).

The plan of the paper is as follows: In the next section, review of literature is presented. Section III briefly reviews external debt profile of Pakistan under the studied period; data and methodology aspect are outlined in Section IV. Section V applies VAR methodology outlined in section IV, while section VI highlights results obtained through applying VAR methodology. Finally, Sections VII summarizes and concludes the paper.

2. Review of Literature

World Bank and IMF (2003) state public debt portfolio is usually the largest financial portfolio in the country so there is need from the side of government to contain risks that make their economies vulnerable to external shocks. Document after emphasizing the importance of public of debt management recommends the use of recent financial

management techniques such VAR, CaR, Debt-Service-at-risk (DsaR) and Budget-at-Risk (BaR) in use by countries such as New Zealand, Denmark, Colombia, Sweden and many other.

Document also highlights certain pitfalls to be watched out for. For instance, the document explicitly states that financial authorities should avoid exposing their portfolios to large or catastrophic losses, even with low probabilities, in an effort to capture marginal cost savings that would appear to be relatively "low risk". For instance excess foreign un-hedged exchange exposures may leave governments vulnerable to economic distortions in the shape of increasing borrowing cost if domestic currency depreciates. Further such a situation can lead to default risk, if rollover option is missing.

Ajilli (2008) uses Delta-Normal VAR application to assess the exposure of exchange rate risk to Tunisian public debt portfolio. By taking daily data of the exchange rates, converting them into geometric returns, author shows that optimal length of time period to validate the assumption of normality is annual. An analysis of the currency risk structure is made through Delta-Normal VAR and its derivatives such as marginal VAR, component VAR, Beta and through other measures.

Pafka and Kondor (2001) study the cause of success behind the Risk Metrics VAR methodology. Risk Metrics for the calculation of VAR undertakes the assumption of normality of distribution of returns, while mean is neglected and standard deviation is taken as the only parameter of the distribution. Standard deviation is calculated through Exponential Weighted Moving Average (EWMA) (see Risk Metrics document, 1996). Authors attribute the success of Risk Metrics methodology to the following factors:

1. EWMA despite being categorized as simple approach for calculation of standard deviation of returns, belongs to ARCH category of models, which according to work of Nelson (1992) estimate volatility rather accurately.

2. Short holding period of one day is another positive aspect of Risk metrics methodology which explains its success. However, as holding period is lengthened the forecast quality deteriorates.

3. Authors by applying the data of 30 of stocks of Dow Jones Industrial Average (DJIA) show that effect of fat tails become much stronger at higher confidence levels, for instance at 99%, while at 95% confidence level VAR results violation frequency was around 5%.

Chan and Tan (2003) study the impact of fat tails through stress VAR approach, which measures potential extraordinary loss according to normal VAR methodology, with respect to

a portfolio of eight Asian currencies. They extend stress VAR to develop stress VAR X by employing Hill estimator (see Hill, 1977) and student t distribution to take into consideration the impact of fat tails. They conclude that despite the evidence of fat tails, stress VAR performed better than Stress VAR X at 95% confidence level , while at 99% confidence level stress VAR X do perform marginally better than stress VAR.

Studies of both Pafka and Kondor(2001) and Chan and Tan (2003) show that impact of fat tails does not dilute VAR results at 95% confidence level. The impact is only visible above 95% confidence level.

Cakir and Raie (2007) apply Delta-Normal VAR application along with Monte Carlo simulation VAR to gauge the impact on investment portfolio of diversification gains from Sukuk (bonds issued according Islamic principles). Despite using 99% confidence level and holding period of 5 business days, the results produced through Delta-Normal VAR are similar to MC VAR, which shows that findings are robust to the method of calculation and normality assumption do not prove to be a hurdle. Further slight differences in the results of both methods are attributed to the deviations of returns of portfolio form normality assumptions.

Vlaar(2000) studies out-of-sample performance of three VAR models i.e. variance-covariance, Monte Carlo simulation and historical simulation for 25 hypothetical portfolios consisting of Dutch government bonds for eight different maturities form 1985 to 1997. VAR results with 99% confidence level and 10 days holding period shows that variance-covariance method works well for models with naive variance, while combined Monte Carlo variance-covariance method (through this method variance-covariance gets variance input from Monte Carlo method) provides good results.

Blejer and Schumacher (1998) provide a complete outlines of the VAR methodology to assess the Central Bank solvency and exposure to risk. The write up is among the first to encourage shift of emphasize form analyzing the sustainability of regime towards assessing the vulnerability. Such an approach , by taking into consideration balance sheet of monetary authorities, not only helps to analyze the sources that are generating risk for the balance sheet of monetary authorities but can help to forecast financial crisis too.

Nocetti (2006) by applying the methodology presented by Blejer and Schumacher (1998) studies early warning indicators of financial crisis with respect to 2001 Argentine Crisis with

99.9% confidence level over three months period through Monte Carlo simulation VAR. According to author "Vulnerability measures portrait fairly well Argentine crisis".

3. External debt Profile of Pakistan from FY 2001 to FY 2006

In FY 2002 and FY 2003, amount of external debt in Pak Rs declined by 2.67% and 3.9% respectively, while FY 2004, 2005 and 2006 exhibited an increase in external debt of 0.5%, 4.9% and 5.7 % respectively (see figure 1 and table 1 below). On the other hand, external debt to GDP ratio showed consistent improvement from FY 2001 to FY 2006. The overall decline in external debt to GDP ratio from FY 2001 to FY 2006 is of 21.6% (see figure 2 and table 1 below).

Table 1

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
External Debt (Billions of Rs)	2061	2006	1928	1938	2032	2148
External Debt as % of GDP	49.5	45.6	40	34.4	30.9	27.9

Data obtained from SBP Annual Report 2006

Figure 1

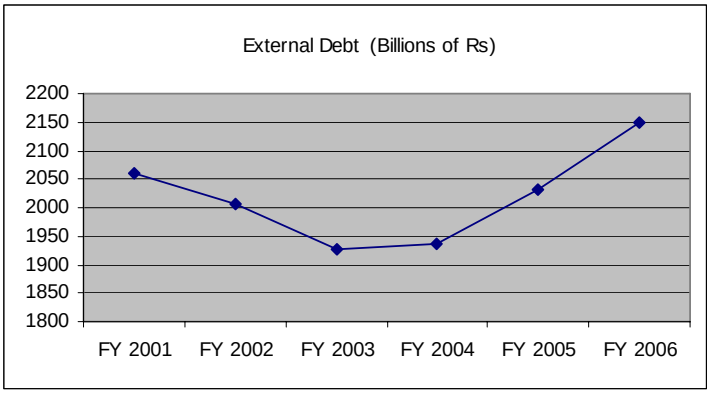
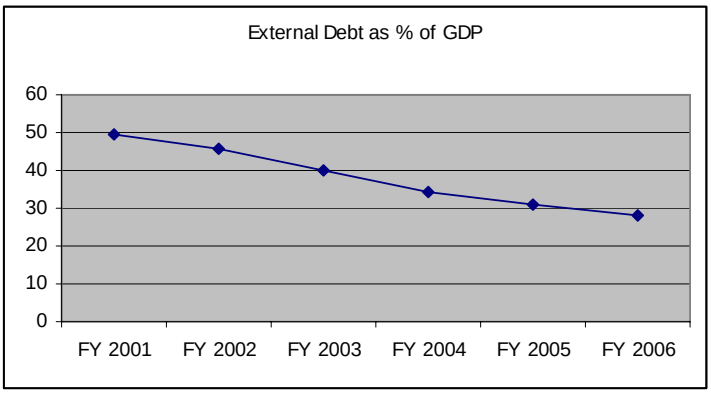


Figure 2



We briefly present below important features of external debt of Pakistan with respect to each fiscal year separately. Most of following analysis is based on Annual reports issued by SBP for each fiscal year[4].

FY 2006

1. Despite increase in outstanding External debt, by US Dollar 2.4 billion, the debt profile of the country was not adversely affected due to new long term concessional loans.
2. By the end of FY 2006, almost quarter of the debt stock was based on floating rate. So the debt profile was not only exposed to exchange rate risk but also interest rate risk.
3. To tap the international capital market, once again Euro bonds of amount US Dollar 800 million were issued.
4. There was improvement in credit rating from B2 to Ba3 (stable outlook) by Moody's with respect to foreign currency ceiling for sovereign bonds. There were further chances of upgrade by Moody's as well as S&P.
5. There was decline in ratios such as total external debt and liabilities (EDL) to GDP, EDL to export earnings and EDL to foreign earnings of 3.4%, 2% and 13.5% respectively and thus showed improved performance.

FY 2005

1. There was increase of 2.19% in External debt (based on US Dollar) i.e. external debt grew from US Dollar 33,307 million in FY 2004 to US Dollar 34,037 million in FY 2005. The main source of increase in external debt were the inflows of funds from Multilateral agencies of US Dollar 1009 million (7% growth), Sukkuk /Eurobonds of US Dollar 242 million (53.6% growth), Islamic Development Bank of US Dollar 249 million (1132% growth). At the same time, there was substantial decrease in inflows from Private loans/creditors, IMF and Paris Club of -19.6%, -8.6% and -4% respectively.
2. Despite increase in External debt in FY 2005 the debt profile of the country improved mainly due to reduced share of expensive EDL and receipts of long term concessional loans.
3. Despite increase in international interest rates; the debt servicing cost was reduced due to decline in the share of expensive debt.
4. To access the international capital market once again, Sukuk bond worth of US Dollar 600 million was issued. Changes in the spread of these bonds were a feedback for economic performance of the country.

[4] http://www.sbp.org.pk/publications/index2.asp

5. Successful completion of PRGF Program of IMF and increase in rating from B+ to B+ stable by Standard & Poor were the success stories of the FY 2005.

FY 2004

1. External debt dropped from US Dollar 33,352 million in FY 2003 to US Dollar 33,307 million in FY 2004 i.e. marginal decline of around 0.13%.
2. Issuance of 5-year Eurobond worth of US Dollar 500 million not only helped to access the international capital market for the first time since 1998 but also yielded a sovereign risk benchmark for Pakistan economy too. Four times oversubscription of the Eurobond, improved credit rating from B2 to B3 by Moody's, and reduction in sovereign risk were the landmarks of the fiscal year 2004.
3. For the first time in Pakistan history, government marked its entry into international derivative market to swap the Eurobond from fixed to floating interest rate with a view that short term interest rate would remain favorable.
4. Prepayment of expensive multilateral loans of US Dollar 1.17 billion of ADB was made. This prepayment not only reduced total multilateral loans but also created a saving on future interest payments.
5. Hard term debt was substituted by the soft term debt.
6. There was write-off of debt by US Government of US Dollar 495 million.
7. Decline in ratios such as total external debt (TED) to GDP, TED to export earnings and TED to foreign exchange earnings by 13.3%, 12.3% and 8.6% showed improvement and thus better debt profile.
8. The benefit of prepayment of expensive multilateral loans of US Dollar 1.17 billion of ADB and write-off of debt by US government could not be materialized much in terms of reduction of TED due to revaluation impact on the non-US Dollar denominated debt , commitment of new loans and interest capitalization.

FY 2003

1. Total External debt declined marginally from US Dollar 33,400 million in FY 2002 to US Dollar 33,307 million in FY 2003 million i.e. marginal decline of around 0.3%.
2. Fresh Loans were of concessional nature and most of the debt retired belonged to the expensive debt category and private commercial debt.
3. There was write-off of bilateral debt of around US Dollar 1 billion by the US Government.
4. TED to GDP, TED to export earnings and TED to foreign exchange earnings showed decline of 14.3%, 0.3% and 20.5%, thus indicated better economic health of the country and improved external debt profile.

FY 2002:

1. TED increased from US Dollar 32,124 million in FY 2001 to US Dollar 33400 million in FY 2002 i.e. increase of around 4%.
2. IMF SBA (Stand By Arrangement) program was successfully completed. This successful completion of the program send positive signals to the global investment community and International lenders.
3. Change in global political scenario paved the path for access to new debt markets/avenues. Further, Pakistan was also able to get better deals on the programs such as medium term PRGF and restricting of bilateral debt by Paris Club.
4. Unprecedented appreciation of Pakistan Rupee against Dollar by 6.7% in FY 2002 is of special importance in context of interpreting the achievements related to External Debt.
5. Both TED to GDP and TED to export earnings increased by 3% and 1.7%, thus showing poor performance. However TED to foreign exchange earnings declined by 3.4%, despite increase in TED by 4%.

FY 2001

1. TED increased from US Dollar 34,281 million in FY 2000 to US Dollar 33400 million in FY 2001 i.e. increase of around 1.2%. Further FY 2001 witnessed substantial change in the profile of external debt, for instance fall in disbursement of Paris Club and resumption of IFI assistance.
2. Substantial depreciation of Pakistan Rupee against US Dollar had profound effect on external debt/liabilities ratio such as external debt/liabilities to GDP ratio.
3. TED to Export earnings and TED to foreign exchange earnings both showed better performance i.e. decline of 7.2% and 9.7%. While at the same time TED to GDP ratio increased by 4.6%.

4. Data and Methodology

The aim of this study is to assess and analyze the exchange rate risk related to three currencies i.e. Euro, American Dollar and Japanese Yen on Pakistan's Public Debt Portfolio (PDPP) from year 2001 to 2006. We use three VAR methods, Delta-Normal , Monte Carlo and Historical Simulation to assess the maximum potential loss over the years, that PDPP could have suffered due to fluctuations in the exchange rates of three currencies (Euro, Dollar and Japanese Yen) over a one day horizon with 95 confidence level from year 2001 to 2006. Delta-Normal Method is further exploited to analyze the nature and source of losses by

employing Marginal VAR, Beta, Component VAR, Diversification and Best Hedge. Data related to three exchange currencies constituting PDPP i.e. Rs/Euro, Rs/Dollar and Dollar/Jyen is obtained from Ecowin, where the source mentioned is State Bank of Pakistan (SBP). While data related to Debt composition related to three currencies is also obtained from Ecowin and for this, the source mentioned is World Bank Group. Rate Rs/Jyen is obtained from cross rates of Rs/Dollar and Dollar/Jyen.

Descriptive Statistics

Relative movement of three exchange rates in relation to each other under the studied period shows that in the year 2001, Rs/Dollar dominated the other two exchange rates, i.e. Pak Rs depreciated most with respect to dollar than the other two currencies (see Graph 1 and 2 in annexure). While a greater degree of co-movement within all rates is observed from the graph, this is more evident in the case of Jyen rate in terms Pak Rs with the other two exchange rates. This is also confirmed through correlation coefficient of 0.66 between Rs/Jyen and Rs/Dollar and 0.72 between Rs/Jyen and Rs/Euro (see table 9 in annex). While we do find appreciation in value of Pak Rs against all the currencies at the end of year 2001.

