MEASURING THE FOREIGN EXCHANGE RISK LOSS OF THE BANK
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Abstract. The present paper obtained a relationship for the Potential Loss of the bank's portfolio of foreign currencies by using the normal distribution assumption of the exchange rates daily variations. Second, it is determined the Potential Loss of a bank that keeps the accounting in Euro for a portfolio consists of five the most commonly traded currencies in 2013. Finally, there are mentioned two main purposes of determining the bank's Potential Loss due to foreign exchange risk.

Keywords: foreign exchange risk, bank's Potential Loss, foreign exchange position, volatility, normal distribution

1.0 INTRODUCTION
The foreign exchange risk (or currency risk) is a component of market risk and expresses the possibility that exchange rate fluctuations negatively affect the profit and equity of the bank. This risk occurs because the bank has operations in foreign currencies. The bank's exposure to foreign exchange risk is the foreign exchange position. The bank foreign exchange position in a certain foreign currency “i” represents the net assets of the bank in that currency. The bank's foreign exchange position is the difference between the bank's assets and the bank's debts expressed in a foreign currency “i”. A certain size of the foreign exchange position and the volatility of the exchange rate of one foreign currency “i” against the national currency used for accounting records may involve the possibility of losses for the bank. The foreign exchange loss may be even higher as the bank has a portfolio of several foreign currencies.

In many research papers, the bank's loss due to market risk is determined by several types of so-called Value at Risk methodologies. For instance, Linsmeier and Pearson (2000) explained the concept of Value at Risk and described in detail the three methods for computing it: historical simulation, the delta-normal method and Monte Carlo simulation. Ammann and Reich (2001) found that the Value at Risk estimates by the variance covariance approach sometimes do not differ greatly from other simulations even for some optioned portfolios. Hendriks (1996) made a historical examination of twelve approaches to Value at Risk modeling and showed that in almost all cases the approaches cover the risk that they are intended to cover. In terms of variability over time, the Value at Risk approaches using longer observation periods tend to produce less variable results than those using short observation periods or weighting recent observations more heavily. Basel Committee on Banking Supervision (2005) has made an amendment to the Bank Capital Accord where suggested that bank's capital charge for market risks can be established by Value at Risk procedures computed on a daily basis with a 99th percentile for a 10 day movement in market prices.

2.0 DETERMINING THE BANK’S POTENTIAL LOSS DUE TO FOREIGN EXCHANGE RISK
Measuring foreign exchange rate risk loss of the bank can be determined by calculating the Potential Loss related to the foreign currencies portfolio of the bank. Further, we will obtain a
relationship for the Potential Loss of the bank's portfolio of foreign currencies by using the normal distribution assumption of the exchange rates daily variations. Let $X$ be a random variable represented by the daily variation of the exchange rate of a currency against another. Then, let $X$ has a normal distribution of mean $m$ and standard deviation $\sigma$. The probability that the random variable $X$ is less than the threshold $x$ is given below:

$$P(X < x) = N(x, m, \sigma) = \int_{-\infty}^{x} \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{x-m}{\sigma} \right)^2} dt$$

where:

- $N(x, m, \sigma)$ is the distribution function (or the probability) from the normal distribution.

Any random variable $X$ with normal distribution can be transformed into a random variable $Z$ having standard normal distribution by changing the variable

$$z = \frac{x - m}{\sigma}.$$

Thus, for a threshold $z$ of the standard normal distribution, there is the equality:

$$N(x, m, \sigma) = N(z, 0, 1)$$

It follows that $x = z * \sigma + m \geq z * \sigma$ since the data series of daily variations in the exchange rate between two currencies have the average $m$ which tends to 0 for a sample of daily data large enough.

From the definition of the probability we have $X < x$ and for a foreign exchange currency portfolio holding for one-day time horizon and under the normal distribution of the daily changes of the exchange rate it follows that the Potential Loss is given by $z * \sigma$.

Let "$i$" be a foreign currency owned by a bank. Then the Potential Loss for the bank foreign exchange position denominated in currency "$i$" is given by the following relationship:

$$PL_i = FP_i * z * \sigma_i$$

(1)

where:

- $PL_i$ is the Potential Loss of the foreign exchange position denominated in currency "$i$";
- $FP_i$ is the foreign exchange position expressed in currency "$i$" (in units of "$i$");
- $z$ is the confidence level from standard normal distribution;
- $\sigma_i = \sqrt{\frac{\sum_{t=1}^{n} (R_{it} - \bar{R}_i)^2}{n-1}}$ is the standard deviation of the daily variations of the exchange rate of the currency "$i$" against the base currency. The base currency is the national currency utilized by the bank to keep its accounting;
- $\bar{R}_i$ is the daily variation of the exchange rate of one currency "$i$" against base currency.

