Current Trends in Prudential Regulation of Market Risk: From Basel I to Basel III

Alexey Lobanov

REA Research Risk Management Group, Non-Commercial Partnership,
and PRMIA Russia Steering Committee, Moscow, Russia

Abstract The recent financial crisis has again evoked interest in regulation of bank risks in general and of market risks in particular. Heavy losses on trading portfolios incurred by some of the largest banks have elicited deficiencies in their internal models and processes for managing market risks. The magnitude of losses and the volume of government-sponsored bailouts have raised doubts about the effectiveness of regulatory approaches proposed by the Basel Committee on Banking Supervision in the mid-1990s and later incorporated into Basel II. These drawbacks were the main reason underlying the revision of the market risk capital regulation passed on by the Basel Committee in 2009 and laid the first building block in the 2010 reform package known as Basel III. The Basel capital requirements for market risks are discussed in the paper. The latest modifications to the internal models approach are shown to significantly increase minimum capital requirements for market risk and hence undermine its incentive-compatible design.

Keywords: Capital Requirements, Market Risk, Basel II, Internal Models Approach, Stressed VaR.

JEL classification: G21, G32

Introduction

As long as the expected loss due to market risk is generally not covered by specific provisions or fully hedged, capital is required to cover losses in excess of expected return including P&L from hedging (Lobanov, 2009).

When estimating the required capital from an internal, or economic, perspective, a bank pursues two distinct yet conflicting objectives. On the one hand, it strives to maximize its return on equity (ROE) or reach a target ROE given the portfolio size and structure. On the other hand, it needs to be solvent at a specified confidence level consistent with its risk appetite. The first of the two goals can be reached by reducing the level of capital relative to the bank's debt, while the most straightforward way of achieving the second goal is a contrary action, i.e. a decrease in leverage. The economic capital is therefore a trade-off between these opposite targets.

D. Sornette et al. (Eds.), *Market Risk and Financial Markets Modeling*,
DOI 10.1007/978-3-642-27931-7_13,

However, it is not as clear which motivation is right for a regulator imposing capital requirements. For instance, the minimum capital adequacy ratio may be set to make sure that the bank is solvent in normal times, i.e. has enough capital to absorb an abnormally long series of 'normal-size' losses. The regulator could also be interested in ensuring that the bank remains solvent after a severe one-off firm-specific loss, such as incurred by Barings in 1995 or Societe General in 2007 due to rogue traders. The supervisory authority would definitely like to avoid a situation in which it would need to recapitalize banks during or after a severe financial crisis, as was the case with UBS or RBS in 2008.[1] Ultimately, the regulator may prefer that banks hold a capital cushion against not only their 'standalone' risks but also (a portion of) systemic risk, i.e. an unexpected build-up of losses propagated through interlinkages of financial institutions. Clearly, each of the above goals implies different minimum capital requirements for banks.

Basel Approaches to Setting Capital Requirements for Market Risk

The Basel Capital Accord from 1988 was aimed at credit risk and did not take market risk into account. Market risk was only marginally recognized as a magnifier of credit risk, e.g. as reflected in the risk weight of 100% for FX-denominated claims on central governments or in add-ons for calculating the credit-equivalent amounts of derivatives. In 1993, the Basel Committee proposed a standardized approach to the treatment of market risk, followed by an internal-models approach in 1995. Both the approaches were released in the 1996 Amendment to the Basel Capital Accord to incorporate market risk, implemented in G-10 member countries by 1998, and incorporated into Basel II with some minor alterations in 2006.

Under the standardized approach, banks must reserve capital against interest rate risk and equity risk in the trading book (both calculated as the sum of general market risk and idiosyncratic 'name' risk) plus currency risk and commodity risk across the bank. While interest rate risk in the banking book was left out of this framework, equity risk in the banking book is accounted for either through deductions from total capital (for non-consolidated equity holdings in subsidiaries) or through credit risk capital charge (by applying a 100% risk weight to other equity investments). The risks are aggregated by simple summing to arrive at the total capital requirement.

Being a 'one-size-fits-all' framework, the standardized approach has been a simple but crude shortcut to estimate the regulatory capital. One of its main drawbacks is that it does not allow banks to recognize non-perfect correlations inside and across risk types on a portfolio level which leads to overestimation of capital requirements for low-risk (e.g. hedged) portfolios.

