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Applied Value at Risk for Risk Management of Investment Assets

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ABSTRACT

Value at risk (VaR) is the evaluation of financial risk through the application of methods of mathematics and probability & statistics. The VaR model is applied to many different purposes and depends on the users. Results of the VaR model help managers and investors to accurately assess and analyze the financial risk level. This article mainly researches on application of the VaR - Historical data model to assess the loss of the long-term investment asset portfolio with a defined confidence level. These research results indicate the loss level of long-term investment assets when this asset value is affected by fluctuation of market value and interest rate. The VaR is used as an evaluation target of the probable loss possibility. So, the selection of evaluation period depends on the enterprise's characteristic portfolio as the Commercial Banks may choose the evaluation period that is one day, one week or one month because of high demands on the liquidity of the portfolio. In contrast, the investment funds can choose a longer evaluation period, usually over one month because the investment funds generally focus on lower illiquid assets such as long-term securities. Besides, the VaR is also used as an evaluation target of income analysis. The results of VaR analysis helps financial institutions get ability to forecast the probable financial loss. Therefore, the selection of confidence level parameter and evaluation period is very important. When the VaR is used for the purpose of establishing capital safety, they must ensure that the VaR can indicate the different types of risks such as credit risk, market risk, liquidity risk and risk activities. Hence, the choice of the confidence level of 95%, 99%, and 99.99% is to reflect the enterprise's prudent level for the financial risk. If the confidence level is higher, the financial risk is greater, i.e. the enterprise has good business strategies to deal with the risk that may occur.

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INTRODUCTION

The Value at Risk is a method of determining the sensitivity of portfolio or position of company by engineering statistical parameters. This technique uses the information to forecast the influence of the standard deviation events for the held asset value and the aggregate impact on income.

The Value at Risk (VaR) is used by the developed countries. This model is applied to measure the financial loss of characteristic asset portfolio with the probability and determined period. The VaR is considered as an effective method to evaluate the lost asset value and its results are the basis for adjusting the asset value according to the market value of the portfolio during the determined period. The hypothesis: market value factors are constant as the asset portfolio has no transaction. The VaR represents the loss maximum or loss percentage of asset portfolio with a defined confidence level, usually at 95%.

Building the VaR model is to answer basic questions such as "How much is maximum financial loss value ? That commercial banks or enterprises may suffer loss in the determined period and how much percentage is the probability of actual loss? "Thus, application of the VaR model is characterized as follows:

(1), It indicates the level of the maximum potential loss of the asset portfolio that can occur.
(2), With a Confidence Level (less than 100%).
(3), Be limited during the determined period.

Therefore, the VaR is a probabilistic measurement. This measurement indicates different values related to different confidence level. The VaR can be evaluated for the different financial instruments and portfolios to help the enterprises be able to compare the financial risks in relation to these financial instruments and portfolios. Therefore, this model is used for three basic requirements: comparing different investment options

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for capital risk of financial institutions; Comparing income on capital use, and exactly evaluating economic transactions based on the risk level in association with them.

The Value At Risk model can be used to evaluate the different levels of financial risks as: the standard deviation of the change in portfolio value, and the expected loss value. The VaR model does not follow only one methodology, they belong to the evaluation techniques "family / group" to achieve three objectives as follows:

(1) Identified risk factors (such as exchange rate, interest rate, stock price, commodity price) may affect the value of the portfolio of the commercial banks or enterprises, and their fluctuation in the future (by a probability distribution).

(2) Portfolio value is constructed by probability distribution of the commercial banks or enterprises in the future (or the loss value is compared with spot value) at each possible risk factor; in case, they are evaluated the value of individual financial instruments in the portfolio.

(3) The summary of probability distribution functions of the portfolio value has one or more variables.

