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Abstract.

In this article, on the basis of the "cash flow at risk" approach, the system of the integrated (credit, market, operational and liquidity risks) risk management in a market-maker commercial bank is developed. This system guarantees reaching profitability, liquidity and coverage of banking risks and thus allows the fullest protection of the interests of depositors, creditors and shareholders of the bank providing its sustainable development.

Key words: integrated risk management, cash flow at risk, economical capital, pricing, interest rate, spread, credit risk, market risk, operational risk, liquidity risk

JEL Classifications: G21, G12, D01

1. INTRODUCTION

The world financial crisis of 2007-2008 revealed serious drawbacks in the modern risk management in banks, particularly, in liquidity risk management. Just that low efficiency of the liquidity risk management is accepted as one of the main causes of the latest crisis. This situation can be explained by the fact that liquidity risk is usually managed independently from the credit, market and operational risks. Such management is performed on the basis of fundamentally different approaches compared to those applied to manage other risks. So, at this moment, the risk management that integrates credit, market and operational risks, as well as liquidity risk, does not exist.

There are two ways to integrate liquidity risk with other types of risk. The first way is based on the "economic capital" approach which is widely used in banking practice (see Lobanov, Chugunov (2003), Guill (2007), Brunnermeier and others (2009)). The second one is built on the "cash flow at risk" approach which is more common in corporations (see Loebnitz (2011), Wiedemann and others, Yan and others (2011)). Note that the "cash flow at risk" approach is much broader than the “economic capital” one. Since the insolvency risk is related only to unexpected losses. On the contrary, the "cash flow risk" approach takes into account both potential losses and negative changes in operational, investing and financial activities. However, the problem of development of integrated risk management in a commercial bank on the basis of the "cash flow at risk" approach is still unsolved.

This article is dedicated to development of the integrated risk management on the base of the "cash flow at risk" approach in the commercial market-maker bank, i.e. the bank setting interest rates in the market.

2. "CASH FLOW AT RISK" APPROACH IN PRICING

In order to protect interests of depositors, creditors and shareholders, it is necessary to provide the following conditions:

- the bank produces cash income, thus securing itself from formation of financial pyramid;

- the bank generates cash income not less than the guaranteed (planned) value, providing guaranteed return on equity (ROE);
- the bank is liquid, which enables well-timed and complete fulfillment of its liabilities;
- the bank`s risks are covered, which ensures the principle of banking at its own risk.

Sequentially consider the satisfaction of all the defined conditions. At the beginning examine the "cash flow at risk" approach.

2.1. *"Cash flow at risk" approach*

Assume that some financial instrument generates cash flows in accordance with contractual maturity dates:

$$B_t^{cont} = \sum_k CF_k^{cont}, \tag{1}$$

where B_t^{cont} – the contractual balance at the time *t*,

CF_k^{cont} – the contractual cash flow, paid in accordance with the contractual maturity date *k*.

However, the predicted (behavioral) cash flows may differ from contractual ones as a result of risks caused by changes in macroeconomic and market situation, customer behavior etc:

$$B_t^{pred} = \sum_k CF_k^{pred}, \tag{2}$$

where B_t^{pred} – the predicted (behavioral) balance at the time *t*,

CF_k^{pred} – the predicted (behavioral) cash flow that is expected to be paid at the time *k*.

Cash flow at risk is the difference between the contractual cash flow and predicted (behavioral) cash flow generated by the financial instrument at the time *k* (see Guill (2007)):

$$cfar_k = CF_k^{cont} - CF_k^{pred}, \tag{3}$$

Cash flow at risk is determined by statistical methods with the selected confidence level. In response to (1) and (3) expressions, rewrite the expression (2) as:

$$B_t^{pred} = \sum_k \left(CF_k^{cont} - cfar_k\right) = B_t^{cont} - CFaR\ , \qquad (4)$$

where $CFaR = \sum_k cfar_k$ – cumulative cash flow at risk.

The "cash flow at risk" approach allows pricing of a financial instrument or banking product.

2.2. *Pricing assets and liabilities of the bank*

Usually, the contractual interest rate R on banking products is based on spreads s, added to or subtracted from some reference interest rate r, for example, risk-free interest rate (see Sinkey (1998), Lobanov and Chugunov (2003)). In this article, special and general spreads are distinguished.

