Interaction between market and credit risk: Focus on the endogeneity of aggregate risk

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8 November 2009

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First Draft: November 8, 2009

EXECUTIVE SUMMARY

As shown in the recent BCBS papers market and credit risks could reinforce each other in certain circumstances, meaning the sum of the parts might be less than an estimate of risk that takes into account the interactions between the two. Market risk factors have an ambiguous impact on the firms' repayment conditions because depreciation of domestic currency for instance favors exporters and harms importers.

Within the task of a 'top-down' aggregation of market and credit risks this contribution presents a general framework to economic capital measurement and active portfolio management splitting exogenous risk factor influence throw different channels. The approach implies an exploiting of banks information about the clients' trade and cash flows related to global economic activity. The way to single out exposures to counterparties belonging to the same pattern of behavioural reactions to the market factors are considered as the bedrock of Factor endogenous behaviour aggregation (FEBA) approach.

***Keywords**: integrated analysis of market and credit risk, risk management, endogenous behaviour, concentration risk.*

JEL classification: E37, E47, G20, G21, G28, G30, G32.

[1] The views and opinions expressed in the document are those of the author and not necessarily those of Sberbank.

1. Introduction

The economies that suffered from crises did not necessarily do so because of contagion or spillover effects. Common shocks such as a slowdown in world's aggregate demand and a decline in commodity prices have stressed Russian economy and have led to an increase of the exchange rate pressure. Behavioural response of borrowers divers and depend on extent of embedding of their businesses into global economy.

Russia's wide regional differences make some regions display the grate degree of trade openness[2] due to their considerable exportable natural resources or their proximity to external markets. Growing export positively affects export-oriented sector of the economy and indirectly the whole economy. The higher the level of openness, the more likely it is that the foreign countries have a stronger affect on the market variables of the home country. This category refers to exogenous factors that can impact domestic financial system.

The nature of endogeneity has to do with incentives to take on risk. Actions that may appear reasonable for individual economic agents may collectively result in undesirable outcomes. This is true both for borrowers and for banks. For instance, during booms fear of loss of short-term profit opportunities can boost credit expansion. And during recession or in response to signs of financial problems, rational individual behaviour can result in a "rush for the exits" that creates generalized financial distress.

That is why the problem arises - how to manage credit and market risks and to determine the necessary amount of economic capital which is needed as a buffer to absorb unexpected losses associated with each of these risks.

The 'bottom-up' approach integrates risks on the level of the individual instruments. This makes the approach more precise. Among the especially challenging problems is that even if there is a reasonable credit risk model for each counterparty, it is difficult to capture the effects of correlation across counterparties[3]. Besides, the fundamental 'endogeneity' of risk is difficult to take into account within individual financial instruments by definition.

Predominantly banks take a 'top-down' approach to measure enterprise-wide risk by measuring each type of risk on a 'silo' basis. But last researches of the Basel Committee suggest that such a 'top-down' approach of integrating market and

[2] A measure of openness (exports + imports) / GDP) is influenced by various factors, in particular the dimension of the territory and economy of individual countries / regions and their distance from major markets as well as by variations in their economic growth.

[3] See D. Duffie (2003)

credit risks could be subject to error due to the 'compounding effect'.

From the point of view of active credit portfolio management (ACPM), economic capital is a measurement of the concentration level[4]. Therefore, the 'compounding effect' is reviewed through the lens of factor risk concentration.

The paper is structured as follows: in section 2, the issues of interaction between market and credit risk on portfolio level are reviewed. Afterwards, in section 3, we introduce the approach to aggregation market and credit risks in which endogenous behaviour of enterprises is considered and finally, in section 4, the main conclusions are summarized.

2. Factor concentration risk in economic capital.

The separate calculation of risk capital for market and credit risks generally follows the separation into banking book and trading book. While credit risk is seen relevant for the banking book, market risk (direct market risk) is usually seen relevant for the trading book. Credit risk factors may be idiosyncratic properties of individual obligors or market variables that are influencing behavioural reaction of obligors in the same way.

Let's consider the market value of the portfolio V(x, y) over the time interval $(t_0,t_0+\Delta t)$. The change in value may occur due to exogenous factors such as a change in the competitive structure in marketplace or change in the FX rates, for example. As shown by Blaschke *et al.* (2001) the market risk in loan portfolio could be divided into two main components[5]:

- Indirect interest rate risk, resulting from the impact of interest rate changes on borrowers' creditworthiness and ability to repay.
- Indirect FX risk, resulting from the impact of FX positions taken by borrowers on their creditworthiness and ability to repay, and thereby on financial institutions.

