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Exchange Rate Risk Exposure Related to Public Debt Portfolio of Pakistan: Application of Value-at-Risk Approaches

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Abstract: *The study analyzes exchange rate risk related to three currencies i.e. euro, US dollar and Japanese yen on Public Debt Portfolio of Pakistan (PDPP) through value-at-risk (VAR) methodology for period 2001 to 2006. It is found that Pakistan's public debt 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. Beta and Marginal VAR analysis reveal that individually dollar is the least risky and Japanese yen as the most risky currency constituting PDPP. The lack of hedging strategy, revealed by beta and component VAR analysis has also been confirmed by the best hedge analysis.*

JEL Classification: *G18, H63.*
Keywords: *value-at-risk, public debt management, exchange rate risk.*

1. Introduction

A prudent public debt management helps economic growth and stability through mobilizing resources with low borrowing cost and limiting financial risk exposure. One of the important corner stone of public debt management is sound management of the financial risk; such risk exposure may include currency risk, interest rate risk, liquidity risk, refinancing risk and 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.

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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 such vulnerabilities increases for smaller and emerging markets due to their less diversified and less developed financial system. 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 the context of developed country is not uncommon. For instance, Danish financial authorities identify interest rate risk, exchange rate risk and credit risk as main risks 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.[1] 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 percent confidence level[2].

The 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 95percent, but it could be at 99 percent or even 99.5 percent, depending on task at hand. Confidence level of 95 percent means that for about 5 percent of the time, portfolio could be expected to lose more than the number

[1] www.nationalbanken.dk
[2] IMF and World Bank "Guidelines for Public Debt Management: Accompanying Document" November, 2002

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).

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 (Jorion, 2007 and Dowd, 1998). The preference of VAR over other risk measurement methodologies is due to its broad range of characteristics. Dowd (1998) outlines the following attractions of VAR.

i. VAR provides more informed and better risk management opportunity to managing authorities.
ii. VAR, being better crisis signal measure than traditional measures, is more preventive in approach towards financial crisis, fraud and human error.
iii. VAR provides more consistent and integrated measure of risk, which leads to greater risk transparency and thus results in better management of risk.
iv. 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.

Along with attractions of VAR, following limitations have also been outlined by Dowd (1998).

i. VAR is backward looking. Forecast through VAR is based on past data. It is not necessary that history may repeat itself. From this perspective, scenario analysis would always be a recommended methodology along with VAR models.
ii. 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.
iii. VAR does not tell the investor the amount of magnitude or magnitude of the actual loss. VAR only provides the maximum value that can be lost for a given confidence level.
iv. VAR is only tool for measuring and managing the risk. VAR system demands a through and in-depth understanding from the users.
v. The measure of VAR also violates the coherent risk property of subaddivity when the return distribution is not elliptical.

There are three main approaches to measuring financial risk related to debt portfolios as categorized by Melecky (2007). These include a) calculation of VAR or CAR through simulating the financial/economic variables; b) simulating economic variables 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; and c) determining 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.

The present study adopts the first approach. 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 to 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 3 deals with data and methodology, and section 4 presents the results. The last section summarizes and concludes the paper.

2. Review of Literature

The VAR (specifically delta-normal) methodology works well with elliptical return distributions such as the normal distribution. VAR is also able to calculate the risk for non-normal distributions; however VAR estimates may be unreliable in this case. On the other hand, there is myriad list of studies, of course along with the RiskMetrics Group (1996) VAR methodology, which show reasonable success of VAR measurements even when the distributions are not normal. Much of the literature review covered in the section is referred in this perspective.

According to International Monetary Fund and World Bank (2003)[3], the public debt portfolio is usually the largest financial portfolio in the country so there is need that governments contain risks that make their economies vulnerable to external shocks. This document, after emphasizing the importance of public 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. The document also highlights certain pitfalls to be watched out. For instance, it 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".

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 other measures.