In 2002, we observe a changing role of Dollar in terms of Pak Rs. From the beginning of 2002 Rs/Dollar rate assumes a much stable role, which can be seen from its lower standard deviation in comparison to year 2001. Its daily volatility declines form 1.9 in 2001 to 0.63 in 2002(decline of around 67%) (See table 2 and 3 in annexure). Further, in year 2002 Pak Rs seems to be depreciating against all the currencies except Dollar (see Graph 3 in annexure). While from mid 2002 Rs/Euro rate dominates the Dollar for the first time and remains well above to both foreign currency rates. Once again high correlation coefficient of 0.862 is found between Jyen and Euro exchange rates. While Dollar rate in terms of Pak Rs has negative correlation coefficient of 0.6 and 0.3 with the Euro and Jyen rates respectively (see table 10 in annexure). In 2003, both Jyen and Euro seem to be appreciating against the Pak Rs while Dollar seems to be more stable, (see Graph 4 in annexure) and there is further decline of around 41% in its daily volatility from 2002 to 2003 (See table 3 and 4 in annexure). While correlation between Rs/Euro and Rs/Jyen continues to remain high and positive (see table 11 in annexure). In 2004 we observe a positive correlation among all the rates, which ideally is not required in the case when all the positions are either long or short (see 12 in annexure). This situation in terms of correlation is comparable to year 2001, where all three rates have positive correlation among them. While Rs depreciates more against Euro and Jyen than Dollar (see Graph 5 in annexure).

In 2005 and 2006 Euro in terms of Pak Rs continues to remain well above the other two currencies from mid 2002 (see Graphs 1,6 and 7 in annexure). In 2005 we find high negative correlation coefficient of 0.7 for Rs/Dollar with Rs/Jyen and Rs/Euro (see table 13 in annexure). While positive correlation continues to remain between Rs/Euro and Rs/Jyen for each year from 2001 to 2006. Specifically in year 2006 though correlation coefficient of 0.4 is positive between Rs/Euro and Rs/Jyen rates but it is much less in comparison to previous years (the decrease is more than 52% in correlation coefficient from 2005 to 2006) (see table 14 in annexure).

So on the whole from 2001 to 2006 we find marginal positive correlation coefficient of 0.05 between Rs/Dollar and Rs/Jyen rates and low negative correlation coefficient of 0.2 between Rs/Dollar and Rs/Euro while 0.7 between Rs/Euro and Rs/Jyen (see table 8 in annexure). Ideally, from risk management perspective, it is recommended to have negative correlation coefficient between leading currencies constituting the portfolio (when the position is either short or long), in our case the portfolio is PDPP and the two leading currencies constituting the portfolio are Dollar and Jyen. Both these currencies constitute on average more than 58% of PDPP and instead of having negative correlation coefficient they are found to be having marginally positive correlation coefficient.

Methodology

Variables

Out first step towards VAR calculation would be to calculate the returns for each exchange rate series for each year. For this we adopt geometric returns:

$$R_{t,Rs/Euro} = \ln \frac{(Rs/Euro)_t}{(Rs/Euro)_{t-1}}$$

$$R_{t,Rs/Dollar} = \ln \frac{(Rs/Dollar)_t}{(Rs/Dollar)_{t-1}}$$

$$R_{t,Rs/Yen} = \ln \frac{(Rs/Yen)_t}{(Rs/Yen)_{t-1}}$$

Delta-Normal VAR

Our second step is to calculate the Delta-Normal VAR of PDPP related to exchange rate risk. For this we set the confidence level as 95% and the time horizon of one day. To calculate this and other measures such as individual VAR, Marginal VAR, Beta, Component VAR and best hedge, we adopt the standard method as outlined in Jorion (2007). Delta-Normal VAR is also

known as "Diversified VAR" because it does take into consideration diversification benefits related to component assets constituting portfolio. We calculate Delta-Normal VAR in accordance with the following equation adopted from Jorion (2007):

$$\text{PDPP VAR} = \text{VAR}_\text{P} = \alpha\sqrt{\text{X}'\sum\text{X}}$$

Here α has value of 1.65 i.e. for 95% confidence level , X represents the debt position in each currency in Pak Rs, while $\sum$ represents covariance matrix.

Individual VAR

Individual VAR represents the VAR associated to individual component or asset constituting portfolio not taking into consideration diversification benefits. Individual VAR is calculated through the following equation:

$$\text{VAR}_\text{i} = \sigma|\text{w}_\text{i}|\text{W}$$

Here VAR_i represents individual VAR, w_i represents weight of the individual currency composing PDPP, σ represents volatility of the specific currency in PDPP, while W is the original value of PDPP.

Undiversified VAR

In our study undiversified VAR represents the sum of all the individual VAR constituting PDPP, when a portfolio consists of no short positions and correlations among the constituents assets are unity. So we expect to find diversified VAR incase of PDPP lower than undiversified VAR. Undiversified VAR is estimated through:

$$\text{VAR}_\text{p} = \text{VAR}_{\text{RS/Euro}} + \text{VAR}_{\text{Rs/Dollar}} + \text{VAR}_{\text{Rs/Yen}}$$

In above equation VAR_prepresents undiversified VAR, while $VAR_{RS/Euro}$, $VAR_{Rs/Dollar}$ and $VAR_{Rs/Yen}$ represent individual VAR related to Euro, Dollar and Jyen respectively.

Marginal VAR

Jorion (2007) defines marginal VAR as "partial (or linear) derivative with respect to component position". Marginal VAR is the change in Portfolio VAR due to increase in one unit currency (Dollar, Euro or Jyen) of a given asset/component in the portfolio (in our study relevant portfolio is PDPP). Marginal VAR is calculated as:

$$\Delta VAR_i = \frac{VAR}{W}\beta_i$$

Here ΔVAR_i represents marginal *VAR*, while β_i is Beta related to specific currency.

Best Hedge

Best Hedge indicates size of the new positions related that minimizes the portfolio risk. It is the extra amount allocated to an asset/component to minimize the portfolio exposure to specific risk. Best hedge is calculated as:

$$a^* = W\beta_i \frac{\sigma_p^2}{\sigma_i^2}$$

Component VAR

Individual VAR though an important measure, does not take into account diversification benefits. Component VAR is the one measure which takes into account the diversification benefits on one hand and informs about the contribution of the component risk into portfolio VAR on the other hand. So component VAR indicates how diversified VAR would change approximately if the given component asset was taken out of the portfolio. Component VAR is calculated as:

$$\text{Component } VAR = VAR\beta_i w_i$$

VAR through Historical Simulation

For Historical simulation we follow the method as outlined in Kevin Dowd(1998), where return related to PDPP for each day is calculated for each year from 2001 to 2006 as:

$$\mathrm{R_t} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{w_i}\, \mathrm{R_i}$$

Here w_i is relative weight of the each currency in PDPP and R_i is the geometric return of each currency for each day for each exchange rate i.e. Rs/Euro, Rs/Dollar and Rs/Jyen. So each observation t gives us a particular PDPP return R_t. The sample of historical observation therefore gives us a sample distribution of PDPP returns. PDPP returns are than translated to profit and losses. Once after determining the profit and losses of PDPP, value at risk is found at 95% confidence level.

VAR through MC

We calculate the Value at risk through Monte Carlo simulation on PDPP due to exchange rates risk for one day horizon on the final day of each year. For calculating VAR through MC,

methodology employed here is adopted from Jorion (2007). Each Exchange rate currency evolves based on Brownian motion:

$$\frac{\Delta(\text{Rs/Euro})_t}{(\text{Rs/Euro})_t} = \mu\,\Delta t + \sigma\sqrt{\Delta t}\,Z_t$$

$$\frac{\Delta(\text{Rs/Dollar})_t}{(\text{Rs/Dollar})_t} = \mu\,\Delta t + \sigma\sqrt{\Delta t}\,Z_t$$

$$\frac{\Delta(\text{Rs/Yen})_t}{(\text{Rs/Yen})_t} = \mu\,\Delta t + \sigma\sqrt{\Delta t}\;Z_t$$

Where μ and σ are the mean and standard deviation of returns over a holding period. Z_t is a standard normal shock that derives the exchange rate change. To account for the correlation of exchange rates returns so that correlation matrix of Z_t is same as the correlation matrix of all the exchange return series, we employ method of Cholesky Factorization which is commonly available in computational softwares. After generation of appropriate random numbers and exchange rates path of all the three currencies, a realization of next period exchange rate is obtained. These realizations give rise to a portfolio as weighted sum of individual exchange rate series. We repeat this procedure for 10,000 times to obtain distribution of next day's portfolio value. In our case the VAR is calculated at 95% level of confidence level over one day horizon period.

Consequences of normality assumption

As can be seen in CDF Graphs (see graph 29 to 31) that normality assumption is completely rejected in the case of returns from all currencies as a single period from 2001 to 2006. But when all the series are divided into 6 annual time series i.e. dividing time period of 2001 to 2006 in years, than we do observe less large Jarque-Bera figures and better convergence towards normal distribution as is evident from the histograms (see graphs 8 to 28 in annexure) and CDF (see graph 32 to 49 in annexure)(see Ajili 2008). Moreover, as we would see, Value-at-risk through Monte Carlo and Historical Simulation also produce almost the similar results as Delta-Normal Method validating that the assumption of Normality is not unreasonable. The convergence of results is greater in case of MC and Delta-Normal than between HS and Delta-Normal (see graph 63 and 64 in annexure). The level of divergence in percentage between MC VAR and Delta-Normal VAR is 1.3%, 2.5%, 0.9%, 2.3%, 4.13% and 4% for years 2001 to 2006 consecutively. For none of the year we find diversion more than 5 % (Best, 1998). In graph 63, diversion of lines related to MC VAR and Delta-Normal VAR is only marginal. This indicates if the normality assumption had any serious consequences for correct estimation of Delta-Normal VAR, than VAR figures from Delta-Normal VAR would

have also given greater divergence. We conclude that assumption of normal distribution of Exchange rate returns of three currencies (Euro, Dollar and Jyen) is not unreasonable in our case.

The issue of normality assumption in case of Risk Metrics, which too assumes normality of returns distribution in calculation of VAR, has been dealt in detail by Pafka and Kondor (2001). According to the study, satisfactory performance of Risk Metrics, despite ignorance of fat tails in distribution function, is the artifact of the choice of the risk measure. First, risk measure choice is short period of forecasting and second is choice of particular confidence level of 95%. As the confidence level is increased from 95% to 99% the effect of fat tails become much stronger and therefore VAR is seriously affected if normality is to be assumed.

5. Application

Confidence Level

Following the convention set by Risk metrics methodology we set confidence level at 95%, especially when the returns distribution is not perfectly normal (although convergence to normal distribution is observed, as evident from the graphs 8 to 28 and from 32 to 49 in annexure).

Time horizon

Time horizon for which the VAR is calculated for each year is one day period.

Covariance Matrix

Covariance matrices of returns of exchange rate series for each year are obtained for the studied period.

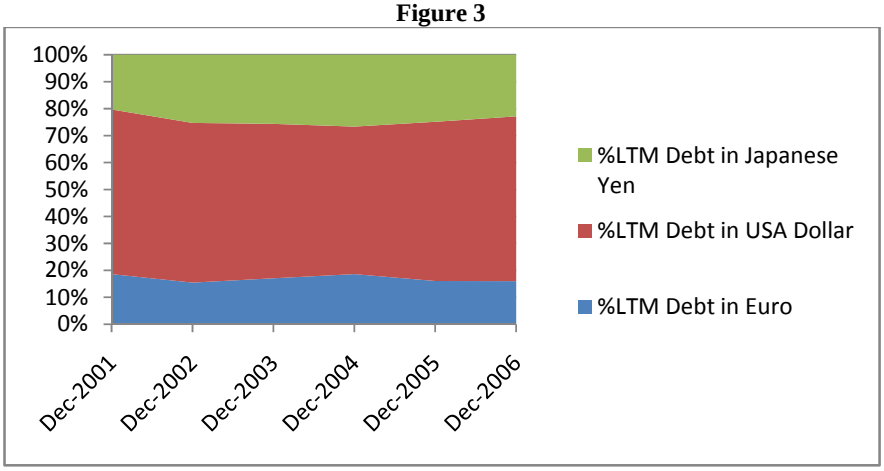
Debt Composition

Following Ajili (2008) and Chan and Tan (2003) each currency position in the PDPP is represented by constant Vector throughout the period from one year to another. Further, PDPP is assumed have value of 100 million Pak Rs, and this too is constant throughout the studied period. Constant value of each currency in the Vector is calculated as the average position of specific currency contribution in PDPP from 2001 to 2006.

Assumption of constant vector is validated through the argument that during the studied period the contribution of each currency in PDPP does not change much form one year to another. Although there were substantial developments and changes that took place in the

studied period with respect to external debt policy, profile and composition (as evident from the section III) but there was no substantial change in percentage-wise currency composition of PDPP (See figure 3 below). For instance, the share of American Dollar, considering the three currencies, in the PDPP fluctuated between 61% and 55%, and continued to have largest share in PDPP. While share of Japanese Yen in the PDPP fluctuated between 20 % and 27%, further it continued to have second large share throughout the studied period. The share of Euro in PDPP also did not fluctuate significantly as it remained between 16% and 19% and continued to have the smallest share.

Figure 3



So in consideration to above argument we can safely opt for average currency position values in the PDPP represented by constant Vector. Average currency position values in terms of percentage share for American Dollar, Euro and Japanese yen are 41%, 12% and 17% respectively. So out of Pak Rs100 million PDPP, Pak Rs70 million is exposed to three exchange currencies i.e. around 70%. We represent debt position of each currency in the debt portfolio by X vector:

$$X = \begin{bmatrix} X_{Euro} & = & 12 \\ X_{Dollar} & = & 41 \\ X_{JYen} & = & 17 \end{bmatrix}$$

Constant vector positions make it convenient to evaluate the risk management performance due to fluctuations in risk factors.

6. Results

1. Correlation Analysis of rates and return indicates lack of hedging strategy and suggests reducing exchange rate risk to which PDPP is exposed.

From the period 2001 to 2006, there exists a marginally positive correlation coefficient between Rs/Dollar and Rs/Jyen. That indicates PDPP is missing hedging strategy related to two leading currencies constituting 58% of the Debt composition. Had there been a negative correlation coefficient, a loss in one currency would have been offset by the gains in another currency. A high correlation of 0.7 is found between Rs/Jyen and Rs/Euro. Nevertheless we do observe a negative correlation between Rs/Euro and Rs/Dollar of 0.2.

Further correlation analysis of return of for the whole period from 2001 to 2006 shows that pair-wise correlation coefficient between all exchange returns series exists to be around 0.5 (see table 15 in annexure). This once again exposes the lack of hedging strategy. Furthermore, in none of the years negative correlation was observed among the returns series of the three currencies from 2001 to 2006. This lack of hedging strategy related to debt management in context of exchange risk would also be corroborated through VAR analysis. And moreover for the Years in which correlation coefficient of more than 0.3 exists between return series of Rs/Dollar and rest of the exchange returns series, we observe a higher realization of VAR figures. For instance this phenomenon can be observed for the years 2001, 2003 and 2004 (See table 16, 18 and 19 and graph 50 in annexure).

2. VAR through Delta-Normal, Monte Carlo and Historical Simulation shows improvement in management of exchange risk exposure to PDPP from one year to another.