Credit risk y deals with value changes caused by moves in credit risk factors, assuming all market risk factors are constant at x_0:

$$\Delta c(y) = v(x_0, y) - v(x_0, y_0).$$

Market risk deals with the value change of a portfolio, assuming that credit risk factors are constant at some y_0:

$$\Delta m(x) = v(x, y_0) - v(x_0, y_0).$$

[4] See BCBS (2009c).

[5] According to M. Čihák (2007) the banking sector's indirect FX risk (FX related credit risk) is more important than its direct FX risk. FX related credit risk appears to be particularly substantial in countries with closely managed exchange rate pegs.

Accordingly, integrated risk is related to the value change caused by simultaneous moves of market and credit risk factors:

$\Delta v(x, y) = v(x, y) - v(x_0, y_0)$.

Due to assumption, mentioned above:

$v(x, y) \approx v(x_0, y_0) + \Delta c(y) + \Delta m(x)$.

As shown by Breuer *et al.* (2008) on the example of borrowers that have only assets in a local currency different from the currency in which their debt is due, the default risk will be higher than in the one currency case, as a consequence of the additional market risk.

In this case the approximation $\Delta c(y)+\Delta m(x)$ does not overestimate but underestimates the true aggregated risk for a portfolio valuation function. If at some point of time t the approximation error z(x, y) is negative, we have negative diversification effect.

$$z(x, y) = \Delta v(x, y) - \Delta c(y) - \Delta m(x). \quad (1)$$

Let's assume that the obligor's payment ability is y, and this credit risk factor y can vary within the interval $[0;\infty)$. The value of the risk is zero if credit risk factor y is greater or equal to the payment obligation x. If x is greater than y, the value of the position is y-x, which is negative. The value of the position to the bank changes from moves in the market risk factor x alone, assuming the payment ability of the obligor will have the value y_0 with certainty, is

$$\Delta m(x) = v(x, y_0) - v(x_0, y_0) = -\max(x - y_0, 0) + \max(x_0 - y_0, 0). \quad (2)$$

Risk values of object portfolio will differ in a great degree at the different points of the economic cycle in line with the extent of rating system's 'PITness[6]. Consider some scenario at the time point $t_0+\Delta t$. No defaults are possible if $y_0 = \infty$. But any other choice of y_0 would also be possible. The smaller y_0 the more defaults will occur in the market risk scenarios. This increase integrated risk and increases the inter-risk concentration effect.

In line with BCBS (2004) A risk concentration[7] is any single exposure or group of similar exposures with the potential to produce (i) losses large enough (relative to a bank's earnings, capital, total assets or overall risk level) to threaten a bank's creditworthiness or ability to maintain its core operations or (ii) a material change in a bank's risk profile.

According to The Joint Forum paper (2008), the definition of 'risk concentrations' refers to concentrated risk exposure(s) that may arise not only within but and

[6] The practice of ACPM can result in the use of point-in-time (PIT) default probabilities for day-to-day risk management with through-the-cycle (TTC) estimates for economic capital computations.

[7] See BCBS (2004), paragraphs 770-777.

across different risk categories throughout the financial conglomerate. Second type of 'risk concentrations' should be distinguished from the narrower concept of concentrated risk exposure(s) within a specific risk category: for instance, typical examples of concentration risk within credit risk are single name and sector concentration risk.

In terms of portfolio risk assessment, we denote all random variables also as $\triangle v, \triangle c, \triangle m$. We apply risk measure ρ to these variables. The $\rho(\triangle v)$ is RC, $\rho(\triangle m), \rho(\triangle c)$ are RC_m and RC_c respectively. The measure of the effect of an integrated analysis of market and credit risk (inter-risk concentration effect) could be defined:

$$Z = \rho(\triangle v) - (\rho(\triangle c) + \rho(\triangle m)) \quad (3)$$

In line with BCBS (2009c) a bank should consider concentrations that are based on common or correlated risk factors that reflect more subtle factors than traditional concentrations, such as correlations between market and credit risks.

The mentioned above compounding effect is determined by interaction of market and credit risks. Jarrow, R. A. and Turnbull S. M. (2000) point out, that in line with economic theory, market and credit risk are related to each other and are not separable. Given this the task of risk aggregation within 'top - down' approach comes down to single out of pools of the borrowers, which have same behavioural reactions to the given market factors.

The borrowers' orientation on foreign or domestic markets is seen as the key criterion for such a clusterisation. Terms of trade[8] and the rate of domestic currency can be used as proxy for exogenous risk. As part of the formation of the approach, the relationship between two variables: the rate of national currency and the prices of credit default swaps (CDS) on some countries[9] with volatile FX rates were analyzed. Time horizon has been identified from February 2008 to February 2009. This period was characterized by the strengthening of exchange rates until August 2008 and falling FX rates (20-50%) compared to the September 2008. The analysis shows a strong direct correlation of FX rate and CDS.

