Business cycle effects on portfolio credit risk: A simple FX Adjustment for a factor model

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1. Executive summary

The recent economic crisis on the demand side of the economy affects the trends and volatilities of the exchange rates as well as the operating conditions of borrowers in emerging market economies. But the exchange rate depreciation creates both winners and losers. With a weaker exchange rate, exporters and net holders of foreign assets will benefit, and vice verse, those relying on import and net debtors in foreign currency will be hurt.

This paper presents a simple FX adjustment framework within Factor Endogenous Behaviour Aggregation (FEBA) approach[3] based on the decomposition of the competitiveness factor into components with meaningful behaviour content and subsequent collapsing into the Adjustment Index.

The setup, while being simple, nicely captures non-linear and non-symmetric nature of the FX risk impact on bank's credit portfolio and could be very useful for modeling credit risk.

Keywords: exchange rate, factor modeling, competitiveness, credit risk, market risk.

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

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[3] The approach was set up in "Interaction between market and credit risk: Focus on the endogeneity of aggregate risk" and mentioned in Roubini Global Economic Digest as "Advance in Credit Risk Management".

1. Introduction

In "The Return of Depression Economics and crisis 2008", Krugman writes: "The world economy is not in depression; it probably won't fall into depression, despite the magnitude of the current crisis (although I wish I was completely sure about that). But while depression itself has not returned, depression economics — the kinds of problems that characterized much of the world economy in the 1930s but have not been seen since — has staged a stunning comeback."

By depression economics, author means the state of the economy when demand is slack. Or, as he puts it: “Essentially it means that for the first time in two generations, failures on the demand side of the economy have become the clear and present limitation on prosperity for a large part of the world."

Slowdown in aggregate demand, which is the main channel of crises transition to Russian economy and the main risk driver for overwhelming majority of Russian companies, placed currencies across the world under severe pressure. The Russian rubble jumped from 25 rubles per US dollar in July 2008 to nearly 36 rubles per US dollar in February 2009, a 48% depreciation rate in a matter of just six months.

But exchange rate depreciation *per se* creates both winners and losers, and financial institutes need to pin down the distribution of these gains and losses and the magnitude of their impact on banks’ credit portfolios.

With a weaker exchange rate, exporters and net holders of foreign assets will benefit, and vice verse, those relying on imports and net debtors in foreign currency will be hurt. Thus aggregate risk of bank’s credit portfolio depends on the trend and volatility of the exchange rate due to subsequent changes in price competitiveness of borrowers.

Banks’ internal rating model, which produces a score based on financial and behavioral ratios, should accurately discriminate between “bad” and “good” obligors - those that have higher and lower *ex ante* estimated PD due to changing outlook on the competitive structure in marketplace. Could such a model be defined as "Depression" or "Crises Risk Management" because of need to focus on the demand side of issue?

The foundations of modern economic theory were laid by M. Keynes in 1929 in the analysis of the Great Depression in the United States. Unlike the economics, the fully fledged risk management shaped up relatively recently during the period of "The Great Moderation"[4], when economists got sure the business cycle was tamed. As a result, modern risk management was thoroughly embedded in the physics-inspired

[4] B. Bernanke (2004) gave speech titled "The Great Moderation" in which he argued that modern macroeconomic policy had in whole solved the problem of the business cycle.

view of the financial economy as a stable and an equilibrium seeking system based on separate calculation of risk capital for market and credit risks. [5]

In this regard, Furman and Stiglits (1998) stated that "the current regulations do not examine total portfolio risk, including the correlations among market risks and between market risk and credit risk" and that "even the United States has deliberately shied away from fully transparent risk adequacy standards based on modern risk analysis. It is unreasonable to expect such mechanisms of indirect control to work effectively in developing countries."

Moreover, "the experiences of the current crisis and the results of extant research strongly indicate the on-going need for both market practitioners and their supervisors to make concerted efforts to achieve a more integrated measurement and management of different forms of risk." (See Hartmann, Kwast and Praet, 2009).