As reference interest rates use the guaranteed interest rate on assets r_A and liabilities r_L. The guaranteed interest rates on assets and liabilities are such rates at which bank accordingly receives interest income on assets and pays interest expense on liabilities taking into account realized risks.

Assume interest rates R_A, r_A on assets, interest rates R_L, r_L on liabilities and special spreads s_A, s_L are positive and measured in annual percents. The spreads s_A, s_L are used for calculation of the contractual interest rates on assets and liabilities R_A, R_L:

$$R_A = r_A + s_A\,, R_L = r_L - s_L\,, \qquad (5)$$

where R_A, R_L, – the contractual interest rates on assets and liabilities accordingly.

From this approach it follows that yield curves for assets and liabilities may have different shapes. For instance, the yield curve for assets may be upward (normal), while the yield curve for liabilities is downward (inverse).

Special spreads for each type of risk are determined by the following condition. Extra interest income on assets or economy in interest expense on liabilities, which are generated by spreads, covers corresponding cash flow losses, i.e. cash flows at the corresponding risk. Note that not all types of risk can be covered with special spreads. Other types of risk can be covered with general spreads.

Illustrate this principle by the example of calculation of credit and deposit special spreads.

2.3. *Credit spread evaluation based on the "cash flow at risk" approach*

Difference between predicted (behavioral) cash flow for loans and contractual cash flow is equal to cash flow at credit risk (see formula (3)).

Write down the equation for coverage of possible losses or reduction of cash flows caused by credit risk with extra income from special spread for the *entire duration of the credit agreement*:

$$\underbrace{\tilde{A}^{pred} \cdot (r_A + s_A) \cdot T}_{(I)} = \underbrace{\tilde{A}^{cont} \cdot r_A \cdot T}_{(II)} + \underbrace{CFaR}_{(III)}, \qquad (6)$$

where *CFaR* – the cumulative cash flow at credit risk;

T – the term of the credit agreement;

$\tilde{A}^{cont}, \tilde{A}^{pred}$ – the average contractual and predicted (behavioral) balances accordingly;

r_A, s_A – the guaranteed interest rate and special spread for credit risk.

Note: hereinafter there would be no capitalization of interests.

The term (I) in the left side of the equation (6) shows predicted income taking into account reduction of the working loans due to credit risk. The term (II) in the right side of the equation (6) sets guaranteed (planned) income which bank intends to obtain during the life of the contract (excluding credit risk), term (III) – cumulative losses or shortage of cash flows caused by credit risk.

It follows from equation (6) that credit spread amounts to:

$$s_A = \frac{\left(\tilde{A}^{cont} - \tilde{A}^{pred}\right) \cdot r_A \cdot T + CFaR}{\tilde{A}^{pred} \cdot T}, \qquad (7)$$

This credit spread will bring the bank an extra income covering possible losses or reduction of cash flows over the loan life. So the bank will receive (not accrue) the *guaranteed* interest income generated by the guaranteed interest rate r_A.

2.4. *Valuation of deposit (rollover) spread*

Special deposit (rollover) spread can be calculated from the condition that economy in interest expense generated by this spread should cover possible cash outflows caused by depositors' refusals to roll over their matured deposits (see Voloshyn (2011)). Write the equation for the special deposit spread:

$$\underbrace{\tilde{L}^{pred} \cdot (r_L - s_L) \cdot T}_{(I)} = \underbrace{\tilde{L}^{cont} \cdot r_L \cdot T}_{(II)} - \underbrace{CFaR}_{(III)}, \quad (8)$$

where *CFaR* – the cumulative cash flow at deposit (rollover) risk, or possible cumulative cash outflows;

T – the chosen time period during which depositors can roll over their deposits;

$\tilde{L}^{cont}, \tilde{L}^{pred}$ – the average contractual and predicted (behavioral) balances of deposits;

r_L, s_L – the guaranteed interest rate and special spread for deposit risk.

The term (I) in the left side of the equation (8) shows the predicted interest expense of the bank taking into account decrease of deposits balances due to rollover risk. The term (II) in the right side of the equation (8) indicates interest expense which bank plans to pay to depositors during the given time period *T* in accordance with contractual terms, the term (III) – the cumulative possible cash outflows caused by deposit (rollover) risk, or the cumulative cash flow at risk.