The evaluation methods of VaR model:

There are many evaluation methods of the VaR such as Merton model, Just-in-time model (JIT), Markov chain etc. However, this article introduces three main methods to measure the VaR:

- Delta - Gamma Method:

This is a simple regression model to evaluate the VaR. Assume that the portfolio risk is linear equation and the risk factors follow a normal distribution. Because the profitability of the portfolio is combined between linear equations and standard variables, thus it complies with the normal distribution that density of distribution function is bell curve. Because, the VaR has relationship between the variables and linear equations leading to Delta - Gamma method is less accurate than Historical data simulation method and Monte Carlo method.

- Historical data simulation method:

Historical data simulation method is adequate valuation method. It is analyzed by historical data and the profit density of assets in historical data range. Assume that the current time is t, and data is observed in t period. The current value of the portfolio is Pt, the function of current risk variables is:

$$p_t = p\left[f_1, t, f_2 t, ..., f_n t \right] \tag{1.1}$$

Sample is taken from the difference of the historical distribution factors with no replacement.

$$\Delta f^k i = \left(\Delta f1, t, \Delta f2, t, ...\Delta f^n, t \right) \tag{1.2}$$

The difference of the historical distribution factors is calculated by formulas below, (depending on research purposes of risk factors to select appropriate formulas).

$$\Delta i_1 = y_i - y_{i-1} \quad \text{or} \quad \Delta i = y_i - y_1 \quad \text{or} \quad \Delta i_2 = \left(\frac{y_i - y_1}{y_1} \right) \times 100 \quad \text{or} \quad \Delta i_3 = \left(\frac{y_i - y_{i-1}}{y_{i-1}} \right) \times 100 \tag{1.3}$$

In which: $y_i (i = 1 \div \mathrm{n})$ is the level of sequence of number, n is each level of sequence of number

From (1.2), the value of each element of simulation is built, starting from the first element

$$f^k i = \left(f1, t + \Delta f1, t, +..... f^n, t + \Delta fn, t \right) \tag{1.4}$$

These factors should be used to build simulation value of the current portfolio in the new context, based on the formula below:

$$p^k = p\left[f^k 1, f^k 2, +..... f^k n \right] \tag{1.5}$$

Now, the change value of the current asset portfolio is calculated by formula:

$$R^k = \left(\frac{p^k - pt}{pt} \right) \tag{1.6}$$

The t is profit and choosing a value corresponding to the differential equations (formula: Rp (c)), example: confidence level $\leq 100\%, \rightarrow 100 \times (1 - \alpha)$of a normal distribution. The VaR is determined from the difference between the average value and differential equation below:

$$\mathrm{V}aR = A\mathrm{VE}\left(\mathrm{R_p} \right) - R_p (c) \tag{1.7}$$

Applying this model for asset portfolio, the formula of discounted cash flow is applied:

$$\mathrm{H_t} = \frac{1}{(1+r)^t} \; ; \mathrm{FV} = \mathrm{F} \times \mathrm{H_t} \tag{1.8}$$

In which:

(1),F: Investment asset value

(2), t: Time of cash flow

(4), r: Interest rate
(5), FV: Net cash flow at time t
(6), H_t : Discount factor

- Monte Carlo method:

This method is similar to Historical data simulation method, except the changing of the risk factors that is created from other normal distribution rules and is based on simulation software compatible with each business. In these three methods, the article emphasizes the historical data simulation method, and applies this method for the Vietnam's commercial banks or enterprises to forecast and monitor the market risk.

2. Data of Economic Events:

Operation process of the banks or enterprises has two values. That is book value and fair value. The book value is historical value. This value is initial recognition when the asset value is bought and unadjusted. The fair value can be varied according to the market value and adjusted when the asset value is varied. The VaR can also be applied to the both values, because they are affected by fluctuation of interest rate and exchange rate.

The application of VaR model is to measure loss of the asset value when their value is varied by the market value. This article mainly studies the historical data simulation method to analyze and evaluate the loss of investment asset portfolio. While building this model we need historical data of interest rate, and the market interest rate is as follows:

Table 1: Average Interest Rate of U.S Dollar (USD).

