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MARKET RISK CHARGE OF THE TRADING BOOK: A COMPARISON OF BASEL II AND BASEL III

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Abstract

This paper aims to investigate if the market capital charge of the trading book increased in Basel III compared to Basel II. I showed that the capital charge rises by 232% and 182% under the standardized and internal model, respectively. The varying liquidity horizons, the calibration to a stress period, the introduction of credit spread risk, the restrictions on correlations across risk categories and the incremental default charge boost Basel III requirements. Nevertheless, the impact of Expected Shortfall at 97.5% is low and long term shocks decrease the charge. The standardized approach presents advantages and disadvantages relative to internal models.

Key Words: *Market Risk*; *Basel*; *Standardized Model*; *Internal Model*

"Regulation isn't about preventing firms and banks from functioning. It's the reverse. Regulation is about the rules of the game, and also an independent enforcement of the rules of the game." – Jean Tirole (2014), Nobel Prize in Economic Sciences 2014

1. Introduction

Financial crisis have been devastating the global economic system proving the need for financial regulation and improvements in banking supervision. Thus, the governors of G10 central banks created what is presently named the Basel Committee on Banking Supervision (BCBS). This triggered the development of Basel Accords: Basel I, Basel II and Basel III. Even after the creation of BCBS, the existent regulation was insufficient to promote financial stability, as proved by the subprime crisis. This demonstrated the pitfalls of Basel II, forcing its rethinking, reformulation and consequent creation of Basel III. However, it must be analysed whether the new framework not only leads to an improved methodology for accounting minimum capital requirements, supervisory review process, market discipline and protection against liquidity risk, but also impacts the level of capital needed to support financial crisis. In turbulent economic periods, the level of prices and its volatility change: the possibility of losses due to these effects is named market risk. For the banking industry, such risk is present in the trading (i.e., securities that are expected to trade in the short-term or hedge the risk from such operations) and banking book. Hence, it is analysed if the market risk charge (MRC) of the trading book increases under the requirements of Basel III, relative to Basel II.

The results show that the capital charge augments under Basel III, except for interest rate risk: the internal model increases the charge between 66% and 182% while the standardized model boosts it from 64% to 232%. However, not all the new requirements introduced by Basel III lead to a higher MRC. Regarding the calculation of the risk statistic, assuming all the other requirements of Basel II, the varying liquidity horizons, the calibration to a period of stress, the introduction of credit spread risk and the limitation of diversification effects across risk categories increase the MRC. Nonetheless, Expected Shortfall (ES) at one-tail 97.5% leads to results similar to Value at Risk (VaR) at one-tail 99% and the application of long-term shocks decreases the charge. The lower MRC in interest rate risk under Basel III comes from the platikurtosis of interest rate returns in the stress period. In what concerns the capital add-on, even though the former framework comprises broader risks, Basel III provides a higher charge. The standardized approach presents advantages and pitfalls relative to the internal model: the stress period defined in the internal approach may not be the most volatile (risky) year but the standardized model may attribute higher risk weights (RW) to risk factors that are not the most relevant for the stress period of certain portfolios.

To address those issues, Section 2 defines financial risk and presents an overview of the BCBS and the capital requirements for the market risk of the trading book in Basel II and Basel III. Section 3, based on the fund BPI Reforma PPR – Investimento, explains the methodology followed to compute the differences of the MRC under Basel II internal model and Basel III (internal and standardized approaches) and which factors lead to that change. Section 4 analyses the results and, finally, section 5 presents the conclusions.

2. From Risk Measurement to Market Risk Charge of the Trading Book

2.1. Financial risk: an overview

Risk is defined as the uncertainty of outcomes that leads to negative effects on wealth, in other words, the possibility of losses. When this uncertainty comes from financial market activities, it is named financial risk. According to Jorion (2007), it is decomposed into operational, liquidity, credit and market risk. Operational risk results from internal problems or external events. Liquidity risk can be further divided into asset liquidity risk (a transaction cannot be done at market prices) and funding liquidity risk (inability to fulfil payment requirements). Credit risk arises when the counterparty defaults on contractual obligations. Market risk comes from changes in the level or volatility of market prices. This last class is based on five broad risk categories: interest rate, credit[1], equity, foreign exchange (FX) and commodity (BIS, 2006 and BIS, 2013).

To measure financial risk there is a set of methodologies as Value at Risk and Expected Shortfall. VaR (by convention a positive number) corresponds to the maximum loss for a financial security/portfolio for a target horizon such that there is a predefined probability. Statistically, there is a probability of α that the loss in the portfolio is higher than VaR:

$$Prob(\Delta V < -VaR) = \alpha \quad \text{(Equation 1)}$$

where ΔV stands for the difference between the change in portfolio value and expected value and α corresponds to the significance level (Jorion, 2007). However, VaR has been criticized as it does not account for kurtosis and skewness, leading to estimation errors. Moreover, a coherent risk measure must satisfy four axioms: monotonicity; translation invariance; homogeneity and subadditivity (Artzner et al, 1999). Nevertheless, VaR does not satisfy this last property: subadditivity states that the risk of a portfolio is at most equal to the sum of the risk of its constituents; using VaR, diversification may not lead to risk reduction. To correct that, it was proposed the use of ES since it takes into account the left tail and met the four axioms for a coherent risk measure (Acerbi et al, 2002). This risk measure is defined as the expected loss from the worst α situations:

$$ES = -E[\Delta V | \Delta V \leq -VaR] \quad \text{(Equation 2)}$$

2.2. Basel framework: the need and evolution of risk regulation

After World War II, financial intermediation gained a growing importance, given the low limits and controls in financial flows and the soaring international communication. Thus,

[1] Credit risk - spread (including migration) and default - is a category introduced by Basel III. Basel II only accounts for specific risk, which includes default risk. The revisions of 2009, Basel 2.5, also require the migration risk.

in the early 1970s, two groups were created to promote international financial regulation: Groupe de Contact and The Euro-currency Standing Committee. Also in this decade, financial markets faced several problems: the Bretton Woods system collapsed; the oil price crisis; banking financial crisis, including the bankruptcy of Bankhaus Hersatt and Franklin National Bank of New York. Nonetheless, the entities already created did not have enough capabilities to face the situation. Hence, central bank governors of G10 created the Committee on Banking Regulations and Supervisory Practices, later renamed Basel Committee on Banking Supervision (BCBS) to make recommendations to improve banking supervision. In 1975 they issued the *Concordat.*

Basel I: Given the 1980's debt crisis in Latin America, the BCBS issued, in 1988, the *Basel Capital Accord* (Basel I). Since, this framework was only focused in credit risk, in 1996 it was published the *Market Risk Amendment to the Capital Accord*.

Basel II: In 2004, BCBS issued the *International Convergence of Capital Measurement and Capital Standards: a Revised Capital Framework*, focused on three pillars: minimum capital requirements (MCR) – sum of credit risk charge (CRC), market risk charge (MRC) and operational risk charge (ORC) –, supervisory review process and market discipline. This accord aims to improve accountability of underlying risks and financial innovation.

Basel III: Even before the Lehman Brothers bankruptcy and the subprime crisis, the BCBS recognized that Basel II should be revised, namely in what concerns complex securitization, and off-balance sheet and trading book exposures. Thus, in 2009, Basel II was revised, giving rise to Basel 2.5, which intended to improve the accountability of market and liquidity risk. In 2010, Basel III proposed to enhance capital (*Basel III: a global framework for more resilient banks and banking systems*) and introduced liquidity principles (*Basel III: International framework for liquidity risk measurement, standards and monitoring*). This new framework should be fully implemented in 2019.

2.3. Trading Book and Banking Book: the Regulatory Boundary

Financial instruments and commodities hold by a bank may belong to the trading or banking book. The BCBS recognized that Basel II presented weaknesses in what concerns the regulatory boundary, thus Basel III aims to correct the gaps found. Both frameworks proposes that the trading book should include the instruments that the bank: "a) holds with the intention of short-term resale; b) holds with the expectation of profiting from actual or expected short-term price movements; c) holds with the intention of locking in arbitrage opportunities; or d) holds for the purpose of hedging risks resulting from instruments meeting criteria a, b or c, above" (BIS, 2013: 48). While Basel II presents a definition of the boundary based on an intent-based approach (i.e., bank defines if its intention met the previous criteria), Basel III defines general presumptions for the instruments that should be included in the trading book as long as one of the criteria referred above is satisfied. Furthermore, the previous accord does not carefully analyse the instruments that should be included in the banking book. Hence, Basel III proposes that positions that cannot be easily liquidated or fair valued on a daily basis should be excluded from the trading book.

2.4. Market Risk Charge: Standardized Approach and Internal Model

Basel II and Basel III present two approaches for the definition of MRC: standardized and models-based. The first defines explicit rules that banks must follow to obtain the MRC (if a particular instrument is not analysed, the standards should be applied by analogy). The second is based on models internally developed by the bank that must be approved by the supervisory authority (the BCBS provides qualitative and quantitative requirements that must be met). Basel III aims to provide a closer relationship between both approaches.

2.4.1. Standardized Approach

The BCBS recognized that there were features that must be improved in Basel II standardized approach, such as the risk sensitivity and the application of diversification and hedging effects. This approach is analysed under Basel III. According to this model, instruments must be decomposed into notional positions and allocated to risk categories and buckets. Market value is applicable to equity, commodity and credit default risk; discounted cash-flows are accounted in interest rate (only fixed cash-flows) and credit spread risk. In FX risk, it is considered the market value for equities, commodities and FX and the fixed discounted cash-flows for fixed income. Notional value of the underlying asset is applicable in derivatives and further defined according to the requirements of the broad risk category (in forwards and futures, the price is considered in interest rate risk).

Notional positions are allocated to buckets based on the security features. Under interest rate risk, according to the maturity of cash-flows, positions are proportionally allocated to vertex points, separately for each currency. Credit risk, besides the residual bucket, distinguishes 12 buckets characterized by credit quality of the asset and main sector of the issuer. These are then decomposed according to the maturity of the cash-flows. Equity risk, aside from the residual bucket, is decomposed on 10 buckets characterized by market cap, region of operation and main sector. FX risk positions are grouped by currency and assigned to the closest bucket (based on maturity). Positions denominated in a foreign currency should be converted at the spot rate in the domestic currency.

Basel III presents formulas to compute the charge for each risk category (see Appendix 1 for more detailed information), including offsetting of positions, RWs and correlations within each bucket[2] and across buckets (not recognizable in the residual bucket). The RWs and correlations are based on the same requirements as the internal model (see 2.4.2. below, for more detailed information). The standardized market risk charge (SMRC) for the trading book is given by the sum of that requirement for each risk category.[3]

[2] Correlation is higher for diversification (positions with the same sign) than for hedging (positions with different sign).
[3] Correlations across different risk categories are not recognized.

