Basel 3.5 vs. Basel III: a radical overhaul of the capital requirements pillar. The case of commodity exposures

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Abstract: Following the implementation of Basel III, the Basel committee has embarked on a thorough review of its market risk directives and enacted new proposals generically called Basel 3.5. They involve a radical transformation of the standardised approach (SA) into a risk-sensitive method and a complete overhaul of the internal models approach (IMA) through the replacement of VaR for ES, amid stringent validation standards. The study analyses Basel's recent regulations for commodities exposures, finding a substantial rise in capital levels for SA and IMA and the relatively disadvantageous position in which IMA is placed, arising from the higher SA's capital requirements and the tougher evaluation criteria only attained by schemes featuring extremes theory. This, in turn, provokes accuracy disincentives and unnecessary immobilisation of funds. Consequently, the paper introduces a straightforward solution designed to level SA and IMA and provide substantial protection against huge market slumps with more reasonable capital levels and reduced implied costs.

Keywords: Basel 3.5; Basel III; standardised approach; internal models approach; IMA; expected shortfall; extreme value theory; EVT.

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1 Introduction

In the aftermath of the most recent financial crises, supranational watchdogs promptly acted to remedy the glitches in the market risk regulations that could have avoided their apparition and propagation. An imaginary timeline would indicate that, firstly, the Basel Committee on Banking Supervision (BCBS) introduced the Basel I Capital Accord (Basel I) in July 1998 after the black Monday (October 1987) (BCBS, 1988); secondly, the market risk amendment and the ensuing Basel II Capital Accord (Basel II) including value-at-risk (VaR) (Jorion, 1996; Jackson et al., 1997; Beder, 1995; Duffie and Pan, 1997; Manganelli and Engle, 2001), were enacted and implemented in December 1996 and December 1997 respectively as a response to the Asian financial crisis of 1997, the 'tequila effect' of 1995 and the Brazilian devaluation of 1996 (BCBS, 1996); and, recently, thirdly, the Basel III Capital Accord with the stressed VaR (sVaR) was issued between July and December 2009 as a reaction to the subprime plight of 2007–2008.

Although it may be labelled as an evolution of its predecessor, Basel III Capital Accord (Basel III) comprises some notable elements: the sVaR, consisting in the addition of a term featuring a VaR computed over a highly strained period to the typical VaR of the internal models approach (IMA) and the calculation of two externally determined capital layers, the capital conservation buffer and the countercyclical capital buffer, to be employed as add-on measures in both avenues, the IMA and the standardised approach (SA). Though the outcome produced higher capital levels and improved the resilience of the financial institutions in terms of capital protection, Basel III received a host of criticisms from the academic circles which poured concern on its adequacy; one of the most relevant demands grounded on the use of VaR as a market risk measure given the difficulties that its usage implies (Dowd, 2005; Alexander, 2008; Danielsson and Zigrand, 2006).

Upon the evidence collected (BCBS, 2012), the BCBS embarked on a thorough review of Basel III –albeit it is yet to be fully implemented before January 2019 and produced two Consultative Documents (BCBS, 2013, 2014) which outline the future regulations to be enacted by the BCBS with reference to the next Basel Capital Accord. Without ambiguity, the extent of the variations appear so striking in comparison with the existing order that the financial press has begun labelling them collectively as Basel 3.5, or even Basel IV[1] (Heltman, 2014).

The proposal, now in a very advanced stage, comprises variations to the credit risk measurement, new liquidity provisions and, most importantly, sweeping alterations to the market risk appraisal, the last being the subject of the present research. Delving into the market risk considerations, Basel 3.5 brings about a lot of deep changes compared with its antecessor regarding the constitution of the minimum capital requirements (MCR) for exposures belonging to interest rate, foreign exchange, equity and commodity risk. Those modifications arise from the overhaul of both the SA and IMA, with risk-oriented patterns instead of the flat rate in the former and the introduction of the expected shortfall (ES) metric (McNeil et al., 2005; Acerbi and Tasche, 2002; Manganelli and Engle, 2001), in place of VaR in the latter, amid more stringent validation proofs and a new interaction between the SA and IMA. In view of the evidence collected in the current article, the BCBS would in principle have attained the reinforcement of the capital base, albeit at the expense of demanding the constitution of somewhat excessive reserves. Although from a regulatory point of view the mission may appear accomplished, it poses a problem for banks as that (unnecessary) immobilisation affects their balance sheets by raising the cost of capital and detracting funds that might result allocated to more productive and profitable destinations like credit, in turn producing unintended consequences for the economy. Therefore, the paper proposes the adoption of corrective measures within the framework established by Basel 3.5, either in the shape of calibration parameters for both SA and IMA or in the reformulation of the structure comprising IMA to reduce the scale of capital largeness in a bid to strike a reasonable compromise between the regulatory stance and the needs of the economy, particularly at times when the expansion of credit is essential to kick start the growth.

