Liquidity Risk & Maximum Cumulative Outflow

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1 Introduction

Liquidity risk refers to the current and prospective risk related to losses resulting from a bank's inability to meet its obligations in full as they fall due under all market conditions. This may be due to the bank's inability to liquidate assets or to obtain funding to meet its obligations. It could also be due to a market disruption or liquidity squeeze whereby the bank may only be able to unwind specific exposures at significantly discounted values. The core business of banks comprises of two main activities. On the one hand, banks borrow funds in the form of deposits which are withdrawable on demand. On the other hand, banks lend funds in the form of loans which are long-dated. Hence, there is a mismatch of maturities between the sources and uses of funds which exposes banks to liquidity risk. As such, it is imperative to properly manage liquidity risk by understanding the characteristics and risks of difference sources of liquidity both from the asset side and liability side of the balance sheet, and implementing appropriate and cost-effective strategies to meet liquidity needs.

One of the main tools used in measuring liquidity risk is the Maximum Cumulative Outflow (MCO) Report. This report is a liquidity gap schedule which measures current and future funding needs by comparing the amount of assets and liabilities maturing over specific time buckets. This paper focuses on the Maximum Cumulative Outflow report to analyze a bank's exposure to liquidity risk. First, a Maximum Cumulative Outflow Report is presented. Afterwards, the model used for slotting core deposits and volatile deposits in the report is presented.

2 Maximum Cumulative Outflow

The Maximum Cumulative Outflow (MCO) report is a liquidity gap report typically prepared every month to measure liquidity. It assumes normal market conditions and is supplemented with stress scenario analysis. The Maximum Cumulative Outflow report considers the expected cash flows from the bank's balance sheet items. The expected cash flows from assets are considered cash inflows while the expected cash flows from liabilities are considered cash outflows. Meanwhile, off-balance sheet items may be considered cash inflows or cash outflows based on whether they supply or use liquidity.

In creating the Maximum Cumulative Outflow, the assets, liabilities, and off-balance sheet items that generate cash flows for the bank are first identified and their expected cash flows are computed using their respective day count convention. Then, the cash flows are slotted in the appropriate time buckets based on their contractual maturity and certain assumptions (*e.g.* prepayment rates and pretermination rates). Balance sheet items with no contractual maturity are slotted under the "Non Maturing" time bucket. The liquidity gap for each time bucket i is then computed as

$$\text{Liquidity Gap}_i = \text{Cash Flow from Assets}_i - \text{Cash Flow from Liabilities}_i + \text{OBS}_i.$$

A positive liquidity gap indicates that the cash inflows exceed the cash outflows for the time bucket. This means that the bank has sufficient funds to meet its obligations maturing within the time bucket. On the other hand, a negative liquidity gap indicates

that the cash outflows exceed the cash inflows for the time bucket. This means that the bank has insufficient funds to meet its obligations maturing within the time bucket. It is recommended that the liquidity gap for the first three time bucket should be positive to ensure that the bank will be able to meet its short-term obligations.

Furthermore, analyzing the cumulative gap is also important to determine whether the total cash inflows until a time bucket exceeds the cash outflows. The cumulative liquidity gap for each time bucket i is computed as

$$\text{Cumulative Gap}_i = \sum_{j=1}^{i} \text{Liquidity Gap}_j,$$

where Liquidity Gap_j is the liquidity gap at the jth time bucket. If the cumulative liquidity gap at a particular time bucket is negative, then this indicates that the bank does not have sufficient sources of fund to meet its obligations. This is an indicator for the bank to find other ways to meet its liquidity needs. Moreover, the cumulative liquidity gap must also not exceed the gap limit set by the bank. Should this occur, the management must take this as a sign to change its current strategy to improve its liquidity.