Months, 2013	average
January	0.160 %
February	0.155 %
March	0.155 %
April	0.154 %
may	0.144 %
June	0.131 %
July	0.121 %
August	0.118 %
September	0.113 %
October	0.104 %
November	0.103 %
December	0.100 %

Source: http://www.global-rates.com/interest-rates/libor/libor-information.aspx

The investment assets will be affected by the long-term interest rates as a year, two years etc. This influence depends on the term of the investment assets. Assume that the term of investment assets is different; the interest rate impacting on the value of investment assets is also different. So, the cash flow of investment assets is evaluated by the discounted cash flow method. Because, the investment assets are long-term, it can be considered as an investment project.

For the reasons above, data of interest rate related to the term of the investment assets is also a basis to evaluate the loss value of investment assets and these results are basis for building the VaR model. According to data source of USD Interest Rate listed in the commercial banks in December 2014, the terms of interest rate are as follows:

Table 2: The Term of USD Interest Rate.

Term	Spot Interest rate
One year	0.9 %
Two years	1.2%
Three years	1.4%
Four years	1.6%
Five years	1.5%

The enterprises can base on the above data to restructure their assets so that these assets become asset groups with the similar terms. After that, the enterprises will arrange these asset groups following the separate terms and corresponding to their interest rates. At the same time, the enterprises are based on the bank's listed forward interest rate corresponding to each year of the investment asset portfolio. Assuming that the enterprise has four groups of investment assets and interest rate terms of the year are as follows:

Table 3: Investment Asset Groups and Correspondent Interest Rate.

Asset Groups	Asset Value	Average Interest Rate	Term - Investment
First group	$100.000.000	2.842 %	2015
Second group	$200.000.000	2.128 %	2017
Third group	$300.000.000	2.130 %	2018
Fourth group	$400.000.000	1.224 %	2023

From the data above, the enterprise can set up the VaR model to evaluate loss of these asset groups as basing on the analyzed results. The results would be evaluated by application of the VaR model below.

3. Application of Var – Historical Data Simulation Method:

After the structure of the asset groups as above, the enterprise can forecast the fluctuation of cash flows from asset groups by formula (1.8), such as Table 4.

Table 4: Cash Flow Fluctuation from Assets of the Banks Determined by the Market Interest Rate.

Years Discount Factor	2014 (1 year)	2015 (2 years)	2016 (3 years)	2017 (4 years)	2018 (5 years)	Market value
	0.99108	0.97643	0.95915	0.93848	0.92826	
First group	$ 2,842,000	$102,842,000				$103,192,519.80
Second group	$4,256,000	$4,256,000	$4,256,000	$204,256,000		$203,672,752.19
Third group	$6,390,000	$6,390,000	$6,390,000	$6,390,000	$306,390,000	$308,136,015.02
Fourth group	$404,896,000					$401,284,440.04
Total cash flows	$418,384,000	$113,488,000	$10,646,000	$210,646,000	$306,390,000	$1,016,285,727.05

To apply the VaR model, the interest rate is identified as a factor causing the value decline of investment assets and it is variable. From the calculation above, the result of $R_p(c)$ is $1,016,285,727.05. Therefore, the future interest rate simulation is built to make the different hypothesis of the investment asset value. The data of market interest rate corresponding to each term in Table 1 is to build simulation of the future interest rate. From these results, the investment asset loss is exactly evaluated to adjust the interest rate fluctuation as follows: (results in table 5 are used by the formulas: (1.3, 1.8 & 1.4)) as the change percentage is calculated by $\Delta i_3 = \left(\frac{y_i - y_{i-1}}{y_{i-1}}\right) \times 100$, deviation $\% = r_i + r_i \times \Delta i_3$, in which: r_i is market interest rate (see formula 1.4) and $H_t = \frac{1}{(1+r)^t}$ (see formula 1.8).

Table 5: Simulation of VaR of Market Interest Rate Fluctuation.