2.4.2. Internal Models Approach

Internal models must comply with qualitative and quantitative requirements to receive approval from the supervisory authority. Although Basel III deepens previous qualitative requirements, they remain similar. The BCBS demands an independent unit within the bank responsible for risk management, independent appraisals, and involvement of top management in the process. The BCBS also requires the model integration with risk measures, compliance with internal methods, continuous integrity[4], and stress testing.

Even though both frameworks allow the estimation of correlations within broad risk categories and require the fulfilment and calculation of MRC on a daily basis, quantitative requirements present notorious differences. Basel II (see BIS (2006) for details), demands a 10-day VaR at one-tail 99% confidence level. A daily VaR is calculated being scaled by $\sqrt{10}$. This risk measure is complemented with the specific risk from interest rate and equity prices. The internal model risk charge (IMRC) is given by the higher of the following: previous day VaR (VaR_{t-1}); product of the average VaR of the previous sixty business days (VaR_{avg}) and a multiplication factor (m)[5] – Equation 3. The multiplication factor is set to a minimum of 3 which may increase up to 4 if backtesting reveals an inaccurate model[6].

$$\mathrm{IMRC}_{\mathrm{Basel\ II}} = \max\left(\mathrm{VaR}_{\mathrm{t-1}}, \mathrm{m} \times \mathrm{VaR}_{\mathrm{avg}}\right) \qquad \text{(Equation 3)}$$

Regarding Basel III (see BIS (2013) for details), the BCBS requires stressed ES[7], as it provides a more stable model and less sensitive to extreme outliers. It is demanded a one-

[4] The integrity of the model is evaluated by backtesting and, in the new framework, Profit and Loss (P&L)

[5] Risk categories not yet covered by the internal model or specific risk not modelled in VaR are capitalized using SMRC. The MRC for these risks is a capital add-on to VaR in Equation 3.

[6] The penalty depends on the number of daily exceptions across the preceding year. Exception is defined as $Profit_{t+1} < -VaR_{t+1|t}$, being VaR for a one-day holding period and one-tail 99% confidence level.

[7] The utilization of the ES instead of VaR leads to a coherent risk measure (Artzner et al, 1999; Acerbi et al, 2002). The calibration of the risk measure to a period of stress is not a novelty implemented by Basel III: Basel 2.5 requires the inclusion of stressed VaR in the calculation of capital charge (BIS, 2009a). This intends to reproduce the risk measure "that would be generated on the bank's current portfolio if the relevant market factors were experiencing a period of stress" (BIS, 2012: 10), enlarging the risk measure as demonstrated in the Quantitative Impact Study (QIS) took in 2009.

tail 97.5% confidence level (BCBS believes that provides a similar risk measure to VaR at one-tail 99% confidence level (BIS, 2013)) and the holding period depends on the liquidity horizon[8] (from 10 to 250 days) to account for liquidity risk. The varying liquidity horizons meets the argument "the relevant horizon will, in particular, likely vary with orientation (…), position in the firm (…), asset class (…), and industry" (Christoffersen and Diebold, 2000:12): the hypothetical portfolio exercise (HPE) taken in 2014 proved that this change increases the MRC. Besides, instead of computing 1-day returns and then scaling them to the aimed liquidity horizon, it is directly applied the desired horizon, following Hallerbach (2003) suggestion. Scaling the standard deviation is only appropriate for normal i.i.d. distributions and this technique over-estimate VaR for fat tail distributions (Christoffersen et al., 1998 and Provizionatou et al, 2005). The ES must be calibrated to a 1-year stress period, defined as the 12 month in which the portfolio faced the largest loss since 2005, using a reduced set of risk factors[9]: $ES_{R,S}$. This value is scaled by the ratio of the ES using the full set of risk factors on the previous 12 months ($ES_{F,C}$) and the ES using the reduced set of risk factors on the last 12 months ($ES_{R,C}$) – see Equation 4.

$$ES = ES_{R,S} \times \frac{ES_{F,C}}{ES_{R,C}} \qquad \text{(Equation 4)}$$

Even banks allowed to apply that approach may exclude desks if they are out-of-scope or fail quantitative criteria: the standardized approach must be used. For desks that obtain approval, it is determined the modellable factors. For non-modellable risks, it is also used the ES at 97.5%, but the holding period is the maximum of the largest period between two price observations over the last year and the regulatory liquidity horizon (SES). The total

[8] BIS (2013) defines liquidity horizon as "the time required to execute transactions that extinguish an exposure to a risk factor, without moving the price of hedging instruments, in stressed market conditions".
[9] The reduced set of risk factors is composed by relevant risks that fulfil data quality and availability requirements, explaining at least 75% of the variation of the full ES model.

SES is obtained by summing the SES of each non-modellable risk. The IMRC for eligible desks (C_A) follows the rationality required by $IMRC_{Basel\ II}$ (excluding specific risk), but limiting correlation across risk categories (i), as shown by Equation 5 and Equation 6:

$$C_A = \max\left[IMCC_{t-1} + SES_{t-1}, m \times \left(IMCC_{avg} + SES_{avg}\right)\right] \quad \text{(Equation 5)}$$

$$IMCC=\rho\left(ES_{R,S}\times\frac{ES_{F,C}}{ES_{R,C}}\right)+(1\text{-}\rho)\left(\sum_{i=1}^{R} ES_{R,S,i}\times\frac{ES_{F,C,i}}{ES_{R,C,i}}\right) \quad \text{(Equation 6)}$$

The risk charge for not eligible trading desks (C_U) is obtained by summing the SMRC of each ineligible trading desk. Incremental default risk charge (*IDR*) is applicable to all positions, except the ones subject to SMRC or which valuations depend only on commodity prices or FX rates. “Banks must use (…) default correlations based on listed equity prices (…) based on a period of stress. The VaR calculation must be done weekly and be based on a one-year time horizon at a one-tail, 99.9th percentile confidence level” (BIS, 2013: 93) . Probabilities of default are set to a minimum of 0.03%. This charge is incremental, i.e., in excess to losses from mark-to-market, and defined as the maximum of average IDR of the last 12 weeks or the previous IDR. Hence the IMRC for the trading book in Basel III is given by the following equation:

$$IMRC_{Basel\ III}=C_A+C_U+IDR \quad \text{(Equation 7)}$$

3. Data and Methodology

In order to analyse the MRC of the trading book it is used the portfolio BPI Reforma Investimento – PPR at July 31, 2014: a diversified portfolio designed for long-term and moderate risk-averse investors. It is assumed that the trading book[10] includes cash, deposits, sovereign bonds, T-Bills, corporate bonds, stock, funds and ETFs and futures (on indexes, interest rates and FX) – see Table 1 for more details.

[10] It is assumed that all assets respect at least one criteria to be included in the trading book, except forward contracts, certain futures, a Lehman Brothers bond and commercial paper for which there are no market data available.

Table 1: Composition of BPI Reforma Investimento – PPR (Gross Values)

Security	EUR	%
Cash	7 875 478	2%
Deposits	30 932 487	8%
Sovereign Bonds and T-Bills	167 895 713	45%
Corporate Bonds	53 947 206	15%
Stock	40 311 722	11%
Funds and ETFs	60 262 625	16%
Futures	8 799 245	2%
Total	370 024 476	100%

Source: CMVM, BPI

Financial data was retrieved from Bloomberg, considering that July 31, 2014 is the most recent day with available data. Data presents daily frequency, including only weekdays to ensure that regardless of the security, the observations refer to the same days.

The MRC is obtained respecting the recommendations and requirements presented by Basel II and Basel III. In order to calculate the risk charge, securities must be allocated to risk categories, as demonstrated in Table 2: it is considered the same allocation for the three models under analysis (except for credit risk that is not considered in Basel II).

Table 2: Risk Category Allocation by Security Type

<table>
<tr><th>Security</th><th>Basel II</th><th>Basel III</th></tr>
<tr><td>Cash</td><td colspan="2">Foreign Exchange*</td></tr>
<tr><td>Deposits</td><td colspan="2">Interest Rate</td></tr>
<tr><td>T-Bills and Bonds</td><td>Interest Rate, Specific</td><td>Interest Rate, Credit Spread, Credit Default</td></tr>
<tr><td>Stock and Funds, ETFs and Indexes+</td><td>Equity, Specific, Foreign Exchange*</td><td>Equity, Credit Default, Foreign Exchange*</td></tr>
<tr><td>Futures</td><td colspan="2">Interest Rate and risk categories of the underlying security</td></tr>
</table>

* Only applicable to securities denominated in a foreign currency. There are no T-Bills, bonds and deposits denominated in a foreign currency, whereupon this risk category was not mentioned in these security types.
+ Funds, ETFs and Indexes are treated as equity even if invested in bonds, as there is no residual bucket in interest rate risk and it is not possible to decompose the funds' cash-flows.

To obtain the SMRC, it is applied the methodology explained in 2.4.1.: however, further assumptions are made. The bond future has an underlying which is a synthetic bond: it is considered the equivalent position of the cheapest-to-deliver security. Bonds' rating is obtained through the average rating attributed to the security by the three major credit rating agencies (Moody's, Standard & Poors and Fitch): if not covered by these agencies, it is considered non-rated. The main region of operation of the issuer is based on the country presenting the largest sales.

Cash-flows are discounted using a risk free and a spread (where applicable). The risk-free rate is set for each individual currency, EUR and USD, assuming that the chosen instruments have no spread risk. For a 1 day maturity, it is considered the overnight interest rate. Overnight indexed swaps (OIS) are used to discount cash flows with maturity up to 1 year: Hull and White (2013) argues that OIS should substitute the interbank rate as the risk free. Interest rate swaps (IRS) are the discount rate for the remaining maturities: these are a better proxy for risk-free rates than sovereign yields (Feldhütter et al, 2008). As bonds have credit risk, cash-flows must be discounted through a risky interest rate: thus, it is added the option adjusted spread (OAS). Since OAS is only available for fixed rate bonds at Bloomberg, the remaining bonds are discounted by the Yield to Maturity (YTM).

There are cash-flows whose residual maturity does not match the maturity of the risk-free instruments. As swap curves do not continuously change slope (Fabozzi, 2002), the usage of splines and linear interpolation provides similar results. Despite the problems of linear interpolation (Fabozzi, 2002) and the existence of more accurate methods, as splines (Hagan and West (2006) gives an overview) and parametric models (as Nielson-Siegel (Nelson et al, 1987)), the first method was chosen given the easiness of implementation.