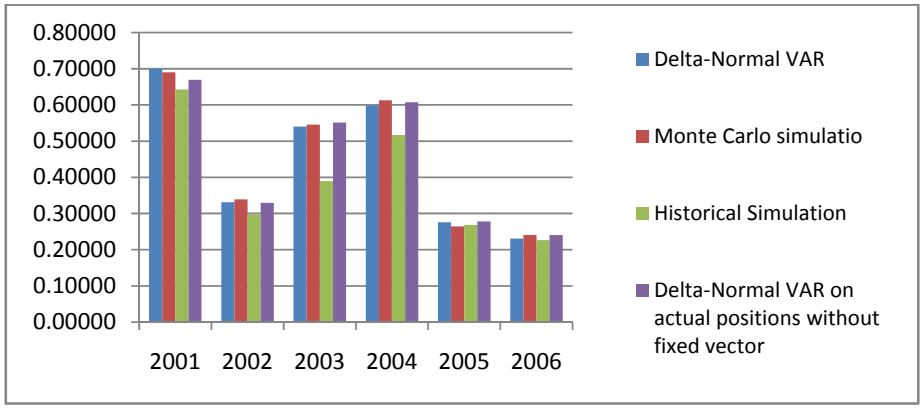
VAR through Delta-Normal, Monte Carlo (Graph from 51 to 62 in annexure) and Historical Simulation show improvement in management of exchange risk exposure to PDPP from one year to another (see graph 50, 63 and 64 in annexure). From year 2001 to 2006 the maximum loss that PDPP worth of Pak Rs 100 million could have suffered due to fluctuation in the exchange rates of three currencies (Euro, Dollar and Japanese yen) is between Pak Rs 0.2 million to Pak Rs 0.7 million (decline of around 67%) over a one day horizon with 95% confidence level. This improvement in management of exchange risk to which PDPP was exposed, was possible mainly due to the changing role of Dollar currency (see section IV, 1), especially in the years 2002, 2005 and 2006. This is also evident from the Beta, component VAR and marginal VAR analysis i.e. lower beta, component and marginal VAR associated to Dollar produced lower VAR for the respective years. Further, as already stated for the years in which correlation coefficient of more than 0.3 exists between return series of Rs/Dollar and rest of the exchange returns series, we observe a higher realization of VAR estimates.

VAR results obtained through Monte Carlo and Historical Simulation do not deviate much from Delta-Normal Method (See Graph 63 and 64 and table 24 in annexure). The

convergence of results is greater in case of MC and Delta-Normal than between HS and Delta-Normal. As already stated that level of divergence in percentage between MC VAR and Delta-Normal VAR is 1.3%, 2.5%, 0.9%, 2.3%, 4.13% and 4% for years 2001 to 2006 consecutively. For none of the year we find diversion more than 5 % (Philip Best, 1998).

The above conclusion with respect to Delta-Normal VAR estimates would only be slightly affected and further the trend virtually remains the same (see figure 4 below), even if actual percentage-wise debt positions of the currencies for each year are taken (see section V, 4) rather than currency position in the PDPP is represented by constant Vector of averaged values over the period.

Figure 4



3. Beta and Marginal VAR analysis reveal that individually Dollar is the least risky and Japanese yen as most risky currency constituting PDPP.

For each year from 2001 to 2006, Beta related to Dollar remained considerably lower than both Euro and Jyen, while Jyen had the highest Beta throughout the years. The same analysis also goes for marginal VAR analysis too. So Marginal VAR analysis and Beta analysis reveal that Dollar is the least risky and Japanese Jyen as the most risky currency constituting PDPP. (See table 25 and graphs 71 and 72 in annexure)

4. Component VAR analysis reveals Dollar's dual role over the years in contribution of exchange risk exposure to PDPP and none out of the three currencies assumes hedging role.

Dollar despite being individually least risky currency in each year from 2001 to 2006 as revealed in marginal VAR and Beta analysis, is found to be contributing highest risk as component VAR i.e. around 50% in Years 2001, 2003 and 2004 (see graph from 65 to 70 and

table 25 in annexure). This is mainly due to the high weight structure of Dollar (i.e. 41%) in PDPP. Component VAR analysis further reveals that Dollar starts as most risk contributing currency in the portfolio i.e. from around 51% in 2001 and ends at being 16% contributing to VAR in 2006. In case of lower component VAR of Dollar in years 2002, 2005 and 2006 is mainly due to its exceptional decline in Beta values. For example the decline in Beta of Dollar from year 2001 to 2002 and from year 2004 to 2006 is around 44% and 78% respectively. Component VAR also reveals that none out of the three currencies assumes hedging role i.e. none of the currency reduces the risk of losses due to another currency associated to exchange risk exposure to PDPP.

5. Best Hedge analysis also reveals extra exposure of PDPP to all the three currencies and calls for reduction in positions for all the currencies in all the years.

Best Hedge analysis suggests to reduce the exposure in all the three currencies (see graph 74 and table 23 in annexure). Had there been any single currency in PDPP with negative Beta and so negative component VAR, we could have observed positive sign associated to Best Hedge values, which is not the case in present scenario from 2001 to 2006.

6. Diversification Degree of VAR of PDPP due to exchange risk has remained fairly stable.

Diversification Degree of VAR of PDPP due to exchange risk has remained fairly stable from 2001 to 2006. (See table 22 and graph 73 in annexure). Diversification degree fluctuates within values of 8% to 11%. Diversificaiton degree could be improved more by employing hedging strategy.

7. Conclusion

VAR analysis of Pakistan's Public Debt Portfolio (PDPP) related to exchange rate risk from one year to another shows signs of improvements in exchange risk management. VAR through Delta-Normal, Monte Carlo and Historical Simulation exhibit considerable decline of around 67% (in case of Delta-Normal) from 2001 to 2006 of maximum potential loss, that PDPP worth of Pak Rs 100 million could have suffered due to fluctuations in the exchange rates of three currencies (Euro, Dollar and Japanese yen) over a one day horizon with 95% confidence level. Our study reveals that Pakistan's Public debt policy management with respect to exchange rate exposure lacks hedging Strategy. None of the currencies constituting the PDPP has negative Beta or negative component Var. Only Dollar has Beta less than unity for all the six years. Beta and Marginal VAR analysis reveal that individually Dollar is the least risky and Japanese yen as most risky currency constituting PDPP. Throughout the period

marginal VAR associated to Dollar never exceeds to those of Euro and Jyen. While Jyen has the highest Beta throughout the period and we obtain the same result through marginal VAR analysis too. Dollar, despite being individually least risky currency throughout the period is found to be contributing highest risk as component VAR in certain years that is mainly due to its positive Beta which declines considerably over the years and large weight structure in the PDPP. Lower component VAR of Dollar in certain years is mainly attributed to its exceptional decline in Beta values of Dollar. Not only Beta and component VAR analysis reveal lack of hedging strategy but this is further confirmed by the Best Hedge analysis , where also all the results exhibit negative signs for all the years throughout the period, suggesting for lower exposure in all currencies including Dollar.

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ANNEXURE

Table No. 1
Descriptive Statistics of exchange rates in 2001-2006

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	59.4132	66.4172	0.51303
Median	59.5500	68.7541	0.51394
Maximum	64.2500	81.1522	0.58367
Minimum	55.6500	51.5450	0.44496
Std. Dev.	1.57228	8.77719	0.02921
Skewness	0.79219	-.205234	0.02972
Kurtosis	4.09466	1.62808	2.72762
Jarque-Bera	241.832	133.718	5.06810
Probability	0.00000	0.00000	0.07933
Sum	92981.7	103943	802.905
Sum Sq. Dev.	3866.31	120489.	1.33476
Observations	1565	1565	1565

Table No. 2
Descriptive Statistics of exchange rates in 2001

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	61.4483	54.9893	0.506092
Median	61.1500	54.5861	0.505541
Maximum	64.2500	59.4386	0.550585
Minimum	57.8000	52.4500	0.453924
Std. Dev.	1.88179	1.58626	0.017721
Skewness	-0.06833	1.02139	0.006109
Kurtosis	1.78163	3.26704	3.266791
Jarque-Bera	16.3461	46.1570	0.775678
Probability	0.00028	0.00000	0.678521
Sum	16038.0	14352.2	132.0900
Sum Sq. Dev.	920.700	654.223	0.081645
Observations	261	261	261

Table No. 3
Descriptive Statistics of exchange rates in 2002

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	59.426	56.153	0.475
Median	59.850	57.386	0.477
Maximum	60.200	60.859	0.516
Minimum	58.050	51.545	0.444
Std. Dev.	0.633	2.756	0.0186
Skewness	-0.850	-0.295	0.1298
Kurtosis	2.319	1.548	2.0391
Jarque-Bera	36.508	26.707	10.774
Probability	0.000	0.000002	0.004
Sum	15510.44	14656.09	124.129
Sum Sq. Dev.	104.4353	1974.900	0.090
Observations	261	261	261

Table No. 4
Descriptive Statistics of exchange rates in 2003

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	57.598	65.180	0.4978
Median	57.7000	65.202	0.490
Maximum	58.200	72.031	0.5366
Minimum	55.650	60.272	0.475
Std. Dev.	0.3743	2.693	0.0176
Skewness	-1.998	0.313	0.879
Kurtosis	8.786	2.434	2.241
Jarque-Bera	537.887	7.760	39.909
Probability	0.000	0.020	0.000
Sum	15033.21	17012.06	129.942
Sum Sq. Dev.	36.430	1886.243	0.0811
Observations	261	261	261

Table No. 5
Descriptive Statistics of exchange rates in 2004

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	58.2355	72.4784	0.53911
Median	57.9350	71.6407	0.53572
Maximum	61.0900	81.0303	0.58367
Minimum	56.4000	67.8038	0.50353
Std. Dev.	1.04779	3.35968	0.01846
Skewness	0.56885	1.01868	0.74833
Kurtosis	2.25780	3.04675	2.90298
Jarque-Bera	20.1439	45.3376	24.5564
Probability	0.00004	0.00000	0.00000
Sum	15257.7	18989.3	141.247
Sum Sq. Dev.	286.546	2946.02	0.08900
Observations	262	262	262

Table No. 6
Descriptive Statistics of exchange rates in 2005

	RS/Dolla	RS/Euro	RS/Jyen
Mean	59.5499	74.0822	0.541656
Median	59.5700	73.1922	0.544522
Maximum	59.8700	80.2147	0.582362
Minimum	58.8600	69.6377	0.493719
Std. Dev.	0.17338	2.85727	0.022870
Skewness	-0.41771	0.31396	-0.341509
Kurtosis	2.87840	1.75547	2.140869
Jarque-Bera	7.72108	21.0506	13.05005
Probability	0.02105	0.00002	0.001466
Sum	15482.9	19261.3	140.8305
Sum Sq. Dev.	7.78600	2114.47	0.135471
Observations	260	260	260

Table No. 7
Descriptive Statistics of exchange rates in 2006

	Rs/Dollar	Rs/Euro	Rs/Jyen
Mean	60.228	75.661	0.517
Median	60.180	76.414	0.516
Maximum	60.940	81.152	0.547
Minimum	59.70500	70.59519	0.502016
Std. Dev.	0.333960	2.647189	0.008873
Skewness	0.357688	-0.176699	0.858468
Kurtosis	1.997318	2.212987	3.644295
Jarque-Bera	16.43563	8.063037	36.43235
Probability	0.000270	0.017747	0.000000
Sum	15659.33	19671.93	134.6711
Sum Sq. Dev.	28.88616	1814.971	0.020390
Observations	260	260	260

Table No. 8
Correlation Coefficient of exchange rates from 2001- 2006

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	-0.204	0.054
Rs/Euro	-0.204	1.000	0.733
Rs/Jyen	0.054	0.733	1.000

Table No. 9
Correlation Coefficient of exchange rates in 2001

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	0.516	0.660
Rs/Euro	0.516	1.000	0.721
Rs/Jyen	0.660	0.721	1.000

Table No. 10

Correlation Coefficient of exchange rates in 2002

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	-0.659	-0.285
Rs/Euro	-0.659	1.000	0.862
Rs/Jyen	-0.285	0.862	1.000

Table No. 11

Correlation Coefficient of exchange rates in 2003

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	-0.505	-0.586
Rs/Euro	-0.505	1.000	0.700
Rs/Jyen	-0.586	0.700	1.000

Table No. 12

Correlation Coefficient of exchange rates in 2004

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	0.752	0.691
Rs/Euro	0.752	1.000	0.904
Rs/Jyen	0.691	0.904	1.000

Table No. 13

Correlation Coefficient of exchange rates in 2005

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	-0.777	-0.748
Rs/Euro	-0.777	1.000	0.899
Rs/Jyen	-0.748	0.899	1.000

Table No. 14

Correlation Coefficient of exchange rates in 2006

	Rs/Dollar	Rs/Euro	Rs/Jyen
Rs/Dollar	1.000	0.847	-0.0151
Rs/Euro	0.847	1.000	0.429
Rs/Jyen	-0.015	0.429	1.000

Table No. 15

Correlation Coefficient of Returns 2001-2006

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1	0.5098	0.547
$R_{Rs/Euro}$	0.509	1	0.507
$R_{Rs/Jyen}$	0.547	0.507	1

Table No. 16

Correlation Coefficient of Returns 2001

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1	0.663	0.664
$R_{Rs/Euro}$	0.663	1	0.533
$R_{Rs/Jyen}$	0.664	0.533	1

Table No. 17

Correlation Coefficient of Returns 2002

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1	0.263	0.410
$R_{Rs/Euro}$	0.263	1	0.342
$R_{Rs/Jyen}$	0.4102	0.342	1

Table No. 18

Correlation Coefficient of Returns 2003

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1	0.523	0.693
$R_{Rs/Euro}$	0.523	1	0.483
$R_{Rs/Jyen}$	0.693	0.483	1

Table No. 19

Correlation Coefficient of Returns 2004

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1	0.569	0.610
$R_{Rs/Euro}$	0.569	1	0.557
$R_{Rs/Jyen}$	0.610	0.483	1

Table No. 20

Correlation Coefficient of Returns 2005

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1.000	0.229	0.236
$R_{Rs/Euro}$	0.229	1.000	0.528
$R_{Rs/Jyen}$	0.236	0.528	1.000

Table No. 21

Correlation Coefficient of Returns 2006

	$R_{Rs/Dollar}$	$R_{Rs/Euro}$	$R_{Rs/Jyen}$
$R_{Rs/Dollar}$	1.000	0.259	0.154
$R_{Rs/Euro}$	0.259	1.000	0.491
$R_{Rs/Jyen}$	0.154	0.491	1.000

Table No. 22

Diversified ,Undiversified and Diversification Degree 200-2006

YEAR	DIVERSIFIED VAR	UNDIVERSIFIED VAR	DIVERSIFICATION DEGREE	%DIVERSIFICATION
2001	0,69960	0,80220	0,10260	10%
2002	0,33080	0,43700	0,10620	11%
2003	0,54010	0,62970	0,08960	9%
2004	0,59850	0,69770	0,09920	10%
2005	0,27600	0,36700	0,09100	9%
2006	0,23080	0,30840	0,07760	8%

Table No.23

Best Hedge of each currency 2001-2006

YEAR	%BEST HEDGE EURO	%BEST HEDGE DOLLAR	%BEST HEDGE YEN
2001	-3%	-1%	-2%
2002	-1%	-1%	-1%
2003	-1%	-1%	-1%
2004	-2%	-1%	-2%
2005	-1%	-1%	-1%
2006	-1%	-1%	-1%