The internal models approach was devised to overcome most of the shortcomings of the standardized approach. It was the first time banks were offered the pos-

[1] In all cases, it is in the interest of the government to minimize the spending of public funds to bail out banks, even if this aid must be repaid.

sibility to calculate regulatory capital using their own estimates of market risk, subject to certain minimum qualitative and quantitative requirements. Under the internal models approach, market risk capital charge is a function of the bank's internal VaR estimates:

$$MRC = \max\left(m \cdot \frac{1}{60} \sum_{i=1}^{60} VaR_{t-i}, VaR_{t-1} \right). \quad (1)$$

where m is a supervisory multiplier subject to the minimum value of 3 (for VaR-models deemed adequate based on backtesting results).

The historical observation period for estimating volatilities, correlations and other input parameters must be at least 250 trading days. The bank must perform backtesting of its VaR-model at least quarterly and, in case of inadequacy, adjust the value of the multiplier m.

If the specific risk of interest rate and equity positions in the trading book is not fully captured by their VaR-models, banks must calculate it using standardized methodology and add it to the VaR-based capital charge as a surcharge. To properly reflect specific risk, the model must meet the following criteria (Basel 2006):

- explain the historical price variation in the portfolio (e.g. has an in-sample R^2 of 90%[2]);
- capture concentrations in the portfolio (magnitude and changes in composition);
- be robust to an adverse environment (e.g. through using a full-cycle historical observation period, simulation, or worst-case scenario analysis);
- capture name-related basis risk (the differences between similar but not identical positions not attributable to the general market risk);
- capture event risk (e.g. migration risk for debt, mergers/takeovers for equity);
- be validated through backtesting.

Event risk beyond the 99% confidence level and 10-day holding period not captured by the model must be factored in, e.g. through stress testing, while market liquidity risk must be reflected through scenario analysis and conservative proxies.

The regulatory multiplier m was widely debated in the academic and professional communities. Many have viewed it as a means to combat 'objective' model risk arising from the estimation error due to the high confidence level. However, the high minimum value of the multiplier could indicate that the Basel Committee intended to also mitigate 'subjective' model risk. In other words, the multiplier could be meant to serve as a penalty imposed to counterbalance incentives to underestimate VaR and thus minimize regulatory capital.

Here it should be noted that such multipliers have long been used in the industry to calculate economic capital. For instance, a multiplier could have been calibrated

[2] Apparently, the required goodness-of-fit pertains to the total variation of returns caused by both general and specific market risk. Regression models with a high in-sample R^2 are generally overfitted (i.e. have too many degrees of freedom) and, as a result, have low out-of-sample predictive power.

as a long-run historical average ratio of stress-test results to average VaR (Monet, 2001). In this case, it would have served to build a capital cushion to absorb losses caused by sharp market movements at the onset of a financial crisis. Other possible interpretations of the multiplier include an implicit capital requirement for market liquidity risk or a 'penalty' for a missing or ineffective corrective action of bank's management to reduce its exposure to market risk.[3]

The multiplier's minimum value of 3 has also come under criticism. Kupiec and O'Brien (1997) in their pre-commitment approach argue that the multiplier is redundant and capital should be set equal to an bank's own loss projection, such as VaR. Lucas (1998) shows that the current minimum value of the multiplier is too low and the add-ons applied to it for models from the 'yellow' zone are not effective to curb the bank's incentives to 'game' the regulator. As a result, the bank is likely to significantly underestimate its VaR figures reported to the regulator for capital adequacy purposes. He suggests using a steeper step-wise penalty function for setting the appropriate value of the multiplier so that its highest value would be more than twice as high as proposed by the Basel Committee (i.e. 8–10 instead of 4). According to internal estimates of J.P. Morgan (Monet, 2001), the multiplier in the real world should be about 12 for some portfolios.

The internal models approach had a truly revolutionary meaning for the industry in that banks were not demanded to have any specific model type for calculating VaR. However, the banks are required to use the same model not only for calculating regulatory capital but also for other internal tasks including limit setting for market risk. Under this approach, banks also must conduct regular stress testing of their portfolios and report the results to the regulator.

The internal models approach looks very appealing for banks but is not free from deficiencies, of which perhaps the most important one is a strong incentive for banks to play down their risk and capital numbers. Given the information asymmetry between the bank and the regulator, the latter has only limited ability to detect and prevent model-related abuses (e.g. the use of multiple models for reporting and internal purposes). For riskier portfolios, a more accurate risk estimate automatically translates into a higher capital charge compared to the standardized approach. This helps explain why most banks preferred to stay with the standardized approach.[4] At the same time, there is some evidence that banks working under the internal models approach may be using overly conservative models, apparently to avoid regulatory interference (Jeffery, 2006).