While many studies have been devoted to Basel II and Basel III and their impact on banks' capital, the motivations of the present study are circumscribed to Basel 3.5 and, to some extent, to its comparison with its predecessor Basel III. The paper aims at the evaluation of the entire revised framework in Basel 3.5, using an integral perspective characterised by the analysis of SA, IMA and their interaction; the assessment of the adequacy (either shortages or excessiveness) of the respective capital levels and possible alternative solutions within BCBS's framework in case potential inconsistencies may appear.

In that vein, the evaluation carried out strongly indicates that the BCBS transformed the SA from a scheme delivering minimal safety against massive market slumps into another providing excessive protection (i.e., immobilisation of reserves), to the extent that capital requirements arising from this approach result more than doubled with reference to Basel's III levels, which in practice means that banks could withstand market crisis of almost three times the scale of the 2008 size. The study also found that coupling SA's status as fall-back with IMA's highly restrictive validation standards that virtually approves only ultra-high leptokurtic models (e.g., EVT), the assertion that Basel IV represents a crackdown on market risk models does not appear far from reality. The paper furthermore proposes the adoption of novel straightforward solutions to align both approaches (SA and IMA) in order to help avoid capital shortage and largeness, simultaneously aligning the incentives to employ each avenue.

Consequently, the main additions and contributions to the existing literature body are susceptible to be subsumed in: firstly, the evaluation of the whole Basel 3.5 framework comprised by the revamped SA, the overhauled IMA and the interrelationship between them; secondly, the analysis of the sufficiency of both appraisals when faced with a real 'black swan'; thirdly, the uncovering of evidence pointing to the gear towards excessively high capital floor determined by the SA, in parallel with the stringent validation criteria for IMA, thus limiting its usefulness, and fourthly, the development of suitable remedies within BCBS framework that allow the realignment of incentives between SA and IMA that may repair the major inconsistency and rekindles interest in IMA.

The paper unfolds as follows: Section 2 carries out the literature review necessary to contextualise the article; Section 3 displays the new elements and familiarise the new concepts of Basel 3.5 juxtaposed to Basel III in order to convey an idea of the extent of the changes; Section 4 presents the Methodology and data bound to be employed in the research; Section 5 details the outcome of the experiment while Section 6 outlines the conclusions and policy implications and, finally, two appendices contain suitable and appropriate clarifications.

2 Literature review

Among its many concerns, BCBS has always envisioned to issue guidelines for the construction of an adequate capital base capable of withstanding massive market dives. However, successive crises have shown dangerous shortages in Basel I and Basel II and, while still under implementation, Basel III has also reaped important criticism (BCBS, 2011) either regarding the risk metric or the particular use of models.

VaR as a measure arguably constitutes the weakest point of Basel III and its predecessor, although they represent a huge leap compared with Basel I. Alexander (2008) underlines that VaR represents only a point estimate of the losses at the specific percentile, neglecting shortfalls beyond that level (Danielsson, 2002). This particular fact could tempt risk managers to overlook those losses – the regulator's main fear – and adopt dangerous positions beyond VaR level, hence bolstering the case for massive bank bail outs. Basak and Shapiro (2001) find that VaR often opens larger exposures in risky assets leaving portfolios more prone to suffer bigger losses whenever they occur. Furthermore, one of the most stinging criticisms derives from VaR's lack of coherence (Artzner et al., 1999). Among the many properties that a coherent risk measure should fulfil, VaR does not achieve sub-additivity, which means that risk measured by VaR may not acknowledge diversification, as McNeil et al. (2005) deduce.

