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Application of Exogenous Liquidity Risk Models to Analyze Single Assets

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Abstract

Exogenous liquidity risk measurement is a measurement of liquidity risk that affects all market participants and is not affected by the actions of any other actors. Exogenous liquidity risk measurement is usually called the Cost of Liquidity (COL). The main problem is how the level of liquidity of one currency against other currencies and the effect of liquidity risk on VaR (Value at Risk) on a single asset. This thesis examines the importance of liquidity risk on a single asset. Combining basic VaR and liquidity risk will result in more effective calculations. The model used is to add the basic VaR value with the Cost of Liquidity (COL) or also called Liquidity VaR (L-VaR). The calculation results show the different effects of liquidity for each country's currency. Indonesian Rupiah (IDR) is the currency that has the highest liquidity component compared to the Japanese Yen (JPY) and the Thai Baht (THB). The lower the liquidity component of a currency, the currency is very liquid, and the Japanese Yen (JPY) is the most liquid currency compared to the Indonesian Rupiah (IDR) and the Thai Baht (THB).

Keywords: volatility, Value-at-Risk, liquidity, exogenous, liquidity costs.

1. Introduction

The monetary crisis in 1998 and the events of September 11, 2001, the tragedy of the World Trade Center (WTC) in the United States had a devastating impact on several countries in the world including in Indonesia. The exchange rate of the rupiah against the dollar immediately dropped dramatically. Indonesia has experienced high inflation until now (Anam, 2013). Experienced and laypeople often assume that liquidity risk is the responsibility of those who commit crimes against the chaos of the monetary crisis on world capital markets. The standard Value at Risk (VaR) concept is used to measure market and credit risk in trading securities from miscalculations of liquidity risk. The exogenous liquidity risk model has the usefulness of analyzing an asset (Aktas et al., 2012).

Research conducted by Anam (2013) aims to examine liquidity risk and evaluate its effect on the profitability of a bank; analyze the increase in deposits can increase bank income; analyze the increase in cash reserves can reduce bank income; analyzing an increase in the liquidity gap can cause a decrease in bank income; as well as analyzing the high Non-Performing Loan (NPL) provisions can cause a decline in bank profits. In his research, Anam used data taken from the financial statements of banking companies (in the form of balance sheets, income/loss statements, cash flows, and changes in the capital) and financial statement records from 26 banks listed on the Indonesia Stock Exchange during 2006-2011. Samples were taken using purposive sampling and met the criteria for sample selection. The multiple regression model is used to estimate the impact of liquidity risk on bank profitability. Based on the results of his research shows that liquidity risk significantly affects bank profitability, with liquidity gaps and NPLs as two factors exacerbating liquidity risk. Each has a negative relationship with profitability. An increase in cash reserves can reduce bank income shows the opposite results that are hypothesized. This shows that bank profitability has increased with an increase in cash and vice versa. There is a positive relationship between the cash and profitability of the banking system.

This paper intends to conduct research on the application of exogenous liquidity risk models to analyze single assets. The aim is to identify the factors that influence the composition of exogenous liquidity risk on the value of total liquidity risk and determine the value of total liquidity risk based on the size of the Risk-at-Risk risk of a single asset.

2. Relationship between Liquidity Risk and Market Risk

Risk can be interpreted as uncertainty about future results. Market risk is concentrated in describing price uncertainty or return due to market movements. Market risk includes uncertainty built from assets (return risk) and uncertainty caused by liquidity risk.

The liquidity risk component is focused on the uncertainty of liquidity costs. The uncertainty caused by liquidity risk is divided into exogenous illiquidity and endogenous illiquidity. Exogenous illiquidity is the result of market characteristics, common to all market participants and is not affected by the actions of any actor. Endogenous illiquidity is specific to one position in the market, all different market participants and the opening of any actor is affected by the action (Bangia, et al., 1998; 1999). Figure 1 shows the relationship between liquidity risk and market risk.