The design of the internal models approach is not flawless either. One of its shortcomings is that the Basel add-ons to the multiplier for 'yellow-zone' models might be too conservative, as banks may quickly improve their VaR models after backtesting.[5] Another weakness lies in the requirement to compare daily VaR num-

[3] For instance, the trading desk's stop-loss limits may be missing or too lax.

[4] See, e.g., Holtdorf et al. (2004).

[5] Live testing of VaR models could ameliorate this problem; however, it is not allowed by the Basel Committee for capital adequacy purposes. One approach to live testing is proposed by Lobanov and Kainova (2005).

bers with both actual P&L (the so-called 'dirty' backtesting) and theoretical P&L ('clean' backtesting)[6] which may lead to controversial conclusions about the model accuracy.

It is worth noting that a simplified version of the standardized approach was already introduced by the Central Bank of Russia in 1999 in its Regulation 89-P (Bank of Russia, 1999). In 2007 it was superseded by Regulation 313-P (Bank of Russia, 2007) which differs from Regulation 89-P only in some details.

While the Central Bank of Russia has not attempted to introduce the internal models approach over the past ten years, the Federal Securities Commission, the regulator of the securities market in Russia, considered implementing a modified version of this approach in 2001. The approach was intended for all non-bank professional market participants that would have to assess daily the adequacy of available funds based on the VaR of their trading books. The most important modifications of the Basel framework concerned the holding period for calculating VaR (20 days for non-listed securities), the capital multiplier (only three possible values were proposed: 3 for adequate models, 4 for 'conditionally adequate' models and 5 for inadequate models), and the backtesting of the internal models (authorized third parties could perform the backtesting besides the regulator; if the financial institution would like to waive the backtesting, its minimum available funds were set equal to the book value of positions).[7]

Market Risk Regulation under Basel III

The global financial crisis of 2007/08 has had a strong impact on the implementation of Basel II in the developed countries. As the inadequacy of both the above regulatory approaches have become apparent, the Basel Committee (2009) had to make significant adjustments including higher capital charges for a specific interest rate risk of securitized assets under the standardized approach and the introduction of 'stressed VaR' as an additional charge in the internal models approach. In the following discussion, we will briefly examine the latter amendment.

Starting from 2011, the capital requirement for market risk must be calculated in the following way:

$$MRC = \max\left(m_c \cdot \frac{1}{60}\sum_{i=1}^{60} VaR_{t-i},\ VaR_{t-1}\right) + \max\left(m_s \cdot \frac{1}{60}\sum_{i=1}^{60} SVaR_{t-i},\ SVaR_{t-1}\right) = \quad (2)$$
$$= \max\left(m_c \cdot VaR_{avg}, VaR_{t-1}\right) + \max\left(m_s \cdot SVaR_{avg},\ SVaR_{t-1}\right),$$

[6] Theoretical P&L is calculated for a static portfolio as a result of changes in market prices of its constituent positions over the trading day, while actual P&L is the true P&L booked by the bank which can be 'contaminated' by intraday trades and fees earned by the brokers.

[7] Market participants would have to supplement VaR calculations with regular stress testing of proprietary and client portfolios over a set of scenarios specified by the Federal Securities Commission.

where *SVaR* denotes the stressed *VaR*, m_c and m_s are regulatory multipliers, each subject to the absolute minimum of 3.

Assuming that the average values of *VaR* and *SVaR* multiplied by m_c and m_s respectively are higher than the previous day's estimates of *VaR* and *SVaR*, expression (2) can be reduced to:

$$MRC = m_c \cdot VaR_{avg} + m_s \cdot SVaR_{avg}. \quad (3)$$

A stressed VaR must be calculated by the bank at least weekly using the same model and input parameters as the 'normal' VaR (i.e. 99% confidence level and 10-day holding period). The only difference lies in the sample of historical data: The stressed VaR is calculated over the continuous 12-month period of significant financial turbulence. The Basel Committee recommends using a yearly period related to the most recent crisis of 2007/08. However, the regulator may permit a bank to use another time frame more relevant for its portfolio. Backtesting is not applied to stressed VaR for obvious reasons.

As in Basel II, the bank's VaR model must account for the specific risk of interest rate and equity instruments in the trading book. For interest rate instruments in the trading book that are subject to the specific risk capital requirement, the bank must also have a methodology to reserve capital against so-called 'incremental' risk, which encompasses default risk and rating migration risk not reflected in its VaR-model (Basel Committee, 2009)[8]. Incremental risk can be accounted for in the internal model or calculated separately as a surcharge under the standardized approach, if the bank's internal model does not capture incremental risk. In either case, the bank must ensure that the incremental risk estimate for a position in the trading book is not less than would be required against credit risk of this position in the banking book under the internal ratings-based approach. However, the Basel Committee no longer demands that banks capture the risk of low-probability, high-severity events beyond the 10-day holding period and 99% confidence level.