One of the most suitable alternatives to VaR is ES, which corrects three of the most prominent VaR failures:

a The acknowledgement of the severity of losses beyond the selected threshold – essential to supervisors – (Yamai and Yoshiba, 2005).

b The achievement of sub-additivity and the ensuing coherence (Artzner et al., 1999; Acerbi and Tasche, 2002; Embrechts et al., 2014).

c The alleviation of mistakes in the selection of a particular confidence level (Dunn, 2009).

However, despite the advantages in comparison with VaR, ES presents many difficulties performing Backtesting on the grounds that the typical VaR proof must be replaced with another test featuring the magnitude of those outliers. When assessed conventionally, a rejection of VaR probably implies the rejection of ES, but, conversely, VaR acceptance does not necessarily mean that ES is approved. Berkowitz and O'Brien (2002), then, suggested backtests that evaluate the conditional coverage of VaR, and Pritsker (2006) checked the autocorrelation of VaR exceedances at all lags but, unfortunately, it is unclear whether those tests are of any use given that VaR violations are, in fact, ES constituents. Kerkhof and Melenberg (2004), develop test statistics applicable to both VaR and ES, claiming that their backtest stats for ES exhibit better behaviour than those for VaR. Wang (2008) devised an interesting alternative for ES based on small samples of VaR violations and, albeit confined to normal distribution, it may also detect non-normal VaR exceedances; however, this test may require banks to disclose confidential information like estimates of tail thickness, which will surely meet stiff resistance. It is not surprising, then, that in view of the aforementioned reasons the BCBS has resorted to a curiously tough stance on IMA, assessing VaR at several confidence levels as well as an ad-hoc and somewhat rudimentary evaluation of the models employed.

The literature has extensively discussed the issue of the models to be used for market risk estimation within IMA. Among the growing quantity, academics have cast doubts on historical simulation (HS) as a precise scheme to estimate market risk in light of its structural pitfalls like the absence of conditionality (Manganelli and Engle, 2001; Penza and Bansal, 2001) as well as its severe sampling limitations (Finger, 2006). Barone-Adesi et al. (1998) and Boudoukh et al. (1998) proposed a modified version of HS denominated filtered historical simulation (FHS) that features a dynamic approach to volatility and a weighting pattern for data: McNeil et al. (2005) posit that it filters the original observations via conditional volatility (CV) and processes data using the empirical distribution of the modified returns (from where 'filtered' and 'historical simulation' derive). Like FHS, CV models also use the dynamic nature of volatility, albeit with a calibrated stochastic distribution instead of the filtered empirical one. CV models also utilise schemes like ARCH (Engle, 1982), GARCH (Bollerslev, 1986) or EGARCH (Nelson, 1991) among many others, determining the parameters through optimisation functions featuring normal, student-t, generalised error, or other distributions (Christoffersen, 2003; McNeil et al., 2005; Alexander, 2008). While stressing the time-varying structure of volatility, Van der Goorbergh and Vlaar (1999) marked that at low confidence levels, the fat tails that financial series exhibit are better modelled by student-t distribution compared to the normal one.

Although the student-t distribution could help model leptokurtic patterns, it does not seem capable of addressing the presence of the 'black swans' – market crises – (Taleb, 2007), and, accordingly, many authors have been fostering the introduction of extreme value theory (EVT)[2] as the most adequate scheme to deal with those events. Danielsson and de Vries (2000), da Silva and de Melo Mendes (2003), McNeil (1998), Coles (2001), Christoffersen (2003), Reiss and Thomas (2007), Neftci (2000) and Nyström and Skoglund (2002)[3] suggested EVT to provide protection against market turmoil used with VaR or ES, and, furthermore, McNeil (1998) pioneered the inclusion of EVT for risk management, both for banking and insurance purposes.

