Is Current Capital Regulation Based on Conservative Risk Assessment?

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We criticize the popular view that separately calculating regulatory capital for market and credit risk yields a conservative aggregate risk assessment. We show that this view depends on a flawed intuition about diversification effects that arise between subportfolios. If a bank's portfolio cannot be neatly divided into two subportfolios along the lines of market and credit risk, simply adding up the respective results may cause the true portfolio risk to be underestimated. Using the example of foreign currency loan portfolios, we show that this underestimation can be quantitatively significant.

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1 Introduction

In work of the Basel Committee on Banking Supervision it has been a tradition to distinguish market risk from credit risk and to calculate the respective capital charges separately; aggregate capital requirements are then derived by adding up. While it is acknowledged that adding up separate market and credit risk numbers is not fully satisfactory compared to a model that integrates different risk categories, regulators mostly feel comfortable with this approach because adding up is widely considered to give a conservative estimate of overall capital requirements.

The intuition for this view is based on a diversification argument: If market risk can be roughly associated with the trading book and credit risk can be roughly associated with the banking book, then these two books can be viewed as two subportfolios of a bank's total portfolio. Any coherent risk measure for the total portfolio will produce a risk number which is smaller than the combined risk of the banking book and the trading book, or at most equal to the combined risk. Therefore the amount of capital calculated by adding up separate risk components will constitute an upper bound.

In this paper we argue that this view is flawed. We show that only if the portfolio can be divided into a market subportfolio depending just on market but not on credit risk factors, and a credit subportfolio depending just on credit but not on market risk factors, will integrated risk capital be smaller than the sum of market and credit risk capital. We argue that in many practically relevant risk assessment situations it is impossible to neatly separate the overall portfolio along the lines of the Basel risk categories. It therefore follows from our analysis that the adding-up approach can lead to an underestimation of the overall portfolio risk. Using the example of foreign currency loans, we show that this underestimation can be quantitatively significant.

Our results lead to an important policy conclusion: It cannot in general be argued that banks which have implemented the Basel II capital requirements deserve a capital relief on the grounds that an integrated framework would automatically deliver capital savings not realized under the current approach of adding up market and credit risk capital.

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2 Integrated versus Separate Analysis of Market and Credit Risk

Current regulation is conceptually based upon the distinction between market and credit risk. Market risk is defined as the risk that the price at which a financial position can be sold on the market may deteriorate. The traditional approach to modeling market price changes of positions is to track changes in underlying market risk factors, such as stock or commodity prices, exchange rates, or interest rates. Credit risk is defined as the risk of not receiving the promised payment on an outstanding claim. Credit risk factors determining default losses – such as default probabilities, loss-given default, exposures at default – may be either idiosyncratic properties of individual obligors, or they may be macroeconomic and market variables that influence all obligors in the same way. That is to say, some risk factors may influence both market and credit risk. Interest rates, for example, are market prices that determine the values of various fixed income instruments, but they affect default probabilities as well.

Risk assessment is based on portfolio valuation. To this effect, let us assume that a function $v:A\times E\rightarrow R$ is given, which specifies the value of a portfolio in dependence of some vector $a\in A$ of credit risk factors, and some vector $e\in E$ of market risk factors. The separation of risk factors into market and credit risk factors is just an assumption at this stage. For our argument it is not important which risk factors are seen as either market or credit risk factors. What matters is that such a separation is made in the first place. In the conclusion we will discuss the failure of this assumption as one indication of the interaction between market and credit risk.

Mathematically speaking, market risk reflects the value change of a portfolio which arises from moves in market risk factors, on the assumption that credit risk factors are constant at some a_0:

$$\Delta m(e):= v(a_0, e)+ v(a_0, e_0).$$

The market risk factors e are usually market prices. Value changes are calculated by comparing the portfolio value after the change of the risk factors with the portfolio value $v(a_0, e_0)$ in a reference scenario (a_0, e_0). Assuming counterparties to default in a pure market risk analysis amounts to setting the default probability a_0 at zero, or to assuming the distance to default to be infinite. In other words, in a pure market risk analysis a_0 is assumed to be fixed; in our analysis, however, it can take on any value.