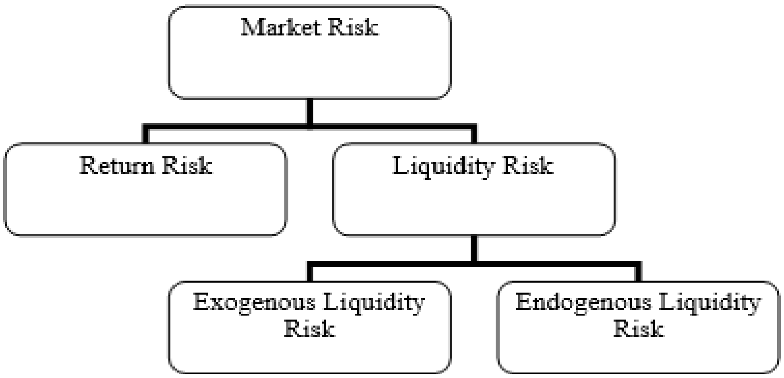

Figure 1: Market Risk Taxonomy

In Figure 1, it can be stated as an area of liquidity/market risk or risk cross which is an estimate of the combined impact of the 2 types of risk shown in Figure 2.

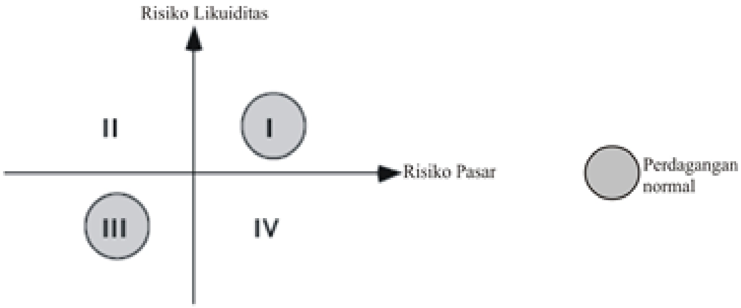

Figure 2: Normal Trading on the Risk Cross Market

Risk cross is a simplification of a more complex relationship between the market and the size of the position involving exogenous and endogenous components of liquidity risk. Normally the trade and market situation falls in regions I and III (Alexander, 1999).

3. Modeling Uncertainty in Market Value

Suppose that one day the asset return at time t, r_t, becomes the log difference from the mid-price P as follows

$$r_t = \ln[P_t] - \ln[P_{t-1}] = \ln\left[\frac{P_t}{P_{t-1}}\right]. \tag{1}$$

The mid-price value P is defined as the average of demand and supply (http://moneyterm.co.uk/mid-prices). Take a one-day horizon where changes in the value of assets are considered, and assuming a one-day return is Gauss, then VaR at a 99% confidence level is

$$VaR_t = P_t\left(1 - e^{E[r_t] - 2.33\sigma_t}\right), \tag{2}$$

where $E[r_t]$ and σ_t^2 are the first moment (average) and the second moment (variance) of return. Without losing generality, let's say the value of $E[r_t]$ is zero.

In this case, the volatility used is exponentially weighted moving average (EWMA) which is formulated as follows

$$\sigma_t^2 = (1-\lambda)r_{t-1}^2 + \lambda\sigma_{t-1}^2, \tag{3}$$

where λ is a constant (Hogg and Craig, 1995; Dowd, 2002).

Suppose the mid-price (P_t) becomes ½ $\bar{S}$ (for example ½ times the average spread). Defined measurement of exogenous liquidity risk in terms of confidence intervals or tail probability. Define the exogenous cost of liquidity (COL) based on the average spread, $\bar{S}$, plus the multiplication of the spread volatility ($a\tilde{\sigma}$), to cover more (say 99%) of the dispersion situation, as follows

$$COL_t = \tfrac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right], \tag{4}$$

where P_t is the mid-day price for assets or instruments, $\bar{S}$ is the average relative spread with relative spread defined as [*Ask* – *Bid*]/*Mid*, $\tilde{\sigma}$ is the volatility of relative spread, *a* is a scale factor, *a* scale factor is between 2, 0 to 4.5 depending on the instrument and market in question, this range is formed from the spread distribution. In general, the further away from normality, the greater the value of *a* (Häberle and Persson, 2000; Erwan, 2002).

The combination of liquidity risk and market risk with the assumption of extreme adverse market environment events in return and extreme events in the spread occur together. The relationship between mid-price movements and their spread is imperfect but strong enough as long as extreme market conditions occur and are encouraged to maintain the market and liquidity risks such as experiencing simultaneous extreme movements. Therefore, in calculating the VaR liquidity risk adjustment included both, the principal 99th percentile movement and in the spread, shown in Figure 3 (Tsai and Lee, 2017).