Regarding internal models, in Basel III, before computing the required statistics, it must be defined the stress period, i.e., the 1-year in which the portfolio suffered the largest loss across all risk categories. This loss corresponds to the difference in the notional positions, assuming that only the full set of risk factors under analysis changes over time [11]. Although it is required data since 2005, there are securities not tradable at that time. Prices previous

[11] As the definition of the stress period is based on the full set of risk factors, Equation 4 is simplified to $ES=ES_{F,C}$.

to the Initial Public Offer (IPO) on the stock exchange where the security is listed are based on its 1-day return – Equation 8 – and the diagonal model (Jorion, 2007) – Equation 9.

$$p_{i,t}=\frac{p_{i,t+1}}{r_{i,t+1}} \qquad \text{(Equation 8)}$$

For the day before the IPO, $p_{i,t+1}$ is the price at the end of the IPO day; for the remaining days, it is the estimated price for the next day. In Equation 8, $r_{i,t+1}$ is given by Equation 9.

$$r_{i,t+1}=\alpha+\beta\times r_{M,t+1} \qquad \text{(Equation 9)}$$

The regression is performed using monthly returns across 5 years[12]. This allows a good trade-off between data points, liquidity and background of the relation with the market. The market proxy (*M*) is an index representative of the stock exchange where the security (*i*) is listed. Several academics, as Levy (1971) and Blume (1975) proved that beta moves toward the mean of 1, Eubank and Zumwalt (1979) argued that adjusted betas reduce the forecast error and services (as Bloomberg, Thomson Reuters and Morningstar) use adjusted beta. Thereby, it is used Bloomberg's adjusted beta that follows Blume (1975) technique (as referred by McKinsey & Company (2010)). Regarding the credit spread, for sovereign bonds, prior to their issue, the spread (which is then linearly interpolated) is obtained by subtracting the risk free curve to the sovereign yield curve for each country; the iTraxx Europe for 3, 5, 7 and 10 years and iTraxx Europe Crossover for 5 and 10 years gives the spread for investment grade and high-yield corporate bonds, respectively.

Since neither framework demand a specific model, as long as the quantitative and qualitative standards are met, it is used the same model under Basel II and Basel III. Given the drawbacks related to the utilization of parametric and non-parametric models (see

[12] It is assumed monthly returns, since it is considered a holding period of 1 month (this matches the liquidity horizon of the majority of the notional positions in the portfolio), as this is the criteria defended by Levy and Gunthorpe (1994). A sample of 5 years conforms the optimal length argued by Alexander and Chernaby (1980) - 4 to 6 years – and the practice in the services, i.e., 2 to 5 years (Damodaran, 1999).

Manganelli and Engle (2001) for an overview), Filtered Historical Simulation (FHS) has been arising as a better solution (Pritsker, 2001 and Barone-Adesi et al, 2001). FHS, introduced by Hull and White (1998) and Barano-Adesi, Giannopolus and Vosper (1999), gathers historical simulation and parametric models: it uses the historical return distribution (considering skewness and kurtosis), but models volatility (accounting for heteroskedasticity) – Pristker (2001). VaR is based on Hull and White (1998) approach using Exponentially Weighted Moving Average (EXMA): the authors argue that their methodology turns the returns approximately stationary. For each portfolio *i*, given the n-day return for day t ($r_{i,t}$), it is estimated the EXMA standard deviation for day t ($\sigma_{i,t}$) and the scaled standardized return for day t ($r^*_{i,t}$)[13], as shown by Equation 10 and Equation 11.

$$r^*_{i,t} = \frac{r_{i,t}}{\sigma_{i,t}} \times \sigma_{i,T} \qquad \text{(Equation 10)}$$

$$\sigma_{i,t} = \sqrt{\lambda \sigma^2_{i,t-1} + (1-\lambda) r^2_{i,t-1}} \qquad \text{(Equation 11)}$$

λ corresponds to the decay factor and it is set to 0.97. According to RiskMetrics (2006), 0.97 is the optimal value for monthly returns: this is not the liquidity horizon of all notional positions, but it is close to the majority. Note that at t=0, $\sigma_i = r_i$. Assuming a zero expected return, α percentile of r* is VaR. ES is obtained through the model developed by Giannopoulos and Tunaru (2005), i.e., averaging the *N* losses $r^*_{i,t}$ larger or equal to VaR (applicable under Basel III), as demonstrated in Equation 12.

$$ES = -\frac{1}{N}\sum_{j=1}^{N} r^*_{i,j} \qquad \text{(Equation 12)}$$

For securities not tradable during the entire stress period, the assumptions made in the definition of that period are applied. However, for stocks, the standard deviation accounts

[13] Hull and White (1998) are assuming a zero expected return, an assumption also taken in RisMetrics (2006).

not only for the volatility in the market proxy, but also in the errors (ε)[14]. Thus, the standard deviation in Equation 10 is replaced by Equation 13.

$$\sigma_{i,t}=\sqrt{\lambda\sigma^2_{i,t-1}+(1-\lambda)r^2_{i,t-1}+\sigma^2_{i,\varepsilon}} \qquad \text{(Equation 13)}$$

To obtain the IMRC, it is considered the following: VaR and IMCC (assuming ρ=0.5) of the previous day is higher than the average of the previous 60 days; specific and default risk are accounted as a capital add-on. The specific risk charge respects the requirements of Basel II standardized model: a RW of 8% for individual stocks and 2% for indexes, ETFs and funds; sovereign bonds are allocated to "government"; investment grade and high yield corporate bonds are assigned to "qualifying" and "other" categories, respectively. IDR is computed as required by Basel III standardized model.

To understand what causes the increase or decrease in the MRC in Basel III, it is considered the impact of changing Basel II requirements by the individual requisites proposed by Basel III. Thus, it is replaced VaR at 99% by ES at 97.5%, 10-day liquidity horizon by varying liquidity horizons, short-term by long-term shocks, current by stress period, and it is included the credit spread risk and limited the correlations across risk categories.

4. Comparing Market Risk Charges across Different Frameworks

Given the allocation of notional positions to risk categories, following the indications of Table 2 (see Appendix 2 for the total value allocated to risk categories), MRC is computed. Results of each broad risk category are analysed individually (except default risk charge) and then it is considered the portfolio as a whole: the results are summarized in Table 3 and Appendix 3. Appendix 4 presents the 12-month P&L assuming the same portfolio since 2005: this is the criteria used to define the period of stress.

[14] The variance of the errors was obtained in Bloomberg, following an equally weighted moving average. The variance of the errors of the portfolio is the sum of the variance of the errors of each security which applies the diagonal model, i.e., it is assumed that errors are independent.

Table 3: Market Risk Charge by Risk Category and for the Portfolio

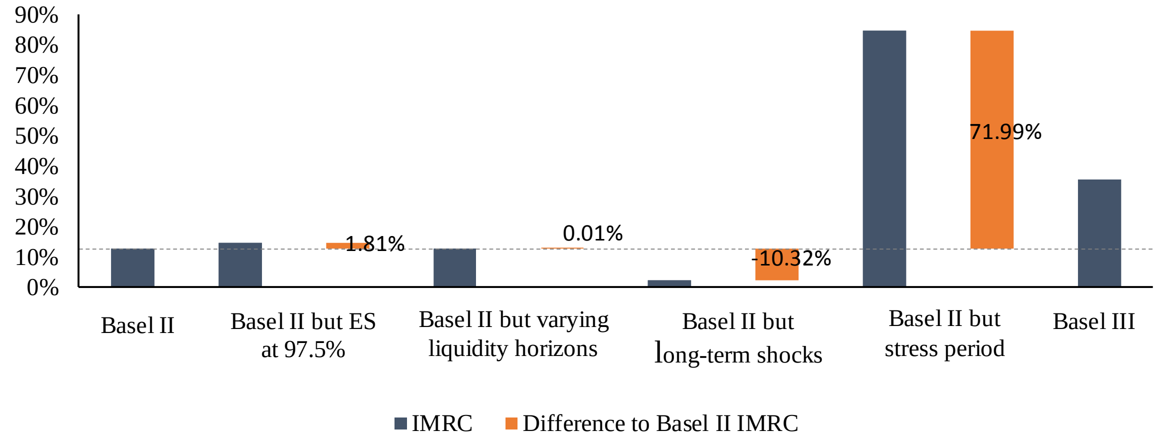
		Basel II	Basel III	
		IMRC	IMRC	SMRC
Equity Risk	EUR	12,885,078	33,418,967	36,661,101
	% notional position	12.73	35.54	23.12
Foreign Exchange Risk	EUR	1,944,913	3,220,347	3,188,902
	% notional position	4.29	7.11	7.04
Interest Rate Risk	EUR	9,042,845	5,313,315	8,945,429
	% notional position	3.42	2.01	3.39
Credit Spread Risk	EUR	n/a	9,387,723	5,233,066
	% notional position	n/a	4.28	2.39
Capital add-on*	EUR	7,993,997	22,829,956	22,829,956
	% notional position	2.53	7.24	7.24
Portfolio	EUR	23,164,553	65,269,852	76,858,454
	% notional position	3.19	5.96	8.13
	% value invested	6.26	15.21	20.77

*The capital add-on is related to specific risk and IDR in Basel II and Basel III, respectively.

4.1. Equity Risk

The MRC under Basel III is larger than under Basel II: using the internal and standardized model the charge is €23,076,177 (179%) and €23,776,024 (185%) higher, respectively.

Graph 1: IMRC of equity risk portfolio



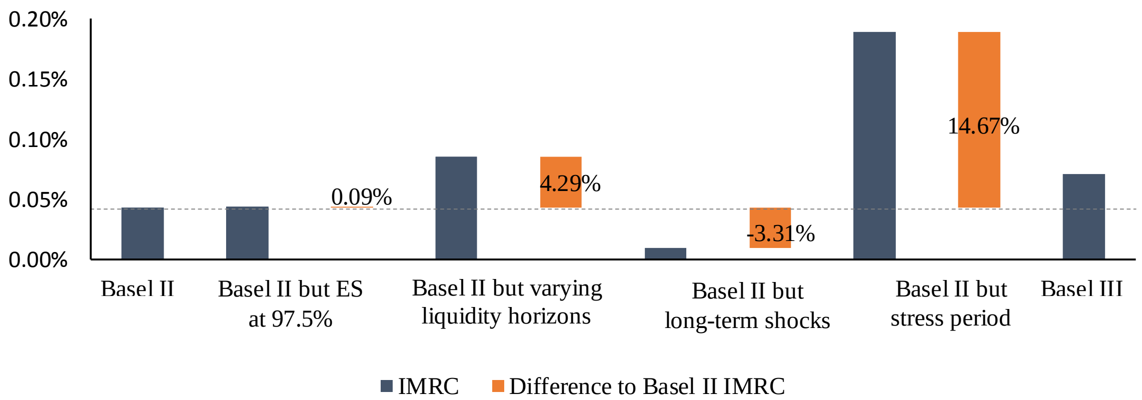
Graph 1 shows that the difference in IMRC of both methods is mainly explained by the calibration to a period of stress, going from 29/10/2007 to 27/10/2008 (characterized by the subprime crisis). The impact of varying liquidity horizons *per se* is reduced as only 5.35% of securities have an investment period superior to 10 business days. The effect of ES at 97.5% is explained by the skew of 14.95 presented on r* assuming the other Basel II requirements. Appendix 5 compares r* for each case represented in Graph 1.