Analogously, *credit risk* analysis deals with value changes caused by moves in credit risk factors, assuming all market risk factors are constant at e_0:

$$\Delta c(a):=v(a, e_0)+ v(a_0, e_0).$$

Credit risk factors are usually related to the payment ability of counterparties, as evidenced by their rating, default probabilities, distances to default, or estimates of recovery rates. Credit risk capital calculations both in Basel II and in most portfolio credit risk models assume market risk factors, such as interest rates or exchange rates, to be constant. Only in the more recent integrated risk models do both market and credit risk factors vary. *Integrated risk* is related to the value change caused by simultaneous moves of market and credit risk factors:

$$\Delta v(a, e):= v(a, e)+ v(a_0, e_0).$$

Adding up regulatory capital for market and credit risk implicitly rests on the assumption that integrated value changes of the portfolio are approximated by the sum of value changes related to both market and credit risk factors:

$$\Delta v(a,e) \approx \Delta c(a) + \Delta m(e). \qquad (1)$$

This corresponds to the approximation

$$v(a,e) \approx v(a_0, e_0) + \Delta c(a) + \Delta m(e).$$

For a general portfolio valuation function $v(a,e)$ the approximation $\Delta c(a)+\Delta m(e)$ may evidently underestimate the true integrated Δv at times. If in some scenario (a,e) the approximation error

$$d(a,e) = \Delta v(a,e) - \Delta c(a) - \Delta m(e)$$

is negative, we have *malign* risk interaction. (Only if d is non-negative in all scenarios, is there a *benign* interaction of credit and market risk.) This negative interaction of risk is caused by the non-additivity of the value function v. The following proposition classifies the functions v for which the approximation error is zero everywhere.

Proposition 1: The approximation is exact, that is $\Delta v(a,e)=\Delta c(a)+\Delta m(e)$, if and only if v has the form

$$v(a,e) = v_1(a) + v_2(e) \qquad (2)$$

In this case the portfolio can be broken down into two components, one depending only on credit risk factors, the other depending only on market risk factors.

This proposition is technically easy but conceptually important. In particular the "only if" part is interesting. Linear value functions v fulfill condition (2) and are therefore exactly approximated (for a proof see Breuer et al., 2007). The components can be real subportfolios or fictitious components into which single positions can be broken.

Turning from valuation to risk assessment, the properties of the value-change functions in various scenarios (a,e) carry over to risk measures and risk capital. If the parameter space $A \times E$ is equipped with a probability measure, the functions Δv, Δc, Δm give rise to random variables. (In somewhat sloppy notation, we denote these random variables also as Δv, Δc, Δm.) To these random variables one can apply any coherent risk measure ρ. The $\rho(\Delta c)$ we get is the risk capital for credit risk. Similarly $\rho(\Delta m)$ is the risk capital for market risk.

We measure the effect of an integrated analysis of market and credit risk by the index

$$I_{rel} := \frac{\rho(\Delta v)}{\rho(\Delta c) + \rho(\Delta m)}$$

which is well-defined if $\rho(\Delta c)+\rho(\Delta m)>0$ and $\rho(\Delta v)\geq 0$. In case of negative inter-risk interaction, $I_{rel}>1$, I_{rel} is unchanged if the portfolio is scaled by some factor; and $I_{rel}=1.2$ means that total risk is 20% larger than the sum of credit and market risk.

Proposition 2: In the case of benign interaction of risk ($d\geq 0$) separate analysis of market and credit risk overestimates true risk:

$$\rho(\Delta v) \leq \rho(\Delta c) + \rho(\Delta m). \qquad (3)$$

This holds for all subadditive risk measures ρ. Otherwise, in the case of malign interaction of risk ($d<0$ somewhere), there exists a coherent risk measure ρ for which separate analysis of market and credit risk underestimates true risk:

$$\rho(\Delta v) > \rho(\Delta c) + \rho(\Delta m). \qquad (4)$$

For a proof see Breuer et al. (2007).

A breakdown of portfolios along credit and market risk considerations was considered by Dimakos and Aas (2004) and Rosenberg and Schuermann (2006). In this case v is of the form $v(a,e)= v_1(a)+ v_2(e)$. For such a portfolio by proposition 2 the approximation is exact, i.e. $\Delta v(a,e)=\Delta c(a)+\Delta m(e)$. Thus $\rho(\Delta v)=\rho(\Delta c+\Delta m)\leq \rho(\Delta c)+\rho(\Delta m)$ and $I>0$ for any subadditive risk measure ρ. This implies that inter-risk interaction is always positive for a portfolio with credit and market risk separated into different subportfolios. Under these conditions, the measure provided by adding up risk capital for market risk and risk capital for credit risk will necessarily be conservative. Because the afore-mentioned authors consider only portfolios that may be neatly divided into market and credit subportfolios, they actually observe diversification effects from the perspective of an integrated analysis of market and credit risk. Yet if there is interaction between credit and market risk, such a separation of risk types into subportfolios is not possible. This is the situation we consider.

