



Adverse risk interaction: An integrated approach

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ARTICLE INFO

JEL classification:

Codes: G21

G28

G32

E44

Keywords:

risk interaction

integrated market and credit risk assessment

banking book

economic capital

macroeconomic stress tests

ABSTRACT

This paper studies adverse interaction between credit and market risk. We develop a comprehensive Merton-type model, in which payment ability of borrowers is driven by the overall economic growth, while the level of their liabilities is sensitive to market variables. To illustrate the model, we apply numerical simulations to estimate credit, market and integrated Value at Risk from the loss distribution using industry-wide data from the Serbian banking sector. We show that—even after accounting for presence of market risk in the banking book—the total risk remains higher than the simple sum of credit and market risk. The results emphasize the importance of integrated approach to assessment of economic capital.

1. Introduction

One of the main lessons learned from the global financial crisis is the importance of an adequate assessment of risk exposures. Financial institutions and their regulators are revising the traditional risk measurement approaches and methods to determine the appropriate levels of capital necessary to absorb unexpected losses (BCBS, 2010; 2013). The conventional wisdom is to treat different sources of risk separately. This view used to be reflected in the Basel regulatory framework: the minimum capital charge under Pillar 1 of Basel II was obtained as a sum of minimum capital requirements for credit, market and operational risk (see, for instance, BCBS, 2006).

The intuition behind a separate capital assessment was its alleged conservativeness – if the capital for any particular type of risk is measured through Value at Risk (VaR), then the sum of individual VaRs is the upper limit of the total VaR. However, potential negative interaction of different types of risk may arise if there are non-linear co-dependencies between the risk factors. As discussed by Breuer et al. (2010) and many authors since, a typical example where defaults may be driven by both credit and market risk factors are foreign-currency loans. For such loans, required payment levels will depend on the exchange rate between the foreign and the local currency, potentially reducing payment ability of the borrowers.

The regulators have also recognized the potential negative impact of risk interaction (BCBS, 2009). This is why current trading book rules

for calculating capital charges are being reformed (BCBS, 2013; 2014). The separation of risks still exists, but they are now grouped in a different way. The main difference is that credit risk in the trading book, captured by risk surcharges, is limited to pure default risk, while the risk of credit migrations to non-default states is now combined with market risk.

This paper contributes to a strand of literature that studies the interaction between market and credit risk. In particular, we seek to identify the specific relationship between adverse movements of exchange rate and interest rates on one hand, and credit risk on the other hand. We develop a universal model for identification and quantification of the adverse interaction between market and credit risk. Moreover, we propose a framework for assessing integrated VaR in the banking book. We illustrate the model on the example of industry-wide data from the Serbian banking sector. Serbia is a country with a very high degree of currency substitution, which makes the choice of data quite convenient for a practical demonstration of the ability of the model to measure adverse interaction effects. However, the proposed framework can be universally applied to any financial sector in an economy in which substantial borrowing occurs in a single foreign currency.

The remainder of the paper is structured as follows. Section 2 presents a brief review of the related literature. Section 3 develops a model of spillover of exchange rate and interest rate movements, which are driven by the macroeconomic fundamentals, into credit risk.

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Section 4 provides an empirical illustration of the model. Results of the Monte Carlo simulation confirm the existence of adverse risk interaction. This is quantified in Section 5 through an increment in VaR above the sum of pure-credit and pure-market VaR. Section 6 discusses possible applications of our results in risk management and banking supervision, and shows how the framework can be extended to design of macroeconomic stress tests. Section 7 concludes.

2. Related literature

Ever since the pioneering work of Robert Merton (1974), there has been a substantial number of publications on various issues related to credit risk modeling (see Duffie and Singleton, 2003, or Capuano et al., 2009, for a review of credit risk models). On the other hand, far less effort was dedicated to an integrated modelling of credit and market risk and, in particular, to interaction of credit and exchange-rate risk. One of the first models of risk interaction can be found in Jarrow and Turnbull (2000), who model the interplay of credit and interest-rate risk. Other related models of interaction between credit and market risk include, for example, Marsala et al. (2004), Medova and Smith (2005), Böcker and Hillebrand (2009) and Grundke (2013).

The most intuitive approach to risk integration is the top-down approach. The idea is to link the loss distribution resulting from different types of risk (see Rosenberg and Schuermann, 2006). A simple aggregation of risk measures across different risk types usually ignores potential diversification benefits, thereby leading to overestimation of risk and redundant capital charges. Alessandri and Drehmann (2010) derive an economic capital model which measures credit and interest-rate risk in the banking book in an integrated fashion. They find the integrated economic capital and compare it to the simple sum of economic capitals for credit and interest-rate risk. Their analysis shows that the simple sum exceeds integrated capital under a broad range of circumstances. The authors provide the intuition for their result by arguing that relatively large portion of credit risk is idiosyncratic, and therefore independent of the macroeconomic environment. However, Grundke (2010) shows that top-down risk integration can underestimate the necessary amount of total capital for lower credit qualities.