2.1 Assumptions

In preparing the Maximum Cumulative Outflow (MCO) report, the following assumptions are used:

1. The time buckets and their corresponding midpoints are: 0 - 1 Month (15 days), 1 - 2 Months (46 days), 2 - 3 Months (76 days), 3 - 6 Months (136 days), 6 - 12 Months (271 days), 1 - 2 Years, 2 - 5 Years, and more than 5 Years.
2. There are no roll-overs, prepayments, and preterminations.
3. The respective day-count convention of the balance sheet items with coupon payment or amortization payment are used to calculate the length of the payment period and the expected cash flow.
4. The expected cash flows are slotted into time buckets based on their corresponding day count convention regardless of their actual maturity.
5. Cash and COCI is slotted on the first time bucket (0 – 1 Month), while the Due to BSP account is slotted under the "Non Maturing" bucket since it has no specific contractual maturity.
6. The core deposits and volatile deposits of the savings deposit are modelled using the delta-normal approach. An in-depth explanation is provided in Section 3.

2.2 Excel Implementation

The preparation of the Maximum Cumulative Outflow (MCO) report using Excel is shown in the following page.

2.2.1 Balance Sheet Items without Amortization

The balance sheet items AFS Non-Reserves (Fixed) [A], AFS Non-Reserves (Fixed rate) [B], Loans (Fixed) [C], Time Deposit (6 months) [F], and AFS Non-Reserves (Fixed) [G] are processed as follows. For illustration purposes, AFS Non-Reserves (Fixed rate) [B] is used.

Planning Account:	AFS Non-Reserves (Fixed rate)
Principal Amount:	225,000,000
Currency:	Php
Coupon Rate:	2.00%
Analysis Date (Today):	1/28/2014
End Date:	3/22/2018
Day Count Convention:	Actual/360
Coupon Frequency:	3 months
Payment Timing:	In Arrears
Coupon	Constant Coupon
Amortization Type:	No Amortization

Figure 1: AFS Non-Reserves (Fixed rate) [B]

First, the coupon frequency and end date are determined to obtain the coupon dates. Afterwards, the day count convention is determined to obtain the coupon period (in years). Then, the coupon payment for the ith coupon date is calculated as

$$\text{Coupon}_i = \text{Principal Amount} \times \text{Coupon Rate} \times (t_i - t_{i-1}),$$

where $(t_i - t_{i-1})$ is the coupon period following the day count convention. Additionally, the principal amount is added to coupon payment at the last coupon date (end date). Finally, the time between the reporting date and the coupon dates are calculated which are used to determine the corresponding time buckets. The table below shows the summary of the calculations for AFS Non-Reserves (Fixed rate) [B].

Coupon Date	Coupon Period	Coupon Payment	Time from Today	Approporiate TB
12/22/2013				
3/22/2014	0.2500	1,125,000.00	0.14722	1 - 2 Mos.
6/22/2014	0.2556	1,150,000.00	0.40278	3 - 6 Mos.
9/22/2014	0.2556	1,150,000.00	0.65833	6 - 12 Mos.
12/22/2014	0.2528	1,137,500.00	0.91111	6 - 12 Mos.
3/22/2015	0.2500	1,125,000.00	1.16111	1 - 2 Yrs.
6/22/2015	0.2556	1,150,000.00	1.41667	1 - 2 Yrs.
9/22/2015	0.2556	1,150,000.00	1.67222	1 - 2 Yrs.
12/22/2015	0.2528	1,137,500.00	1.92500	1 - 2 Yrs.
3/22/2016	0.2528	1,137,500.00	2.17778	2 - 5 Yrs.
6/22/2016	0.2556	1,150,000.00	2.43333	2 - 5 Yrs.
9/22/2016	0.2556	1,150,000.00	2.68889	2 - 5 Yrs.
12/22/2016	0.2528	1,137,500.00	2.94167	2 - 5 Yrs.
3/22/2017	0.2500	1,125,000.00	3.19167	2 - 5 Yrs.
6/22/2017	0.2556	1,150,000.00	3.44722	2 - 5 Yrs.
9/22/2017	0.2556	1,150,000.00	3.70278	2 - 5 Yrs.
12/22/2017	0.2528	1,137,500.00	3.95556	2 - 5 Yrs.
3/22/2018	0.2500	226,125,000.00	4.20556	2 - 5 Yrs.