3 Separate versus Integrated Risk Assessment of Foreign Currency Loan Portfolios

As an example where the need for an integrated analysis of market and credit risk is obvious and where true risk is underestimated under the current regulatory paradigm we now analyze foreign currency loans. Foreign currency loans have become a particular concern for supervisory authorities because households have become inclined to take out foreign currency mortgages in recent years. Foreign currency-denominated mortgage financing has been especially popular in Austria and in Central and Eastern Europe. Foreign currency loans can be seen as a carry trade. In a carry trade, an investor takes advantage of the differential between low borrowing costs in one country and high investment yields in another country.

Breuer et al. (2007) study a stylized example of a foreign currency loan portfolio to establish a rough idea about the order an underestimation effect might have. They consider a portfolio of foreign currency loans with N obligors indexed by $i=1,...,N$. All loans are underwritten at the initial time $t=0$. In order to receive the home currency amount l_i an obligor takes a loan of $l_i/f(0)$ units in the foreign currency. The bank borrows $l_i/f(0)$ units of the foreign currency on the interbank market. When the loan expires after one period at time $t=1$, which we take to be one year, the bank repays the foreign currency on the interbank market with an interest rate r_f while claiming from the customer a home currency amount. The latter is exchanged at the rate $f(1)$ to the foreign currency amount $(l_i/f(0))(1+r+s_f)$, which is the original loan plus interest r_f rolled over from four quarters plus a spread s_f. So the customer's payment obligation to the bank at time 1 in home currency is

$$o_i=l_i(1+r_f)f(1)/f(0)+l_i s_f f(1)/f(0). \quad (5)$$

The first term on the right-hand side is what the bank has to repay on the interbank market, the second term is the spread profit of the bank. For a home currency loan the payment obligation would be $o_i=l_i(1+r_h+s_h)$, where r_h is the interest rate in the home currency and s_h is the spread to be paid by the customer on a home currency loan. Whether an obligor will be able to meet this obligation depends on his payment ability a_i. Like in a structural credit risk model, we assume that an obligor defaults if his payment ability at the end of the period is smaller than his payment obligation.

The profit of the bank with obligor i is therefore

$$v_i:=min(a_i,o_i)-l_i(1+r_f)f(1)/f(0) \quad (6)$$

In this respect $f(0)$ is the known exchange rate at time $t=0$, whereas $f(1)$ and r are random variables. In the profit function v_i the first term is what the obligor repays and the second term is what the bank has to pay on the interbank market.

Payment ability is modeled as a function of macroeconomic conditions, described by real GDP growth and an idiosyncratic shock with a log normal distribution. The parameters of the lognormal distribution are calibrated such that they match the obligors' ratings and a profit target for the bank. The probability law driving the risk factors

– exchange rate, interest rate and GDP growth – is estimated by a time series model capturing macroeconomic interaction between countries, the so-called global vector autoregressive model (GVAR; see Pesaran et al., 2006) We use time series of quarterly data. In the GVAR these variables are estimated taking into account the macroeconomic interdependence between Switzerland and Austria and their three most important trading partners – Germany, Italy and France – as well as the United States. For a more formal discussion and details we refer to Breuer et al. (2007).

With this stylized model of cash flows related to the foreign currency loan portfolio and the estimated and calibrated probability law for systematic and idiosyncratic risk factors, a portfolio loss distribution can be simulated using Monte Carlo techniques. The example portfolio contains $N=100$ loans of l_i=EUR 10.000 taken out in CHF by customers in the rating class B+, corresponding to a default probability of p_i=2%, or in rating class BBB+, corresponding to a default probability of p_i=0.1%.

When applying the traditional approach to assessing the risks of the portfolio, one would look at market and credit risk in isolation. From a pure market risk point of view, the bank has only an open position with respect to the spread s as long as no defaults occur. From a pure credit point of view, the portfolio would be naively treated as consisting of different obligors with their respective default probabilities p_i. In this case it is obvious why this approach is naive. The probability of default is related to the borrower's payment obligation and payment ability as well as – as a direct function of the market risk factors – to the underlying exchange rate, interest rates and GDP growth. If obligors default, the bank suddenly has bigger open foreign exchange positions vulnerable to moves in the exchange rate, and this matters not only under credit risk considerations but also from a market risk perspective. Clearly the two risks have to be considered simultaneously here. Consequently it is important to cross-check the capital requirements established with an adding-up approach against the requirements established with an integrated approach.