Kondor and Pafka (2001) study the cause of success behind the RiskMetrics Group (1996) VAR methodology. RiskMetrics Group (1996) takes the assumption of normality of distribution of returns for the calculation of VAR 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). Authors attribute the success of RiskMetrics Group (1996) methodology to the following factors.

i. EWMA, despite being categorized as simple approach for calculation of standard deviation of returns, belongs to ARCH[4] category of models which estimates volatility rather accurately (Nelson, 1992).
ii. Short holding period of one day is another positive aspect of RiskMetrics Group (1996) methodology which explains its success. However, as holding period is lengthened the forecast quality deteriorates.
iii. The effect of fat tails becomes much stronger at higher confidence levels like 99 percent. While at 95 percent confidence level VAR results violation frequency was around 5 percent.

[3] International Monetary Fund and World Bank (2003). Guidelines for Public Debt Management; December 9, 2003.
[4] Autoregressive conditional heteroskedasticity

Chan and Tan (2003) study the impact of fat tails through stress VAR approach, which measures potential extra ordinary 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 (Hill, 1975) 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 percent confidence level, while at 99 percent confidence level stress VAR X do perform marginally better than stress VAR. Studies of both Kondor and Pafka (2001) and Chan and Tan (2003) show that impact of fat tails does not dilute VAR results at 95 percent confidence level. The impact is only visible above 95 percent 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 to Islamic principles). Despite using 99 percent 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.

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 percent 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 percent confidence level over three months period through Monte Carlo simulation VAR. According to author “Vulnerability measures portrait fairly well Argentine crisis”.

3. Data and Methodology

We have used three VAR methods, i.e. 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 one-day horizon with 95 percent confidence level. delta-normal method is further exploited to analyze the nature and sources of losses by employing marginal VAR, beta, component VAR, diversification and best hedge. Data related to exchange rates of three currencies and debt composition has been taken from Ecowin.

The first step towards VAR calculation is to calculate the returns for each exchange rate series for each year. For this we adopt geometric returns as follows.

$$\begin{aligned} R_{t,Rs/Euro} &= \ln[(Rs/Euro)_t / (Rs/Euro)_{t-1}] \\ R_{t,Rs/dollar} &= \ln[(Rs/dollar)_t / (Rs/dollar)_{t-1}] \\ R_{t,Rs/yen} &= \ln[(Rs/yen)_t / (Rs/yen)_{t-1}] \end{aligned} \quad (1)$$

Delta-normal VAR

The 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 percent and the time horizon of one day. To calculate the delta-normal VAR 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). The delta-normal VAR is also known as "Diversified VAR" as it takes into account diversification benefits related to component assets constituting portfolio. We calculate delta-normal VAR in accordance with the following equation adopted from Jorion (2007).

$$PDPP\ VAR = VAR_p = \alpha\sqrt{X'\Sigma X} \quad (2)$$

Here α has value of 1.65 i.e. for 95 percent confidence level, X represents the debt position in each currency in terms of rupee, while Σ represents covariance matrix. For example, considering the fixed weights related to each currency in PDPP from year 2001 to 2006 as 0.119, 0. 413 and 0.1709 for Euro, US dollar and Japanese yen respectively, X is calculated by multiplying respective weights with the total of PDPP, which we assume to be equivalent to Rs 100 million. The covariance matrix related to the currency returns in year 2001 for Euro, US dollar and Japanese yen respectively is found to be:

$$\Sigma = \begin{bmatrix} 0.000079 & 0.000033 & 0.000040 \\ 0.000033 & 0.000032 & 0.000032 \\ 0.000040 & 0.000032 & 0.000074 \end{bmatrix} \quad (3)$$

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.

$$VAR_i = \sigma|w_i|W \quad (4)$$

VAR_i represents individual value-at-risk, w_i is weight of the individual currency in PDPP, σ represents volatility of a currency, and W is the original value of PDPP.