In this context Sokolov (2009) put forward a method to take the interaction between market risk and credit risk into account, which exerts its influence by FX risk via firms' net open positions and the change of the firms' competitiveness.

Regarding to emerging market economies (henceforth EME) the range of practitioners' needs were most comprehensively outlined by Vallés (2006). This concerns the ability of bank's rating systems to adapt to stressed economic conditions, when behaviour of obligors is so different that observable macroeconomic variables are not enough to account the economic crisis effect. The author (*op. cit.*) underscores, that "in emerging economies with financial information affected by macroeconomic crisis, it is not sufficient to collect historical data. Considerable changes in economic conditions influence the variables used to assess risk. There are other aspects to be considered, such as the quality of the data and the methodology and adjustments required to incorporate crisis data."

In order to adjust scoring information to crises data the implementation of additional information about the borrower characteristics into the model seems reasonable. The Factor Endogenous Behaviour Aggregation (FEBA) approach implies the use of additional dimension of uncertainty - the extent to which borrowers rely on foreign or domestic consumption. In line with the approach "difference in borrower's behaviour" during the economic crisis should be commensurate with the ambiguous influence of exchange rate on borrowers' creditworthiness and endogeneity of aggregate risk.

Based on these observations, this contribution set out the simple framework to adjust factor model to crisis data and to increase underlying degree of cyclicality. The setup implies decomposition of competitiveness factor into components with meaningful behaviour content and subsequent collapsing into Competitiveness Adjustment Index.

[5] A 'top-down' approach of integrating market and credit risks could be subject to error due to the 'compounding effect'. On this, see for example Hartmann *at al.* (2009).

The implementation of the framework, from technical perspective, can be done as if the *AI* (stands for Competitiveness Adjustment Index) were a common single factor, what it actually is. But, from a content point of view, it is similar to the multifactor correlation model and provides additional information in the context of borrowers' behaviour.

The paper is structured as follows: in section 2, FX factor, which is interpreted as the state of the business cycle, is distangled to components with economic and behavioral content. Afterwards, in section 3, we introduce the FX Adjustment mechanism which accounts for an indirect market risk related to the obligor's competitiveness and, hence, ability of company to manage through the cycle. Finally, in section 4, the main conclusions are summarized.

2. FX Factor and risk modeling

With regard to risk modeling, we wish to explain the company's economic success by means of some global underlying influence. Actually, there are two approaches to incorporate macroeconomic effects in credit risk assessments. Implicit factor models assume the factors are latent in the date[6]. Explicit factor models relate the asset values to observable information such as GDP growth, unemployment, inflation, exchange rates, real trade variables and so on. The main advantage of the last approach is that we can use it to ask and answer explicit questions about both the drivers of default behaviour and the impact of business cycle on the portfolio.

Thus we can demarcate risk factors which are taken into account, (explicitly or implicitly), from an unobservable set of factors. Both components have an impact on the default dynamics, but the first one also determines rating scores dynamics, while the second one causes, together with idiosyncratic risk, the movements of defaults around the *ex ante* estimated PDs.

In this regard, Cornaglia and Morrone (2009) proposed the method to pin down degree of cyclicality in a rating system as the ratio between the sensitivity to macroeconomic conditions which is embedded in the score variables and the total sensitivity of defaults. Understanding ratings dynamics and underlying rating philosophy can be important to assess if the system is well functioning and if it is well suited to encompass for stressed economic conditions.

In this paper we consider factor model with respect to the segment of lower-rated companies, for which cyclical downturn may involve the threat of default before the opportunity to participate in the subsequent upturn. Clearly, such factor model must have the higher degree of cyclicality. The next question is what types of macro

[6] If the bank does not use macro-variables the observed defaults contain the effects of these variables.

information are best suited to identify the buildup of systematic risk, as opposed to firm-specific risk.