From the equation (8) find the formula for the liquidity spread:

$$s_L = \frac{\left(\tilde{L}^{pred} - \tilde{L}^{cont}\right) \cdot r_L \cdot T + CFaR}{\tilde{L}^{pred} \cdot T}, \quad (9)$$

Additionally, set the conditions for evaluation of special spreads which cover certain other risks.

2.5. *Some types of special spreads*

Assets liquidity spreads (by the example of loans)

1. **Prepayment spread** brings extra income which covers possible losses of interest income caused by prepayment risk during the loan life.

2. **Renewal spread** brings extra income which covers possible losses of interest income caused by renewal risk: when borrowers refuse to renew the matured loans.
3. **Drawdown spread** brings extra income which covers possible cash outflows caused by drawdown risk: when borrowers decide to draw on their credit lines, overdrafts etc.

Liabilities liquidity spreads (by the example of deposits)

4. **Early withdrawal spread** brings economy in interest expense which covers cumulative possible cash outflows due to early withdrawal risk that is reduced on financial penalties for early withdrawal.
5. **Withdrawal spread** brings economy in interest expense which covers cumulative possible run-off from non-maturity accounts (checking, savings, NOW, current accounts etc.).

Cross-currency risk of cash flows

6. **Cross-currency risk spread** (for assets and liabilities nominated in national currency) brings extra interest income which covers possible cash flows reduction in comparison to foreign currencies due to devaluation of national currency.

The given list of the special spreads is not exhaustive and may change with time. The importance and priority of the special spreads depend on the current macroeconomic and market situation, and are determined by the bank. For example, if the bank has essential renewal risk for its credit lines, then it introduces additional special spread to cover this type of risk.

On the basis of the proposed methodology consider the statement of predicted cash flows of the bank.

2.6. S*tatement of predicted cash flows*

The statement of predicted cash flows enables to evaluate both net cash generated from operating activities, i.e. received cash income, and liquidity (see IAS #7 "Statement of Cash Flows").

Consider the simplified statement of the predicted (over one year) cash flows of the bank, which conducts only loan and deposit operations and has operating costs. Assume the bank is exposed only to credit and rollover risks. Let maturity term of loans is equal to one year (T = 1 year), and the maturity term of deposits is equal to one month. That is, one year loans are funded with one month deposits that expose the bank to rollover risk. Suppose there is no correlation between credit and rollover risks.

The formulae represented in Table 1 are intended to calculate items of statement of predicted cash flows. Using the expressions (4, 7 and 9), after simple algebraic transformations, rewrite these formulae for an equivalent statement of predicted cash flows, given in Table 2.

The formulae in Table 1 use predicted (behavioral) balances taking into account risks. And the formulae in Table 2 utilize planned contractual balances neglecting risks. For that reason, the statement in Table 2 is much more convenient to deal with.

Thereby, the proposed risk-adjusted pricing allows substantial simplification of the predicted cash flows statement and working merely with planned contractual balances.

Extra income from special spreads compensates credit and rollover risks. These spreads ensure receipt and payment of interests on guaranteed interest rates. In other words, the bank exactly knows the guaranteed cash income that it will obtain. It also protects the bank from formation of financial pyramid.

Positive value of cash at the end of the year assures bank`s *liquidity*.

Table 1. Statement of predicted cash flows for the year ended 31 December 201X

Order #	Items	The formulae for calculations
	Cash flows from operating activities	
1	Interest received	$\tilde{A}^{pred} \cdot (r_A + s_A) \cdot T$
2	Interest paid	$\tilde{L}^{pred} \cdot (r_L - s_L) \cdot T$
3	Operating costs	oc
4	Net cash income generated from operating activities before changes in operating loans and deposits	$\tilde{A}^{pred} \cdot (r_A + s_A) \cdot T - - \tilde{L}^{pred} \cdot (r_L - s_L) \cdot T - oc$
	Changes in operating loans and deposits	
5	Net (increase) / decrease in operating loans	ΔA^{pred}
6	Net increase / (decrease) in operating deposits	ΔL^{pred}
7	Net cash used in operating activities	$-\Delta A^{pred} + \Delta L^{pred}$
8	Net decrease in cash taking into account the formulae (4, 7, and 9) or periodical (yearly) liquidity gap	$gap = \tilde{A}^{cont} \cdot r_A \cdot T - \tilde{L}^{cont} \cdot r_L \cdot T - - oc - \Delta A^{cont} + \Delta L^{cont}$
9	Cash at the beginning of the year	$Cash_{t-1}$
10	**Cash at the end of the year**	$Cash_t = Cash_{t-1} + gap$