The SMRC is higher than the $IMRC_{Basel\ III}$: about 60% of the notional amounts in equity risk are funds, ETFs or indexes which are allocated to the residual bucket that has a 70% RW (the highest in this risk category) and no correlation within the bucket or with the remaining buckets. This method may overestimate the charge and discourage the investment in these securities (which aims to diversify the portfolio). This pitfall is overcome if banks know the detailed composition of the referred assets.

4.2. Foreign Exchange Risk

As under equity risk, Basel III provides a higher MRC than Basel II for FX risk: €1,275,434 (66%) and €1,243,989 (64%) larger, for internal and standardized model, respectively.

Graph 2: IMRC of foreign exchange risk portfolio



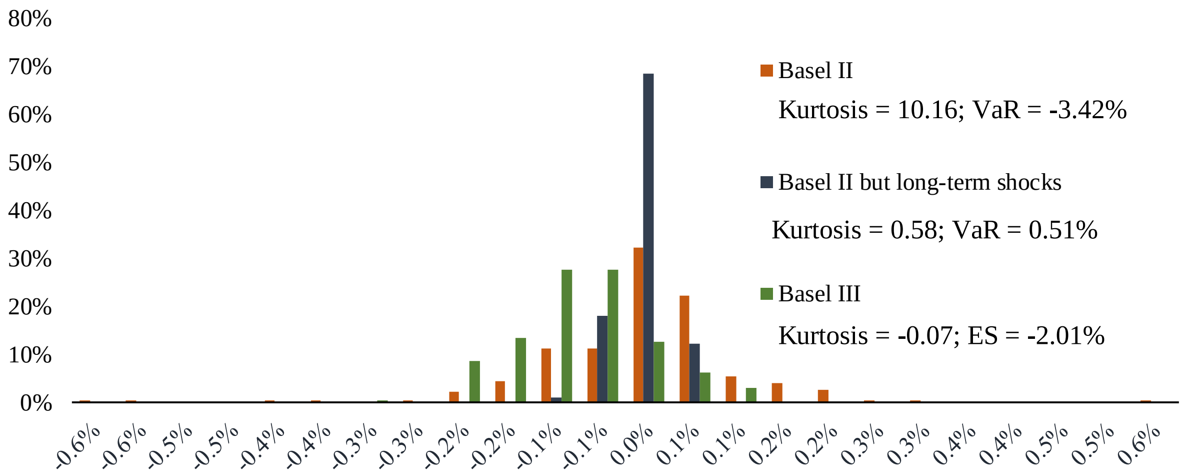
As demonstrated by Graph 2, the change to ES at 97.5% does not present a significant impact: even if VaR at 97.5% is considered in Basel III, the IMRC would be higher than demanded by Basel II. The utilization of varying liquidity horizons (changing from 10 to 20 business days) and the calibration to a period of stress (from 18/12/2007 to 19/12/2008) are the factors that mainly contribute to the higher IMRC under Basel III. Appendix 6 compares r*, providing an overview of the impact of the referred factors. The lower SMRC compared to $IMRC_{Basel\ III}$ is related to the undervaluation of RWs[15].

[15] There are no correlation across buckets (all positions are allocated to bucket 1) and correlations across FX positions are close to 60%

4.3. Interest Rate Risk

In opposition to the previous risk categories, Basel II provides a higher MRC for interest rate risk than Basel III: €3,721,073 (70%) and €88,959 (1%), under internal and standardized model, respectively. Appendix 7 demonstrates r* under different scenarios.

Graph 3: Distribution of r* for interest rate risk portfolio



There are two main reasons that explain these results for the internal model, as demonstrated in *Graph 3*: the difference in kurtosis of r* in Basel II and Basel III, and the application of long-term shocks instead of scaling short-term shocks. The stress period is the 1-year in which the portfolio faced the largest loss[16] that may not correspond to the year with the most volatile and leptokurtic returns. The SMRC is closer to the $IMRC_{Basel\ II}$, as the standardized model implements specified RWs and correlations applicable to stress periods based on the BCBS studies, i.e., ignoring the return distribution of portfolios.

4.4. Credit Spread Risk

Contrary to the previous broad risk categories, credit spread risk is only considered in Basel III. The SMRC is €4.154.657 (44%) lower than the IMRC. If this charge was considered in Basel II, assuming the same requirements of the other risk categories, it would be

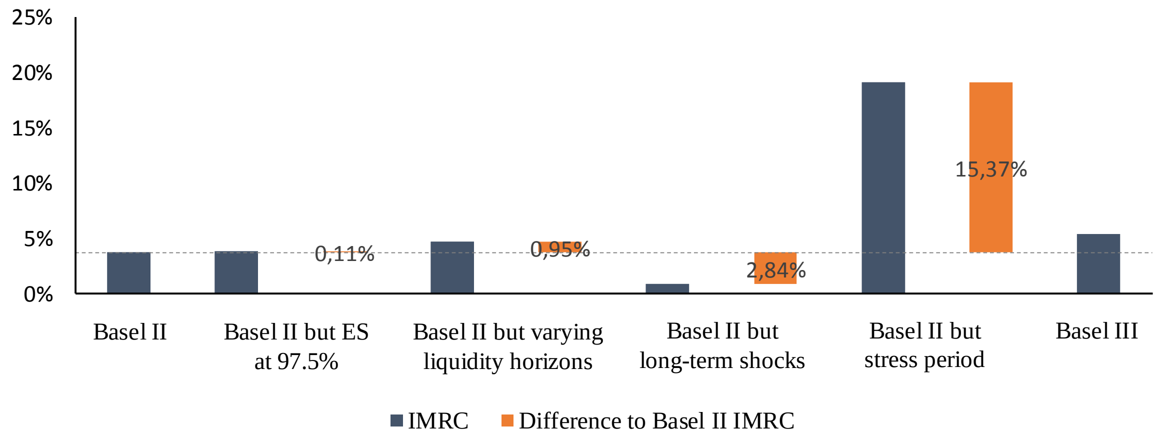
[16] The stress period for interest rate risk goes from 02/08/2010 to 03/08/2011, a period marked by the European sovereign crisis. BPI Reforma Investimento – PPR at 31/07/2014 had a 45% stake in sovereign bonds, including debt from Portugal, Spain, Italy and Ireland, four of the most affected countries.

€4,604,904 (i.e. lower than Basel III MRC). The standardized model is undervaluing credit spread risk: the return distribution across the stress period is more volatile than predicted by that model. Although the selected stress period (26/11/2010 to 25/11/2011) refers to the sovereign crisis, the lower RWs defined by the standardized model are allocated to sovereign bonds. The larger RWs assigned to corporate bonds (which stress period is from 15/12/2007 to 17/12/2008) are not enough to cover the risk of sovereign bonds. Increasing the RWs of sovereign bonds to the second lower weights for the same maturity range and credit quality, augments the SMRC to €9,136,560 (only 3% lower than the IMRC).

4.5. Global Portfolio Risk

The MRC of the portfolio is higher in Basel III, both internal and standardized model – €42,105,299 (182%) and €53,693,901 (232%), respectively – than Basel II. Appendix 8 demonstrates the impact in r* of each of Basel III requirements in Basel II

Graph 4: IMRC of global portfolio, except capital add-on



Considering the factors in Graph 4, the stress period (from 17/10/2007 to 16/10/2008) is the main cause for the increase in the IMRC: however, the other requirements minimize its impact. The inclusion of a new risk category, credit risk, *certeris paribus*, reduces VaR to 3.03%, but increases it to €19,093,636: the new risk category, on the one hand, leads to diversification effects, and, on the other hand, augments the sum of notional positions.

Even though the specific risk is more comprehensive than the IDR, the charge for the first is almost three times lower. This difference comes from the lower RWs attributed to securities in Basel II, particularly for fixed income instruments: while in the previous framework RWs vary from 0% to 12%, Basel III requires a range from 0.5% to 50%. IDR was more carefully analysed in 2009 (BIS, 2009b).

Table 4: IMCC and IMRC and limitation of diversification and hedging (Euro)

	$IMRC_{Basel\ II}$		$IMRC_{Basel\ III}$			$SMRC_{Basel\ III}$
	Diversified	Undiversified*	ρ=1	ρ=0.5	ρ=0	-
IMCC	n/a	n/a	33,819,232	42,439,896	51,060,560	n/a
IMRC	23,164,553	31,858,376	56,649,188	65,269,852	73,890,516	76,858,454

*Undiversified IMRC across risk categories obtained by summing VaR for each category and the specific risk. Correlations within risk categories are considered.

Regarding diversification and hedging across risk categories, the increase in its recognition leads to a decrease in the MRC (see Table 4 for details). Nevertheless, the value of ρ presents a large impact in IMRC and IMCC under Basel III. The higher SMRC not only comes from the restriction of correlations across asset classes, but also from the reasons referred in 4.1 and the undervaluation of RWs or correlations based on BCBS studies.

5. Conclusions

BCBS aims to improve banking supervision: the increasing financial intermediation raised financial risks (operational, liquidity, credit and market risks). To achieve its goal, the BCBS has been releasing accords: Basel I, Basel II and Basel III. This last framework arose to correct the flaws in Basel II recognized during the subprime crisis. Basel II regulates 3 pillars – MCR, supervisory review process and market discipline – and Basel III is also focused on liquidity. Regarding the MCR, it is analysed the charge arising from market risk (movements in market prices and its volatility) in the trading book. The BCBS allows the application of two models: standardized and internal. The first has pre-defined formulas, RWs, correlations and rules to offset positions; the second is developed by banks and must respect qualitative and quantitative requirements to be approved by supervisors.

While Basel II and Basel III have similar qualitative requirements, the quantitative are substantially different. The MRC in Basel II is based on a 10-day VaR at one-tail 99% confidence level (based on 1-day returns and then scaled by $\sqrt{10}$). Basel III requires the stressed ES at one-tail 97.5% applying long-term shocks for different liquidity horizons.