As stated Mishkin (1999) "emerging market economies face at least one factor affecting balance sheets that can be extremely important in precipitating financial instability that is not important in most industrialized countries: unanticipated exchange rate depreciation or devaluation." The deterioration in balance sheets increases adverse selection and moral hazard problems, which leads to a sharp decline in investment and economic activity.

Regarding to depreciation, we can outline two components of this process. First, this is a fundamental depreciation as the weakening of the real FXrate that brings the exchange rate back to equilibrium. Second, the overshooting effect resulting from EME market's insufficiency is any weakening above and beyond the fundamental depreciation (see Cavallo, Kisselev, Perri and Roubini, 2002). In the context of EME, an overshooting effect defines additional meaning of FX rate as a systematic factor in risk modeling.

For modeling defaults that are dependent on the state of the business cycle, it is customary to implement a factor model specification for asset returns. A firm defaults when its asset value index V_j falls below a threshold b_j. Negative realization of the common shock can make asset firm values fall below their corresponding threshold values and then lead these obligors into default.

Let D_j symbolize the default event of firm j, then we can observe that:

if $V_j < b_j$, then $D_j = 1$; $D_j = 0$ otherwise.

$$PD_j = P(V_j\ (x;y) < b_j) \quad (1)$$

Where the default boundaries b_j are pre-specified and obtained from the (unconditional) probabilities of default PD_j. V_j (x;y) are the creditworthiness of obligor j, y- credit risk factors, x- market risk factors (interpreted as the state of the business cycle). In this work we follow Čihák (2007) and divide the FX rate influences[7] on the creditworthiness of borrowers into two main components. First, it influences the corporate balance sheets directly via firms' net open positions in foreign currencies. The second component, which makes our main interest in this work, is borrowers' price competitiveness relative to the foreign corporate sector.

In general, the higher is the degree of co-movement across all individual firm default probability time series, the fewer is the number of factors needed to explain a large portion of the variance of the original series. As shown by Chan-Lau (2008), exchange rate changes and the spreads of credit default swaps have the joint dynamics. At low levels of macro risk, most of the variance of the FX rate is

[7] In the Cavallo, Kisselev, Perri and Roubini work was emphasized that if even banks try to hedge by borrowing in foreign currency and lending in foreign currency to corporations and households, the exchange rate is risk only transferred to the non-financial private sector.

explained by factors other than those affecting macro and sovereign risk. When economic fundamentals of EME are undergoing rapid deterioration they play a bigger role on exchange rate movements.

Since the exchange rate has a diametrical impact on export and import activities, the competitiveness of related companies can be expressed as follows:

$$C_{\varepsilon}(t)=sin\ (t) \quad (2)$$

$$C_{\gamma}(t)=cos\ (t) \quad (3)$$

Where $C_{\varepsilon}(t)$ - the price competitiveness of exporting companies, $C_{\gamma}(t)$- the price competitiveness of importing companies.

Gylfason (2002) estimated the long-run price elasticities of exports and imports to FX rate for 15 industrial countries and nine emerging market economies. The estimates of the sum of the elasticities lie between 1.5 and 2.5 in the mature economies and between 1.5 and 4.1 in the EME. This observation premises that EME have a stronger incentive to adjust to currency depreciation by curtailing imports and increasing exports than developed market economies[8]

3. The construction of a Competitiveness Adjustment Index

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 for example. To this end market risk deals with the value change of a portfolio, assuming that credit risk factors are constant at some y_0:

$$\Delta m(x) = v(x,\ y_0) - v(x_0,\ y_0) \quad (4)$$

The market factor that drives the process is a vector of competitiveness $C(x)$ purported to impact upon the asset value through the business cycle. The change of $C(x)$ could be disentangled to the main directions of activity of the borrower:

$$C'(x) = c(d;\varepsilon;\gamma) - c(d_0;\varepsilon_0;\gamma_0) \quad (5)$$

Where d, ε and γ denote domestic, export and import components of borrower's activities.