Months	Average	Change Percentage	Simulation Model	
			Deviation %	Ht_i
1 year; market interest rate = 0.9 %				
January	0.1600%			
February	0.1550%	-3.1250%	0.8719%	0.99136
March	0.1550%	0.0000%	0.9000%	0.99108
April	0.1540%	-0.6452%	0.8942%	0.99114
May	0.1440%	-6.4935%	0.8416%	0.99165
June	0.1310%	-9.0278%	0.8188%	0.99188
July	0.1210%	-7.6336%	0.8313%	0.99176
August	0.1180%	-2.4793%	0.8777%	0.99130
September	0.1130%	-4.2373%	0.8619%	0.99146
October	0.1040%	-7.9646%	0.8283%	0.99178
November	0.1030%	-0.9615%	0.8913%	0.99117
December	0.1000%	-2.9126%	0.8738%	0.99134
2 years; interest rate = 1.2%				
January	0.1600%			
February	0.1550%	-3.1250%	1.1625%	0.97715
March	0.1550%	0.0000%	1.2000%	0.97643
April	0.1540%	-0.6452%	1.1923%	0.97657
May	0.1440%	-6.4935%	1.1221%	0.97793
June	0.1310%	-9.0278%	1.0917%	0.97852
July	0.1210%	-7.6336%	1.1084%	0.97820
August	0.1180%	-2.4793%	1.1702%	0.97700
September	0.1130%	-4.2373%	1.1492%	0.97741
October	0.1040%	-7.9646%	1.1044%	0.97827
November	0.1030%	-0.9615%	1.1885%	0.97665
December	0.1000%	-2.9126%	1.1650%	0.97710

3 years; market interest rate = 1.4%				
January	0.1600%			
February	0.1550%	-3.1250%	1.4438%	0.95791
March	0.1550%	0.0000%	1.4000%	0.95915
April	0.1540%	-0.6452%	1.4090%	0.95889
May	0.1440%	-6.4935%	1.4909%	0.95657
June	0.1310%	-9.0278%	1.5264%	0.95557
July	0.1210%	-7.6336%	1.5069%	0.95612
August	0.1180%	-2.4793%	1.4347%	0.95816
September	0.1130%	-4.2373%	1.4593%	0.95747
October	0.1040%	-7.9646%	1.5115%	0.95599
November	0.1030%	-0.9615%	1.4135%	0.95877
December	0.1000%	-2.9126%	1.4408%	0.95799
4 years; market interest rate = 1.6%				
January	0.1600%			
February	0.1550%	-3.1250%	1.6500%	0.93664
March	0.1550%	0.0000%	1.6000%	0.93848
April	0.1540%	-0.6452%	1.6103%	0.93810
May	0.1440%	-6.4935%	1.7039%	0.93465
June	0.1310%	-9.0278%	1.7444%	0.93316
July	0.1210%	-7.6336%	1.7221%	0.93398
August	0.1180%	-2.4793%	1.6397%	0.93702
September	0.1130%	-4.2373%	1.6678%	0.93598
October	0.1040%	-7.9646%	1.7274%	0.93379
November	0.1030%	-0.9615%	1.6154%	0.93791
December	0.1000%	-2.9126%	1.6466%	0.93676
5 years; market interest rate = 1.5%				
January	0.1600%			
February	0.1550%	-3.1250%	1.5469%	0.92612
March	0.1550%	0.0000%	1.5000%	0.92826
April	0.1540%	-0.6452%	1.5097%	0.92782
May	0.1440%	-6.4935%	1.5974%	0.92382
June	0.1310%	-9.0278%	1.6354%	0.92209
July	0.1210%	-7.6336%	1.6145%	0.92304
August	0.1180%	-2.4793%	1.5372%	0.92656
September	0.1130%	-4.2373%	1.5636%	0.92536
October	0.1040%	-7.9646%	1.6195%	0.92282
November	0.1030%	-0.9615%	1.5144%	0.92760
December	0.1000%	-2.9126%	1.5437%	0.92627

From results of the simulation of interest rates above, the hypothesis of future interest rates are similarly varied as historical interest rates. These future interest rates impact on market value of the investment asset portfolio. How does the future interest rate fluctuation impact on the group of investment asset portfolio? The results of VaR below are calculated by

$VaR = AVE(R_p) - R_p(c)$. And $AVE(R_{pi}) = F_i \times Ht_i$ in which: F_i is cash flow, $i = 1 \div 5$.