Rightly enough, policy makers appear particularly worried about market slumps and on those grounds the respective mandates are enacted to prevent them from wreaking havoc on the banks' financial health. Regulators were quick to blame VaR for failing to forestall the 2008 crisis (Financial Services Authority, 2009; BCBS, 2013), and though Rossignolo et al. (2013) showed that enforcement of EVT within Basel II framework could have avoided Basel III, they decided to scrap VaR in favour of ES in Basel 3.5. But if VaR was one of the chief culprits of the 2007-2008 nightmare, it remains unclear whether full adoption of Basel 3.5 brings about solutions to its predecessor's pitfalls. The issue of the precise level of reserves is difficult and contentious, and academics have taken steps to consider it: for instance, Alexander and Sheedy (2008) proposed the development of precise stress tests in market models, hinting at the somewhat largeness in official MCR (Basel II). Within the context of active risk management, Santos et al. (2012) and Drenovak et al. (2016) optimised the MCR for Basel II (VaR) and Basel III (sVaR) respectively. However, while the former required the previous affixing of Backtesting results in order to construct the portfolio, the latter developed a methodology that worked with the current portfolio weights and managed to restrain VaR violations to the no-penalty zone in Backtesting, while simultaneously reducing the sVaR. Additionally, Drenovak et al. (2016) find that, in times of market stress, the optimal portfolios derived from their model outperform other specifications in terms of MCR and return due to the decrease in the cardinality, thus supporting the evidence of the reduction in the number of assets in the aftermath of financial crises. On the other hand, within passive risk management, McAleer et al. (2009) and Kuo et al. (2013) reformulated the market risk disclosure (MRD) through a dynamic learning strategy (DYLES), albeit only for Basel II amid certain subjectivities.

The paper aims at the evaluation of the entire revised framework in Basel 3.5, using an integral perspective characterised by the analysis of SA, IMA and their interaction; the assessment of the adequacy (either shortages or excessiveness) of the respective capital levels and possible alternative solutions within BCBS's framework in case potential inconsistencies may appear. Not only does the appraisal contribute to literature dealing with Basel 3.5 instead of Basel II or Basel III and, consequently, with ES in lieu of VaR, but also bringing into play the SA and its relationship with the IMA (as opposed to IMA only) and offering straightforward routes to channel unintended results that hamper Basel's 3.5 objectives.

3 The prospective changes in Basel 3.5

The set of reforms under Basel 3.5 undoubtedly represents the deepest overhaul of the regime, given the changes in the quantification of market risks via SA and IMA, the validation process, the interplay between SA and IMA and the calculation of the MCR. The present section succinctly reviews the main characteristics.

3.1 The revised SA

Up to Basel III, the SA had lacked risk sensitivity and showed very limited acknowledgement of hedging and diversification, derived from the simple flat rate applied to the size of the exposures (BCBS, 1988, 1996, 2009). The overhaul has been carried out following three main objectives:

1 The enactment of a renewed, more risk oriented methodology to compute MCR for those banks not requiring a refined risk model.

2 The provision of a credible fall-back to any defective IMA, including the likely application as a capital floor.

3 The constitution of a common ground to facilitate the comparison of MCR across jurisdictions.

The general procedure states that exposures should be allocated to risk buckets with a maximum number of twelve per asset class, which encompasses classes of securities with similar risk characteristics.[4] If a security cannot be assigned to a risk bucket (bracket) for an asset class, it will be placed into a 'residual' risk bracket that, unlike the rest, shall not receive the benefits of hedging and diversification. All notional positions belonging to a risk bucket will be applied a single risk weight and two prespecified correlation parameters: the first one corresponding to positions bearing the same sign to acknowledge diversification and the second one applying to exposures with different sign, thus recognising hedging. The BCBS intends to address, conservatively, the advantages of hedging and diversification arising from the unstable and changing patterns of the correlation parameters, particularly in highly strained moments. For commodities, offsetting between long and short positions in exactly equal instruments is allowed given that the risk buckets are created with regards to the commodity class (i.e., crude oil, metals, etc.). Conversely, the correlation parameters between pairs of commodities corresponding to positions in the same risk bucket (employed in the risk bucket aggregation formula) are defined slightly more specifically reflecting the differences in grades, delivery location, maturity and sign. Finally, two extra correlation parameters are applied between pairs of risk buckets for cross-risk bracket calculations. Then, the capital charge for commodity risk using SA requires:

a Offsetting of long and short positions in identical instruments.[5]

b Allocation of notional exposures into corresponding risk buckets according to the layout with the corresponding risk weight attached (Table 1).