The sensitivity of the "Domestic" portfolio to the FX rate can be very high and depends on the degree of market openness in terms of industries and regions. The degree of openness to trade indicates the importance of international trade linkages for a country and regions. Tighter connections between domestic and foreign markets can reduce the effectiveness of demand stimulation by fiscal and monetary policies.

8 Widely recognized, economic agents prefer stability of their income before income fluctuations. The increased exchange rate volatility in EME can force companies to charge higher prices by including a risk premium.

For example, increased spending by domestic consumers might be directed at foreign firms to the extent of import penetration into domestic markets.

For simplicity sake let's consider the market value of the portfolio *V(x, y)* related to active participants of foreign economic activity, i.e. acting both as importers and as exporters. Fully-fledged globalization of these companies should make them less vulnerable to exchange rate movements by creating natural hedges. In the spirit of Minsky we could identify this type of borrowers as the "Natural Hedge Borrowers" (NH).

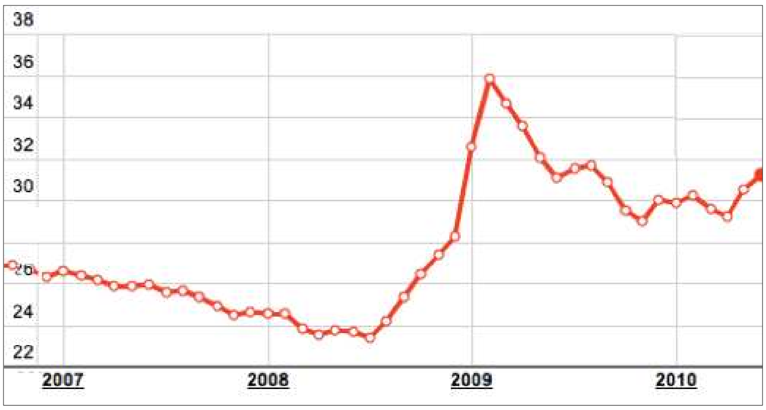
Intuitively one would expect a change in level off competitiveness to vary across industry groups or regions with different international orientation due to fact that demand-driven cycle is specific to a particular industry or region. The borrowers' competitiveness (C) related to this type of portfolio could be state as:

$$\begin{bmatrix} Competitiveness \\ (C\ ) \end{bmatrix} = \begin{bmatrix} Export \\ Competitiveness \\ (C\varepsilon) \end{bmatrix} + \begin{bmatrix} Import \\ Competitiveness \\ (C\gamma) \end{bmatrix}, \text{where}$$

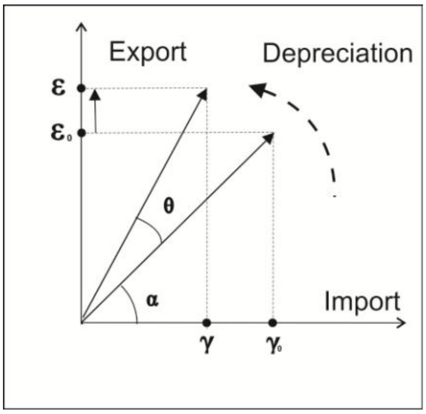
$$\begin{bmatrix} Export \\ Competitiveness \\ (C\varepsilon) \end{bmatrix} = \begin{bmatrix} Export \\ Specific \\ Factor\ (E) \end{bmatrix} \times \begin{bmatrix} Global \\ Economic \\ Factor\ (W) \end{bmatrix} \times \begin{bmatrix} Regional \\ Eonomic \\ Factor(R) \end{bmatrix} \times \begin{bmatrix} Industrial \\ Sector \\ Factor(S) \end{bmatrix}$$

$$\begin{bmatrix} Import \\ Competitiveness \\ (C\gamma) \end{bmatrix} = \begin{bmatrix} Import \\ Specific \\ Factor\ (I) \end{bmatrix} \times \begin{bmatrix} Global \\ Economic \\ Factor\ (W) \end{bmatrix} \times \begin{bmatrix} Regional \\ Eonomic \\ Factor(R) \end{bmatrix} \times \begin{bmatrix} Industrial \\ Sector \\ Factor(S) \end{bmatrix}$$

Since FX rate is proxy for systematic risk, we can define "states of the economy" in terms of the extent of deviation from a trend growth path. The "low state" comprises observations below the 25th percentile of the distribution of deviations from trend – i.e. those in which the deviation from trend is large and negative – and the "high state" comprises observations above the 75th percentile.