Table 6: The VaR Simulation: Market Value of the Investment Asset Portfolio.

2014 (1 year)	2015 (2 years)	2016 (3 years)	2017 (4 years)	2018 (5 years)	Sum	VaR
$418,384,000	$13,488,000	$10,646,000	$210,646,000	$306,390,000	$AVE(R_{pi})$	Confidence Level (95.0%)
$414,767,743.73	$13,179,788.79	$10,197,895.95	$197,298,455.15	$283,753,855.83	$919,197,739.45	-$97,087,987.60
$414,652,130.82	$13,170,022.97	$10,211,101.59	$197,687,124.73	$284,409,681.10	$920,130,061.21	-$96,155,665.84
$414,675,994.01	$13,172,038.25	$10,208,373.39	$197,606,804.93	$284,274,136.04	$919,937,346.62	-$96,348,380.43
$414,892,437.67	$13,190,327.75	$10,183,686.79	$196,880,568.77	$283,048,958.54	$918,195,979.51	-$98,089,747.54
$414,986,299.67	$13,198,265.00	$10,173,014.04	$196,566,904.10	$282,520,019.06	$917,444,501.86	-$98,841,225.19
$414,934,657.69	$13,193,897.56	$10,178,883.64	$196,739,384.48	$282,810,859.98	$917,857,683.35	-$98,428,043.70
$414,743,851.49	$13,177,770.16	$10,200,622.52	$197,378,680.44	$283,889,208.05	$919,390,132.67	-$96,895,594.38
$414,808,909.65	$13,183,267.38	$10,193,201.14	$197,160,345.66	$283,520,864.51	$918,866,588.34	-$97,419,138.71
$414,946,917.57	$13,194,934.29	$10,177,489.65	$196,698,416.40	$282,741,774.89	$917,759,532.80	-$98,526,194.25
$414,687,697.16	$13,173,026.68	$10,207,035.89	$197,567,432.24	$284,207,695.16	$919,842,887.12	-$96,442,839.93
$414,759,884.50	$13,179,124.75	$10,198,792.70	$197,324,839.32	$283,798,368.96	$919,261,010.23	-$97,024,716.82

From the results of VaR above, they are calculated by descriptive statistic method as follows:

Table 7: Results of VaR.

Items	Value
Mean	(97,387,230.40)
Standard Error	285,078.66
Median	(97,087,987.60)
Standard Deviation	945,498.94
Sample Variance	893,968,248,858.12
Minimum	(98,841,225.19)
Maximum	(96,155,665.84)
Sum	(1,071,259,534.38)
Count	11
Confidence Level (95.0%)	635194.832

From the application process of VaR models, the results will be evaluated and analyzed below:

RESULTS AND DISCUSSION

From the data in the Table 4, the results of cash flow are affected by market value through figure 3.1 below:

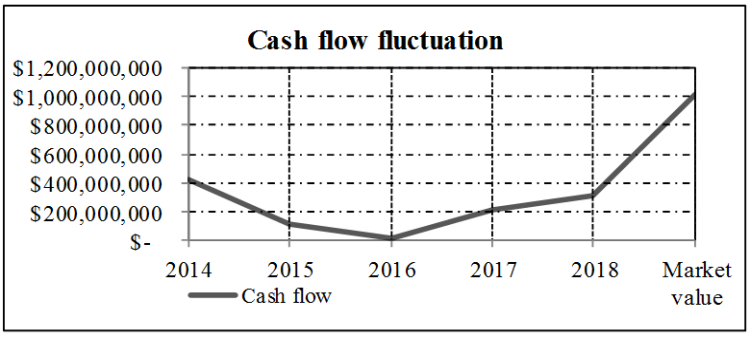

Fig. 3.1:

Figure 3.1 shows the volatility of cash flows that are affected by the fluctuation of market interest rates in the future as: in 2014, the value of investment assets was $ 113,488,000 but in 2015 and 2016 investment asset value will be decreased by $ 10,646,000. This case is the first asset group that has the end of investment. However, in 2018, the cash flow of the investment assets will increase by $306,390,000. If these cash flows are compared with the cash flows of the market value, the value of investment assets is suffered heavy loss. Any market value fluctuation will immediately affect the asset investment value, and the value of entire assets of the business. The cash flow volatility of the market value is basis for comparison between the historical value of investment assets and the market value of investment assets. Therefore, when the interest rate fluctuation is adverse, it will impact on the value of investment assets. Investment assets are assessed the ability of their biggest loss, with a certain Confidence Level, to be able to offer appropriate solutions for capital.

The data of Table 4 and Table 5 are combined together to evaluate the data in table 6 and the data in Table 6 is basis to assess the VaR simulation of investment assets. The results are presented through figure 3.2 below.

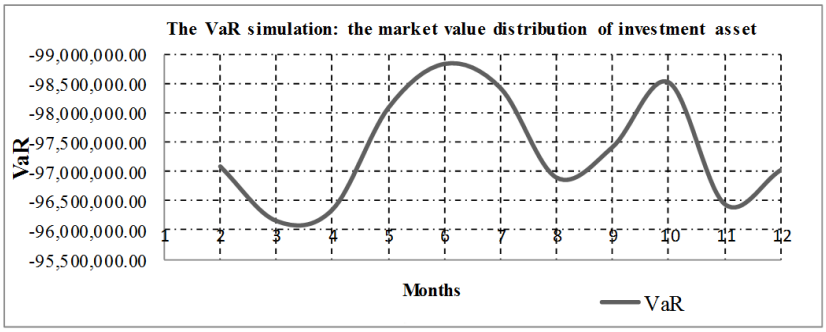

Fig. 3.2:

Application of the descriptive statistic method to evaluate the VaR of investment asset portfolio with Confidence Level (95.0%), we have results of Mean, Median, Standard Deviation, Sample Variance etc. However, the VaR is based on Standard Deviation to evaluate the risk level of investment assets. Base on the result of descriptive statistic method, the VaR is assessed at $ 945,498.94, with Confidence Level (95.0%). This

result shows that the loss value of investment assets is $ 945,498.94 and the result will be basis for the enterprises to make accurate decisions and give better solutions for their capital investment. The enterprises should be added their capital to offset the loss value of investment assets, or adjusted the investment asset portfolio in accordance with fluctuation of interest rate or foreign exchange.

In addition, the Figure 3.2 shows the results of VaR in each month as: in March, the risk level of assets is the lowest but in June, the risk level of assets is the highest etc. The enterprises can base on the results of each month to hedge appropriate risk level and not exceed the hedging value of $ 945,498.94. According to the initial hypothesis, the enterprise invests $ 1,000,000,000 in five years with the fixed interest rates of 2,842%, 2,128%, 2,130%, 1,224%. In the investment process, the enterprise's asset value is affected by market interest rates that are 0.9%, 1.2%, 1.4%, 1.6%, 1.5% in five years. The results of Table 4 show that market interest rate fluctuation made the enterprise lose $43,268,272.95 because the market interest rate is lower than the enterprise's fixed interest rate leading to his cash flows are lower than the cash flows of market interest rate.