Table 2. Equivalent statement of predicted cash flows for the year ended 31 December 201X

Order #	Items	The formulae for calculations
	Cash flows from operating activities	
1	Interest received	$\tilde{A}^{cont} \cdot r_A \cdot T$
2	Interest paid	$\tilde{L}^{cont} \cdot r_L \cdot T$
3	Operating costs	oc
4	Net cash income generated from operating activities before changes in operating loans and deposits	$Prof_{rf} = \tilde{A}^{cont} \cdot r_A \cdot T - \tilde{L}^{cont} \cdot r_L \cdot T - oc$
	Changes in operating loans and deposits	
5	Net (increase) / decrease in operating loans	ΔA^{cont}
6	Net increase / (decrease) in operating deposits	ΔL^{cont}
7	Net cash used in operating activities	$-\Delta A^{cont} + \Delta L^{cont}$
8	Net decrease in cash taking into account the formulae (4, 7, and 9) or periodical (yearly) liquidity gap	$gap = \tilde{A}^{cont} \cdot r_A \cdot T - \tilde{L}^{cont} \cdot r_L \cdot T - oc - -\Delta A^{cont} + \Delta L^{cont}$
9	Cash at the beginning of the year	$Cash_{t-1}$
10	**Cash at the end of the year**	$Cash_t = Cash_{t-1} + gap$

Currently, guaranteed interest rates on assets and liabilities continue to be undetermined. The guaranteed interest rate on assets r_A is defined as a sum of the guaranteed interest rate r_L on liabilities and positive general spread s_G:

$$r_A = r_L + s_G \,. \tag{10}$$

And the guaranteed interest rate r_L for the liabilities is being set (not calculated). This is the interest rate on such bank`s liabilities which is free from early withdrawal risk and has the longest maturity term that exceeds management or forecasting horizon.

Consider evaluating of the general spread s_G.

2.7. *Types of general spread*

Conventionally distinguish two components of general spread: operating costs spread s_{OC} and common risks spread s_{risk}. Then the general spread equals:

$$s_G = s_{oc} + s_{risk} . \tag{11}$$

Operating costs spread s_{OC} brings the bank extra interest income which covers operating costs and ensures guaranteed (planned) return on equity (ROE).

The operating costs spread s_{OC} is calculated from the formula for net cash income (Table 2, line 4) taking into account formula (10):

$$\left(\tilde{A}^{cont} \cdot \left(r_L + s_{oc}\right) - \tilde{L}^{cont} \cdot r_L\right) \cdot T - oc = ROE_{rf} \cdot E . \tag{12}$$

where T – the management horizon (T=1 year);

oc – the annual operating costs;

E – the bank`s capital;

ROE_{rf} – the risk-free guaranteed (planned) return on equity, % per annum.

From the formula (12) the operating costs spread s_{OC} is defined:

$$s_{oc} = \frac{ROE_{rf} \cdot E + oc + \left(\tilde{L}^{cont} - \tilde{A}^{cont}\right) \cdot r_L \cdot T}{\tilde{A}^{cont} \cdot T} . \tag{13}$$

Common risks spread s_{risk} brings extra interest income which covers such risks as currency risk of banking and trading books, market risk of trading portfolio and operational risk (i.e. common risks).

The common risks spread s_{risk} is determined by the following condition. The extra interest income, generated by this spread, over a certain period (for instance, T = 1 year) covers possible losses from common (currency, market and operational) risks:

$$s_{risk} \geq \frac{Losses}{\tilde{A}^{cont} \cdot T} , \tag{14}$$

where *Losses* – possible losses from revaluation of the open currency position of the banking book, the revaluation of assets traded in the market, and operational risk.

Note that interest rate risk cannot be compensated by an appropriate spread. This risk is managed using interest rate derivatives and approaches: "cash flow matching" and "immunization" (see Sharpe and others (1999), Lobanov and Chugunov (2003)).