Hence, it should be analysed if the MRC in Basel III is higher than in Basel II. To answer that, it was applied the standardized approach as required by Basel III and the FHS using Hull and White (1998) method with EXMA for internal models. The FHS has the advantage of considering heteroskedasticty, while accounting for kurtosis and skewness.

It is concluded that Basel III increases the MRC relative to Basel II, except for interest rate risk (exception mainly explained by the platikurtosis of r* in the stress period). The HPE, developed in 2014, concluded that the Basel III risk measure increases for all asset classes, except for equities, relative to Basel 2.5. The MRC under Basel 2.5 is larger and less likely to be insufficient in adverse market conditions than required by Basel II (Alexander et al, 2013). Regarding the IDR, Basel 2.5 led to an increase of this charge[17] (BIS, 2009c).

As BIS (2013) argues, VaR at 99% and ES at 97.5% lead to similar results: the increase due to the ES is offset by the lower confidence level. Moreover, the calibration of the risk measure to a period of stress and the application of varying liquidity horizons boosts the capital charge: these findings meet the arguments in QIS taken in 2009 and HPE performed in 2014, respectively. The stress period overlaps the third quarter of 2008, as in HPE 2014, except for interest rate and credit spread risk, due to the sovereign crisis in 2011. However, long-term shocks reduce the MRC: scaling short-term volatility may overestimate the standard deviation (Christoffersen et al, 1998 and Provizonatou et al, 2005).

[17] Basel 2.5, as Basel III, bases this charge on a 10-day VaR at 99.9% confidence level. Basel III deepens these requirements, in spite of the exclusion of credit migration risk (measured in credit spread risk). Even excluding the migration risk, the IDR increases relatives to specific risk surcharge in Basel II (BIS, 2009c).

Considering the portfolio as a whole, results are as follows: $IMRC_{Basel\ II}$< $IMRC_{Basel\ III}$ <$SMRC_{Basel\ III}$. The increasing charges corresponds to increasing restrictions in correlation across risk categories. Nevertheless, as $IMRC_{Basel\ III}$ is sensitive to the choice of ρ, supervisors should be careful in its definition. The introduction of the credit spread risk, on the one hand, increases the total value of notional positions; on the other hand, leads to diversification, shrinking the α percentile. For this portfolio, the first effect is greater, leading to a higher absolute charge. Regarding the capital add-on, even though the specific risk is broader, it leads to a charge more than 3 times lower, given the smaller RWs.

Under Basel III, the SMRC is either lower or higher than the IMRC. The application of fixed RWs and correlations may not adequately reflect the risk of the portfolio: if the stress period affects mainly certain buckets, but these have the lowest RWs, then the risk measure might be undervalued. However, if the period facing the largest loss is not particularly volatile and n-day returns are platikurtic, the SMRC might provide a better result.

Nonetheless, this analysis presents limitations. Firstly, it only looks to one portfolio which does not contain all security types: namely, it does not account for off-balance sheet positions and complex securitisations, major flaws found in Basel II. Secondly, it was not available all financial data needed since 2005. Thirdly, it was not possible to obtain the composition of the funds and ETFs in the portfolio, a pitfall deepened in the bond fund. Regarding the specific risk and IDR charge, it was applied in the internal model the standardized approach. Finally, it was only considered one model, FHS, to compare the IMRC to the SMRC: however, different models may lead to different risk charges.

To complement the present work project, it should be performed a stress testing, a P&L and a backtesting: such analysis would allow to better compare the effectiveness of Basel II and Basel III in risk measurement and management.

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Appendix 1

The MRC for each bucket in interest rate, credit spread, equity and commodity risk is computed using *Equation 14*. The MRC for interest rate risk is given by *Equation 15* and for credit spread, equity and commodity is obtained using *Equation 16*.

$$K_b = \sqrt{\sum_i RW_i^2 NV_i^2 + \sum_i \sum_{i \neq j} \rho_{ij} RW_i NV_i RW_j NV_j} \qquad \text{(Equation 14)}$$

$$SMRM_a = \sqrt{\sum_b K_b^2 + \sum_b \sum_{b \neq c} \rho_{bc} K_b K_c} \qquad \text{(Equation 15)}$$

$$SMRM_a = \sqrt{\sum_b K_b^2 + \sum_b \sum_{b \neq c} \rho_{bc} \left(\sum_{i \in b} RW_i NV_i \right) \left(\sum_{i \in c} RW_i NV_i \right) + K_{residual}} \qquad \text{(Equation 16)}$$

Regarding FX risk, the MRC for each currency is given by *Equation 17* and the aggregate risk charge for that risk category is provided by *Equation 18*.

$$K_d = \sqrt{\Sigma_i NV_b^2 \, \Sigma_b \Sigma_b \rho_{bc} NV_b NV_c} \qquad \text{(Equation 17)}$$

$$SMRM_a = 0{,}15 \sqrt{\sum_i K_d^2 \sum_d \sum_{d \neq e} 0.6 K_d K_e} \qquad \text{(Equation 18)}$$

K	MRC for bucket or currency	ρ	Correlation	d, e	Currency
NV	Notional value	i, j	Bucket		
RW	Risk Weight	a	Risk category		

Appendix 2 – Notional Positions

Table 5: Notional positions per risk category

Category	Basel II	Basel III
Equity risk	€101,193,190	€101,193,190
Foreign exchange risk	€45,297,267	€45,297,267
Interest rate risk	€263,872,926	€263,872,926
Credit spread risk	n/a	€219,265,243
Credit default risk	€315,496,287	€315,496,287
Global portfolio	€725,674,087	€944,939,329

Appendix 3 – From Basel II to Basel III

Table 6: Change in MRC from Basel III to Basel II by risk category

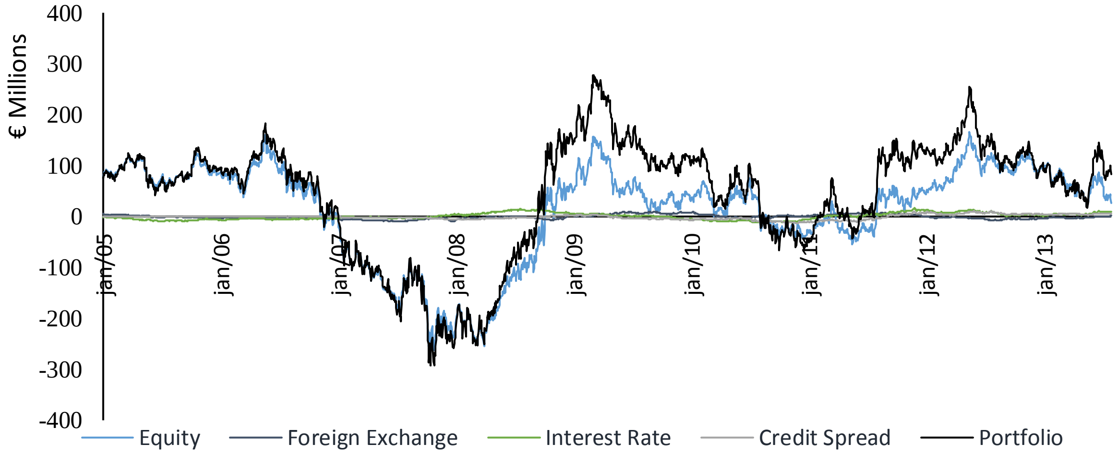
Risk Category	Equity	Foreign Exchange	Interest Rate	Credit Spread	Capital Add-on	Global Portfolio
IMRC	179%	66%	-41%	n/a	186%	182%
SMRC	185%	64%	-1%	n/a	186%	232%

Table 7: Impact on Basel II by Basel III new requirements

Risk Category \ Factor	ES at 97.5%	Varying Liquidity Horizon	Long-term shocks	Stress Period	Credit Spread
Equity	14%	0%	-81%	565%	n/a
Foreign Exchange	2%	100%	-77%	388%	n/a
Interest Rate	-2%	100%	-85%	99%	n/a
Portfolio	2%	17%	-50%	271%	17%