Undiversified VAR

The 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:

$$VAR_p = VAR_{Rs/euro} + VAR_{Rs/dollar} + VAR_{Rs/yen} \quad (5)$$

In the above equation VAR_p represents undiversified VAR, while others represent individual VARs of respective currency.

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 yen) of a given asset/component in the portfolio. Marginal VAR is calculated as:

$$\Delta VAR_i = \beta_i[VAR/W] \quad (6)$$

Here ΔVAR_i represents marginal VAR, while β_i is beta related to specific currency. The beta risk is the foundation of capital asset pricing model (CAPM), developed by Sharpe (1964). In context of marginal VAR analysis, the concept of beta is the

same as explained through CAPM. In terms of CAPM, the beta is defined as standardized measure of systematic risk, i.e. Beta measures the sensitivity of a security's returns to changes in the market return. The CAPM holds that, in equilibrium, the expected return on risky asset is equivalent to risk-free rate plus a beta-adjusted market risk premium. More specifically beta can be defined as:

$$\beta_i = \text{cov}_{i,mkt} / \sigma^2_{mkt} \tag{7}$$

In the above equation $cov_{i,mkt}$ signifies the covariance between the market returns and the security returns, while σ^2_{mkt} represents variance of returns on the market portfolio. The beta can also be measured through regressing security/currency returns on the market portfolio returns. In this context beta is the slope of coefficient in a regression.

With respect to our model of VAR analysis, we can define beta in more detail as,

$$\beta_i = \frac{\text{cov}(R_i, R_p)}{\sigma^2_p} = \frac{\sigma_{ip}}{\sigma^2_p} = \frac{\rho_{ip}\sigma_i\sigma_p}{\sigma^2_p} = \frac{\rho_{ip}\sigma_i}{\sigma_p} \tag{8}$$

Where $cov\ (R_i, R_p)$ = covariance between currency returns and portfolio returns; σ^2_p =Variance of the portfolio returns; ρ_{ip} = Correlation between portfolio returns and security returns; σ_i =Standard deviation of security returns; σ_p=Standard deviation of portfolio returns. Further, mathematically beta, considering all assets, can be shown as $\beta_i = \Sigma w/(w'\Sigma w)$.

Best Hedge

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

$$\alpha^* = w\beta_i[\sigma^2_p / \sigma^2_i] \tag{9}$$

Component VAR

Individual VAR though an important measure does not take into account diversification benefits. However, component VAR takes into account the diversification benefits on the one hand and informs about the contribution of the component risk into portfolio VAR on the other. So component VAR indicates

how diversified VAR would change approximately if the given component asset was taken out of the portfolio. The component VAR is calculated as:

$$Comp\ VAR = VAR\ \beta_i\ w_i \tag{10}$$

VAR through Historical Simulation

For historical simulation, we follow Dowd (1998) method, where returns related to PDPP for each day is calculated for each year from 2001 to 2006 as:

$$R_t = \sum_{i=1}^{n} w_i R_i \tag{11}$$

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. 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 then translated to profit and losses. Once after determining the profit and losses of PDPP, value at risk is found at 95 percent 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, the methodology employed here is adopted from Jorion (2007). Each Exchange rate currency evolves based on Brownian motion:

$$\begin{aligned}
\frac{\Delta(Rs/Euro)_t}{(Rs/Euro)_t} &= \mu\Delta t + \sigma\sqrt{\Delta t}Z_t \\
\frac{\Delta(Rs/dollar)_t}{(Rs/dollar)_t} &= \mu\Delta t + \sigma\sqrt{\Delta t}Z_t \\
\frac{\Delta(Rs/yen)_t}{(Rs/yen)_t} &= \mu\Delta t + \sigma\sqrt{\Delta t}Z_t
\end{aligned} \tag{12}$$

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 the same as the correlation matrix of all the exchange return series, we use

Cholesky factorization. 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 percent level of confidence level over one day horizon period.