The incorporation of stressed VaR into the regulatory formula (2) reflects the industry trends that have long manifested themselves in internal methodologies for allocating economic capital developed by large dealer banks. For instance, J. P. Morgan calculated in the early 2000s its economic capital for market risk (EC) in the following way (Monet, 2001):[9]

$$EC = K \cdot Risk\ Index, \quad (4)$$

$$Risk\ \ Index = 50\% \cdot M \cdot VaR(1\ day,\ 99\%) + 50\% \cdot Stress\,Loss\ , \quad (5)$$

[8] Default risk and rating migration risk are removed from the definition of specific risk to avoid double-counting.

[9] J. P. Morgan (see Monet, 2001) reported that the Risk Index was about 1.2 annual standard deviations of revenue (varied by business).

where *K* denotes a capital multiplier applied to Risk Index (it was set equal to 2 for portfolios managed to an index and to 4 for other portfolios);

M is a multiplier set for each business based on a long run historical ratio of stress test to VaR;

Stress Loss is a historical or hypothetical estimate of extreme monthly losses based roughly on the worst month in the previous 15 years.

The second term in formula (2), reflecting the contribution of stressed VaR to the capital requirement, can be viewed as analogous to the Stress Loss parameter in J. P. Morgan's methodology (5). The major difference between them is that the Stress Loss in the Risk Index is estimated through stress testing, i.e. scenario analysis, while the Basel Committee requires obtaining a stressed VaR by means of the bank's VaR-model. The Basel Committee (2009) does not prescribe any specific ways of calculating the stressed VaR, yet suggests applying e.g. 'antithetic' scenarios or absolute rather than relative volatilities.

Admittedly, the idea of using VaR-models for stress testing is also not entirely novel. Best (1999) proposed stressing VaR for variance-covariance or Monte-Carlo based models by varying volatilities and/or correlations as their input parameters. It should be noted, however, that the covariance, or delta-normal, method for calculating VaR and, to a lesser extent, its higher-order modifications including delta-gamma and delta-gamma-vega are based on linear approximations of price changes to (infinitely) small increments of risk factors (so-called 'deltas'). For options and other instruments with non-linear payoff functions, the approximation error grows with the increase in changes of underlying risk factors. Since stress testing by definition presumes extreme jumps of risk factor values, the usage of such models requires estimating the linear sensitivity of position prices to such large changes or, alternatively, stressing only a correlation matrix rather than a covariance matrix.

The purpose of the multiplier m_s from the Basel formula (2) is unclear, as scaling up stress losses does not meet any of the possible interpretations of a capital multiplier considered above. While applying the first multiplier (m_c) could be justified by the need to hold capital against unexpected losses caused by a sharp increase in volatility, we cannot help observing that the second multiplier (m_s) has been introduced only to enhance the minimum capital requirement. To show this, notice that the average SVaR at any given time for a given portfolio will almost always be at least as high as the average portfolio VaR. This allows formula (3) to be rearranged as follows:

$$MRC = m_c \cdot VaR_{avg} + m_s \cdot \left(VaR_{avg} + SVaR_{avg} - VaR_{avg}\right) = \left(m_c + m_s\right) \cdot VaR_{avg} + m_s \cdot \left(SVaR_{avg} - VaR_{avg}\right) \quad (6)$$

Recalling the minimum value of 3 for each of the multipliers, it is straightforward to see that market risk must now be covered with bank capital *at least* sixfold compared with the minimum ratio of three in Basel II before the 2009 revisions. As the Basel Committee allows banks to scale up their daily VaR figures to 10-day holding period by multiplying them by the square root of 10, the minimum capital will be about 19 times higher than the average daily VaR. It can be easily shown that formula (6), combined with capital charges for specific and incremental risks, may

yield a capital requirement in excess of the market value of the position,[10] which obviously does not make economic sense. It should be noted that the Basel Committee (2009) has not bounded the minimum capital requirement for market risk with the market value of the position similar to the cap imposed for credit risk (Basel Committee, 2006).

Surprisingly, the overhaul of the internal models approach has not been extended to the equity risk in the banking book, i.e. to non-consolidated equity holdings subject to credit risk capital charge. Under one of the possible approaches to treating this risk, the so-called 'internal models method', banks may set the regulatory capital for these investments equal to a 99% VaR measure calculated for the difference of the equity's quarterly returns and a risk-free rate estimated over a long-term observation period (Basel Committee 2006).