3. Factor aggregation of the endogenous risk

Developing models which are able to capture the endogeneity of risk is possibly the most important challenge risk management models and stress tests need to

[8] 'Terms of trade' is the ratio between import and export prices.

[9] The correlation coefficients between these variables are: Brazil: 0.9409, Norway: 0.8065, Canada: 0.7738, Russia: 0.7731.

meet[10]. It is reasonable that ERM system and international trading services system should be combined to expand the universe of necessary data and to capture the endogeneity of aggregate risk. The input information for implementation of the approach consists of three main parts:

- Banking information from management information system at the business and firm-wide level;
- macro economic information from the perspective of branches of economy and trading partners' countries;
- banking information about foreign trade and other financial transactions of the banks clients[11].

The starting point for to clusterisation of credit risk concentrations should be a more detailed review of the impact channels of indirect FX risk on credit portfolio. A change in the FX rate influences the creditworthiness of borrowers in two main ways[12]:

- First, it influences the corporate balance sheets directly via firms' net open positions in foreign currencies;
- Second, it changes its competitiveness relative to the foreign corporate sector.

A recession in demand adversely impacts Russia's economy and in turn result in greater loan defaults. For instance, an export-oriented company that suffers losses may not be able to repay all of its debts as it faces a negative cash flow.

With regard to first way of exogenous impact, a depreciation of the home currency means that the borrowers must repay less than they borrowed initially. The net real position of the borrower has, in fact, improved. With regard to second way, a lower domestic currency is positive for an export-oriented company. Let's denote exposure to export-oriented company in local currency as '*EL*'. With regards to behavioural reaction, it is expected that a depreciation in the nominal exchange rate leads to lower loan defaults and losses.[13]

This situation is reversed if the borrowers are primarily borrowing in foreign funds, in which case they stand to benefit from an appreciation of their domestic currency. Generally, the relationship between the exchange rate and loan losses is

[10] See M. Drehmann (2008)

[11] In case of Russia, under Currency Law (1994), banks as official currency control agents monitor all FX transactions, including transaction passports for contracts involving settlement between residents and non-residents for goods imported into, or exported out of the Russia, for services rendered, information or intellectual property transferred. The same systems work in a row of emerging markets (e.g. China).

[12] See M. Čihák (2007)

[13] If the domestic currency's depreciation coincides with a drop in aggregate demand, the short-term effect of increased competitiveness could be offset, triggered by the effect of lower demand.

ambiguous.

Depreciation of the domestic currency leads to a decline of export prices, which are denominated in the FX currency, and conversely to an increase of import prices which are denominated in the domestic currency. Depending on the elasticity of demand and supply it increases the real amount of exports and at the same time it decreases the real amount of imports.

The FX rate is an important indicator for domestic producers. As predicted by theoretical models of the exchange rate's impact on enterprises, greater import penetration into domestic markets raises the *sensitivity* of home producers to exchange rates.

In the final analysis it is possible to highlight six main types of portfolios based on endogenous firms' responses on market factors:

- DL – loan to enterprises of Domestic market in Local currency;
- DF – loan to enterprises of Domestic market in Foreign currency;
- IL – loan to Importers in Local currency;
- IF – loan to Importers in Foreign currency;
- EL – loan to Exporters in Local currency;
- EF – loan to Exporters in Foreign currency.

In case of local currency appreciation, buying more inputs or finished goods abroad did not only reduce costs, but also made those companies (EL, EF types of portfolios) less vulnerable to exchange rate movements by creating *natural hedges*. Therefore in this analysis we can also highlight active participants of foreign economic activity, i.e. acting both as importers and as exporters.

Basel Committee working group gives the example[14] of quantative assessment of FX factor impact on loan portfolio of domestic borrowers (*DF* type of portfolios):

Analysis of foreign currency loans in Austria, conducted by members of Basel Committee working group, indicates that adding the two risk types (default risk and FX risk) separately significantly underestimates the overall risk. For a B+ rated obligor[15], an integrated approach leads to an overall risk that is 1.5 to 7.5 times higher (due to compounding effect) than an approach that tackles the risks in isolation.

A relatively low level of foreign currency - denominated loans (*DF* and *IF* types of portfolios) means that the indirect, second-round foreign exchange risk is limited, which contrasts the situation in many other European countries where FX lending

[14] See BCBS (2009b)

[15] Standard & Poor's rating methodology.

represents an important source of concern[16]. If the bank has different groups of clients aside from domestic borrowers, its banking book will consist of several types of portfolios described above.