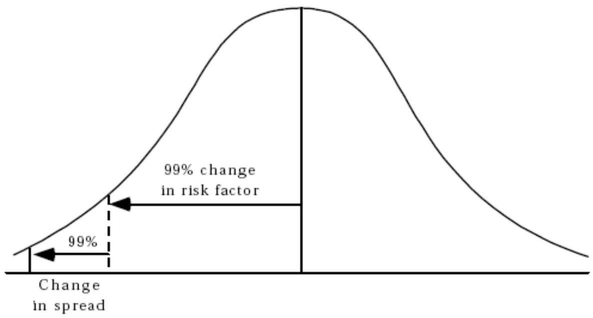

Figure 3: Combined Market and Liquidity Risk Charts

To re-translate prices, for example depicting 1% of the worst-case price (P') and VaR parametric along with liquidity for a single asset as

$$P' = P_t e^{-2.33\sigma_t} - \frac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right], \tag{5}$$

$$LVarR_t = VaR_t + COL_t = P_t\left(1 - e^{-2.33t}\right) + \frac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right]. \tag{6}$$

4. Calculation of Total Liquidity and 1% Worst Price

To find the value of total liquidity and the worst 1% price, we must first look for average return volatility (σ_t), average relative spread ($\bar{S}$), relative spread volatility ($\tilde{\sigma}$), VaR risk component (VaR_t) and risk component value VaR liquidity (COL_t).

On September 11, 2001 (t) the selling exchange rates of IDR, JPY, THB against USD were IDR9,585.00, ¥121.18, B44.67, and the buying exchange rate of IDR, JPY, THB against the USD in the same dates in a row are Rp8,585.00, ¥121.20, B44.77. On September 10, 2001 (t–1) the selling exchange rates of IDR, JPY, THB against the USD were IDR9,600.00, ¥119.83, B44.46, and the purchase exchange rate of IDR, JPY, THB against USD on the same date in a row is IDR8,600.00, ¥119.93, B44,51. Based on the definition of mid-price, the mid-price of 11 September 2001 (P_t) for the currencies of IDR, JPY, THB are

$$P_{t(IDR)} = \frac{\text{IDR}9{,}585.00 + \text{Rp}8{,}585.00}{2} = \text{IDR}9{,}085.00,$$

$$P_{t(JPY)} = \frac{¥121.18 + ¥121.20}{2} = ¥121.19,$$

$$P_{t(THB)} = \frac{\text{B}44.67 + \text{B}44.77}{2} = \text{B}9{,}44.72.$$

After the mid-price (P_t) is obtained, using equation (1) return value (r_t) of IDR, JPY, THB currency transactions on September 11, 2001 can be obtained. Assuming the value of $\lambda = 0.94$, the value of return (r_t) and the volatility of the average return (σ_t) on January 24, 2001 is 0, then the average return volatility value of the transaction currency is IDR ($\sigma_{t(IDR)}$), JPY ($\sigma_{t(JPY)}$), THB ($\sigma_{t(THB)}$) September 11, 2001 based on equation (3) and calculated using the Microsoft Office Excel 2003 program, respectively 1.90%, 0.60%, and 0.30%. The value of the risk return component of VaR (VaR_t) for IDR, JPY, THB currency exchange rates on September 11, 2001 based on equation (2) is

$$VaR_t = P_t\left(1 - e^{-2.33\sigma_t}\right).$$

The value of the risk return component of VaR for the IDR ($VaR_{t(IDR)}$) currency transaction exchange rate on September 11, 2001 is

$$VaR_{t(IDR)} = P_{t(IDR)}\left(1 - e^{-2.33\sigma_{t(IDR)}}\right) = \text{IDR}9{,}805.00\left(1 - e^{-2.33 \cdot 1.90\%}\right) = \text{IDR}394.24.$$

The value of the risk return component of VaR for the JPY ($VaR_{t(JPY)}$) currency transaction exchange rate on September 11, 2001 is

$$VaR_{t(JPY)} = P_{t(JPY)}\left(1 - e^{-2.33\sigma_{t(JPY)}}\right) = ¥121.19\left(1 - e^{-2.33 \cdot 0.60\%}\right) = ¥1.69.$$