While applying the above measures in case of Pakistan, we set confidence level at 95 percent, especially when the returns distribution is not perfectly normal (although convergence to normal distribution is observed). The time horizon for which the VAR is calculated for each year is one day period. A fixed value of Rs 100 million is assumed for PDPP and following Ajili (2008) and Chan and Tan (2003), each currency position in the PDPP is represented by a constant vector throughout the period. Constant vector positions make it convenient to evaluate the risk management performance due to fluctuations in risk factors. The vector is made up of the average position of each currency in PDPP during 2001-2006. The following vector X shows the average currency position as percent share.

$$X = \begin{bmatrix} X_{Euro} = 12 \\ X_{dollar} = 41 \\ X_{yen} = 17 \end{bmatrix} \tag{13}$$

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 but there was no substantial change in percentage-wise currency composition of PDPP.

4. Results

The 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 from 2001 to 2006, there exist a marginally positive correlation coefficient between Rs/dollar and Rs/yen. That indicates PDPP is missing hedging strategy related to two leading currencies constituting 58 percent 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/yen and Rs/Euro. Nevertheless, we do observe a negative correlation between Rs/euro and Rs/dollar of 0.2.

Further correlation analysis of returns during this period shows that pair-wise correlation coefficient between all exchange returns series are around 0.5 and in none of the years a negative correlation was observed. It shows the lack of hedging strategy in Pakistani debt profile. This result is also corroborated through VAR analysis. For the years in which correlation coefficient of more than 0.3 existed between return series of Rs/dollar and rest of the exchange returns series, we observed a higher realization of VAR figures.

VAR through delta-normal, Monte Carlo and historical simulation shows improvement in management of exchange risk exposure to PDPP over time.

VAR through delta-normal, Monte Carlo (see figures given in annexure) and historical simulation shows improvement in management of exchange risk exposure to PDPP from one year to another (Table 1). From year 2001 to 2006 the maximum loss that PDPP worth of Rs 100 million could have suffered due to fluctuation in the exchange rates of three currencies is between Rs 0.2 million to Rs 0.7 million (decline of around 67 percent) over a one day horizon with 95 percent 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 over time. 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 years 2005 and 2006.

VAR results obtained through Monte Carlo and historical simulation do not deviate much from delta-normal method. The convergence of results is greater in case of MC and delta-normal than between HS and delta-normal.

The above conclusion with respect to delta-normal VAR estimates would only be

Table 1. Results of Diversified VAR, MC Simulation and Historical Simulation

	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

slightly affected if actual debt positions of the currencies for each year are taken instead of a constant vector; however, the trend still remains the same.

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 yen, while yen had the highest beta throughout the years. The same analysis also goes for marginal VAR analysis too. The marginal VAR analysis and beta analysis reveal that dollar is the least risky and yen as the most risky currency constituting PDPP (Table 2).

Table 2. Beta, Marginal VAR and Comp VAR Results

	2001	2002	2003	2004	2005	2006
Beta of euro	1.1599	1.4258	1.1157	1.1025	1.7415	1.9137
Beta of dollar	0.8755	0.4894	0.851	0.8742	0.3757	0.2755
Beta of yen	1.1893	1.9377	1.2796	1.2326	1.9922	2.1143
Marg. VAR euro	0.0115	0.0067	0.0086	0.0094	0.0068	0.0063
Marg. VAR dollar	0.0087	0.0023	0.0065	0.0074	0.0015	0.0009
Marg. VAR yen	0.0118	0.0091	0.0098	0.0105	0.0078	0.0069
Comp. VAR euro	0.1376	0.0799	0.1021	0.1118	0.0815	0.0749
Comp. VAR dollar	0.3599	0.0951	0.2700	0.3074	0.0609	0.0374
Comp. VAR yen	0.2021	0.1557	0.1679	0.1792	0.1336	0.1185

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.