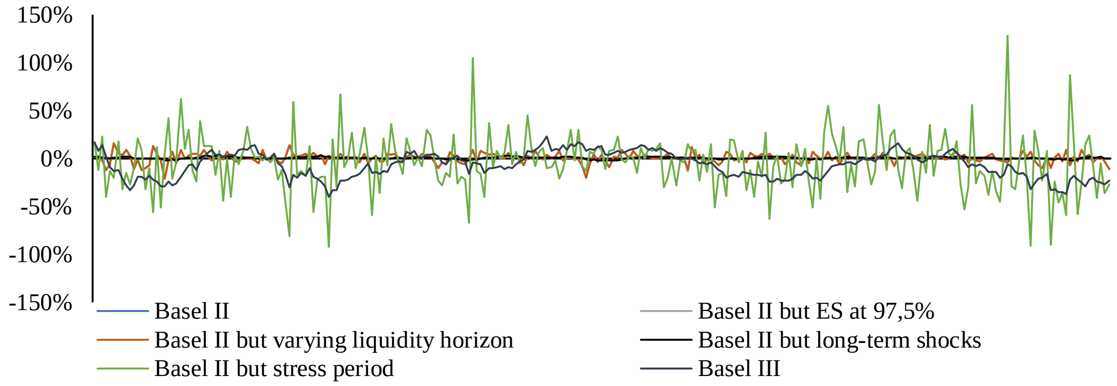
Appendix 4 – Profit and Loss

Graph 5: Profit and Loss by broad risk category



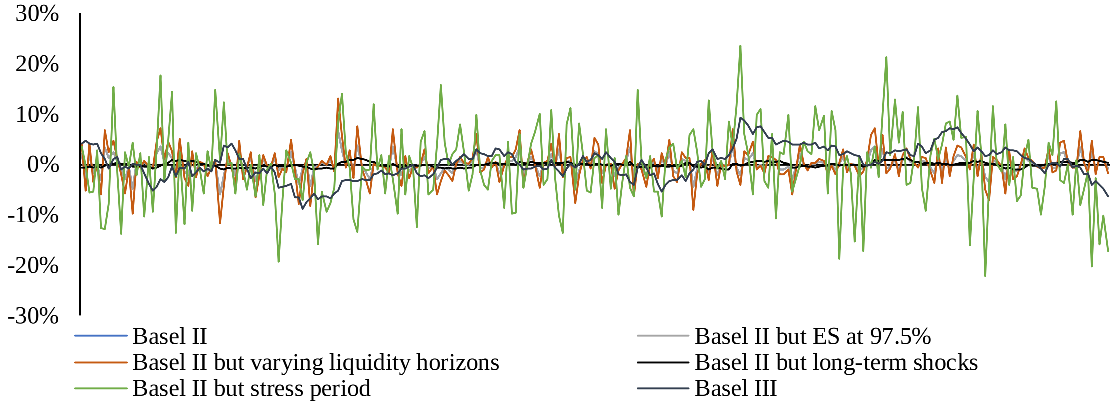
Appendix 5 – Equity Risk

Graph 6: Scaled Standardized Returns of equity risk portfolio



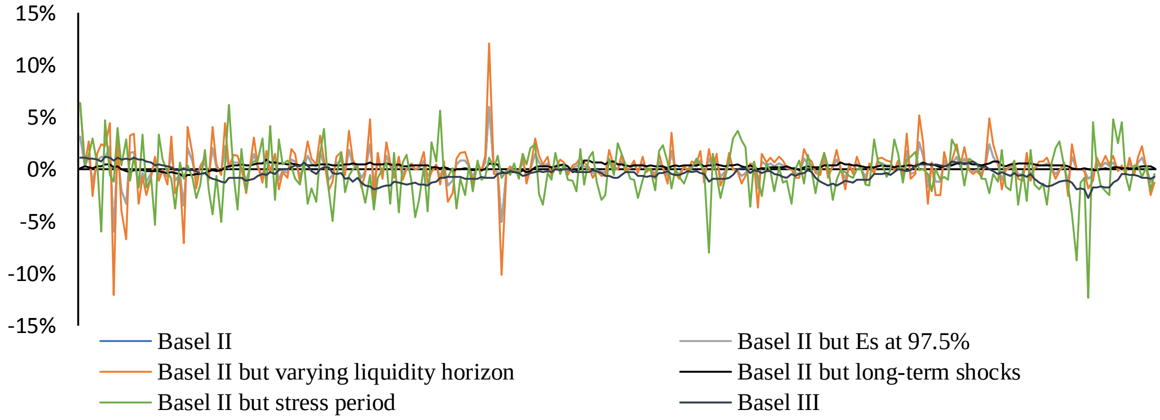
Appendix 6 – Foreign exchange risk

Graph 7: Scaled standardized return of foreign exchange risk portfolio



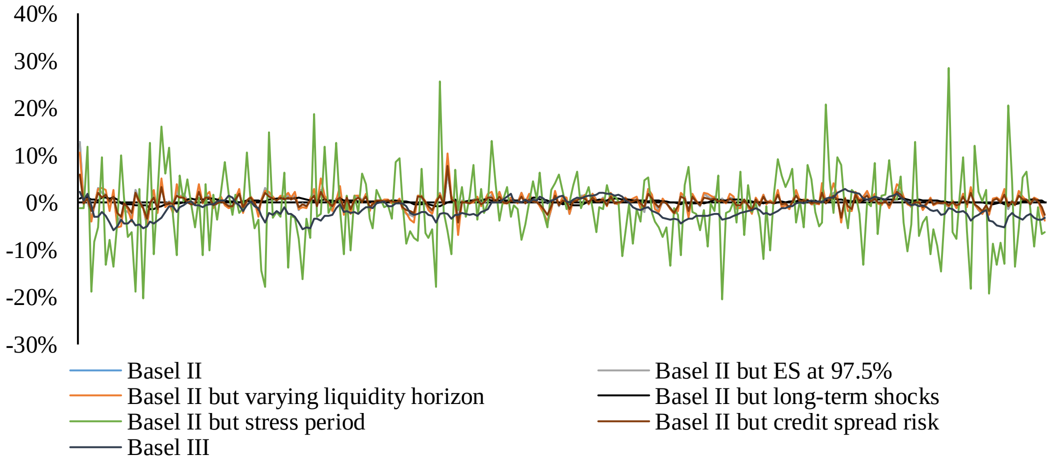
Appendix 7 – Interest rate risk

Graph 8: Scaled standardized return of interest rate risk portfolio



Appendix 8 – Global portfolio risk

Graph 9: Scaled standardized return of global portfolio



MARKET RISK CHARGE OF THE TRADING BOOK: A COMPARISON OF BASEL II AND BASEL III

Appendices

FLÁVIA MANIQUE BRITO, 657

A Project carried out on the Risk Management course, under the supervision of:
Professor Miguel Ferreira

JANUARY 2015

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Appendix 9 – Liquidity Horizons

Table 8: Liquidity Horizon by risk factor category

Risk factor category	n	Risk factor category	n
Interest Rate	20	Credit Spread – Sovereign (IG)	20
Equity Price (large cap)	10	Credit Spread – Sovereign (HY)	60
Equity Price (small cap)	20	Credit Spread – Corporate (IG)	60
FX rate	20	Credit Spread – Corporate (HY)	120

Source: BIS (2013)

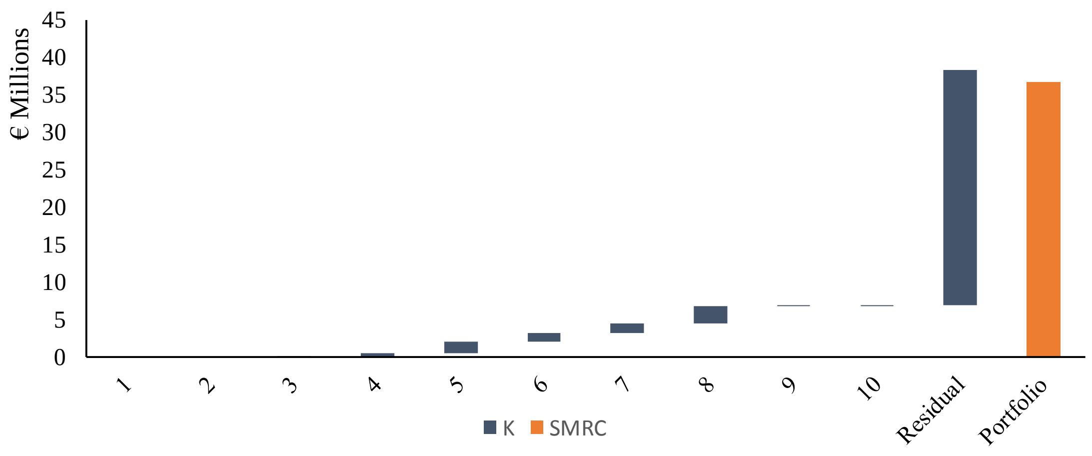
Appendix 10 – Equity Risk

Table 9: Buckets characterization and risk weights for equity risk

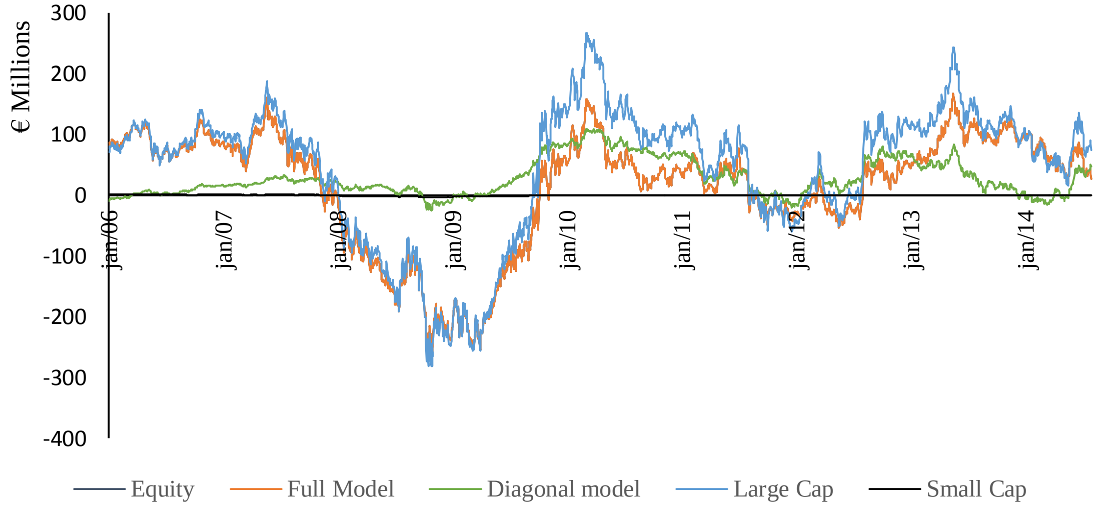
Size	Region	Sector	Bucket	Risk Weight
Large	Emerging Markets	Consumer, utilities	1	55%
		Telecommunications, industrials	2	60%
		Basic materials, energy	3	45%
		Financial, technology	4	55%
	Developed Markets	Consumer, utilities	5	30%
		Telecommunications, industrials	6	35%
		Basic materials, energy	7	40%
		Financial, technology	8	50%
Small	Emerging Markets	All sectors	9	70%
	Developed Markets	All sectors	10	50%
			Residual	70%

Source: BIS (2013)

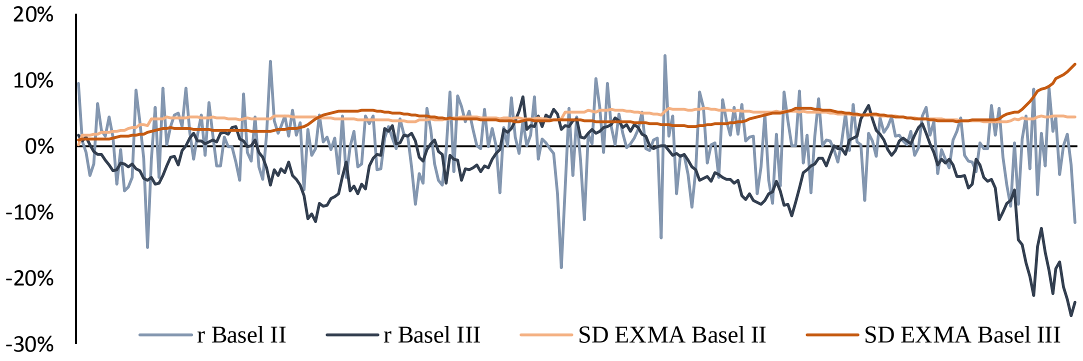
Graph 10: SMRC by bucket and for equity risk portfolio