Table 1 Risk buckets and risk weights within buckets

Bucket	*Commodity*	*Risk weight*
1	Coal	30%
2	Crude oil	35%
3	Electricity	60%
4	Freight	80%
5	Metals	40%
6	Natural gas	45%
7	Precious metals (including gold)	20%
8	Other	50%
9	Grains and oilseed	35%
10	Livestock and diary	25%
11	Soft and other agricultural	35%

c Acknowledgement of hedging and diversification within each risk bucket. The risk exposure for each bracket for notional exposures $i = 1, 2, \ldots, n$ is obtained through.[6]

$$K_b = \sqrt{\sum_{i=1}^{n} RW_i^2 MV_i^2 + \sum_{i=1}^{n} \sum_{j \neq i}^{n} \rho_{ij} RW_i MV_i RW_j MV_j} \tag{1}$$

where MV_i and RW_i denote the market value and the risk weight (Table 1) assigned to the notional position i respectively, and ρ_{ij} the correlation parameter between positions i and j, in accordance with the relationships between the security and the underlying commodity expressed in Tables 2A to 2C:

d Calculation of the commodity risk capital (CRC) using SA (CRC^{SA}) It recognises hedging and diversification across buckets in view of the aggregation of risk exposures of the respective risk exposures:

$$CRC^{SA} = \sqrt{\sum_{b=1}^{BK} K_b^2 + \sum_{b=1}^{B} \sum_{c \neq b} \gamma_{bc} S_b S_c} + K_{\text{residual}} \tag{2}$$

where K_{residual} denotes the capital requirement surging from commodities under the Residual bracket, $S_b = \sum_{i \in b} RW_i MV_i$, and γ_{bc} represents the correlation parameter between risk buckets b and c using the correlations in Table 2D.

Table 2 Correlation coefficients for maturity differences and matrix of correlation parameters

Correlation coefficients for maturity difference less than six months				
Sign	*Same location, same grade*	*Same location, different grade*	*Different location, same grade*	*Different location and grade*
Same	90%	70%	70%	50%
Different	80%	60%	60%	40%
Correlation coefficients for maturity difference from six months to one year				
Sign	*Same location, same grade*	*Same location, different grade*	*Different location, same grade*	*Different location and grade*
Same	80%	60%	60%	40%
Different	70%	50%	50%	30%
Correlation coefficients for maturity difference more than one year				
Sign	*Same location, same grade*	*Same location, different grade*	*Different location, same grade*	*Different location and grade*
Same	70%	50%	50%	30%
Different	60%	40%	40%	20%

Matrix of correlation parameters across buckets γ											
B	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1											
2	35%										
3	5%	5%									
4	20%	45%	0%								
5	20%	45%	5%	25%							
6	25%	15%	0%	0%	5%						
7	15%	30%	15%	10%	25%	5%					
8	0%	0%	0%	0%	0%	0%	0%				
9	25%	35%	0%	15%	25%	15%	15%	0%			
10	10%	5%	5%	0%	10%	0%	10%	0%	5%		
11	20%	35%	5%	15%	35%	10%	20%	0%	30%	10%	

3.2 The revised IMA

The main objective pursued by the BCBS is the constitution of a capital base to provide coverage for the potential losses arising from significant market slumps. The BCBS states that models must identify and capture all material risks factors and intends to offer a common treatment for exposures subject to similar risks in a bid to achieve uniformity among the different approaches. Furthermore, it introduces a very stringent validation process to authorise entities at firm-wide, trading desks and individual risk factor assessment, where failure to pass one or more of the evaluation tests means that the risk model is disallowed and the bank must employ SA.

3.2.1 General requirements

Besides many qualitative standards (BCBS, 2013), BCBS demands quantitative ones:

1 ES computed on a daily basis using a 97.50%, one-tailed confidence interval.

2 ES calibrated to a period of stress following an 'indirect' approach via a reduced set of risk factors. Banks must outline a streamlined group of risk factors relevant for their portfolio with a minimum history of observations of ten years, able to explain at least 75% of the variation in the full ES model. The ES for risk capital purposes is expressed as:

$$ES = ES_{R,S} = \frac{ES_{F,C}}{ES_{R,C}} \tag{3}$$

where:

$ES_{R,S}$ ES based on a stressed sample period using a reduced set of factors.

$ES_{F,C}$ ES based on the most recent 12 month observation term using the full set of factors.