The value of the risk return component of VaR for the THB ($VaR_{t(THB)}$) currency transaction exchange rate on September 11, 2001 is

$$VaR_{t(THB)} = P_{t(THB)}\left(1 - e^{-2.33\sigma_{t(THB)}}\right) = \text{B}44.72\left(1 - e^{-2.33 \cdot 0.30\%}\right) = \text{B}0.31.$$

Calculating the value of the liquidity risk component of VaR (COL_t) required the relative spread value, the average relative spread of $\bar{S}$, the relative spread volatility ($\tilde{\sigma}$). By using Microsoft Office Excel 2003, the relative spread value is obtained, the average spread of $\bar{S}$. The average value of the relative spread of IDR, JPY, THB are $\bar{S}_{(IDR)}$ = -0.10794, $\bar{S}_{(JPY)}$ = 0.000386, $\bar{S}_{(THB)}$ = 0.000871, respectively. Calculating the relative spread volatility ($\tilde{\sigma}$) of the Minitab program 14. Consecutively the relative spread volatility value ($\tilde{\sigma}$) for IDR, JPY, THB transaction rates are $\tilde{\sigma}_{(IDR)}$ = 0.007609, $\tilde{\sigma}_{(JPY)}$ = 0.000767, $\tilde{\sigma}_{(THB)}$ = 0.000677. Referring to Bangia et al (1998), it is assumed that the scale factor values of $a_{(IDR)}$ = 3.5, $a_{(JPY)}$ = 2.5, $a_{(THB)}$ = 3.5. Therefore, the value of the liquidity risk component of VaR(COL_t) for the currency exchange rate of IDR, JPY, THB dated September 11, 2001 based on equation (4) is

$$COL_t = \tfrac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right].$$

The value of the liquidity risk component of VaR ($COL_{t(IDR)}$) for the IDR currency transaction rate on September 11, 2001 is

$$COL_{t(IDR)} = \frac{1}{2}\left[P_{t(IDR)}(\bar{S}_{(IDR)} + a_{(IDR)}\tilde{\sigma}_{(IDR)})\right] = \frac{1}{2}\left[\text{IDR}9{,}085.00(-0.10794) + 3.5\cdot 0.007609\right] = -\text{IDR}369.36\,.$$

The value of the liquidity risk component of VaR ($COL_{t(JPY)}$) for the IDR currency transaction rate on September 11, 2001 is

$$COL_{t(JPY)} = \frac{1}{2}\left[P_{t(IDR)}(\bar{S}_{(JPY)} + a_{(JPY)}\tilde{\sigma}_{(JPY)})\right] = \frac{1}{2}\left[¥116.77(0.000386) + 2.5\cdot 0.000767\right] = ¥0.14\,.$$

The value of the liquidity risk component of VaR ($COL_{t(THB)}$) for the IDR currency transaction rate on September 11, 2001 is

$$COL_{t(THB)} = \frac{1}{2}\left[P_{t(THB)}(\bar{S}_{(THB)} + a_{(THB)}\tilde{\sigma}_{(THB)})\right] = \frac{1}{2}\left[\text{B}44.72(0.000871) + 3.5\cdot 0.000677\right] = \text{B}0.07\,.$$

Total liquidity adjusted by VaR ($L\text{–}VaR_t$) based on equation (6) is

$$LVarR_t = VaR_t + COL_t = P_t\left(1 - e^{-2.33t}\right) + \frac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right].$$

Total liquidity adjusted for VaR for the IDR ($L\text{–}VaR_{t(IDR)}$) currency transaction rate on September 11, 2001 is

$$LVarR_{t(IDR)} = VaR_{t(IDR)} + COL_{t(IDR)} = \text{IDR}394.24 + (-\text{IDR}396.36) = \text{IDR}24.88\,.$$

Total liquidity adjusted for VaR for the IDR ($L\text{–}VaR_{t(JPY)}$) currency transaction rate on September 11, 2001 is

$$LVarR_{t(JPY)} = VaR_{t(JPY)} + COL_{t(JPY)} = ¥1.69 + ¥0.14 = ¥1.83\,.$$

Total liquidity adjusted for VaR for the IDR ($L\text{–}VaR_{t(THB)}$) currency transaction rate on September 11, 2001 is

$$LVarR_{t(THB)} = VaR_{t(THB)} + COL_{t(THB)} = \text{B}0.31 + \text{B}0.07 = \text{B}0.38\,.$$

The effect of the liquidity risk component on total liquidity adjusted by VaR for the exchange rates of IDR, JPY, THB currencies on September 11, 2001 was -1485%, 8%, 19%, respectively.