Figure 2: Summary of Coupon Payment for AFS Non-Reserves (Fixed rate) [B]

2.2.2 Balance Sheet Items with Amortization

The balance sheet items Loans (Fixed) [D] and Loans (Fixed) [E] are processed as follows. For illustration purposes, Loans (Fixed) [E] is used.

Planning Account:	Loans (Fixed)
Principal Amount:	2,457,000
Currency:	Php
Coupon Rate:	4.750%
Analysis Date (Today):	1/28/2014
End Date:	11/6/2014
Day Count Convention:	Actual / 365
Coupon Frequency:	monthly
Payment Timing:	In Arrears
Coupon	Constant Coupon
Amortization Type:	Fixed Annuity
Amortization Frequency	monthly

Figure 3: Loans (Fixed) [E]

The periodic loan payments are calculated using an amortization table. First, the amortization frequency and end date are determined to obtain the payment dates. Afterwards, the day count convention is determined to obtain the coupon period (in years). Then, the amortization type is also determined to obtain the appropriate principal payment schedule. With this, the coupon payment for the ith coupon date is calculated as

$$\text{Coupon}_i = \text{Remaining Principal}_i \times \text{Coupon Rate} \times (t_i - t_{i-1}),$$

where $(t_i - t_{i-1})$ is the coupon period following the day count convention and

$$\text{Remaining Principal}_i = \text{Remaining Principal}_{i-1} - \text{Principal Payment}_{i-1},$$

where $\text{Principal Payment}_{i-1}$ follows the principal payment schedule determined by the amortization type. Finally, the time between reporting date and the coupon dates are calculated which are used to determine the corresponding time buckets. The table below shows the amortization table for Loans (Fixed) [E].

Payment Date	Principal Payment	Coupon Payment	Total Payment	Remaining Principal	Time from Today	Appropriate TB
1/6/2014				2,457,000.00		
2/6/2014	241,152.53	9,912.14	251,064.68	2,215,847.47	0.0247	< 1 Mo.
3/6/2014	242,990.49	8,074.18	251,064.68	1,972,856.98	0.1014	1 - 2 Mos.
4/7/2014	242,848.94	8,215.73	251,064.68	1,730,008.03	0.1890	2 - 3 Mos.
5/6/2014	244,535.67	6,529.00	251,064.68	1,485,472.36	0.2685	3 - 6 Mos.
6/6/2014	245,071.91	5,992.76	251,064.68	1,240,400.45	0.3534	3 - 6 Mos.
7/7/2014	246,060.59	5,004.08	251,064.68	994,339.85	0.4384	3 - 6 Mos.
8/6/2014	247,182.66	3,882.01	251,064.68	747,157.19	0.5205	6 - 12 Mos.
9/8/2014	247,855.99	3,208.68	251,064.68	499,301.19	0.6110	6 - 12 Mos.
10/6/2014	249,245.30	1,819.37	251,064.68	250,055.89	0.6877	6 - 12 Mos.
11/6/2014	250,055.89	1,008.79	251,064.68	0.00	0.7726	6 - 12 Mos.

Figure 4: Amortization Table for Loans (Fixed) [E]

Finally, the expected cash flows from the balance sheet items as well as the core deposits and volatile deposits (Section 3) are slotted into the appropriate time buckets in the Liquidity Gap Report. The liquidity gap and the cumulative gap are also calculated following the formula stated previously. A check was also made to determine whether the gap exceeded the limit set by the bank. Figure 8 shows the Maximum Cumulative Outflow (MCO) report.