Table No. 24

Diversified VAR,MC VAR and HS VAR 2001-2006

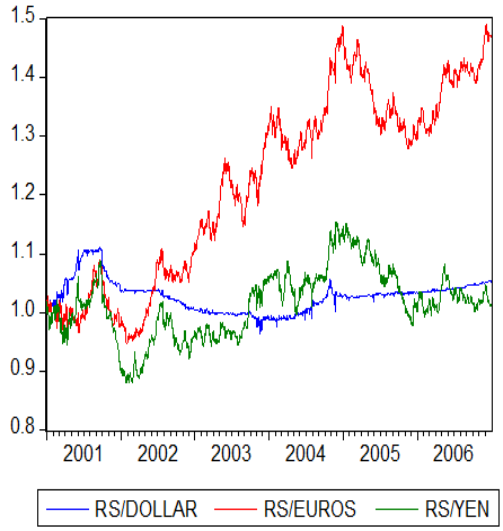
YEAR	DIVERSIFIED VAR	MONTE CARLO SIMULATION	HISTORICAL SIMULATION
2001	0,69960	0,69020	0,64270
2002	0,33080	0,33940	0,29780
2003	0,54010	0,54550	0,38960
2004	0,59850	0,61260	0,51680
2005	0,27600	0,26460	0,26820
2006	0,23080	0,24050	0,22630

Table No. 25

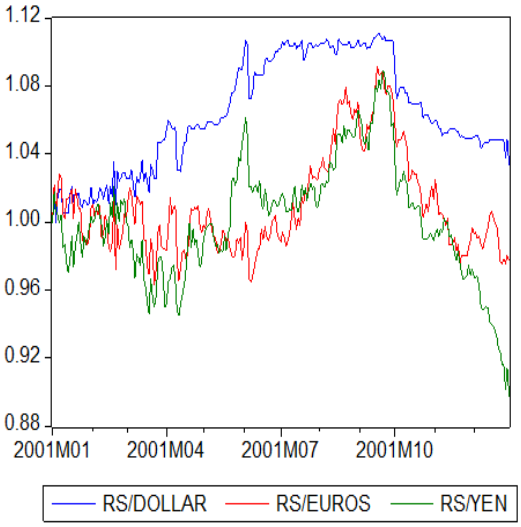
Beta, Margianl VAR and component VAR of each currency 2001-2006

YEAR	BETA OF EURO	BETA OF DOLLAR	BETA OF YEN	MARG. VAR EURO	MARG. VAR DOLLAR	MARG. VAR YEN	COMP. VAR EURO	COMP. VAR DOLLAR	COMP. VAR YEN
2001	1,1599	0,8755	1,1893	0,0115	0,0087	0,0118	0,1376	0,3599	0,2021
2002	1,4258	0,4894	1,9377	0,0067	0,0023	0,0091	0,0799	0,0951	0,1557
2003	1,1157	0,851	1,2796	0,0086	0,0065	0,0098	0,1021	0,27	0,1679
2004	1,1025	0,8742	1,2326	0,0094	0,0074	0,0105	0,1118	0,3074	0,1792
2005	1,7415	0,3757	1,9922	0,0068	0,0015	0,0078	0,0815	0,0609	0,1336
2006	1,9137	0,2755	2,1143	0,0063	0,0009	0,0069	0,0749	0,0374	0,1185

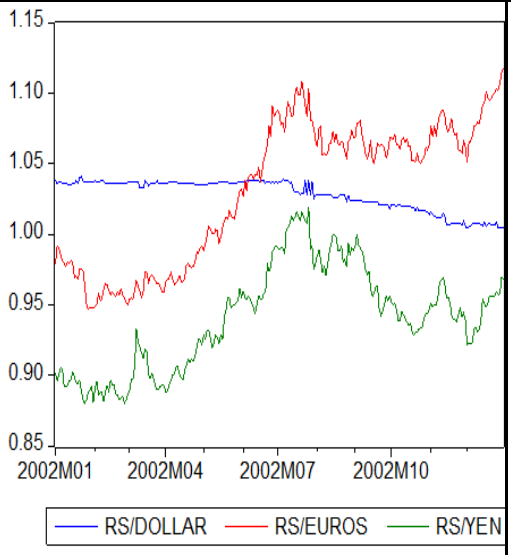
Graph No. 1
Relative movement of exchange rates from 2001-2006



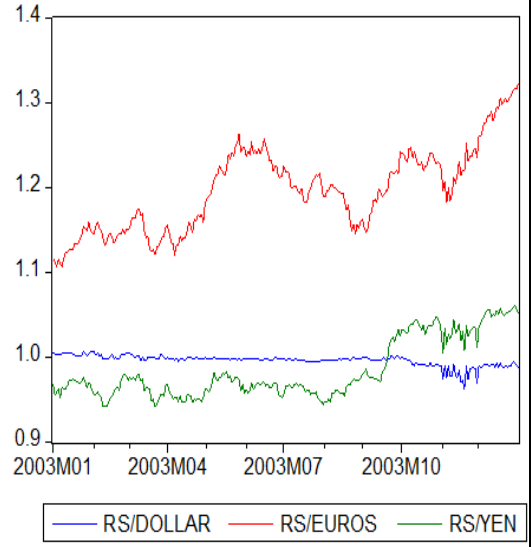
Graph No. 2
Relative movement of exchange rates in 2001



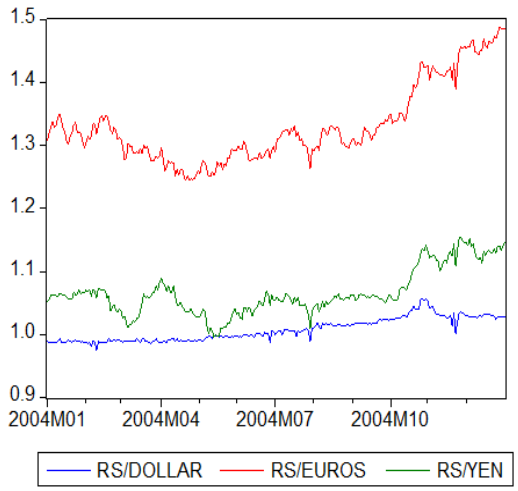
Graph No. 3
Relative movement of exchange rates in 2002



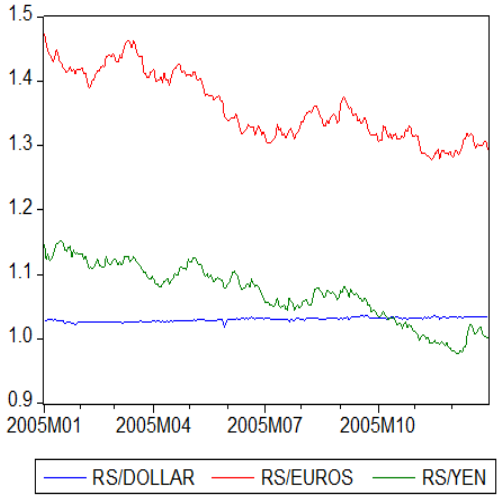
Graph No. 4
Relative movement of exchange rates in 2003



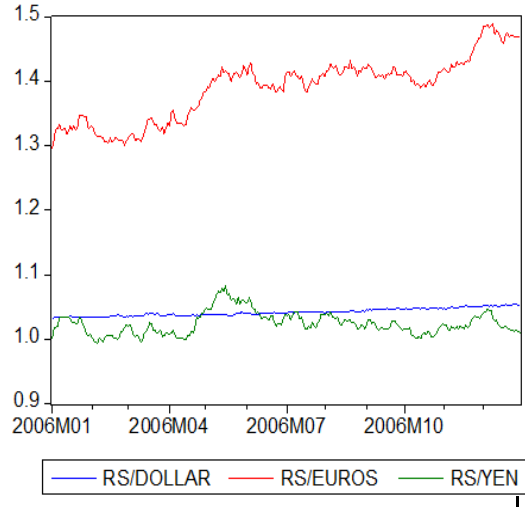
Graph No. 5
Relative movement of exchange rates in 2004



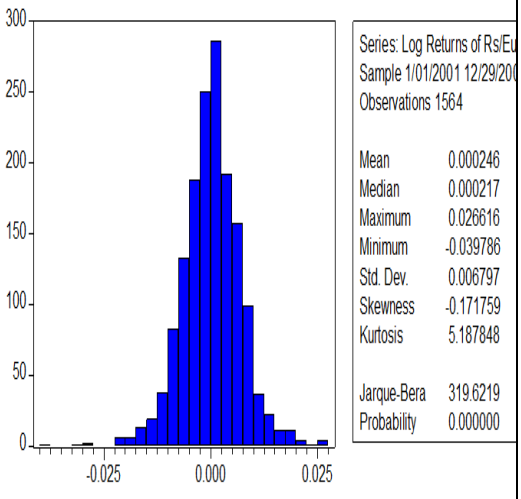
Graph No. 6
Relative movement of exchange rates in 2005



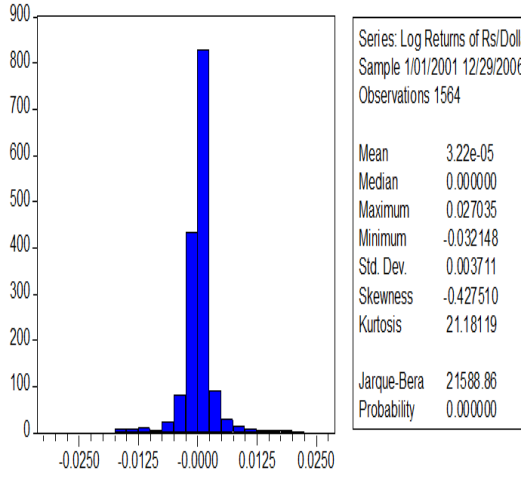
Graph No. 7
Relative movement of exchange rates in 2006



Graph No. 8
Histogram Geometric returns of RS/Euro Currency from 2001-2006



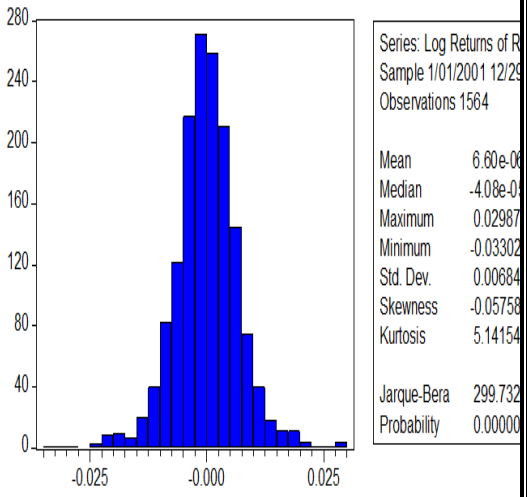
Graph No. 9
Histogram of Geometric returns of RS/Dollar from 2001-2006



Series: Log Returns of Rs/Doll
Sample 1/01/2001 12/29/200
Observations 1564

Mean	3.22e-05
Median	0.000000
Maximum	0.027035
Minimum	-0.032148
Std. Dev.	0.003711
Skewness	-0.427510
Kurtosis	21.18119
Jarque-Bera	21588.86
Probability	0.000000

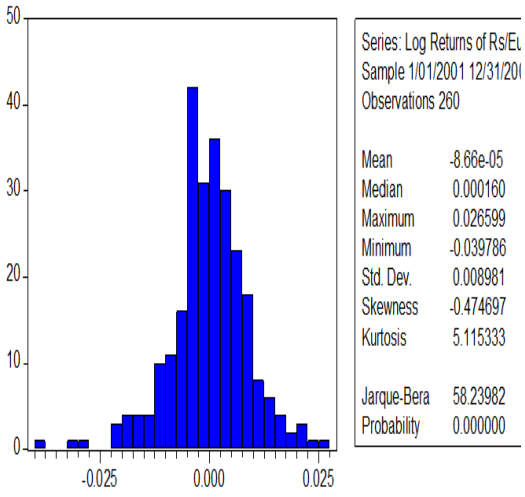
Graph No. 10
Histogram of Geometric returns of RS/Yen from 2001-2006



Series: Log Returns of R
Sample 1/01/2001 12/29
Observations 1564

Mean	6.60e-06
Median	-4.08e-05
Maximum	0.02987
Minimum	-0.03302
Std. Dev.	0.00684
Skewness	-0.05758
Kurtosis	5.14154
Jarque-Bera	299.732
Probability	0.00000

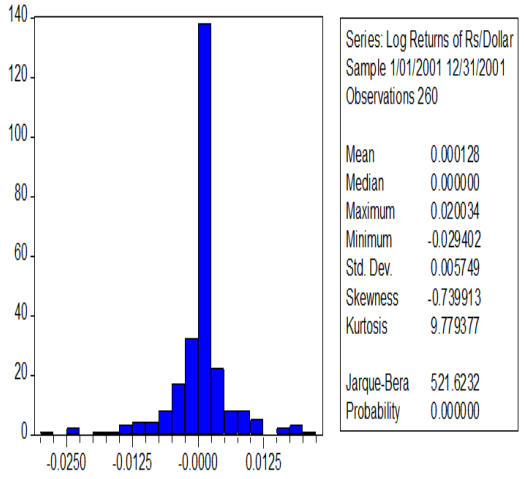
Graph No. 11
Histogram of Geometric returns of RS/Euro in 2001



Series: Log Returns of Rs/Eu
Sample 1/01/2001 12/31/20
Observations 260

Mean	-8.66e-05
Median	0.000160
Maximum	0.026599
Minimum	-0.039786
Std. Dev.	0.008981
Skewness	-0.474697
Kurtosis	5.115333
Jarque-Bera	58.23982
Probability	0.000000

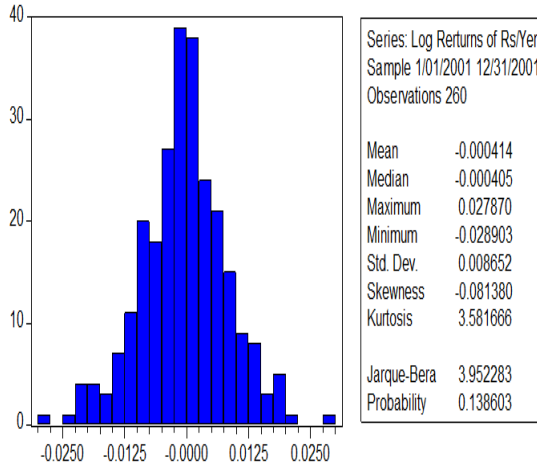
Graph No. 12
Histogram of Geometric returns of RS/Dollar in 2001



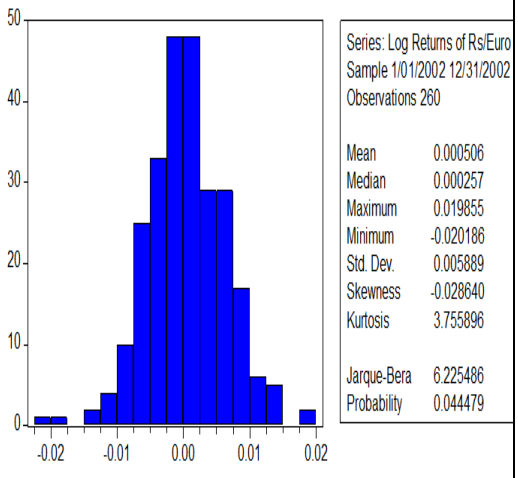
Series: Log Returns of Rs/Dollar
Sample 1/01/2001 12/31/2001
Observations 260