The enterprise's application of the VaR model to manage the financial risk is necessary. This model is widely used to measure the loss of specific asset portfolio with the identified confidence level and identified duration. Simultaneously, the VaR is considered as a loss degree of investment assets, the loss value of these assets is adjusted according to the market value with hypothesis of normal market conditions and no transactions of imvestment assets. In 2013, the market interest rate has no sudden volatility (see table 2) and the groups of assets are still invested. It is necessary for the enterprises to apply this model. $ 945,498.94 of VaR is evaluated and the greatest loss of investment asset portfolio with confidence level is 95 %. The VaR can be applied to all categories of asset value that can be adjusted according to the market. All similar asset value can be adjusted according to market value rules with probability distribution and all causes of market risk rules form this probability distribution. In addition, the VaR is determined on the basis of the probability distribution rules for the market value of the portfolio. Normally, the fluctuation of the asset value complies with the normal distribution, with two characteristic values that are the mean and variance, the results of mean and variance are -$97387230.40 and $893,968,248,858.12 and Standard Deviation is $945498.94. These results are calculated by the descriptive statistic method. Therefore, the VaR is comprehensive measurement method for the market risk.

Conclusions:

The financial system of developed countries should be calculated by the VaR model with the identified confidence level, e.g. Germany, the banks or enterprises should apply the VaR model in 10 days with 99 % of confidence level and they also will periodically accurately test the VaR through Backtest. If the loss result of this test is exceeded the expected VaR, the VaR system is not exact and these results will be adjusted in conformity with the actual result of VaR.

To apply this VaR model, the Vietnamese enterprises will initially build conformity with historical data of investment asset portfolio and build variables based on the fluctuation factors of market such as: interest rate, exchange rate etc. The enterprises can get data in about 10 years and apply the VaR model to assess the risk level through mathematical models. However, this article applies the VaR- historical data simulation method. Because, this method has relatively accurate results and is easy to set up. Many developed countries apply this model such as: America, Germany, etc.

Highlight benefits of this VaR model are effective hedge of the financial risk as well as interest rate. Moreover, this model helps the enterprises well manage the financial risk. They use the VaR model to evaluate the risk level of investment assets and ensure the business capital as results of the above discussions. Besides, the effectiveness of applying this model is consistent with the development of Vietnam's economy and applying this model is necessary to minimize the financial risk. However, the use and development of this model on the Vietnamese market is still limited. These limitations are due to the enterprises and commercial banks, as well as macroeconomic policies which do not give specific solutions. This model is little applied by the enterprises and the commercial banks. Hence, the Vietnamese enterprises need to assess the effectiveness of this model, the application conditions and the development direction of the VaR model in the future.

The effectiveness of the VaR model for measuring the interest rate is to minimize the loss of investment assets. This is the prerequisite for the application of the VaR model to hedge the interest rate risk in the market. The interest rate fluctuation is also important factors making difficulty for the enterprises to forecast the loss of investment assets.

The interest rate is complexly varied. Therefore, the enterprises need savvy and have good skills in the application of this model. Simultaneously, they also have the technical knowledge about the VaR model. Particularly, the application of this model is to evaluate the risk level and help the enterprises set up appropriate financial hedging strategies. In addition, they must also develop the VaR – historical data simulation method by financial mathematics. Besides, the enterprises should also develop technology because it is necessary to evaluate fluctuation level of interest rate. Because, the VaR model is built on the basis of the application of complex algorithms to forecast the loss of investment assets in the future

For the developed countries, they always appreciate the stable interest rate policies because they play a very important role in the economic development such as the development of trade, investment, etc. Implementation of stable interest rate is goal of each country. The Vietnam's stable interest rate policies have made significant changes and some of regulations were issued for the VaR model. However, the VaR - historical data simulation method of Vietnam is still in its infancy, underdeveloped through the high financial risk, some enterprises even apply this model but it is not effective. Although this model is widely applied for hedging forward price in the world such as: Backtest, Stress-test, Black- Scholes, Markowitz etc. and they bring profit up to hundreds of billions of dollars. Therefore, the use of this model to hedge the interest rate risk in Vietnam is necessary.

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