$ES_{R,C}$ ES based on the most recent 12 month sample period using the reduced set of factors.

3 The stressed period to estimate $ES_{R,S}$ corresponds to the term in which the portfolio suffered its largest loss and ought to span back at least to 2005, with equally weighted (EW) observations updated no less than monthly or whenever some material changes take place;

4 Banks are allowed to apply any ES model as long as it captures all the material risks incurred and passes both Backtesting and profits and losses attribution tests (P&LAT).

5 Calculation of the CRC employing IMA (CRC^{IMA}):

Banks must satisfy daily the *CRC* determined as the higher of the previous day's capital charge and the average of such measures in the preceding 60 days:

$$CRC^{IMA} = \max\left(CRC_{t-1}^{IMA}; CRC_{avg}^{IMA}\right) \tag{4}$$

with CRC_t^{IMA} determined via (3).

3.2.2 Validation process

IMAs must overcome a three-stage validation process that would determine whether the respective portfolios should be capitalised with IMA or SA; failure to comply with any proof invalidates the scheme and activates SA.

3.2.2.1 First stage: classic Backtesting

It encompasses the qualitative and quantitative requirements contained in Basel II (BCBS, 1996): 99% one-tailed daily VaR with no model prescribed.[7] The outcome of this Backtesting is, thus, evaluated in terms of the three zone framework envisaged by the BCBS authorising techniques falling into the green zone (0–4 exceptions), penalising those in the yellow zone (4–9 exceptions) and excluding the ones in the red zone (ten or more exceptions), where 'exceptions' are understood as real P&L overcoming the model's VaR forecast ($P\&L_t > VaR_t$).

3.2.2.2 Second stage: additional Backtesting and P&LAT

IMAs must pass a two-step validation process comprised by further Backtesting and newly enacted P&LATs.

3.2.2.2.1 Additional Backtesting

It involves the comparison between daily VaR metric at 99% and 97.5% percentiles against the portfolio's actual P&L, nullifying models delivering more than 30 exceptions at 97.5% and more than 12 at 99% in the most recent 12 month period.

3.2.2.2.2 P&LATs

Two separate monthly tests are aimed at assessing the proportion of unexplained variation in the P&L forecasts over the last year. In this light, the BCBS proposes the following ratios that compare the theoretical P&L and the actual (real) P&L[8]:

a P&LAT1

It calculates the quotient between the mean unexplained daily P&L and the standard deviation of the actual P&L. Values outside the interval [–10%; 10%] are labelled as 'breach' and four or more breaches in the last twelve months invalidate the model. Mathematically:

$$\text{P\&LAT1} = \frac{\text{P\&L}_t^T - \text{P\&L}_t^A}{\sigma\left(\text{P\&L}^A\right)} \tag{5}$$

b P&LAT2

It comprises the ratio between the variances of unexplained daily P&L and actual daily P&L; any figure in excess of 20%[9] is considered a 'breach' and more than four breaches in the most recent year proclaim inadequacy. Hence:

$$\text{P\&LAT2} = \frac{\sigma^2\left(\text{P\&L}_t^T - \text{P\&L}_t^A\right)}{\sigma^2\left(\text{P\&L}^A\right)} \tag{6}$$

where, in (5) and (6) $P\&L^T$ and $P\&LT^A$ denote theoretical and actual P&L.

3.2.2.3 Third stage: risk factor analysis

It identifies risk factors[10] susceptible of being included in the bank's IMA for the calculation of MCR. Continuous real prices for a representative set of transactions must be available, reporting at least 24 yearly observations with a maximum of one month between two consecutive observations. The study will assume that the aforementioned provisions are attained; hence this third stage shall be omitted.

3.2.2.4 The specification of risk factors (SRF)

Banks must specify an appropriate set of risk factors sufficient to grab all the material risks facing the exposures (on and off-balance), i.e., the market rates and prices that impact on the value of the trading positions. The BCBS enunciates the minimum risk factors and/ or indications belonging to each category of market drivers: for commodity prices[11] banks should employ risk factors corresponding to all the commodity markets in which they operate. Were those positions limited, a straightforward specification of risk factors would suffice; on the other hand, intensive trading would entail sophisticated modelling[12] and, in both instances, the R^2 of the corresponding linear regression acts as the evaluation beacon.[13] In view of the nature of the exposures dealt with in the current study, the commodities involved will be modelled using a straightforward approach, i.e., applying a referred commodity index.