The alternative perspective focuses on interactions among risk factors and their impact on capital. This bottom-up approach, in which capital charges for credit and market risk are separately estimated and then simply added up, can lead to substantial underestimation of capital required to absorb unexpected losses. Bellini (2013), for instance, analyzes bottom-up risk integration perspective, elaborating a general model to assess banking solvency in both long- and short-run. In some cases, not only there is no diversification between credit and market risk, but the evidence can be found that there is in fact a “negative diversification”. This adverse risk interaction follows from violation of sub-additivity and would mean that the overall risk is actually *higher* than the simple sum of its stand-alone components. Breuer et al. (2010) use a simple model and its real-world extension to show that a simple addition of separately measured foreign-exchange and default risk underestimates the actual level of risk several times. For instance, for an obligor with a B+ credit rating, the integrated risk measurement approach leads to an overall risk that is 1.5 to 7.5 times larger than the one derived when each component is measured separately and then added up. This effect becomes even more pronounced for portfolios with lower ratings.

Böcker and Hillebrand (2009) investigate the interaction between credit and market risk of a portfolio. They combine Merton-like factor models for credit risk with linear factor models for market risk and analytically calculate their inter-risk correlation. Taking a practitioner's perspective, they show how inter-risk correlation bounds can be derived. Breuer et al. (2008) show that the compounding effect is more pronounced for loans with bad ratings and high loan-to-value ratio. Kretzschmar et al. (2010) make another compelling case for

integrated risk management using balance sheet of a composite European bank and simulate economic conditions at the end of 2007. Lucas and Verhoef (2012) show that model specification may impact diversification benefits for aggregated market and credit risk assessment. At higher confidence levels this specification effect can lead to VaR reductions as high as 47 percent. They also demonstrate the effect empirically by calibrating their model on US data.

Kiesel et al. (2003) develop a factor model for integrating spread risks into a ratings-based credit portfolio model. Grundke (2005) extends this model by including interest rate-risk and systemic component of credit risk. Drehmann et al. (2010) develop a framework for measuring the integrated impact of credit and interest-rate risk on bank portfolios. They apply the framework to a hypothetical bank in normal and stressed conditions and show that it is essential to measure the impact of interest-rate and credit risk jointly. Chen et al. (2013) examine the interaction between default risk and interest-rate risk in determining the term structure of credit default swap spreads. Their estimation for different industry sectors and credit rating classes shows that credit risk exhibits intricate dynamic interactions with the interest-rate factors. Kupiec (2007) considers an infinitely diversified portfolio of corporate bonds and uses an integrated model of credit and interest rate risk to show that the sum of separate market and credit risk underestimates integrated risk under many circumstances. Raupach (2015) extends this approach and finds realistic conditions under which a substantial underestimation occurs.

Brockmann and Kalkbrener (2010) propose a general framework for aggregating economic capital across different risk types. They argue that multi-period models provide the natural setting for aggregating risk types with different liquidity profiles. Baldan et al. (2012) use data from an Italian bank to show that reduction of its liquidity risk profile in order to comply with Basel III framework lowered its interest margin, but also enabled the bank to reduce the amount of capital absorbed by the interest rate risk, resulting in a globally positive effect. Imbierowicz and Rauch (2014) use a sample of US commercial banks to analyze the relationship between liquidity and credit risk. They show that both sources of risk increase banks' probability of default. However, the impact of interaction between liquidity and credit risk depends on the overall level of risk that a bank has, and can contribute either positively or negatively to joint risk exposure. Li et al. (2015) analyze aggregation of credit, market and operational risk. They compare diversification benefits between a simple summation, variance-covariance and copula approach.

Bellini and Bocchi (2013) discuss the applications of risk integration to stress testing. Grundke (2011) argues that bottom-up risk integration approaches are ideal candidates for carrying out quantitative reverse stress tests, as they model interactions between different types of risk on the instrument level or the risk-factor level. Basu (2013) estimates the impact of stressed outflows on liquidity and solvency positions and finds that the associated fall in book value of assets is more than the aggregate Common Equity Tier 1 Capital.

Chan-Lau and Santos (2006) take the perspective of a borrower and propose several structural models for measuring default risk for firms with currency mismatches in their asset/liability structure. Their paper offers two wider model applications: the measurement of systemic risk in the corporate sector and the estimation of prudential leverage ratios in firms' balance sheets consistent with regulatory capital ratios in the banking sector.

A good summary of the existing literature on risk interaction can be found in Hartmann (2010). We contribute to this field by offering a comprehensive framework for estimating whether the interaction between credit risk and market risk is adverse or beneficial and quantifying the impact of the interaction on the capital requirements.

3. The model

We model the adverse interaction of market and credit risk using a

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