Mean	0.000128
Median	0.000000
Maximum	0.020034
Minimum	-0.029402
Std. Dev.	0.005749
Skewness	-0.739913
Kurtosis	9.779377
Jarque-Bera	521.6232
Probability	0.000000

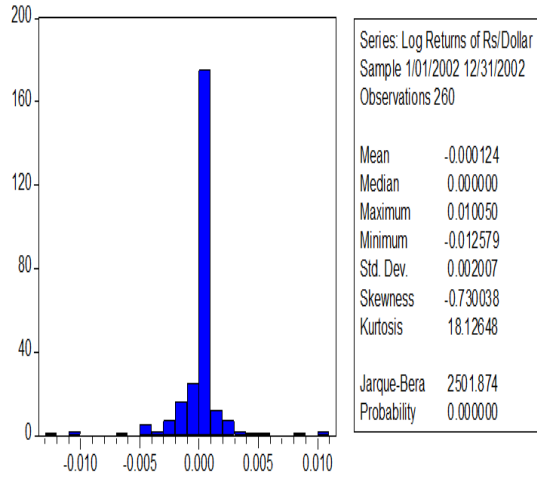
Graph No. 13
Histogram of Geometric returns of RS/Yen in 2001



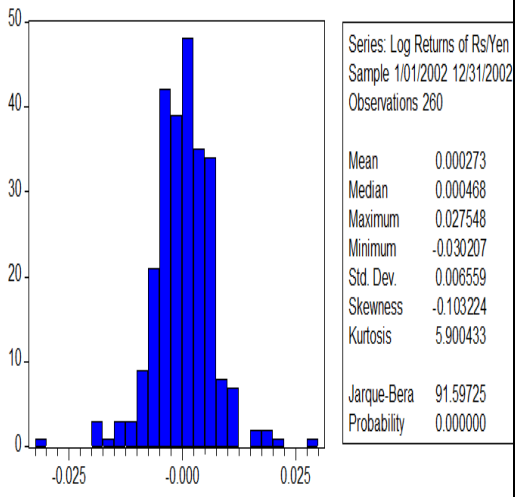
Graph No. 14
Histogram of Geometric returns of RS/Euro in 2002



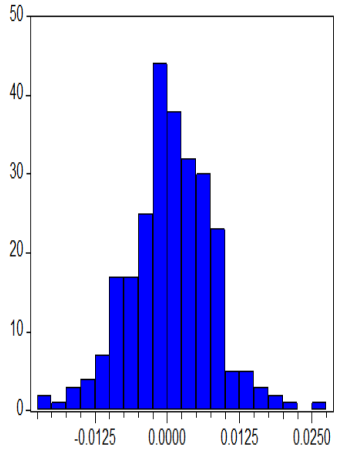
Graph No. 15
Histogram of Geometric returns of RS/Dollar in 2002



Graph No. 16
Histogram of Geometric returns of RS/Yen in 2002



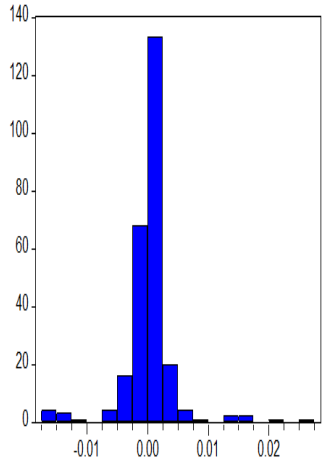
Graph No. 17
Histogram of Geometric returns of RS/Euro in 2003



Series: Log Returns of Rs/Euro
Sample 1/01/2003 12/31/2003
Observations 260

Mean	0.000653
Median	0.000710
Maximum	0.026616
Minimum	-0.021421
Std. Dev.	0.007231
Skewness	-0.031826
Kurtosis	3.801807
Jarque-Bera	7.008586
Probability	0.030068

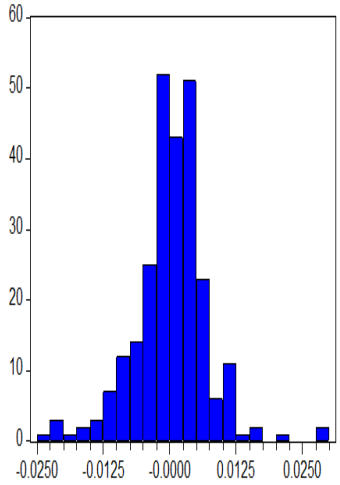
Graph No. 18
Histogram of Geometric returns of RS/Dollar in 2003



Series: Log Returns of Rs/Dollar
Sample 1/01/2003 12/31/2003
Observations 260

Mean	-6.68e-05
Median	0.000000
Maximum	0.027035
Minimum	-0.017158
Std. Dev.	0.004272
Skewness	0.839531
Kurtosis	15.39598
Jarque-Bera	1695.194
Probability	0.000000

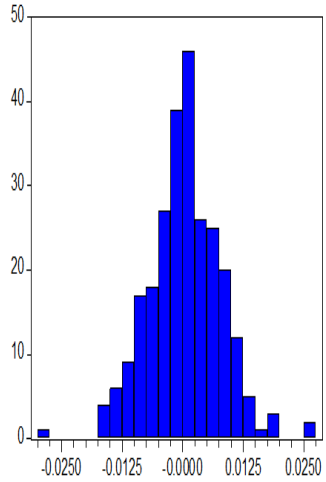
Graph No. 19
Histogram of Geometric returns of RS/Yen in 2003



Series: Log Returns of Rs/Yen
Sample 1/01/2003 12/31/2003
Observations 260

Mean	0.000322
Median	0.000609
Maximum	0.029876
Minimum	-0.024933
Std. Dev.	0.006952
Skewness	-0.002959
Kurtosis	6.289145
Jarque-Bera	117.2005
Probability	0.000000

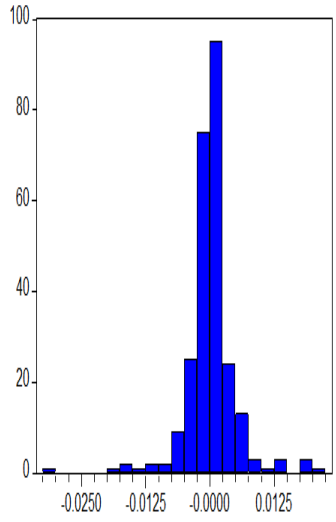
Graph No. 20
Histogram of Geometric returns of RS/Euro in 2004



Series: Log Returns of Rs/Euro
Sample 1/01/2004 12/31/2004
Observations 261

Mean	0.000485
Median	0.000372
Maximum	0.025856
Minimum	-0.029086
Std. Dev.	0.007464
Skewness	0.008381
Kurtosis	4.101607
Jarque-Bera	13.20029
Probability	0.001360

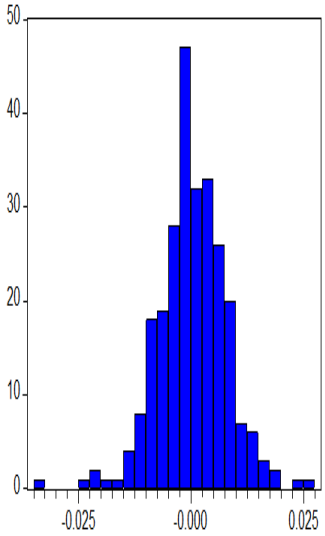
Graph No. 21
Histogram of Geometric returns of RS/Dollar in 2004



Series: Log Returns of Rs/Dollar
Sample 1/01/2004 12/31/2004
Observations 261

Mean	0.000147
Median	0.000000
Maximum	0.020255
Minimum	-0.032148
Std. Dev.	0.004914
Skewness	-0.484488
Kurtosis	14.04906
Jarque-Bera	1337.849
Probability	0.000000

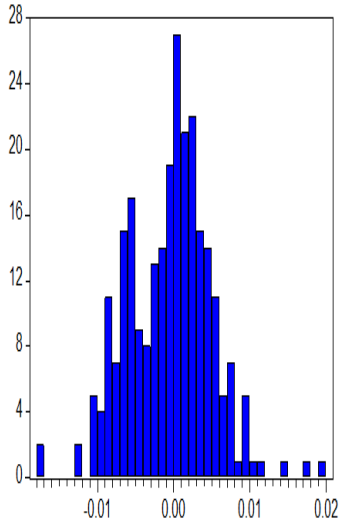
Graph No. 22
Histogram of Geometric returns of RS/Yen in 2004



Series: Log Returns of Rs/Yen
Sample 1/01/2004 12/31/2004
Observations 261

Mean	0.000326
Median	6.44e-08
Maximum	0.025804
Minimum	-0.033020
Std. Dev.	0.007607
Skewness	-0.242180
Kurtosis	4.839962
Jarque-Bera	39.36823
Probability	0.000000

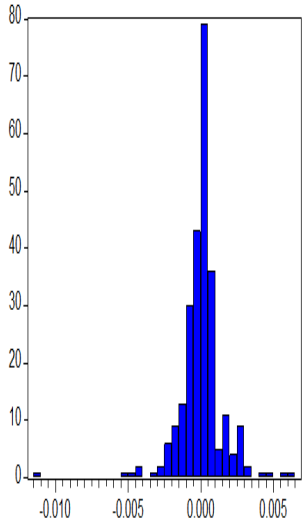
Graph No. 23
Histogram of Geometric returns of RS/Euro in 2005



Series: Log Returns of Rs/Euro
Sample 1/03/2005 12/30/2005
Observations 259

Mean	-0.000502
Median	0.000000
Maximum	0.019673
Minimum	-0.017229
Std. Dev.	0.005453
Skewness	0.061691
Kurtosis	3.695428
Jarque-Bera	5.383348
Probability	0.067767

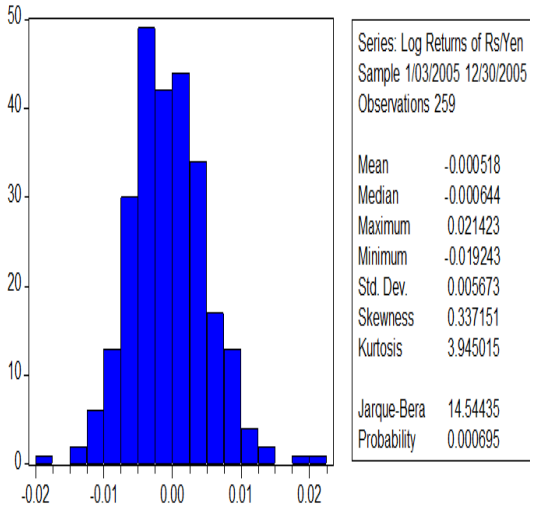
Graph No. 24
Histogram of Geometric returns of RS/Dollar in 2005



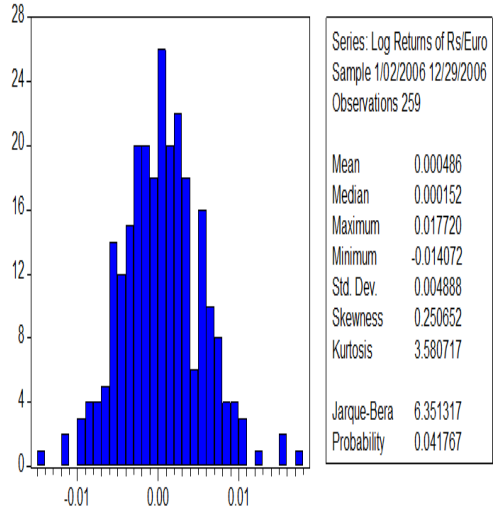
Series: Log Returns of Rs/Dollar
Sample 1/03/2005 12/30/2005
Observations 259

Mean	1.55e-05
Median	0.000000
Maximum	0.006063
Minimum	-0.011151
Std. Dev.	0.001511
Skewness	-1.190580
Kurtosis	16.33026
Jarque-Bera	1978.823
Probability	0.000000

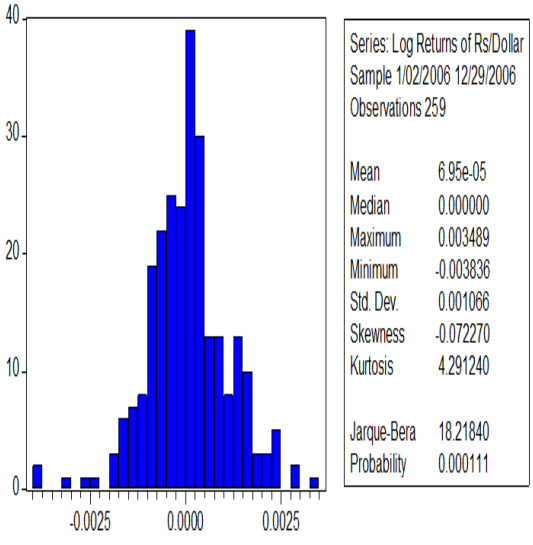
Graph No. 25
Histogram of Geometric returns of RS/Yen in 2005



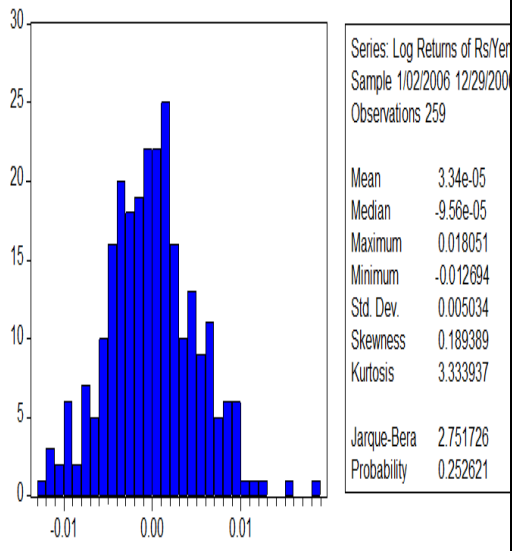
Graph No. 26
Histogram of Geometric returns of RS/Euro in 2006



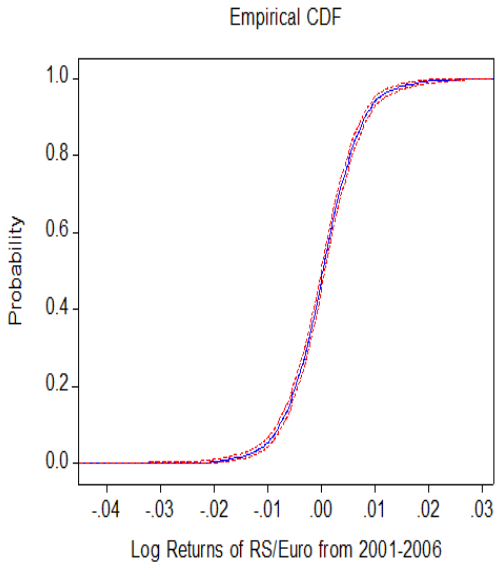
Graph No. 27
Histogram of Geometric returns of RS/Dollar in 2006