3 Core Deposit and Volatile Deposit

As previously stated, one of the core activities of banks is borrowing funds. In fact, a significant source of funds is from deposit accounts, which can be classified into demand deposits (CA), savings deposits (SA), and time deposits (TD). Demand deposits and savings deposits (CASA deposits) can be withdrawn by clients at any time. Thus, it is important for banks to estimate its core deposit and volatile deposit. Core deposit is the portion of savings deposit that is expected to remain in the bank's balance sheet for a longer period; therefore, it is distributed across longer time buckets (*i.e.* time buckets beyond 1 year). On the other hand, volatile deposit is the portion of savings deposit that is expected to be withdrawn in the near future; hence, it is distributed across shorter time buckets (*i.e.* time buckets less than or equal to 1 year).

The following notations are used to estimate a bank's core deposit and volatile deposit. Let K denoted the deposit level at the end of 12 months from report date (or the date today). The value of K is unknown today and thus considered as a random variable. If D_0 is the current deposit level (and assuming for simplicity that there are no additional deposits during the next 12 months), then the volatile deposit or the amount withdrawn during the next 12 months is (D_0–K). The percentage of amount withdrawn with respect to the current deposit level is then

$$\frac{D_0 - K}{D_0}.$$

Let R be a random variable corresponding to the one-year continuously compounded return, which is given by

$$R = \ln\left(\frac{K}{D_0}\right).$$

Then, using Taylor series expansion, the deposit level at the end of 12 months K can be approximated as

$$K = D_0\, e^R \approx D_0\,(1 + R)\,.$$

Consequently,

$$\frac{D_0 - K}{D_0} \approx -R.$$

Thus, the negative of the annual return $-R$ corresponds to the volatile portion (in percentage) of the deposit over the next 12 months. Hence, the maximum amount of volatile deposit at 99% confidence level can be estimated using the delta-normal approach.

Consider the historical data of daily deposit balances. Let D_i be the deposit balance i banking days ago, where $i = 1, 2, \ldots, N$ and D_0 be the deposit balance today. Then, assuming 260 banking days in a year, the one-year continuously compounded return is

$$R_i = \ln\left(\frac{D_i}{D_{i+260}}\right), \qquad i = 0, 1, 2, \ldots, N - 260.$$

Suppose that the standard deviation of $\{R_i\}$ is s. Assuming that R is normally distributed with mean 0 and standard deviation s, then the maximum amount of volatile deposit at 99% confidence level, denoted by Y, is

$$\mathbb{P}\left(D_0 - K \leq Y\right) = 0.99.$$

Then,

$$\begin{aligned}
\mathbb{P}\left(\frac{D_0 - K}{D_0} \leq \frac{Y}{D_0}\right) &= 0.99 \\
\mathbb{P}\left(-R \leq \frac{Y}{D_0}\right) &= 0.99 \\
\mathbb{P}\left(\frac{R}{s} \geq \frac{-Y}{D_0 s}\right) &= 0.99 \\
\mathbb{P}\left(\frac{R}{s} \leq \frac{-Y}{D_0 s}\right) &= 0.01.
\end{aligned}$$

Since $\dfrac{R}{s}$ has a standard normal distribution, if $F(\cdot)$ is the cumulative distribution function (cdf) of the standard normal distribution, then

$$\begin{aligned}
F\left(\frac{-Y}{D_0 s}\right) &= 0.01 \\
\frac{-Y}{D_0 s} &= F^{-1}(0.01) \\
Y &= D_0 s \cdot \left|F^{-1}(0.01)\right| \\
Y &\approx (2.326 \cdot s) \cdot D_0.
\end{aligned}$$

Hence, the maximum amount of volatile deposit at 99% confidence level is approximately $(2.326 \cdot s) \cdot D_0$ or $(2.326 \cdot s)$ when expressed as a percentage of the current deposit level. It also follows that the core deposit amount is $(1 - 2.326 \cdot s) \cdot D_0$ or $(1 - 2.326 \cdot s)$ when expressed as a percentage of the current deposit level.