Picture 1: RUR/USD exchange rate dynamics



Picture 2: AI for *"NH"* portfolio

The idea is to choose the vector of competitiveness $C(\varepsilon;\gamma)$ and to fix its projection on each of the competitiveness' axes (see Picture 2). A change in the FX rate at a time

$t_0+_\Delta t$ relates to rotation of vector $C(\varepsilon;\gamma)$ at θ degrees. The rotation angle varies on a grid from 0 to π/2.

The extreme values of the range should be commensurate with the shock values of exchange rate that are used for stress-testing. As the currency depreciates the angle of vector increase on θ, the export component of $C'(\varepsilon)$ increases at $(\varepsilon + \varepsilon_0)$ (and vice-versa competitiveness related to import reduces). Therefore the change in the competitiveness will be:

$$C'(\varepsilon) = |x| \cdot sin(\alpha + \theta) \quad (6)$$

$$C'(\gamma) = |x| \cdot \cos(\alpha + \theta) \quad (7)$$

A class of orthogonal matrices useful for our purposes is rotation matrices. These matrices have a simple representation in terms of sine, cosine functions. In our case a 2 × 2 rotation matrix H has the form:

$$H = \begin{bmatrix} Cos\theta & -Sin\theta \\ Sin\theta & Cos\theta \end{bmatrix} \quad (8)$$

Given by (5), (6), and (7) the Competitiveness Adjustment Index for two dimension case, i.e. ″NH″ portfolio, is modeled as follows:

$$AI_{NH} = \left[E \cdot w_\varepsilon \cdot r_\varepsilon \cdot s_\varepsilon;\ I \cdot w_\gamma \cdot r_\gamma \cdot s_\gamma\right] \cdot H \cdot \begin{bmatrix} 1 \\ 1 \end{bmatrix} \quad (9)$$

Where $E;\ I$ are the shares of export and import operations in turnover of the ″NH″ portfolio borrowers. The other entries of the matrix w, r, s, "elasticities", correspond to how a given portfolio reacts to variations of exchange rate.

To assess the dynamic range of the Competitiveness Adjustment Index, we consider the values of the sums of the projections of the competitiveness index AI_{NH} in the equilibrium exchange rate and then in the stressed ones. For simplicity sake, we take all the "elasticities", equal to 1.

With regard to the ″NH″ portfolio, in equilibrium the obligor's competitiveness will be $AI_{NH} = \sqrt{2}\ /\ 2$. In the "high state", i.e. $\theta = 0$, as well as in other stress value of the exchange rate ($\theta = \pi\ /\ 2$), it will be 0,5.

Consequently, the obligor's competitiveness, related to the ″NH″ - types of portfolios, can vary within the interval [0,5 ; $\sqrt{2}$]. In case of portfolio ″Importers″, the Competitiveness Adjustment Index attains the maximum not under the equilibrium FX rate, but under maximum rate of national currency. The range of AI_I change could be defined as [0; 0,5].

Finally, the fact that impact of FX shocks is neither linear nor symmetric can be summarized by looking at the mean, the standard deviation and the skewness[9] of the distribution of indirect market risk related to the obligor's competitiveness.

[9] In case of positive skewness the mean will be higher than the median.

The indirect market risk is inversely proportional to the Competitiveness value, and is also inversely proportional to the Adjustment Index (with assumption that elasticities are equal to 1). Using a USD/RUB exchange rate we obtained the indirect market risk estimates in Table1.