An Example of Calculating a Market Risk Capital Charge for a Portfolio of Russian Stocks

Let us consider an illustrative example of calculating capital charges for equity risk in compliance with the version of the standardized framework used by the Central Bank of Russia (Bank of Russia, 2007) and the internal models approach before and after the 2009 revisions[11]. A sample trading portfolio consists of liquid Russian stocks from the MICEX10 Index, in which position sizes are inversely proportional to the prices of the respective stocks (see Table 1).

All calculations were conducted as of 30th December, 2010 based on MICEX closing prices. VaR numbers were obtained using three different methodologies: historical simulation, Monte Carlo simulation, and a variance-covariance approach. For the latter two models, a conservative assumption of a zero expected return was made. All the VaR-models were found adequate based on backtesting results and, as they qualified for the 'green zone', both the capital multipliers were set equal to their minimum values of three.[12]

Under the standardized approach, the minimum capital requirement for equity risk is 12% of the portfolio value. When turning to the internal models approach, the capital charge is significantly higher and ranges from 38.1% for Monte Carlo simulation to 42.2% for historical simulation. Adding scaled stressed VaR under Basel III leads to almost doubling of the regulatory capital and varies from 85.2%

[10] The capital requirement will exceed the market value of the position if the average 10-day VaR is at least 1/6=0.167 of the position value. For the one-day VaR, this threshold is met already at VaR equal to 1/19=0.053 of the position value. Such volatility is not infrequently observed in practice, especially in emerging markets. Given the second positive term in formula (6), the threshold levels of VaR at which market risk capital surpasses the position value are in fact even lower.

[11] See formulas (1) and (2) above.

[12] Model backtesting, VaR and capital calculations in this example were conducted using *Prognoz. Market Risk* software. The author thanks Sergey Ivliev (Prognoz) for sharing the data and computation results.

for Monte Carlo simulation to 89.4% for historical simulation (see Table 1 for details).

Table 1: An example of calculating market risk capital under different approaches

Instrument	Position size, # of shares	Market value, RUB	Market risk capital (MRC) before 2009 Basel II revisions, %[1]			Stressed VaR, %
			Monte Carlo simulation	Historical simulation	Variance-covariance	
AK Transneft (pref)	26	982,670.00	69.51	63.23	69.15	23.03
VTB	9,900,990	999,999.99	46.56	56.90	47.24	20.37
NorNickel GMK	140	1,003,100.00	39.16	31.67	39.01	16.98
Gazprom	51,680	1,000,008.00	39.39	37.08	39.56	25.43
LUKOIL	574	999,908.00	37.50	36.70	37.41	24.75
Rosneft	4,569	999,925.65	46.72	50.44	46.49	17.28
RusGidro	606,428	999,999.77	45.77	47.45	46.54	15.19
Sberbank	9,599	1,000,023.82	47.73	46.35	47.93	20.19
Sberbank (pref)	13,316	1,000,031.60	49.59	48.13	49.48	26.52
Severstal	1,924	1,000,191.40	57.88	47.41	56.83	14.94
Portfolio	MRC under Basel II[1]	9,985,858.23	38.13	42.23	38.34	
	MRC under Basel III[2]		85.26	89.35	85.47	15.71

[1] By formula (1) with $m = 3$.
[2] By formula (2) with $m_c = m_s = 3$.

Conclusion

The modifications of the internal models approach introduced by the Basel Committee in 2009 bring about a significant increase in minimum regulatory capital for market risk due to a stressed VaR add-on. Although some banks have long reserved economic capital against a loss that might be incurred during a market crisis, they mostly used scenario-based stress testing to size up such a loss. The Basel Committee requires obtaining this estimate with the same VaR-models banks use under normal market conditions. This might potentially entail significant approximation errors for non-linear positions if large price shocks are modeled using a linear approximation to changes of risk factors. The multiplier applied to translate a stressed VaR into the regulatory capital lacks a clear economic explanation. More-

over, under some plausible conditions, it can produce a capital requirement that exceeds the market value of the portfolio.

Some tentative calculations performed for a portfolio of liquid Russian stocks indicate that the new Basel III rules lead to more than a doubling of regulatory capital compared to the original 1996 version of internal models approach. Unlike Volcker Rule (U.S. Congress, 2010) that restricts proprietary derivatives trading and equity investments of U.S. banks, Basel III makes banks increasingly cover market risk of their portfolios with their own funds. Unsurprisingly, the internal models approach may lose its incentive-compatible design for banks that are currently using it and become even less attractive for banks working under the standardized approach.

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