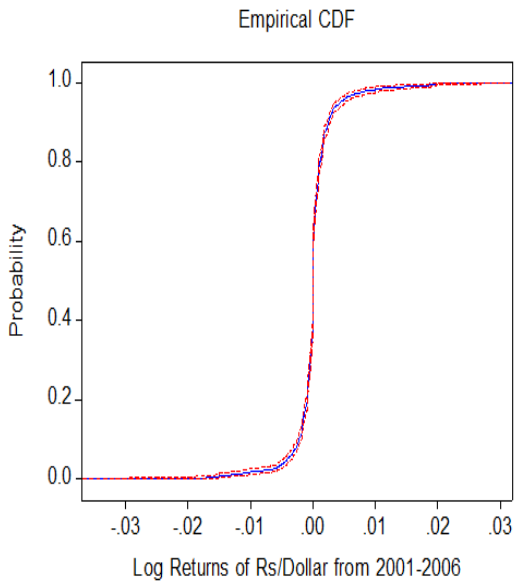
Graph No. 28
Histogram of Geometric returns of RS/Yen in 2006



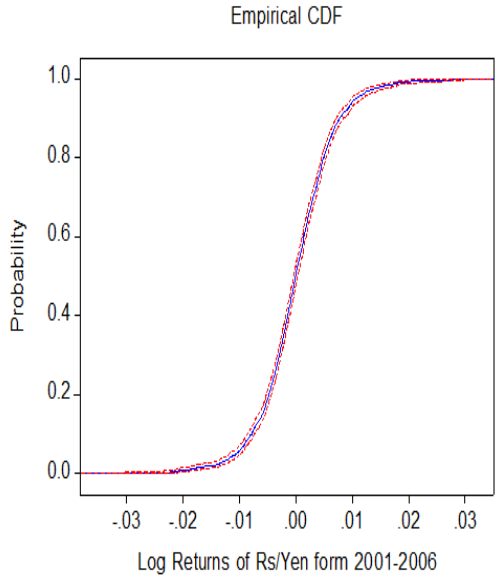
Graph No. 29
CDFof Geometric returns of RS/Euro from 2001-2006



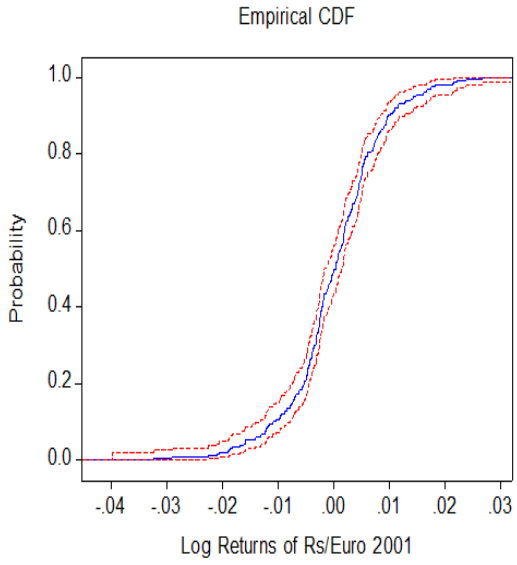
Graph No. 30
CDFof Geometric returns of RS/Dollar from 2001-2006



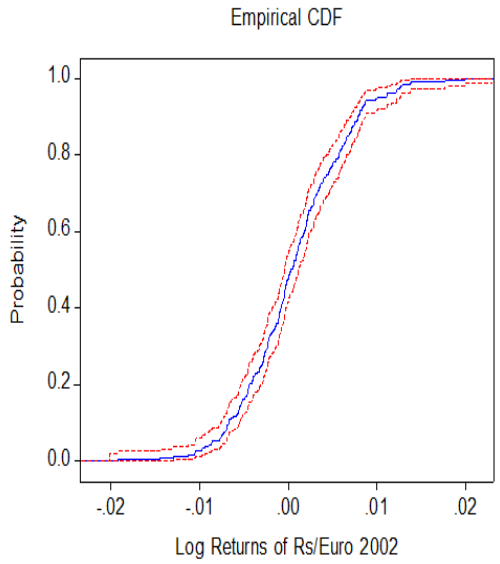
Graph No. 31
CDF of Geometric returns of RS/Yen from 2001- 2006



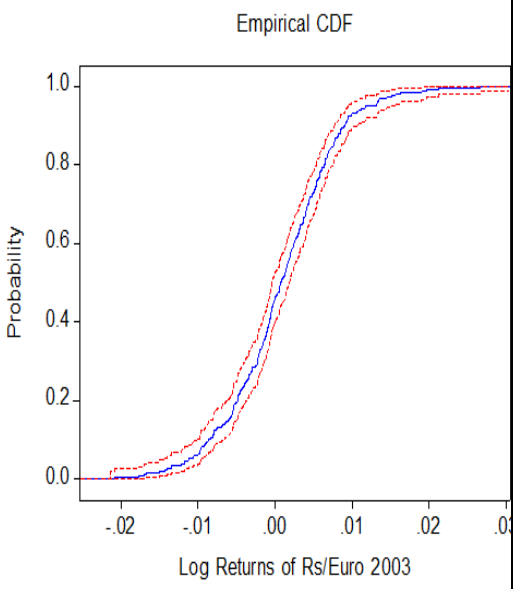
Graph No. 32
CDF of Geometric returns of RS/Euro in 2001



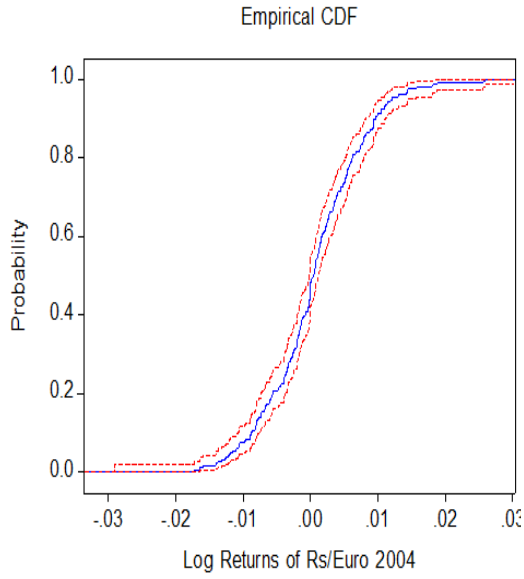
Graph No. 33
CDF of Geometric returns of RS/Euro in 2002



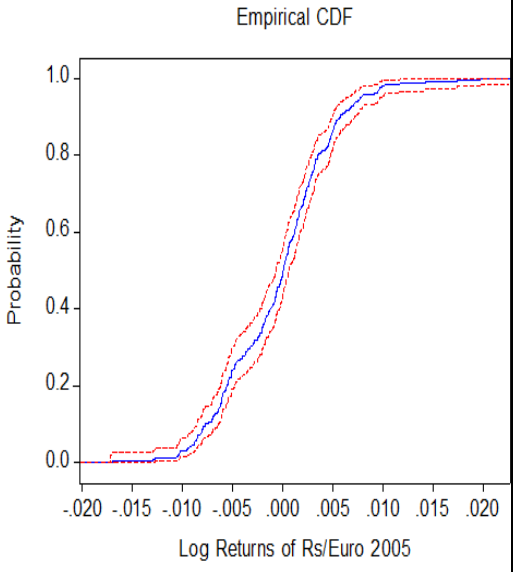
Graph No. 34
CDF of Geometric returns of RS/Euro in 2003

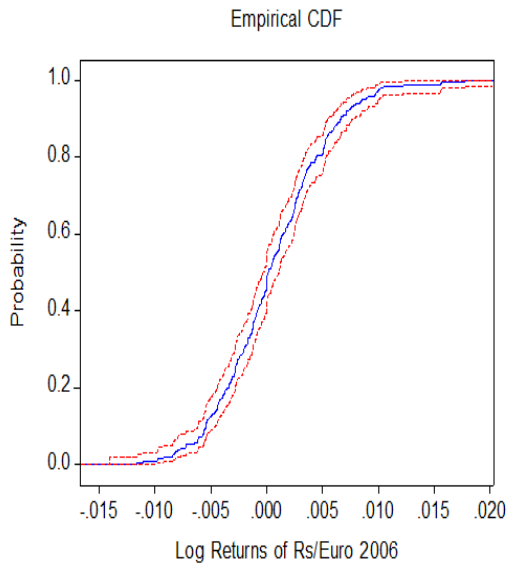
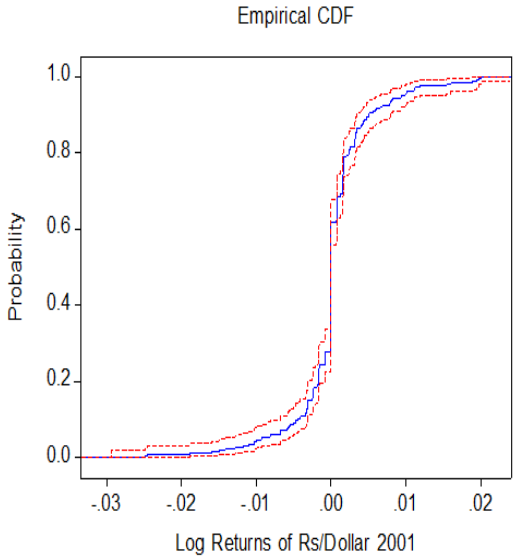
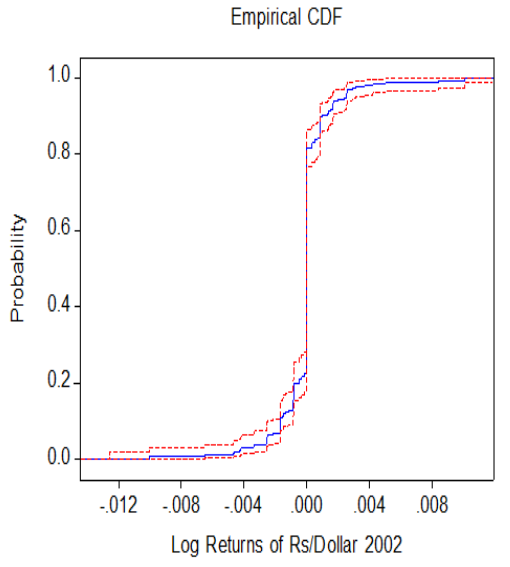
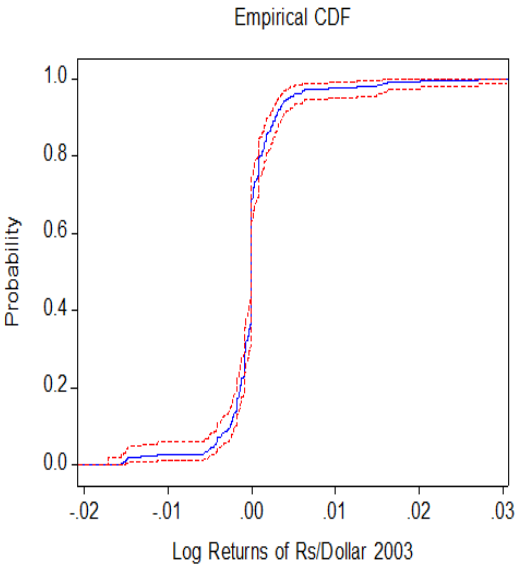


Graph No. 35
CDF of Geometric returns of RS/Euro in 2004

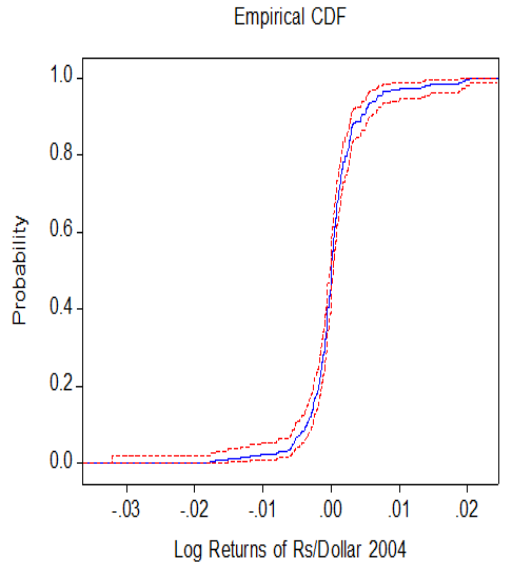


Graph No. 36
CDF of Geometric returns of RS/Euro in 2005

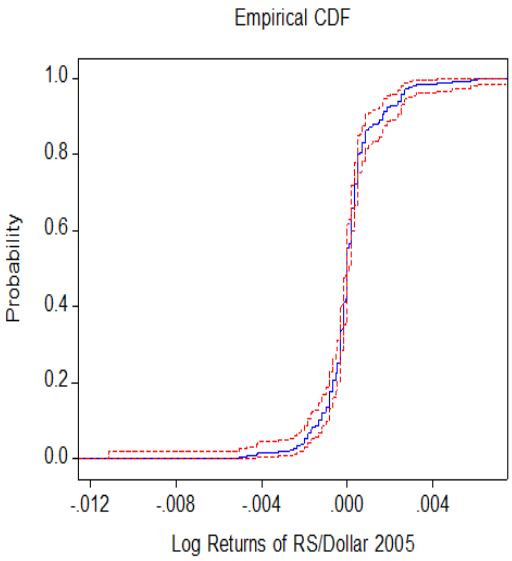


Graph No. 37 CDF of Geometric returns of RS/Euro in 2006	Graph No. 38 CDF of Geometric returns of RS/Dollar in 2001
	
Graph No. 39 **CDF of Geometric returns of RS/Dollar in 2002**	**Graph No. 40** **CDF of Geometric returns of RS/Dollar in 2003**
	

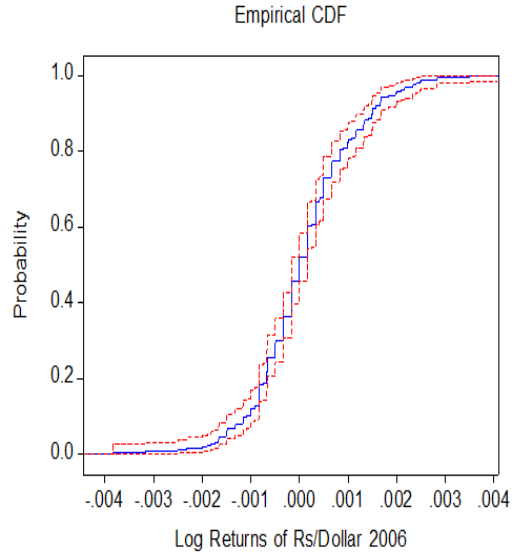
Graph No. 41
CDF of Geometric returns of RS/Dollar in 2004



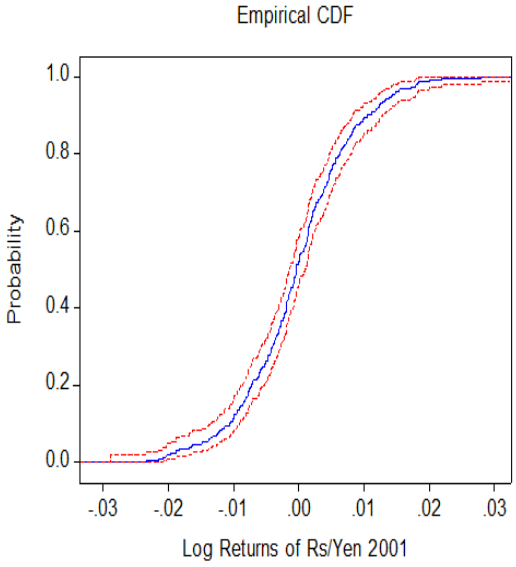
Graph No. 42
CDF of Geometric returns of RS/Dollar in 2005