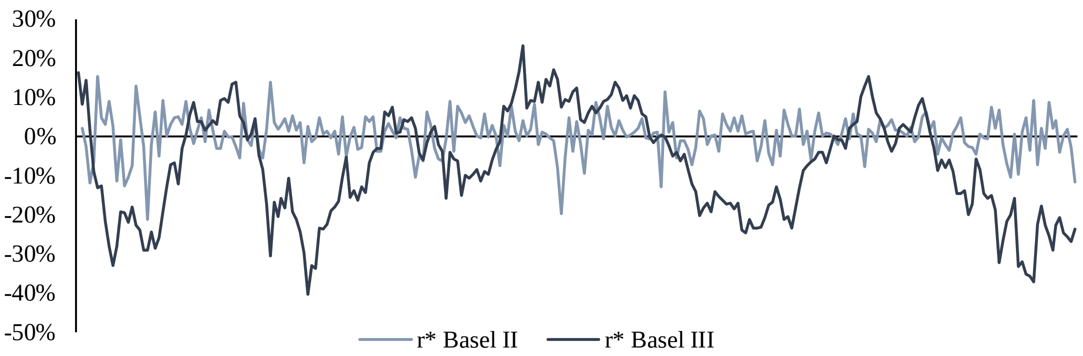
Graph 11: Profit and Loss in Equity Risk Portfolio



Graph 12: Return and Standard Deviation of Equity Risk Portfolio

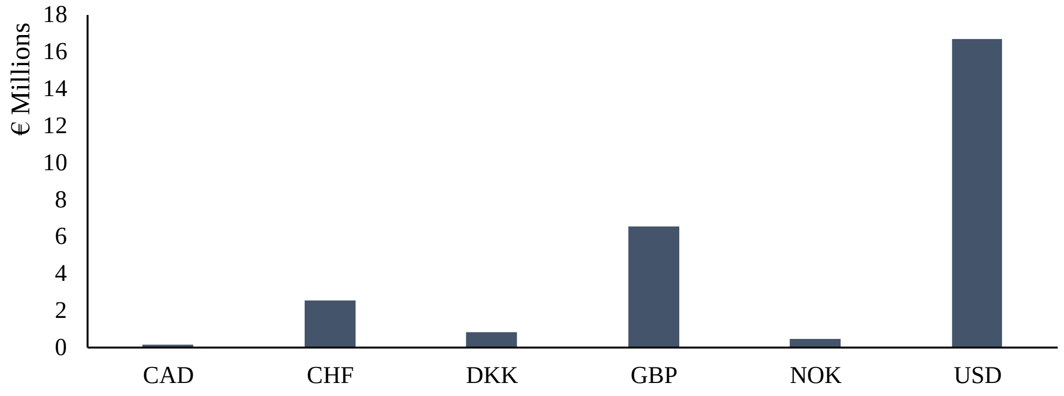


Graph 13: Scaled Standardized Return of Equity Risk Portfolio

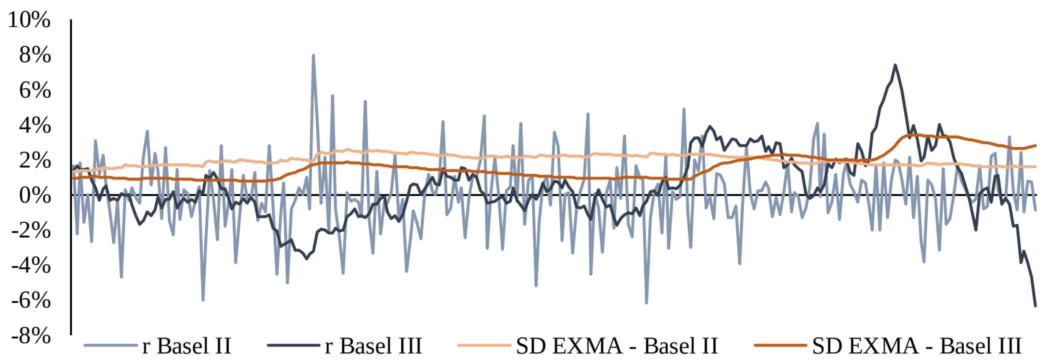


Appendix 11 – Foreign Exchange Risk

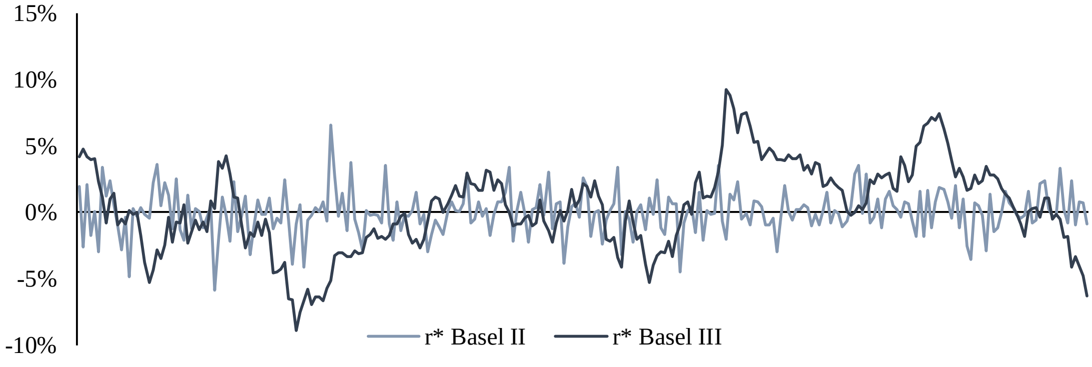
Graph 14: Notional Value allocated by foreign currency



Graph 15: Return and Standard Deviation of Foreign Exchange Risk Portfolio



Graph 16: Scaled Standardized Return of Foreign Exchange Risk Portfolio



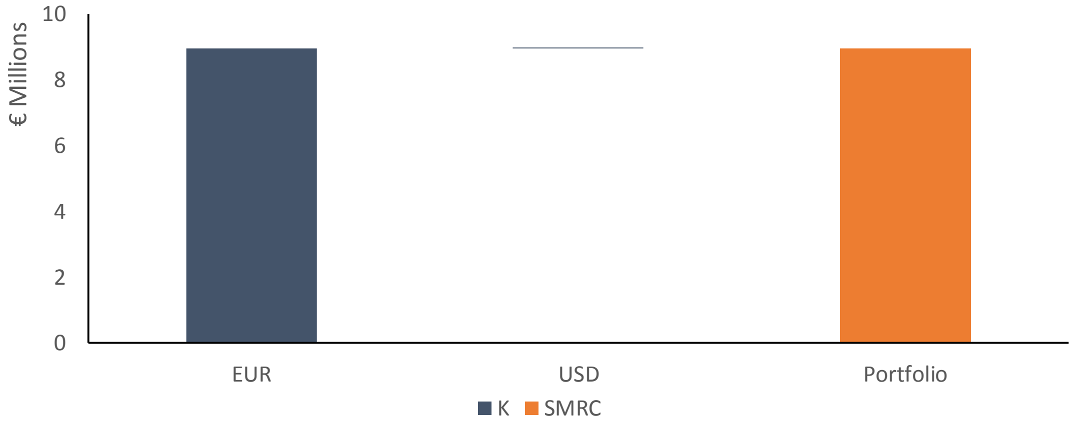
Appendix 12 – Interest Rate Risk

Table 10: Risk weights by vertex

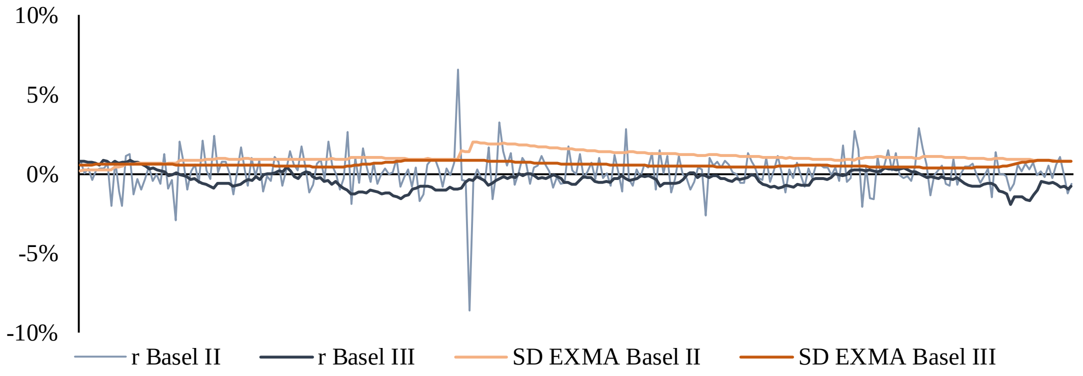
Vertex	0,25y	0,5y	1y	2y	3y	5y	10y	15y	20y	30y
RW	0.4%	0.8%	1.5%	2.5%	3.5%	5%	10%	15%	20%	30%

Source: BIS (2013)

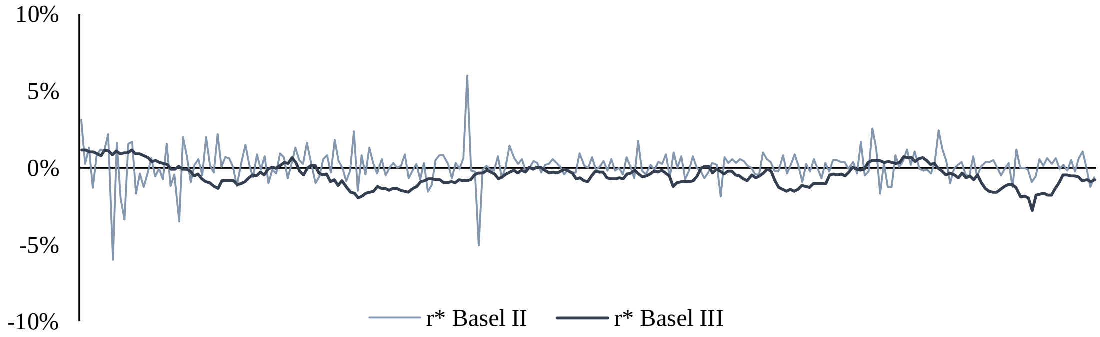
Graph 17: SMRC by currency and for interest rate risk portfolio



Graph 18: Standard Deviation of Interest Rate Risk Portfolio



Graph 19: Scaled Standardized Return of Interest Rate Risk Portfolio



Appendix 13 – Credit Spread Risk

Table 11: Buckets characterization for credit spread risk

Bucket	Quality	Sector
1	Investment Grade	Sovereigns
2		Financial (includes national banks)
3		Basic materials, energy, industrials
4		Consumer
5		Technology, telecommunications
6		Health care, utilities, local government, government-backed securities
7	High-yield and Non-rated	Sovereigns
8		Financial (includes national banks)
9		Basic materials, energy, industrials
10		Consumer
11		Technology, telecommunications
12		Health care, utilities, local government, government-backed securities
Residual		