The 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 percent in years 2001, 2003 and 2004. This is mainly due to the high weight structure of dollar (i.e. 41 percent) in PDPP. Component VAR analysis further reveals that dollar starts as the most risk contributing currency in the portfolio, i.e. from around 51 percent in 2001 and ends at being 16 percent contributing to VAR in 2006. The lower component VAR of dollar in years 2002, 2005 and 2006 are 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 percent and 78 percent respectively. The 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.

Best Hedge analysis also reveals extra exposure of PDPP to all the three currencies.

The best hedge analysis suggests reduction of the exposure in all the three currencies (Table 3). Had there been any single currency in PDPP with negative beta and so negative component VAR, we could have observed positive sign associated to the best hedge values, which is not the case in the present scenario.

Table 3. Results of Best Hedge of Currencies 2001-2006 (percent)

	Euro	**Dollar**	**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

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

The diversification degree of VAR of PDPP due to exchange risk has remained fairly stable from 2001 to 2006 (Table 4). The diversification degree fluctuates within values of 8 percent to 11 percent. It could be improved more by employing hedging strategy.

Table 4. Diversified, Undiversified and Diversification Degree, 2001-2006

	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

5. 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 the exchange risk management. VAR through delta-normal, Monte Carlo and historical simulation exhibit considerable decline of around 67 percent (in case of delta-normal) from 2001 to 2006 of maximum potential loss, that is PDPP worth of 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. 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. The 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 yen. While yen 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.

References

Ajili, W. (2008), A Value-at-Risk Approach to Assess Exchange Risk Associated to a Public Debt Portfolio: The Case of a Small Developing Economy; World Scientific Studies in International Economics, 3, 11-60.

Best, P. (1998), Implementing Value at Risk; John Wiley & Sons.

Blejer, Mario I. and Liliana Schumacher (1998), Central Bank Vulnerability and the Credibility of its Commitments: A Value-at-Risk Approach; IMF Working Paper No.98/65.

Cakir, Selim and Raei, Faezeh (2007), Sukuk vs. Eurobonds: Is There a Difference in Value-at-Risk?; IMF Working Paper WP/07/237.

Chan, I. L. and Tan, K. H. (2003), Stress Testing Using VAR Approach, a Case for Asian Currencies; Journal of International Financial Markets, Institutions & Money, 13, 39-55.

Dowd K. (1998), Beyond Value at Risk: The New Science of Risk Management; John Wiley and Sons.

Hill, B. M. (1975), A Simple General Approach to Inference about the Tail of a Distribution; The Annals of Statistics, 3, 1163–1174.

Jorion, Phillippe, (2007), Value at Risk: The New Benchmark for Managing Financial Risk; 3rd ed., McGraw-Hill.

Kondor, I., and Pafka, S. (2001), Evaluating the Risk Metrics Methodology in Measuring Volatility and Value-at-Risk in Financial Markets; Physica A 299, 305-310.

Melecky, M. (2007), Choosing the Currency Structure for Sovereign Debt: A Review of Current Approaches; World Bank Policy Research Working Paper 4246.

Nelson D. (1992), Filtering and Forecasting with Misspecified ARCH Models: Getting the Right Variance with the Wrong Model; Journal of Econometrics, 52, 61-90.

Nocetti, D. (2006), Central Bank's Value at Risk and Financial Crises: An Application to the 2001 Argentine Crisis. Journal of Applied Economics; November,9:2, ABI/INFORM Global 381-402.

RiskMetrics Group (1996), Risk Metrics Technical Document; J.P. Morgan/Reuters.

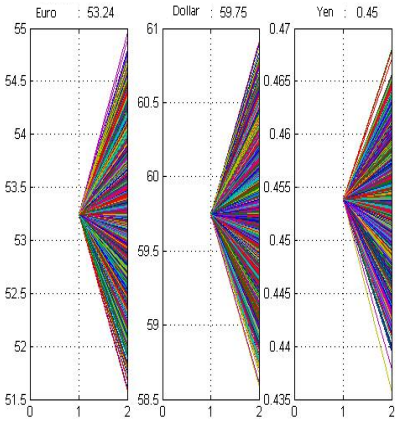
Sharpe,W.F. (1964), Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk; Journal of Finance, 19, 425-442.