One simple assumption on the slotting of deposits in the Maximum Cumulative Outflow (MCO) report is to distribute the volatile deposit in time buckets less than or equal to one year and to distribute the core deposits in the time buckets greater than one year. For each time bucket less than or equal to one year, the amount entered is

$$\frac{\text{volatile deposit}}{n} \cdot t,$$

where t is the number of days in the given time bucket and n is the total number of days in the time buckets less than or equal to one year. On the other hand, the core deposit is evenly distributed among the time buckets greater than one year. For each time bucket greater than one year, the amount entered is

$$\frac{\text{core deposit}}{m},$$

where m is the number of time buckets beyond one year.

3.1 Assumptions

In determining the core and volatile portions of the savings deposit, the following assumptions are used.

1. The time buckets and their corresponding midpoints are: 0 - 1 Month (15 days), 1 - 2 Months (46 days), 2 - 3 Months (76 days), 3 - 6 Months (136 days), 6 - 12 Months (271 days), 1 - 2 Years, 2 - 5 Years, and more than 5 Years.

2. There are 260 banking days in one year. This is used to approximate the one-year continuously compounded returns R_i.

3.2 Excel Implementation

The calculation of the core deposit and volatile deposit using Excel is shown below.

1. First, the historical data of daily deposit balances are sorted and the one-year continuously compounded return R_i is computed as $\ln\left(\frac{D_i}{D_{i+260}}\right)$, assuming there are 260 banking days in one year.

Date	Savings	R_i
1/28/2014	692,965,896.54	0.2059
1/27/2014	697,190,831.54	0.2396
1/24/2014	695,820,638.54	0.2327
1/23/2014	696,445,658.54	0.2132
1/22/2014	686,229,738.54	0.1943
1/21/2014	694,664,571.54	0.2060
1/20/2014	700,444,076.12	0.2297
1/17/2014	691,218,596.12	0.2075
1/16/2014	692,042,925.12	0.2093
1/15/2014	683,616,848.12	0.1866
1/14/2014	685,426,040.12	0.1867
1/13/2014	688,677,750.12	0.2083
1/10/2014	689,447,255.12	0.1969
1/9/2014	697,741,035.12	0.2197
1/8/2014	691,378,712.12	0.2099
1/7/2014	696,127,115.12	0.2115
1/6/2014	696,348,412.90	0.2255
1/3/2014	700,136,801.90	0.2283
1/2/2014	701,644,659.90	0.2276

Figure 5: Daily Deposit Balances and One-Year Continuously Compounded Return

2. Afterwards, the standard deviation of the one-year continuously compounded return $\{R_i\}$ is computed as s. The current deposit balance today is also determined. Using these, the amount of volatile deposit and core deposit are calculated using the formula previously stated.

Date Today	1/28/2014
Deposit Level Today	692,965,896.54
Banking Days in a Year	260
Standard Deviation	0.0784
NORMSINV(0.99)	2.3263
Volatile Deposit	126,359,901.12
Core Deposit	566,605,995.42

Figure 6: Core Deposit and Volatile Deposit Using The Delta Normal Approach

3. Finally, the amount of volatile deposit and core deposit are slotted into the respective time buckets using the assumption made previously (*i.e.*, volatile deposits are slotted in time buckets less than or equal to one year and core deposits are slotted in time buckets greater than one year).

Start Date	TB	No. Days in TB	Total Amount	Type of Deposit
1/28/2014	< 1 Mo.	31	10,673,452.14	
2/28/2014	1 - 2 Mos.	30	10,329,147.23	
3/30/2014	2 - 3 Mos.	31	10,673,452.14	Volatile Deposit
4/30/2014	3 - 6 Mos.	91	31,331,746.60	
7/30/2014	6 - 12 Mos.	184	63,352,103.02	
1/30/2015	1 - 2 Yrs.	-	188,868,665.14	
1/30/2016	2 - 5 Yrs.	-	188,868,665.14	Core Deposit
1/30/2019	> 5 Yrs.	-	188,868,665.14	