	"NH" BORROWERS			IMPORTERS			EXPORTERS		
	mean	std	skew	mean	std	skew	mean	std	skew
2008	0,62	0,06	-0,47	1,04	0,07	1,83	13,88	20,43	5,46
2009	0,53	0,05	1,97	5,08	26,24	13,77	1,23	0,18	0,58
2010	0,5	0,002	1,8	1,51	0,12	0,27	1,35	0,1	0,59

Table 1: Distribution of indirect market risk related to the obligor's competitiveness.

Interestingly, for the "NH" portfolio, annualized mean and standard deviation of indirect market risk, FX shocks had virtually no effect. Only in the 2010 a decrease in the standard deviation values of the risk for the "NH" portfolio is noticed.

In contrast to the "NH" portfolio, a portfolio "Exporters" has annualized mean in 2008 that is 11times more than in other year with volatility that is 113 times greater value. During the second half of 2008, the RUR/USD rate had a strong positive dynamic (see picture1).The annualized mean of indirect market risk of portfolio ″Importers″ increased 4 times in 2009, with 370 times volatility increase.

With such a versatile change in the level of indirect market risk, which characterizes the credit markets of EME, the pattern of behavioral reactions to the market factors of borrowers could not be same.

One example of the accounting for sensitivities to states of the economy is found in S&P: "Sensitivity to cyclical factors – and ratings stability – also varies considerably along the rating spectrum". While for lower-rated companies a "cyclical downturn may involve the threat of default before the opportunity to participate in the upturn that may follow" and, consequently, in their case "cyclical fluctuations will usually lead directly to rating changes", "companies viewed as having strong fundamentals…are unlikely to see their ratings changed significantly due to factors deemed to be purely cyclical."

As a consequence, we deal with FX Factor Concentration risk which currently exists in a credit portfolio, and under certain circumstances, even a formerly well diversified portfolio can become concentrated due to the deterioration or default of certain parts of the portfolio. In the same way that FX factor concentration can be viewed as a sensitivity or "first derivative" of the loss distribution with respect to FX factor, the "second derivative" measures how risk concentrations change under stress, i.e. dynamic concentration risk.

It is worth noticing that from the point of view of active credit portfolio management (ACPM), economic capital is a measurement of the concentration level.[10] Therefore, despite the fact, that changes in *ex ante* factor concentration due to market stress events could be viewed as second order effects, it is useful to be aware of non-linear and non-symmetric impact of market factor on concentration, in order to develop strategies in advance that make the portfolio more robust against stress events.

4. Concluding Remarks

In this paper we have presented a Sine-Cosine framework, which was developed within FEBA approach for managing the bank's loan portfolio - actively controlling factor concentrations and keeping an eye on the return of the portfolio relative to the risk.

The presented framework - unlike previous results in the literature on using FX rates for systematic risk modeling – explicitly suggests that currency rate has different impact on portfolio credit risk depending of the types of portfolios.

The implementation of the framework, from technical perspective, can be done as if the Competitiveness Adjustment Index were a common single factor, what it actually is. But, from a content point of view, it is similar to the multifactor correlation model and provides additional information in the context of borrowers' behaviour.

Some important conclusions can be drawn from our exercise. First, portfolio risk in terms of volatility significantly depends on the type of portfolio. In this regard, the least risky portfolio is a portfolio "Natural Hedge Borrowers".

Second, the problem of "difference in borrower's behaviour" during the economic crisis should be considered in the light of a non-linear and non-symmetric impact of FX factor on borrowers' creditworthiness.

Third, from the point of view of active credit portfolio management it is useful to be aware of non-linear and non-symmetric impact of FX factor on concentration, in order to develop strategies in advance that make the portfolio more robust against stress events.

Furthermore, given that our setup is based on market data, it could be nicely integrated with stress tests for credit risk and market risk, particularly, if scenario analysis for bilateral exchange rates and aggregate demand are a state of the art practice. This is an important step in the direction of a fully integrated approach to measure and manage all risks that banks face at different stages of business cycle including "Depression economy".

[10] See BCBS (2009).

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