Vlaar Peter J.G. (2000), Value at Risk Models for Dutch Bond Portfolios; Journal of Banking & Finance, 24, 1131-1154.

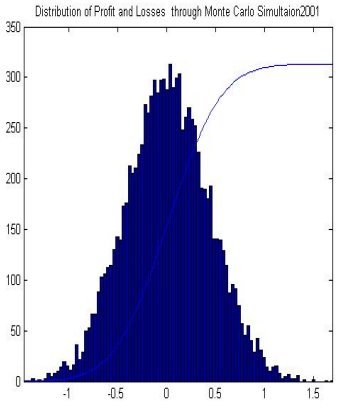
World Bank (2007), Managing Public Debt: From Diagnostics to Reform Implementation; Washington D.C.

Annexure: Exchange Rate Paths and Histograms of Profit and Loss

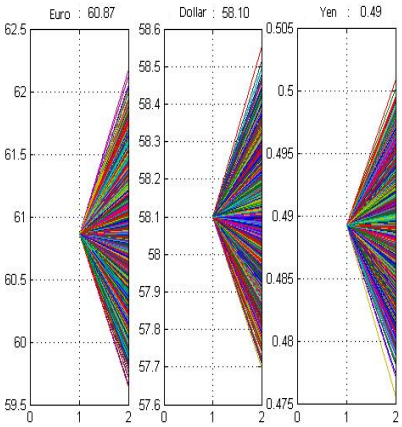
A1. Excange Rates Path on the final day of 2001 (10,000 MC Simulations)



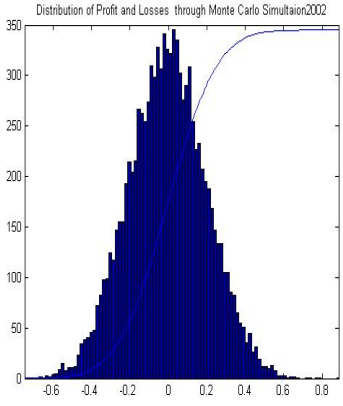
B1. Histogram of Profit and Losses on PDPP on the final day of 2001 (10,000 MC Simulations)



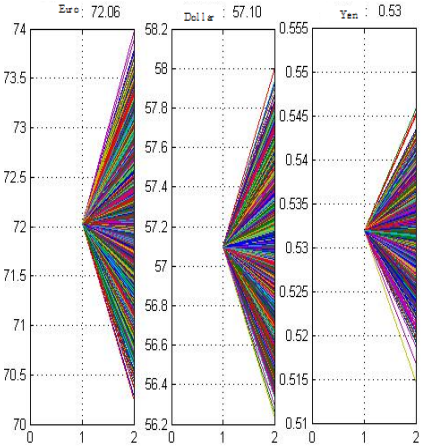
A2. Excange Rates Path on the final day of 2002 (10,000 MC Simulations)



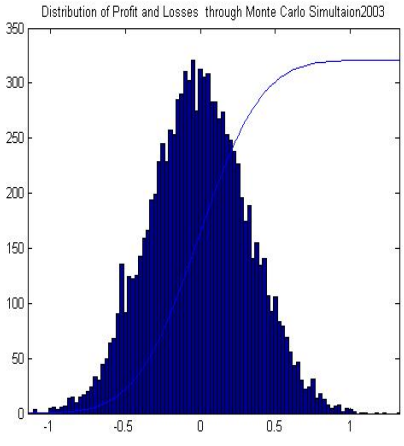
B2. Histogram of Profit and Losses on PDPP on the final day of 2002 (10,000 MC Simulations)