The value of the 1% worst-case price (P') based on equation (5) for the currency exchange rates of IDR, JPY, THB on September 11, 2001 is

$$P' = P_t e^{-2.33\sigma_t} - \frac{1}{2}\left[P_t(\bar{S} + a\tilde{\sigma})\right].$$

The worst-case 1% price value (P'_{IDR}) for the IDR currency transaction rate on September 11, 2001 is

$$\begin{aligned} P'_{IDR} &= P_{t(IDR)}e^{-2.33\sigma_{t(IDR)}} - \frac{1}{2}\left[P_{t(IDR)}(\bar{S}_{(IDR)} + a_{(IDR)}\tilde{\sigma}_{(IDR)})\right] \\ &= \text{IDR}9{,}085.00e^{-2.33\cdot 1.90\%} - \frac{1}{2}\left[\text{IDR}9{,}085.00(-1.10794 + 3.5\cdot 0.007609)\right] \\ &= \text{IDR}9{,}060.12. \end{aligned}$$

The worst-case 1% price value (P'_{JPY}) for the IDR currency transaction rate on September 11, 2001 is

$$P'_{JPY} = P_{t(JPY)} e^{-2.33\sigma_{t(JPY)}} - \frac{1}{2}\left[P_{t(JPY)}(\bar{S}_{(JPY)} + a_{(JPY)}\tilde{\sigma}_{(JPY)})\right]$$

$$= ¥121.19 e^{-2.33 \cdot 0.60\%} - \frac{1}{2}\left[¥121.19(0.000386 + 2.5 \cdot 0.000767)\right]$$

$$= ¥119.36.$$

The worst-case 1% price value (P'_{THB}) for the IDR currency transaction rate on September 11, 2001 is

$$P'_{THB} = P_{t(THB)} e^{-2.33\sigma_{t(THB)}} - \frac{1}{2}\left[P_{t(THB)}(\bar{S}_{(THB)} + a_{(THB)}\tilde{\sigma}_{(THB)})\right]$$

$$= B44.72^{-2.33 \cdot 0.30\%} - \frac{1}{2}\left[B44.72(0.000871 + 3.5 \cdot 0.000677)\right]$$

$$= B44.34.$$

A summary of total liquidity values adjusted to VaR for the transaction rates of IDR, JPY, THB on September 11, 2001 is listed in Table 1.

Table 1: Liquidity risk and return risk on September 11, 2001

	IDR	**JPY**	**THB**
Prices on September 11, 2001 (P_t)	IDR9,085.00	¥121.19	B44.72
Average return volatility (σ_t)	1.90%	0.60%	0.30%
Average and relative spread volatility ($\bar{S}, \tilde{\sigma}$)	-0.10794, 0.007609	0.000386, 0.000767	0.000871, 0.000677
The risk return component of VaR (VaR_t)	IDR394.24	¥1.69	B0.31
Liquidity risk component of VaR (COL_t)	-IDR369.36	¥0.14	B0.07
Price of 1% worst cases (P')	IDR9,060.12	¥119.36	B44.34
Total liquidity adjusted for VaR ($L\text{–}VaR_t$)	IDR24,88	¥1,83	B0,38
Liquidity component (%)	-1485%	8%	19%

On September 11, 2001, the liquidity component greatly affected the value of IDR and THB. The liquidity component for JPY is not large, this happens because the JPY is a stable currency.

5. Conclussion

The factors needed to obtain the magnitude of the influence of exogenous liquidity risk components on the value of total liquidity risk combined with standard VaR are the value of average return volatility, average value and relative spread volatility, the value of the risk-return component of VaR (value at risk). The value of total liquidity risk is more accurate than the standard VaR. Exogenous liquidity risk is very influential on all market risks. The smaller the value of the liquidity component, the more liquid the currency is. The events of September 11, 2001, that were the tragedy of the WTC in the United States did not affect the exchange rate and the level of liquidity of the Indonesian Rupiah, Japanese Yen, Thai Baht against the United States Dollar.

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