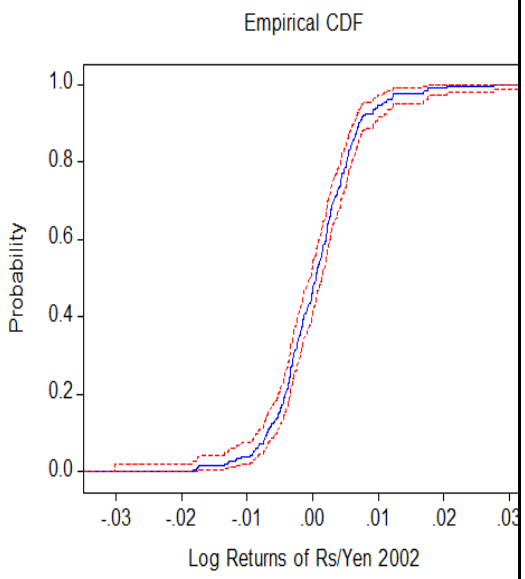
Graph No. 43
CDF of Geometric returns of RS/Dollar in 2006



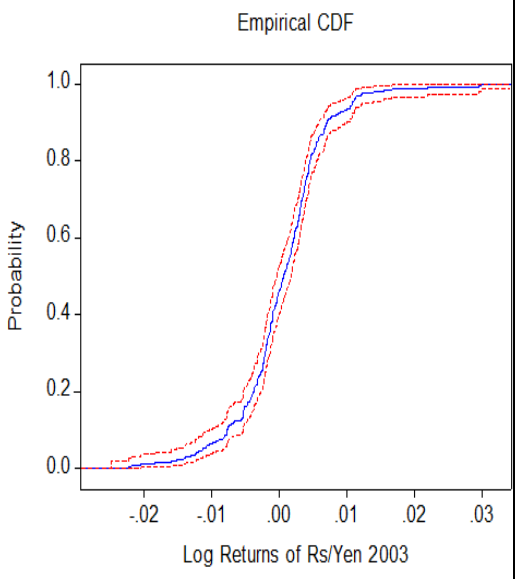
Graph No. 44
CDF of Geometric returns of RS/Yen in 2001



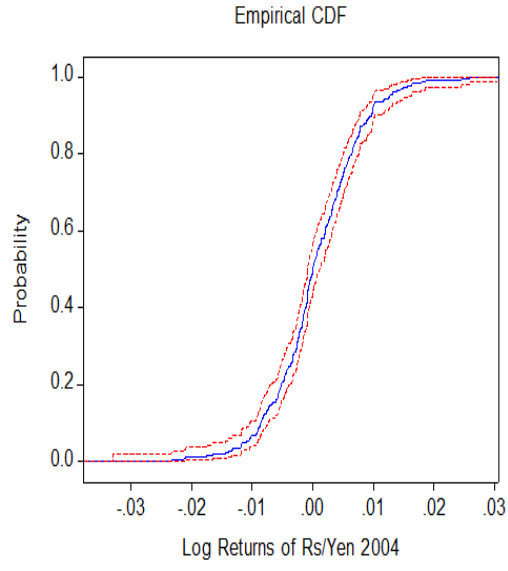
Graph No. 45
CDF of Geometric returns of RS/Yen in 2002



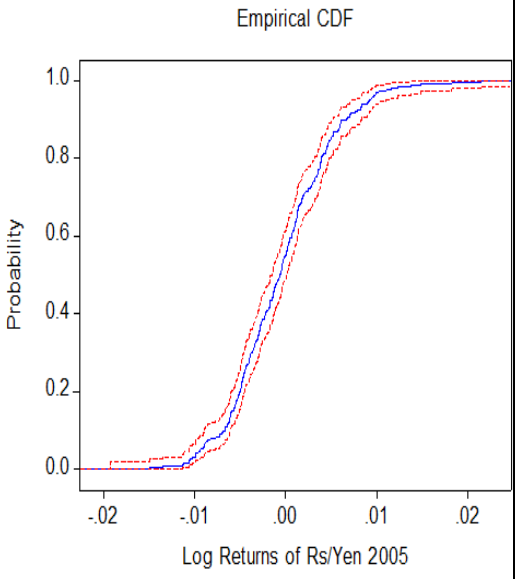
Graph No. 46
CDF of Geometric returns of RS/Yen in 2003



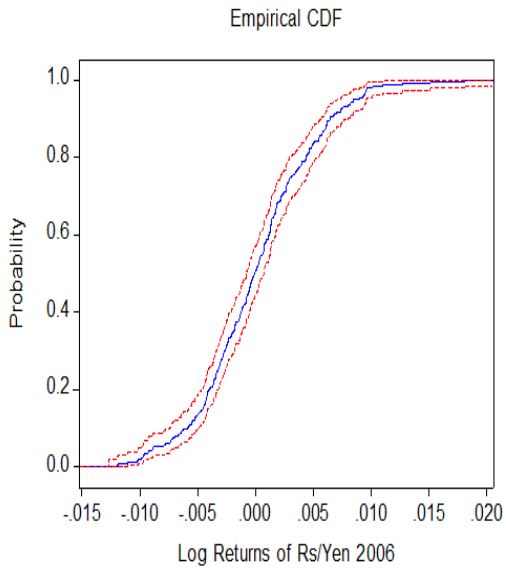
Graph No. 47
CDF of Geometric returns of RS/Yen in 2004



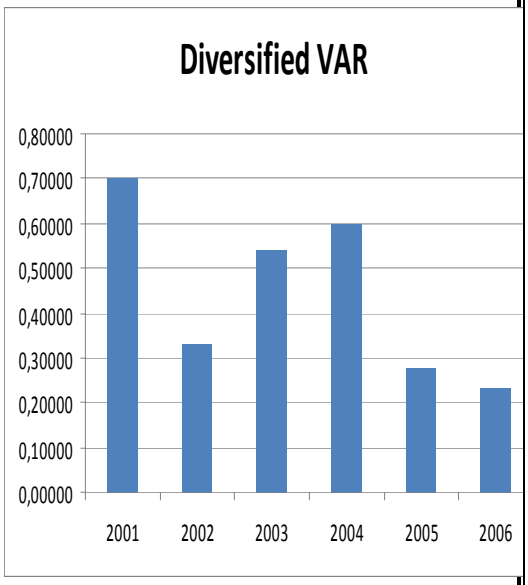
Graph No. 48
CDF of Geometric returns of RS/Yen in 2005



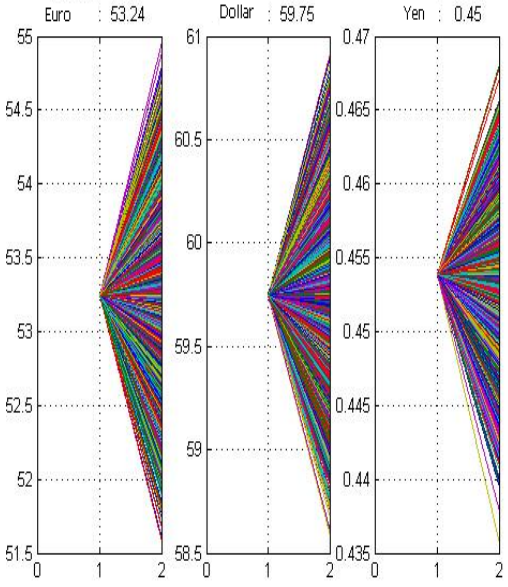
Graph No. 49
CDF of Geometric returns of RS/Yen in 2006



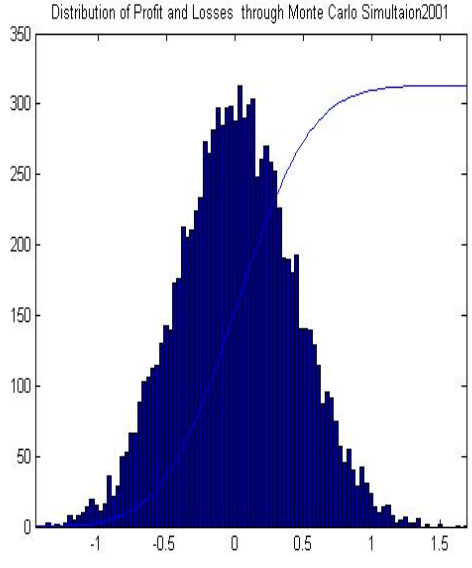
Graph No. 50
Diversified VAR/Delta-Normal VAR from 2001 to 2006



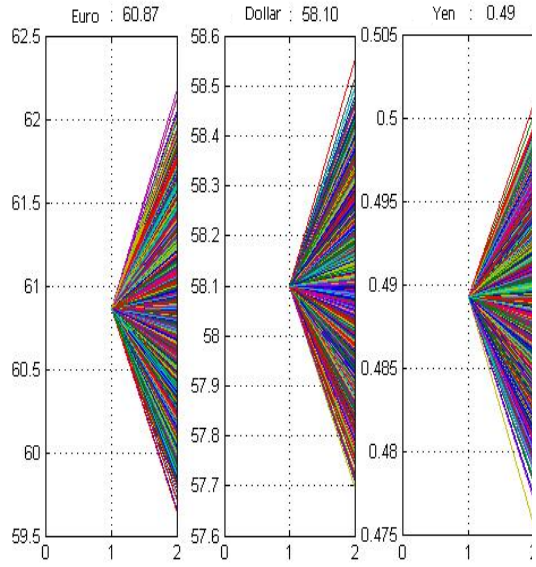
Graph No. 51
Excange Rates Path on the final day of 2001 (10,000 MC Simulations)



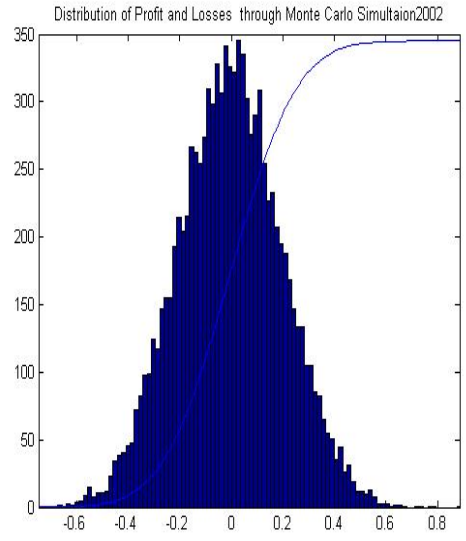
Graph No. 52
Histogram of Profit and Losses on PDPP on the final day of 2001 (10,000 MC Simulations)



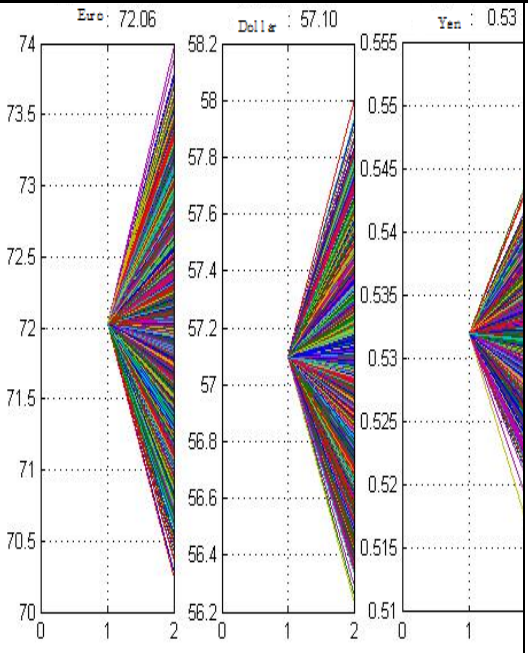
Graph No. 53
Excange Rates Path on the final day of 2002 (10,000 MC Simulations)



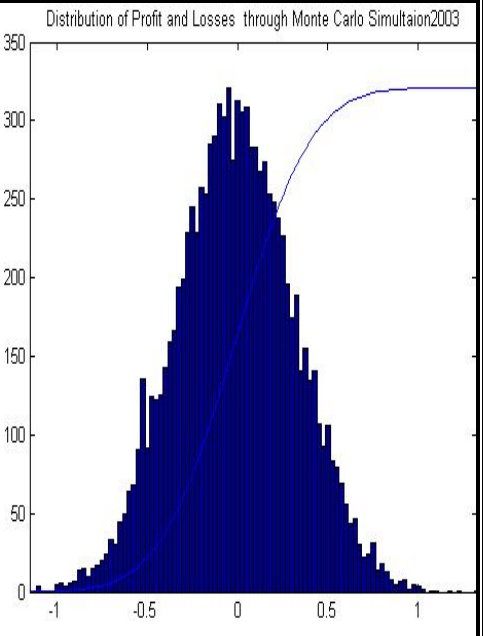
Graph No. 54
Histogram of Profit and Losses on PDPP on the final day of 2002 (10,000 MC Simulations)



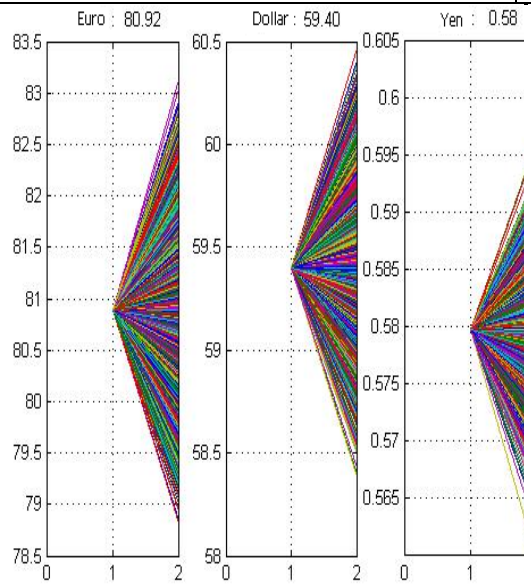
Graph No. 55
Excange Rates Path on the final day of 2003 (10,000 MC Simulations)



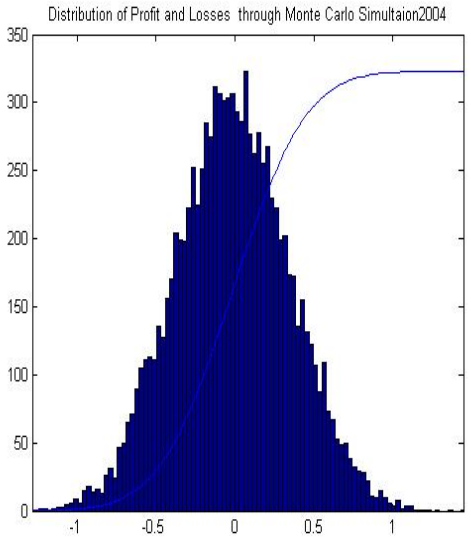
Graph No. 56
Histogram of Profit and Losses on PDPP on the final day of 2003 (10,000 MC Simulations)