3.2.2.5 The capitalisation of risk factors

Banks ought to calculate:

1 An unconstrained internal model capital charge at the bank-wide level (*IMCC*(*C*)) though computing the correlations among the series of risk factors.

2 ES-based internal model capital charges ($IMCC(C_i)$) for each of the regulatory risk factors (interest rates, foreign exchange, equity prices and commodity prices), and sum them in order to obtain a risk-factor ES charge.

Therefore, the total capital charge for model able risk factors (*IMCC*) will be equal to the weighted sum of 1 and 2:

$$IMCC = \rho[IMCC(C)] + (1-\rho)\left[\sum_{i=1}^{n} IMMC(C_i)\right] \tag{7}$$

where

$$IMCC(C) = ES_{R,S}\frac{ES_{F,C}}{ES_{R,C}} \tag{8}$$

and

$$IMCC(C_i) = ES_{R,S,i}\frac{ES_{F,C,i}}{ES_{R,C,i}} \tag{9}$$

using the same stress period. Furthermore, ρ represents the weight assigned to the Internal Model but, considering that it remains to be determined by the BCBS following next QIS, the present article will assume that $\rho = 0.5$, thus transforming (7) into:

$$IMCC = 0.5[IMCC(C)] + 0.5\left[\sum_{i=1}^{n} IMCC(C_i)\right] \tag{10}$$

However, considering that only one risk factor (commodities) is involved, the sub-index *i* in (10) is 1, hence[14]:

$$IMCC = 0.5[IMCC(C)] + 0.5[IMCC(C)] = IMCC(C) \tag{11}$$

For regulatory purposes, the aggregated capital charge *CRC* equals, like in Basel II or Basel III, the maximum of the most recent observation and a weighted average of the previous 12 weeks, or 60 days scaled by a multiplier m_c:

$$CRC^{IMA} = \max\left[IMCC_{t-1} + SES_{t-1};\, m_c * \left(IMCC_{avg} + SES_{avg}\right)\right] \tag{12}$$

where SES denotes the aggregate regulatory capital measure for those risk factors in risk desks deemed unmodellable which, rooting in the structure of the present paper, will be neglected, i.e., $SES = 0$. Therefore

$$CRC^{IMA} = \max\left[IMCC_{t-1};\, m_c * \left(IMCC_{avg}\right)\right] \tag{13}$$

and, additionally

$$m_c = 1.5(1+k) \tag{14}$$

where *k* is related to the ex-post performance embedded in the outcome of the Backtesting of the bank's daily VaR at 99% based on the current observations on the full set of risk factors (VaR_{FC}). Given that the procedure leading to the determination of the value of *k* is analogous to that of Basel II and Basel III, the respective values of *k* make m_c range from 1.5 to 2.[15]

4 Methodology

In order to cover a wide spectrum of basic materials, long positions comprising 13 different spot commodities will be employed[16]: Brent crude (crude oil), silver and gold (precious metals including gold), corn, wheat and rice (grains and oilseed), copper (metals), coffee, sugar and cotton (soft's and other agriculturals), natural gas (natural gas) and live cattle (livestock and diary), with daily values retrieved from Thomson Reuters®.

Following the most objectively feasible approach, two sets comprised of three randomly selected commodities are then constructed: while in the first one (Set A) the assets are EW, in the second one (Set B) the securities are weighted according to the minimum variance portfolio (MVC) stated by Markowitz (1952). Both sets, alongside their weights and the rest of the characteristics to compute the *CRC* are classified in terms of Basel 3.5 mandate and depicted in Table 3.

Both the SA and IMA follow the guidelines established by BCBS (2014) and a variety of models will be applied to develop the latter: HS, FHS and CV using GARCH and EGARCH filters coupled with normal and student-t distributions, EVT via peaks-over-threshold (POT) after GARCH-normal pre-whitening and linear (standard deviation) scaled by normal and student-t distributions.