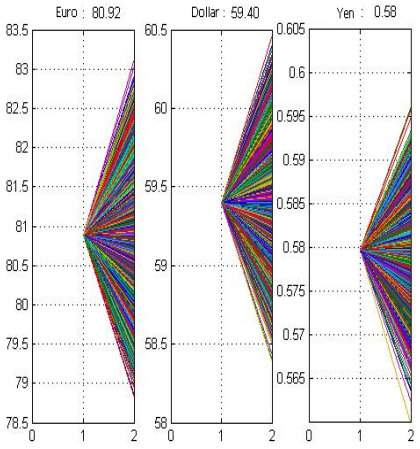
A3. Excange Rates Path on the final day of 2003 (10,000 MC Simulations)



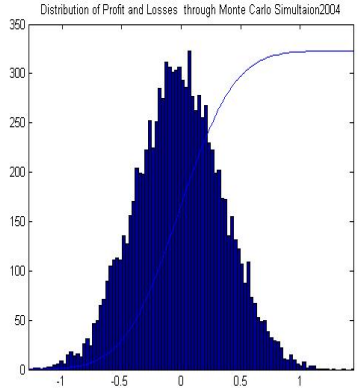
B3. Histogram of Profit and Losses on PDPP on the final day of 2003 (10,000 MC Simulations)



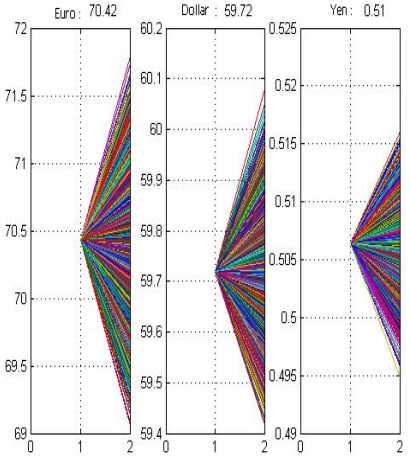
A4. Excange Rates Path on the final day of 2004 (10,000 MC Simulations)



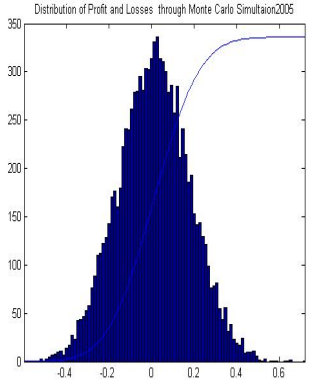
B4. Histogram of Profit and Losses on PDPP on the final day of 2004 (10,000 MC Simulations)



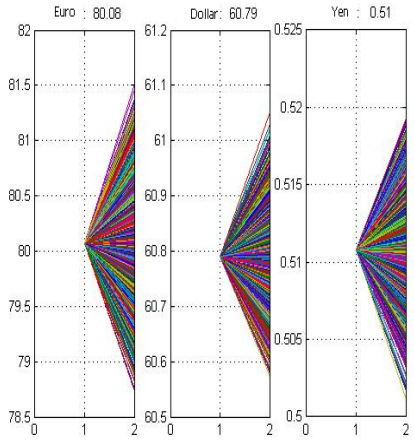
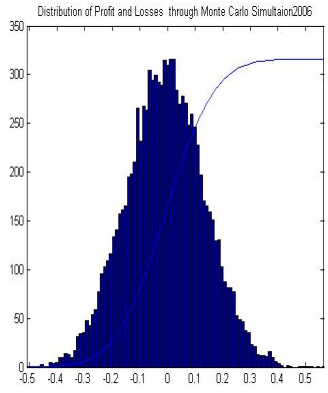
A5. Excange Rates Path on the final day of 2005 (10,000 MC Simulations)



B5. Histogram of Profit and Losses on PDPP on the final day of 2005 (10,000 MC Simulations)



A6. Excange Rates Path on the final day of 2006 (10,000 MC Simulations)



B6. Histogram of Profit and Losses on PDPP on the final day of 2006 (10,000 MC Simulations)