Figure 7: Slotting of Deposit Cash Flows

4 Results and Discussion

The Maximum Cumulative Outflow (MCO) report, presented in Figure 8, shows a negative Liquidity Gap for the time buckets 2 - 3 Months, 6 - 12 Months, and 1 - 2 Years. This indicates that the expected cash outflows of the bank will exceed its expected cash inflows in these particular time buckets. Hence, it is recommended for the bank to set aside cash inflows from the previous time buckets as reserves or secure sufficient funding to meet its financial obligations during these time buckets. It is also worth noting that the bank has a negative Liquidity Gap at the 2 - 3 Months time bucket, suggesting a potential problem meeting its short-term obligations. However, the Cumulative Liquidity Gap for all time buckets are positive, indicating that the cumulative cash inflows are sufficient to cover the cumulative cash outflows. In other words, the bank has sufficient funds from the previous months to meet their liquidity needs even for the time buckets with a negative Liquidity Gap. Finally, the Cumulative Liquidity Gap does not exceed the imposed Gap Limits for all time buckets. Nevertheless, the positive Liquidity Gap could also indicate an inefficient use of funds.

5 Appendix

LIQUIDITY GAP REPORT	Amount (in PHP)								
TIME BUCKET	< 1 Mo.	1 - 2 Mos.	2 - 3 Mos.	3 - 6 Mos.	6 - 12 Mos.	1 - 2 Yrs.	2 - 5 Yrs.	> 5 Yrs.	Non Maturing
Beginning Dates	*1/28/2014*	*2/28/2014*	*3/30/2014*	*4/30/2014*	*7/30/2014*	*1/30/2015*	*1/30/2016*	*1/30/2019*	
Midpoint	*15*	*46*	*76*	*136*	*271*				
Assets									
Cash and COCI	15,953,597	-	-	-	-	-	-	-	-
AFS Non-Reserves (Fixed)	-	1,125,000	-	305,806,333	2,287,500	19,770,833	280,929,167	330,458,333	-
Loans (Fixed, No Amortization)	10,031,431	-	-	-	-	-	-	-	-
Loans (Fixed, With Fixed Amortization Payments)	14,697	14,411	14,480	42,694	82,598	78,697	-	-	-
Loans (Fixed, With Fixed Annuity)	251,065	251,065	251,065	753,194	1,004,259	-	-	-	-
Due from BSP-SDA	15,500,000	-	-	-	-	-	-	-	-
Total Cash Inflow	41,750,789	1,390,475	265,545	306,602,221	3,374,356	19,849,530	280,929,167	330,458,333	-
Liabilities									
Time Deposit	-	-	-	96,776,083	-	-	-	-	-
Savings Deposit	10,673,452	10,329,147	10,673,452	31,331,747	63,352,103	188,868,665	188,868,665	188,868,665	-
Due to BSP	-	-	-	-	-	-	-	-	13,231,770
Total Cash Outflow	10,673,452	10,329,147	10,673,452	128,107,830	63,352,103	188,868,665	188,868,665	188,868,665	13,231,770
On Book Gap	31,077,337	(8,938,672)	(10,407,907)	178,494,392	(59,977,747)	(169,019,135)	92,060,502	141,589,668	(13,231,770)
Off-Balance Sheet Items									
Derivative	1,000,000	22,000,000	(3,000,000)	15,000,000	10,000,000	-	-	-	-
Liquidity Gap	32,077,337	13,061,328	(13,407,907)	193,494,392	(49,977,747)	(169,019,135)	92,060,502	141,589,668	(13,231,770)
Cumulative Liquidity Gap	32,077,337	45,138,665	31,730,758	225,225,149	175,247,403	6,228,268	98,288,769	239,878,437	
Gap Limit	(20,000,000.00)	(20,000,000.00)	(30,000,000.00)	(100,000,000.00)	(100,000,000.00)	(200,000,000.00)	(200,000,000.00)	(200,000,000.00)	
Gap Exceeded?	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	

Figure 8: Maximum Cumulative Outflow (MCO) Report