$$R_{it} = \frac{S_{it}}{S_{it-1}} - 1$$

where: $S_{it}$ and $S_{it-1}$ are the exchange rates between currency "$i$" against base currency in the days $t$ and $t-1$ respectively;
The average of the exchange rate daily variations data sample; $n$ is the number of observations in the sample of statistical data. The Potential Loss for one day of a bank portfolio consists of $m$ foreign currencies can be determined as follows:

$$PL_p = \sqrt{PL_p^2}$$

where:

- $PL_p$ is the Potential Loss of the foreign exchange portfolio of the bank for one day;
- $\rho_{ij}$ is the correlation coefficient between the daily variations exchange rate data series $R_{it}$ and $R_{jt}$ of the foreign currencies “$i$” and “$j$” against base currency.

$$\rho_{ij} = \frac{\sum_{t=1}^{n}(R_{it} - \bar{R}_i)(R_{jt} - \bar{R}_j)}{\sqrt{\sum_{t=1}^{n}(R_{it} - \bar{R}_i)^2}\sqrt{\sum_{t=1}^{n}(R_{jt} - \bar{R}_j)^2}}$$

$R_{it}$ and $R_{jt}$ respectively;
- $\sigma_i$ and $\sigma_j$ are the Potential Losses of the bank expressed in base currency;
- $i, j = 1...m$.

The Potential Loss of the bank portfolio consists of $m$ foreign currencies for a period of $T$ days can be determined as follows:

$$PL_p(T \text{ days}) = PL_p \cdot \sqrt{T}$$

Further, we determined the Potential Loss of a bank having Euro as the base currency for a portfolio of other five primary foreign currencies the most traded in 2013 (as it mentioned in "Foreign exchange turnover in April 2013: preliminary global results" of the Bank for International Settlements). Besides the Euro, other five primary currencies most traded in 2013 were the following: the United States dollar (USD), the Japanese yen (JPY), the Pound Sterling (GBP), the Australian dollar (AUD) and the Swiss franc (CHF).

We set a sample of the daily variations of the exchange rates of the five currencies against the Euro with a length number of 254 observations. The data source for the exchange rates USD/EUR, JPY/EUR, GBP/EUR, AUD/EUR and CHF/EUR is the Statistical Data Warehouse of the European Central Bank.
In Table 1 are presented the daily average volatilities $\sigma_i$ of the USD, JPY, GBP, AUD and CHF exchanges rates against EUR. It can be noted that the daily average volatilities of the five exchange rates are between 0.2919% (for CHF / EUR - the least volatile exchange rate) and 0.8623% (for JPY / EUR - the exchange rate with the highest volatility).

**Table 1: The daily average volatilities of the USD, JPY, GBP, AUD and CHF exchanges rates against EUR**

<table>
<thead>
<tr>
<th>Exchange rate</th>
<th>Daily average volatility $\sigma_i$ (in %)</th>
<th>The value of the exchange rate for the last day of the year 2013 $S_{12/31/2013}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/EUR</td>
<td>0.4851</td>
<td>0.7251</td>
</tr>
<tr>
<td>JPY/ EUR</td>
<td>0.8623</td>
<td>0.0069</td>
</tr>
<tr>
<td>GBP/ EUR</td>
<td>0.4537</td>
<td>1.1995</td>
</tr>
<tr>
<td>AUD/ EUR</td>
<td>0.6614</td>
<td>0.6484</td>
</tr>
<tr>
<td>CHF/ EUR</td>
<td>0.2919</td>
<td>0.8146</td>
</tr>
</tbody>
</table>

The matrix of correlation coefficients between the daily variations series of USD, JPY, GBP, AUD and CHF exchanges rates against EUR is presented in Table 2. It can be noted that the correlation coefficients of the five exchange rates daily variations are between 0.0288 (for the pair of exchanges rates CHF/EUR - USD/EUR) and 0.5322 (for the pair of exchanges rates JPY/EUR - CHF/EUR).

**Table 2: The matrix of correlation coefficients between the daily variations series of USD, JPY, GBP, AUD and CHF exchanges rates against EUR**