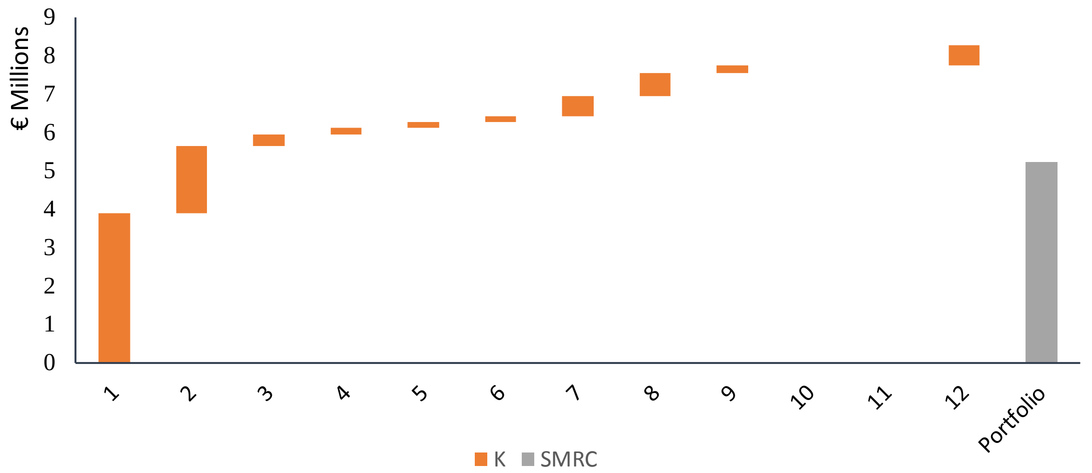
Source: BIS (2013)

Table 12: Risk weights for credit spread risk

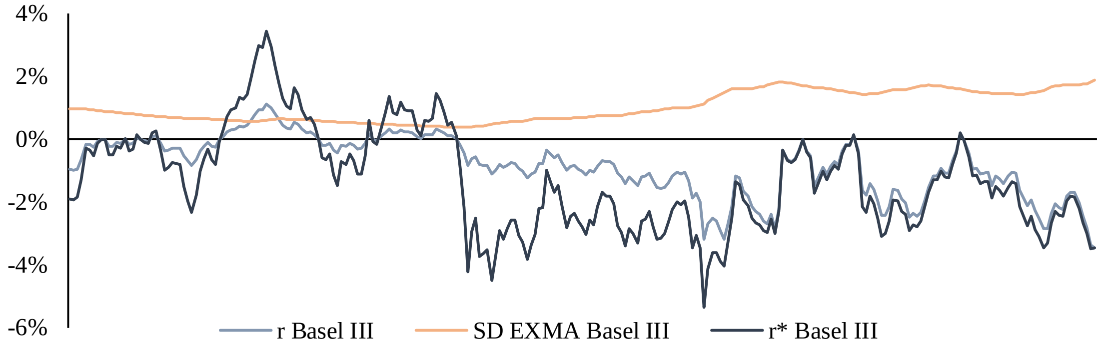
Bucket	Maturity of less than five years	Maturity from five to less than 10 years	Maturity from 10 to less than 20 years	Maturity of 20 years or more
1	5%	5%	10%	20%
2	10%	20%	35%	55%
3	5%	15%	25%	45%
4	5%	10%	20%	45%
5	5%	10%	20%	40%
6	5%	10%	20%	40%
7	5%	10%	20%	35%
8	20%	40%	55%	80%
9	15%	30%	50%	75%
10	15%	35%	50%	70%
11	15%	35%	45%	65%
12	10%	25%	40%	65%
Residual	20%	40%	55%	80%

Source: BIS (2013)

Graph 20: SMRC by bucket and for credit spread risk

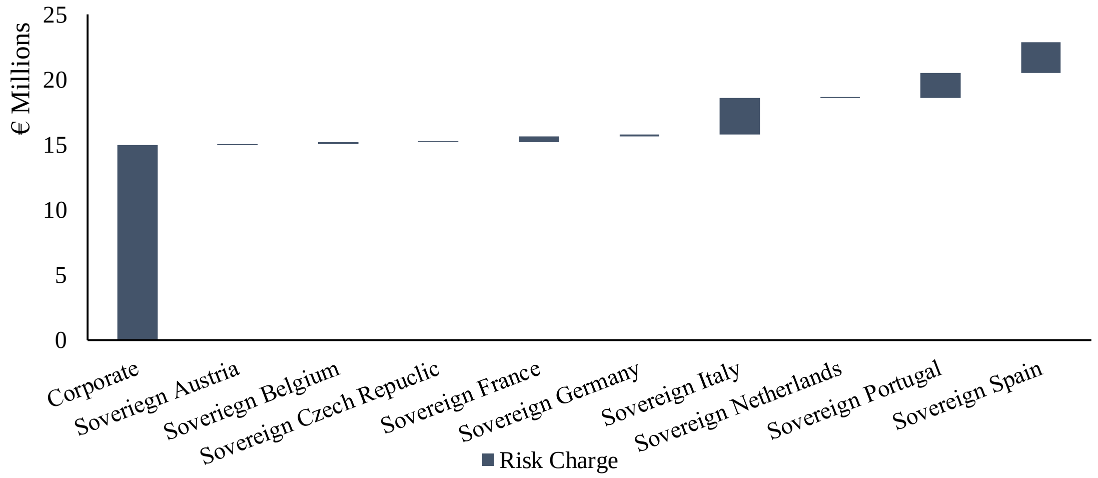


Graph 21: Returns, Standard Deviation and Scaled Standardized Returns of Credit Spread Risk Portfolio



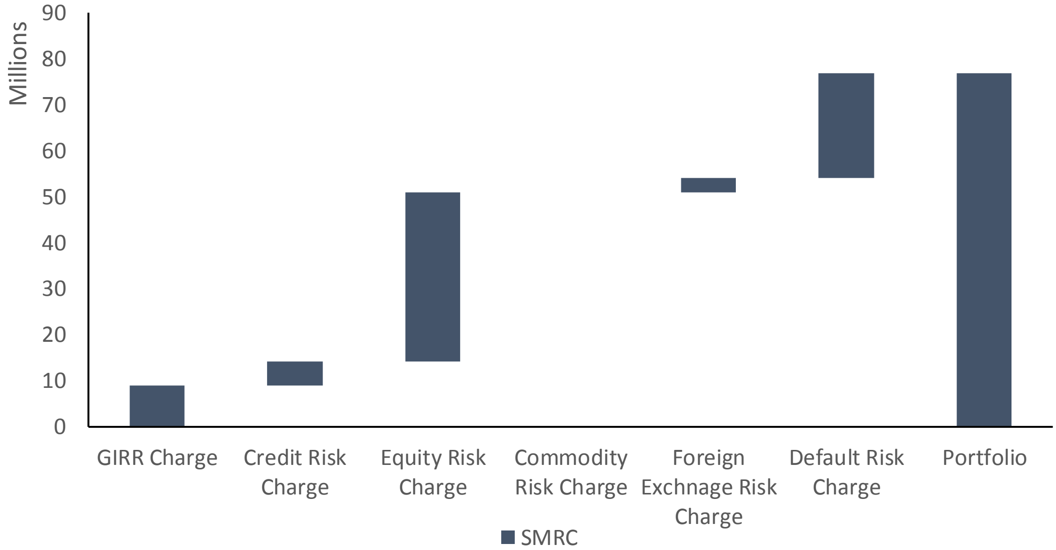
Appendix 14 – Incremental default risk

Graph 22: Decomposition of SMRC for credit default risk

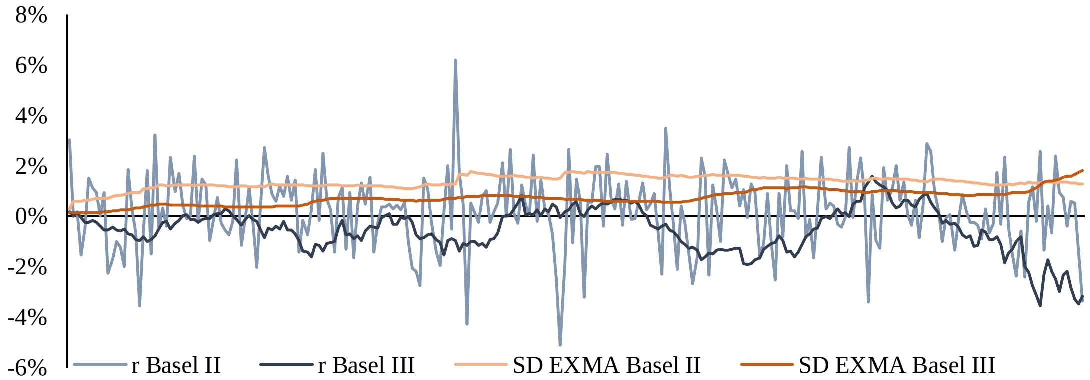


Appendix 15 – Global Portfolio Risk

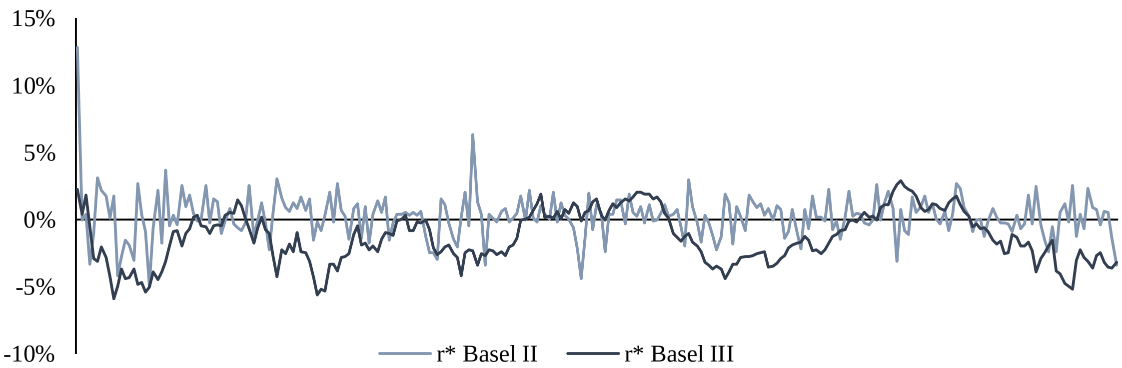
Graph 23: Decomposition of SMRC for global portfolio



Graph 24: Returns and Standard Deviation of Global Portfolio



Graph 25: Scaled Standardized Returns of Global Portfolio



Appendix 16 – Multiplication factor

Table 13: Penalty applied to the multiplication factor

Zone	Number of Exceptions	Penalty
Green	0-4	0
	5	0.40
	6	0.50
Yellow*	7	0.65
	8	0.75
	9	0.85
Red	10 or more	1.00

**The penalty is applied unless the bank proves the integrity of the model.*
Source: BIS (2013)