Moreover, note that the bank, in addition to net interest income, also receives net commissions and net trading income. These types of incomes are easily taken into account in the equation (12).

Predicted net cash income which the bank plans to receive over a certain period of time can be called the guaranteed or risk-free income:

$$Prof_{rf} = \left(\tilde{A}^{cont} \cdot r_A - \tilde{L}^{cont} \cdot r_L\right) \cdot T - oc - Losses - CNII \geq ROE_{rf} \cdot E \, , \tag{15}$$

where *CNII* – change in net interest income as a result of fluctuations in interest rates on assets and liabilities, which is estimated, for example, according to the scenario of parallel shift of the yield curve (at ± 200 bp) or more complex scenarios.

2.8. *Numerical example*

Return to the consideration of the bank that conducts only credit and deposit operations, described in part 2.6 (Statement of predicted cash flows). Possible changes in net interest income due to fluctuations in interest rates are neglected.

Examine the algorithm of spreads calculation.

1. Choose the management (prediction) horizon, for example, one year.
2. Set the planned contractual loans and deposits balances, the amount of capital.
3. Set the operating costs, losses from common risks and the guaranteed (planed) return on equity (ROE).
4. Determine the guaranteed interest rate on deposits – the deposit interest rate for the longest maturity term. In the example below, it equals 15% per annum (Table 3).

5. Calculate the operating costs spread by the formula (13).
6. Determine the common risks spread by the formula (14).
7. Calculate the guaranteed interest rate on loans by the formula (10).
8. Determine the special credit spread by the formula (7).
9. Calculate the special deposit spread by the formula (9).
10. Determine contractual interest rates on loans and deposits by the formula (5).

An illustrative example of interest rates calculation by the proposed algorithm is presented in Tables 3-5.

Table 3. Calculation of the general spreads and the guaranteed interest rates on loans and deposits

Indices	Values
Guaranteed return on equity (ROE)	12.0%
Capital, $ millions	150
Operating costs, $ millions per annum	5
Guaranteed interest rate on deposits	**15.0%**
Average loans balance, $ millions	900
Average deposit balance, $ millions	1000
Management horizon, years	1
Operating costs spread	**4.2%**
Common risks losses, $ millions	10
Common risks spread	**1.2%**
Guaranteed interest rate on loans	**20.4%**

Table 4. Calculation of the special credit spread and the contractual interest rate on loans

Loan indices	**Values**		
	At the beginning of the year	At the end of the year	Mean
Planned balance, $ millions	800	1000	900
Predicted balance with cash flow losses, $ millions	800	980	890
Cash flow at risk, $ millions		20	
Maturity term, years		1	
Guaranteed interest rate on loans		20.4%	
Special credit spread		2.5%	
Contractual interest rate on loans		**22.9%**	

Table 5. Calculation of the special deposit spread and the contractual interest rate on deposits

Deposit indices	**Values**		
	At the beginning of the year	At the end of the year	Mean
Planned balance, $ millions	900	1100	1000
Predicted balance with cash flow losses, $ millions	900	1070	985
Cash flow at risk, $ millions		30	
Management horizon, years		1	
Guaranteed interest rate on deposits		15.0%	
Special deposit spread		2.8%	
Contractual interest rate on deposits		**12.2%**	

Thus the point values of contractual interest rates have been got.

If the year management horizon will be subdivided into several periods (quarterly or monthly) then yield curves for assets and liabilities will be got.

3. CONCLUSION

Thus the system of risk management based on the "cash flow at risk" approach that integrates credit, market, operational and liquidity risks of the commercial market-maker bank was developed. This approach provides:

- guaranteed risk-free return on equity (ROE);
- guaranteed liquidity;
- consolidation of different types of risk based on the "cash flow at risk" approach;
- risks coverage with extra interest income produced by general and special spreads.

Hence, the proposed approach allows protection of the interests of depositors, creditors and shareholders of the bank, and ensures sustainable development of the bank.

However, for the market-taker bank (i.e. for the bank that takes interest rates from market) the calculated interest rates can distinguish from the market ones. As a result, such bank can not entirely cover all the risks only by spreads. So, the further research should be focused on the development of a comprehensive risk management system based on "cash flow at risk" approach for the market-taker bank. Another promising area of investigations lies in usage of the proposed approach for development of new banking regulation and supervision system.

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