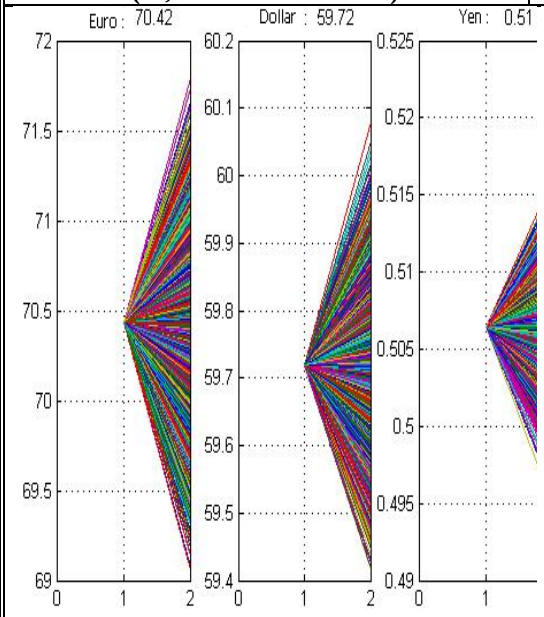
Graph No. 57
Excange Rates Path on the final day of 2004 (10,000 MC Simulations)



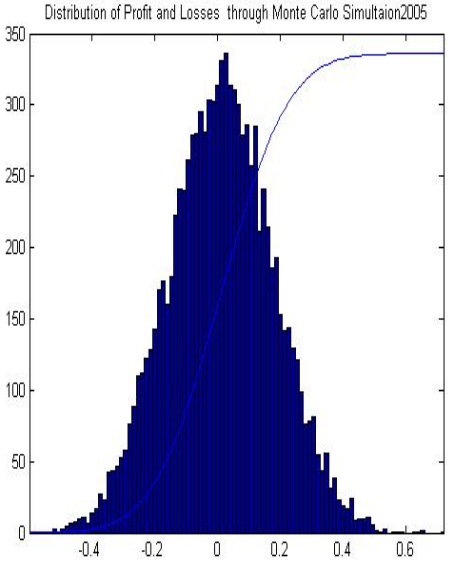
Graph No. 58
Histogram of Profit and Losses on PDPP on the final day of 2004 (10,000 MC Simulations)



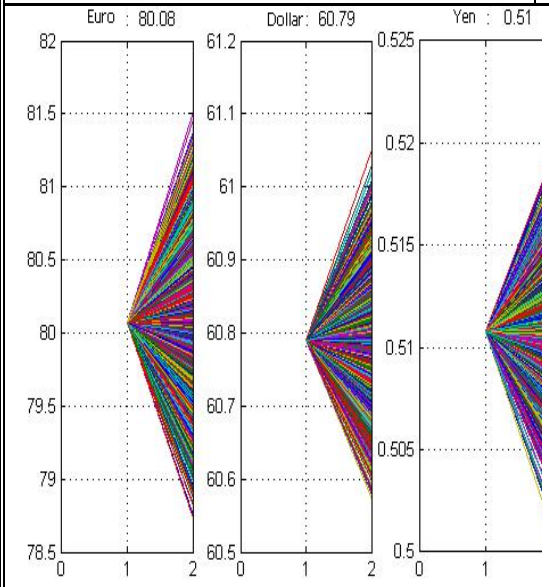
Graph No. 59
Excange Rates Path on the final day of 2005 (10,000 MC Simulations)



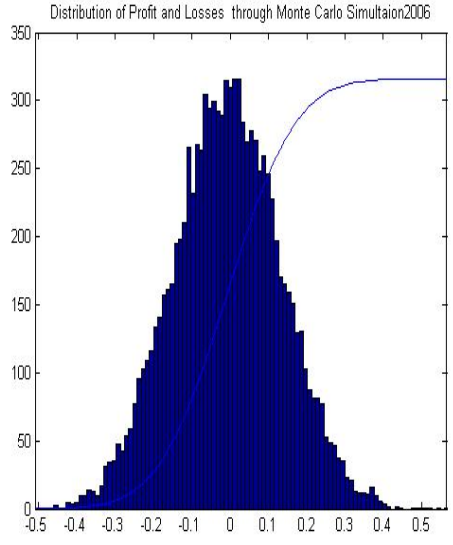
Graph No. 60
Histogram of Profit and Losses on PDPP on the final day of 2005 (10,000 MC Simulations)



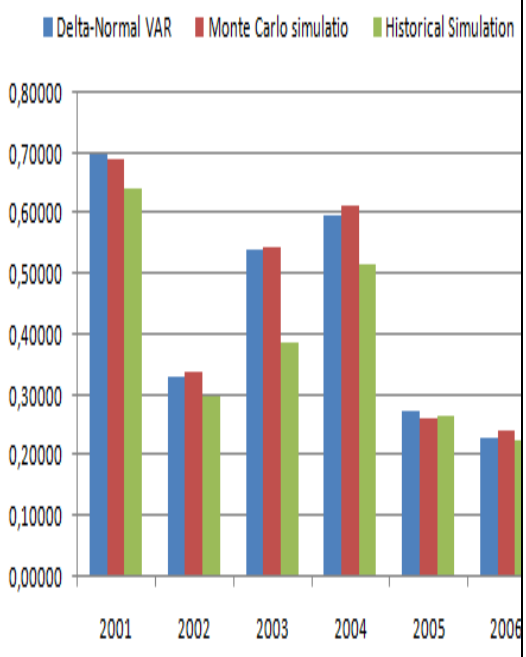
Graph No. 61
Excange Rates Path on the final day of 2006 (10,000 MC Simulations)



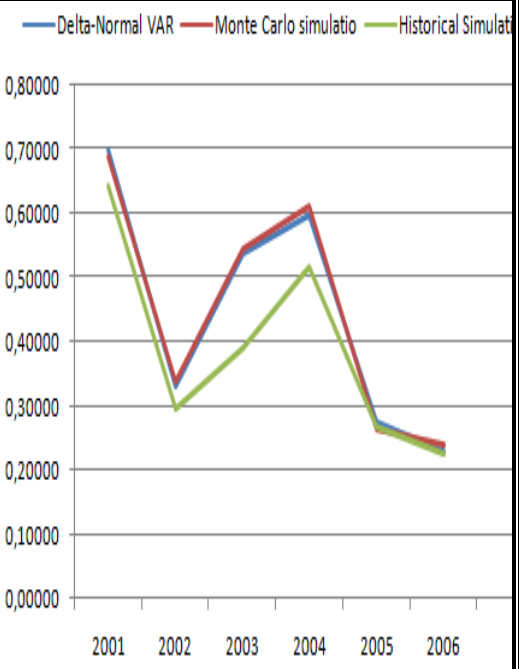
Graph No. 62
Histogram of Profit and Losses on PDPP on the final day of 2006 (10,000 MC Simulations)

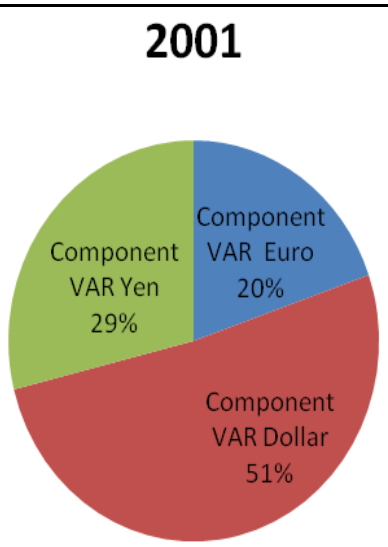
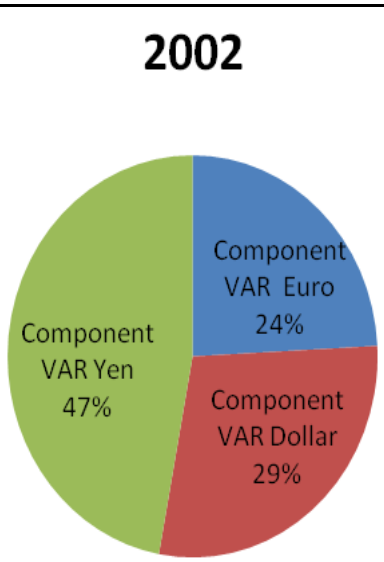
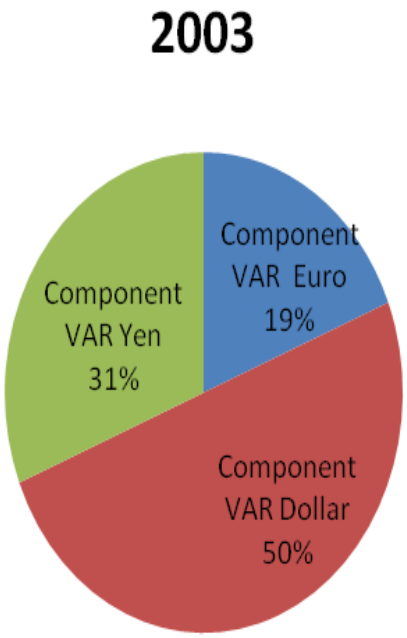
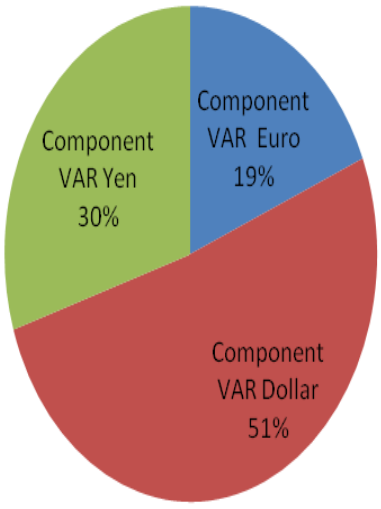


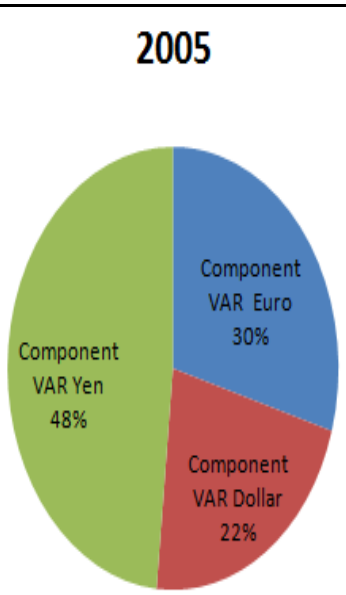
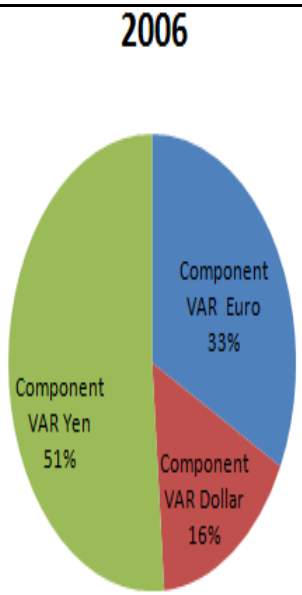
Graph No. 63
Comparison of VAR through Monte Carlo, Delta-Normal and Historical Simulation

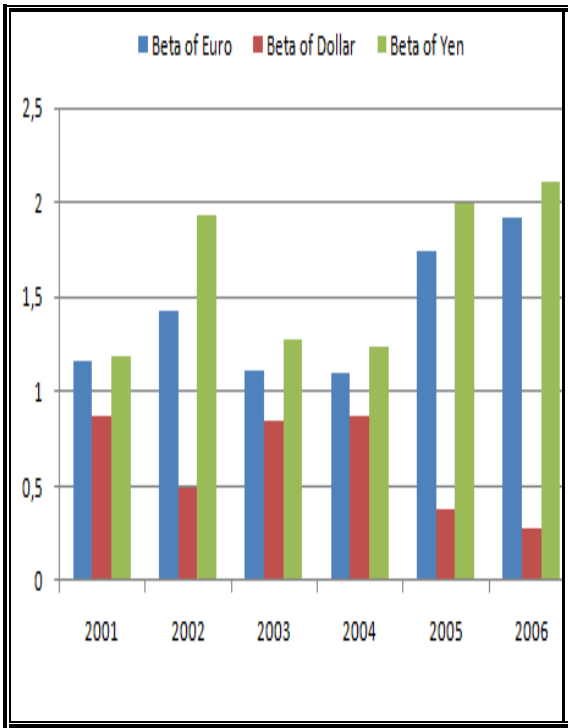


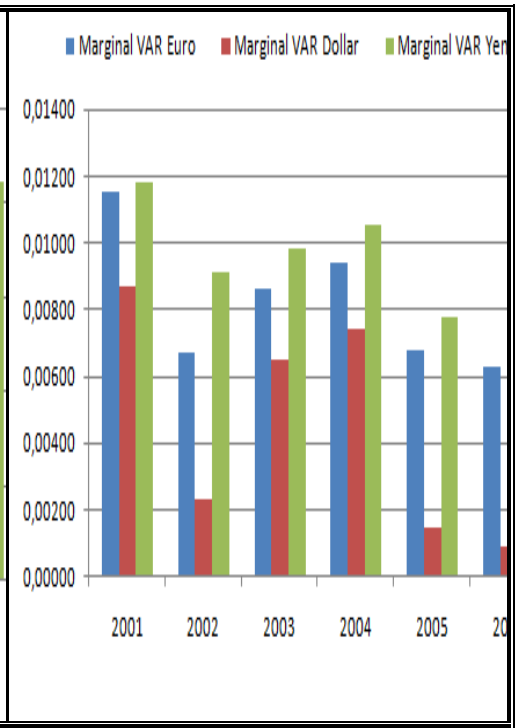
Graph No. 64
Comparison of divegence of VAR through Monte Carlo, Delta-Normal and Historical Simulation



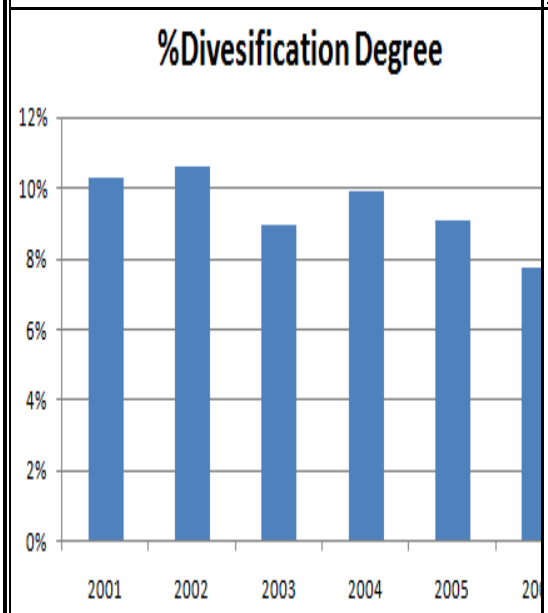
Graph No. 65 Component VAR Related to each Curreny 2001	Graph No. 66 Component VAR Related to each Curreny 2002
	
Graph No. 67 **Component VAR Related to each Curreny** **2003**	**Graph No. 68** **Component VAR Related to each Curreny** **2004**
	

Graph No. 69 Component VAR Related to each Curreny 2005	Graph No. 70 Component VAR Related to each Curreny 2006
	
Graph No. 71 Beta related to Euro,Dollar and Yen from 2001 to 2006	***Graph No. 72*** Marginal VAR related to Euro,Dollar and Yen from 2001-2006





Graph No. 73
Level of Diversificatin Degree
from 2001- 2006



Graph No. 74
Best Hedge related to Euro,Dollar and Yen
From 2001-2006