Breuer et al. (2007) find the following risk capital values for pure market risk, pure credit risk and integrated risk, respectively, and consolidate these values into an inter-risk interaction index I_{rel}:

Rating	α	RC(Δm)	RC(Δc)	RC(Δv)	I_{rel}
BBB+	10%	1,059	0	1,193	1.13
BBB+	5%	1,234	0	1,522	1.23
BBB+	1%	1,576	0	3,056	1.94
BBB+	0.5%	1,698	1	4,641	2.73
BBB+	0.1%	1,951	3	16,076	8.22
B+	10%	1,102	795	2,711	1.43
B+	5%	1,285	1,022	4,420	1.92
B+	1%	1,641	1,523	11,201	3.54
B+	0.5%	1,768	1,730	15,658	4.48
B+	0.1%	2,032	2,257	32,568	7.59

The rating classes refer to the individual loans in the portfolio and α refers to the various quantiles of the loss distribution.

These are dramatic effects. Depending on the quantile, the true portfolio risk under the traditional approach would be underestimated by a factor 1.5 to 8. These strong effects clearly reflect a malign interaction of market and credit risk which cannot be covered by providing separately for market and credit risk. Holding separate risk capital for market and for credit risk is by far not sufficient to cover the true integrated risk capital. This does not come as a surprise. The main risk of foreign currency loans, namely the danger of increased defaults triggered by adverse exchange rate moves, is captured neither by market risk nor by credit risk models.

4 Conclusions

In this paper we challenge the traditional regulatory approach of separating risks into the familiar categories of market and credit risk. We argue that this approach is conceptually problematic because many portfolios cannot be neatly separated into a market subportfolio and a credit subportfolio. We argue that as a consequence risk assessment and the calculation of regulatory capital can be seriously flawed. Only if a portfolio is separable into market and credit subportfolios, can we be sure that calculating regulatory capital independently for market and credit risk will always provide an upper bound for the necessary risk capital when added up. The current regulatory approach is conservative only for separable portfolios. If portfolio positions depend *simultaneously* on market and credit risk factors, the nature of the risk assessment problem changes. If for such a portfolio market and credit risk are calculated separately, the portfolio valuation is flawed and will lead to a wrong assessment of true portfolio risk. Using the example of foreign currency loans, we show that under the current regulatory concepts we could have a serious underestimation effect of the true risk of such a portfolio.

These results imply that there is no general justification for the presumption that the appropriate regulatory capital for a portfolio subject to market and credit risk is lower than the sum of the regulatory capital calculated separately for these risk categories. It can therefore not in general be argued that banks that have implemented the Basel II capital requirements deserve a capital relief on the grounds that an integrated framework would automatically deliver capital savings not realized under the current approach.

In keeping with our example of the foreign currency loan portfolio, the exchange rate may alternatively be interpreted[2] to be both a market and a credit risk factor. The exchange rate is a market risk factor because it has an effect on the portfolio value in case no defaults happen, but it is also a credit risk factor because it has an effect on the size of default losses.

If a risk factor affects both market and credit risk, one basic assumption of our analysis in section 2 fails: Credit risk factors are not separate from market risk factors. Imposing such a separation amounts to committing a modeling error in either the market or the credit risk model. (This modeling error is related but not identical to the modeling error our analysis reveals in the forced separation of a portfolio into a market and a credit portfolio.)

A proper model of credit risk has to take into account all risk factors which have an effect on default losses. For the foreign currency loan portfolio this means that the credit risk model has to reflect moves of the exchange rate or other “market” risk factors which have an effect on default losses. It usually takes an integrated model to meet this requirement rather than a credit risk model. Similarly, the market price of a position reflects expected default losses, even if default has not yet occurred or may never occur. Therefore a proper market risk model has to take into market value changes caused by

[2] *We thank the referee for this suggestion.*

changes in default probabilities, default correlations or loss-given default – which will in fact only be possible with an integrated model.

In the example of foreign currency loans, counting the exchange rate as either a market or a credit risk factor but not as both will underestimate the other risk. In our analysis we counted the exchange rate among the market risk factors and kept it fixed in the credit risk analysis. This produced credit risk numbers far below the true integrated risk, as a comparison of the columns RC(Δc) for credit risk capital and RC(Δv) for market risk capital shows. In this interpretational framework our results show that an approximate credit risk analysis assuming fixed values of the market risk factors can dramatically underestimate true credit risk if market and credit risk interact.

Both interpretations of our analysis imply that a separate calculation of pure market risk and pure credit risk is not an admissible approximation to integrated risk if market and credit risk interact.

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