In the context of FX loans to importers and domestic market (*IF* and *DF*) credit risk has the payoff profile of a short put on the payment ability y with strike x_0, which reflects Merton's key idea of structural credit risk models, regarding a loan as short put on the payment ability. Market risk of these portfolios has the payoff profile of a short call on the exchange rate x with strike y_0.

The effect of extreme depreciation of domestic currency could significantly improve the financial situation of exporters (*EL and EF*), which could have a strong effect on the quality of credit portfolio. A simultaneous fall in aggregate demand, however, would counteract this effect. If the shift in demand is temporary, the impact of the depreciation might simply be postponed until demand returns to its initial level. However, if the reduction of demand is significant and long-lasting, it may completely nullify the short-term impact of the FX rate movement.

In the case of *EL* type of portfolio (home currency loans to exporters) described above credit risk has the payoff profile of a short call on the payment ability y with strike x_0 and market risk of these portfolios has the payoff profile of a short call on the exchange rate x with strike y_0.

Taking equations (3) allows us to define the economic capital for given credit subportfolio with given endogenous behaviour on a 'silo' basis by adding credit and market risks within all subportfolios and sector concentration risk.

$$EC_{\mu} = \sum_{i=1}^{\varphi} (\rho(\triangle c) + \rho(\triangle m)) \pm Z\varphi \tag{4}$$

Where Z_φ is the changing of economic capital due to the sector concentration (concentration in narrow sense) of the portfolio, that consists of φ subportfolios[17].

On this level of aggregation of the credit portfolio, *ex ante* sector concentrations should be single out in line with the type of behavioural reaction to market risk factors: Favorably affected branches of economy; adversely affected branches of economy; not affected branches of economy.

Exchange-rate- pressure can differ from one industry branch to another. As part of the Outlook Survey the Bank of Canada asked firms about how they are responding to FX movements. These surveys of market participants[18] could be an important

[16] See IMF WP (2008)

[17] See K. Dullmann (2006)

[18] A similar study of behavioural models has been conducted in Russia in 2005 by the Institute for Complex Strategic Studies in cooperation with the Institute for the Economy in Transition.

tool for building models of risk measurement and can help predict agents behavioural responses to macroeconomic shocks. For instance, adversely affected firms tended to be clustered in sectors with a high exposure to trade (i.e., primary industries and manufacturing). In these two sectors, about 80 percent of firms were adversely affected by the appreciation in the exchange rate[19].

Finally, the economic capital could be modelled as a sum of portfolio positions within banking book.

$$EC = \sum_{j=1}^{\mu\varphi}\left(\sum_{i=1} (\rho(\triangle c) + \rho(\triangle m)) \pm Z\varphi \right) \tag{5}$$

As shown above the market risk in loan portfolio includes indirect interest rate risk, resulting from the impact of interest rate changes on borrowers' ability to repay and to obtain new credit.

Drehmann *et al* (2007) shows that interactions between credit risk and interest rate risk can indeed be substantial and should be taken into account and could require a sophisticated framework. Bank's pricing policy, when talking about endogenous behaviour, should consider sensitivity of a particular portfolios to interest risk.

Moreover endogenous risk could appear whenever there is the conjunction of (i) banks reacting to market risk factors and (ii) where banks influence the ability of the banks' borrowers to pay. The approach clearly indicates that portfolios of the IF-type (loans to importers in foreign currency), for instance, have increased sensitivity in the given macroeconomic situation.

4. Conclusions

The paper considers the effect of interaction between credit risk and market risk, which might exert its influence via several channels. The first one is the influence of FX-risk via firms' net open positions in foreign currencies and the second one is the change of the firms' competitiveness.

Given the nature of financial crisis spreading channel - aggregate demand on export – the exogenous market risk factors is considered in conjunction with the endogenous behaviour of market participants. To capture the endogeneity of aggregate risk the framework implies that ERM system and international trading services system should be combined to expand the universe of necessary data.

As a complement to the other models used at banks, the approach may be useful for managing the bank's loan portfolio - actively controlling concentrations and keeping an eye on the return of the portfolio relative to the risk. Therefore, the approach can be used by risk management, or a credit oriented business unit, like

[19] See Bank of Canada review (2005)

corporate and investment banking, division of work with problem assets.

The further work, two extensions seem important. As already mentioned, the first extension is to define *ex ante* sector concentrations in line with the type of behavioural reaction to exogenous risk factors.

In the light of increasing globalization another key direction is to consider the patterns in behaviour of different types of market participants, for instance multinational companies (firms under foreign control). The framework could be extended by analyses of correlation between riskiness of borrower's behaviour and type of the goods (their investment orientation) and geographical allocation of borrowers' trade flows.

For practical purposes further development of FEBA approach may also be useful for shaping of global perspective by using base scenarios for aggregate demand and bilateral exchange rates.

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