<table>
<thead>
<tr>
<th></th>
<th>USD/EUR</th>
<th>JPY/EUR</th>
<th>GBP/EUR</th>
<th>AUD/EUR</th>
<th>CHF/EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/EUR</td>
<td>1.0000</td>
<td>0.4383</td>
<td>0.5213</td>
<td>0.4492</td>
<td>0.0288</td>
</tr>
<tr>
<td>JPY/EUR</td>
<td>0.4383</td>
<td>1.0000</td>
<td>0.4714</td>
<td>0.3989</td>
<td>0.5322</td>
</tr>
<tr>
<td>GBP/EUR</td>
<td>0.5213</td>
<td>0.4714</td>
<td>1.0000</td>
<td>0.4338</td>
<td>0.2711</td>
</tr>
<tr>
<td>AUD/EUR</td>
<td>0.4492</td>
<td>0.3989</td>
<td>0.4338</td>
<td>1.0000</td>
<td>0.0261</td>
</tr>
<tr>
<td>CHF/EUR</td>
<td>0.0288</td>
<td>0.5322</td>
<td>0.2711</td>
<td>0.0261</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Next, we consider the hypothetical example of a bank that keeps its accounting transactions in EUR and the foreign currency positions in USD, JPY, GBP, AUD and CHF are each of 10,000 euro equivalent. In Table 3 there are shown the foreign exchange positions and the daily Potential Losses of the bank from the assumed example for a threshold of $z = 2.33$ corresponding to a probability of 99% in the standard normal distribution. Therefore, the Potential Losses are higher for the bank exposures in foreign currencies with higher volatility of the exchange rates against the base currency EUR.
Table 3: The foreign exchange positions and Potential Losses of the bank. Hypothetical example

<table>
<thead>
<tr>
<th>Currency „i“</th>
<th>Foreign exchange position (FP_i)</th>
<th>Daily Potential Loss (PL_i) in currency „i“ ((z=2.33)) Normal distribution</th>
<th>Daily Potential Loss (PL_i) in EUR ((z=2.33)) Normal distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD</td>
<td>13,791 USD</td>
<td>156 USD</td>
<td>113 EUR</td>
</tr>
<tr>
<td>JPY</td>
<td>1,449,275 JPY</td>
<td>29118 JPY</td>
<td>201 EUR</td>
</tr>
<tr>
<td>GBP</td>
<td>8,337 GBP</td>
<td>88 GBP</td>
<td>106 EUR</td>
</tr>
<tr>
<td>AUD</td>
<td>15,423 AUD</td>
<td>238 AUD</td>
<td>154 EUR</td>
</tr>
<tr>
<td>CHF</td>
<td>12,276 CHF</td>
<td>83 CHF</td>
<td>68 EUR</td>
</tr>
</tbody>
</table>

\[ FP_i = \frac{10,000}{S_{12/31/2013}} \]

Note:

Using the correlations coefficients from Table 2, the daily Potential Losses in EUR from the Table 3 and the relationship (2) we obtained the daily Potential Loss for the hypothetical five foreign exchange (USD, JPY, GBP, AUD, CHF) portfolio of the bank:

\[
\begin{pmatrix}
1.0000 & 0.4383 & 0.5213 & 0.4492 & 0.0288 \\
0.4383 & 1.0000 & 0.4714 & 0.3989 & 0.5322 \\
0.5213 & 0.4714 & 1.0000 & 0.4338 & 0.2711 \\
0.4492 & 0.3989 & 0.4338 & 1.0000 & 0.0261 \\
0.0288 & 0.5322 & 0.2711 & 0.0261 & 1.0000
\end{pmatrix}
\begin{pmatrix}
113 \\
201 \\
106 \\
154 \\
68
\end{pmatrix} = 11,765,199
\]

\[
PL_p = 3,430 \text{ EUR}, \text{ for one day.}
\]

As suggested by the Basle Committee on Banking Supervision, a bank may keep capital for unexpected losses from foreign exchange risk to a size equal to the Potential Loss of the portfolio of currencies for a period of 10 days. In our example, the Potential Loss of the foreign exchange portfolio that consists of five currencies, for a period of 10 days is 10,847 EUR:

\[
PL_p(10 \text{ days}) = 3,430 \times \sqrt{10} = 10,847 \text{ EUR}
\]

Another utility of the Potential Loss resulting from bank's exposure to certain foreign currencies is that this Potential Loss can be used as a threshold for stop the loss of the bank. Once attained the threshold will mean that the bank's foreign exposure should be reduced for the foreign currency in question, especially for those that their exchanges rates against the base currency in which the bank keeps the accounting have the highest daily average volatility.

3.0 CONCLUSIONS

The findings of this paper are multiple. First, we obtained a relationship for the Potential Loss of the bank's portfolio of foreign currencies by using the normal distribution assumption of the exchange rates daily variations; we also mentioned the methods of calculating the elements necessary for determining the Potential Loss of the bank. Second, using statistical daily data of
foreign exchange rates, we determined the Potential Loss of a bank that keeps the accounting in Euro for a bank portfolio consists of five the most commonly traded currencies in 2013 besides the euro (USD, JPY, GBP, AUD, CHF) in a hypothetical example on the bank's foreign exchange positions. Third, we mentioned two main purposes of determining the bank's Potential Loss due to foreign exchange risk: (i) setting up capital for unexpected losses from foreign exchange risk; (ii) stopping the bank’s loss coming from the manifestation of the foreign exchange risk.

REFERENCES