For every set, the sample term spans 1990 data points, from 05/01/2000 to 31/12/2007, thus leaving the year 2008 as the Backtesting period. Furthermore, TRJCRB (Thomson Reuters/core commodity excess return) and TRJCRBNETR (Thomson Reuters/core commodity total return) will constitute the indices used to model ES_{RS}, for which the twelve month stressed periods and the corresponding losses posted (between brackets) are 01/02/2001–31/01/2002 (25.54%) and 01/11/2000–31/10/2001 (15.52%) respectively. The indices for every portfolio, EW and MVC, are selected on the grounds of the R^2 after linearly regressing the respective portfolio returns and the index returns – abiding by the methodology described in BCBS (2014). This criterion addresses the SRF for IMA, recalling that usage of market indices provided by data vendors to map the whole portfolio is recommended by BCBS (2014).

CRC are afterwards determined employing SA and IMA, and the several specifications of the latter validated using the criteria detailed in Basel 3.5, procedure that will enable the determination of those models that overcome the evaluation scheme. The most accurate internal model is compared with SA, both in terms of the level of *CRC* and the protection provided to the intended positions as measured by the loss coverage ratio (LCR). In the light of those results, some alternatives to the proposals contained in Basel 3.5 are proposed in a bid to smooth the inconsistencies that may eventually surge between SA and IMA, to the extent that old incentives problems present in Basel II and Basel III seem again resurfacing.

Table 3 Commodities general information, sets and portfolios, set A to G

Commodity	*Sector*	*Location: city-country*	*Stock exchange*	*Grade*	*Bucket no.*
Brent Crude	Crude oil	London – UK	ICE	Different	2
Gold	Precious metals (including gold)	New York – USA	CEC	Different	7
Corn	Grains and oilseed	Chicago – USA	CBOT	Different	9
Copper	Metals	New York – USA	CEC	Different	5
Soybeans	Grains and oilseed	Chicago – USA	CBOT	Different	9
Coffee	Softs and other agriculturals	New York – USA	CEC	Different	11
Natural gas	Natural gas	New York – USA	CEC	Different	6
Silver	Precious metals (including gold)	New York – USA	CEC	Different	7
Wheat	Grains and oilseed	Chicago – USA	CBOT	Different	9
Rice	Grains and oilseed	Chicago – USA	CBOT	Different	9
Sugar	Softs and other agriculturals	London – UK	ICE	Different	11
Cotton	Softs and other agriculturals	New York – USA	CEC	Different	11
Live cattle	Livestock and diary	Chicago – USA	CBOT	Different	10
Cocoa	Softs and other agriculturals	New York – USA	CEC	Different	11

Table 3 Commodities general information, sets and portfolios, set A to G (continued)

Set A – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Brent crude	33.33%	9.39%
Gold	33.33%	66.42%
Corn	33.33%	24.19%
Set B – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Copper	33.33%	36.08%
Soybeans	33.33%	43.93%
Coffee	33.33%	19.99%
Set C – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Natural gas	33.33%	7.04%
Silver	33.33%	42.41%
Wheat	33.33%	50.55%
Set D – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Rice	33.33%	36.41%
Sugar	33.33%	28.14%
Cotton	33.33%	35.45%
Set E – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Copper	33.33%	55.12%
Live cattle	33.33%	34.10%
Cocoa	33.33%	10.78%
Set F – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Brent crude	33.33%	25.33%
Soybeans	33.33%	50.24%
Coffee	33.33%	24.43%
Set G – commodities and weights		
Commodity	*Portfolio 1*	*Portfolio 2*
Brent crude	33.33%	19.66%
Silver	33.33%	35.62%
Wheat	33.33%	44.72%

5 Results

As expected, the whole process that starts with the validation procedure for the different IMA followed by the calculation of the *CRC* and ends comparing SA and the most precise IMA yields very different results to those in the previous Capital Accords. In that vein, the numerical findings underpin the claim that the BCBS has fulfilled its principal aim of strengthening the capital base for the commodity markets, although the approval criteria designed for IMA appears somewhat biased.

5.1 Assessment of IMA: stages 1, 2 and SRF

Table 4 displays the outcome of the Backtesting process (stage 1) carried out at 99%; depicting the quantity of exceptions and the penalisation charges using the scale provided by BCBS (2014). The outcome through year 2008 plainly shows the typical inability of HS and both linear specifications to produce adequate answers to a crisis period, consequently disqualifying them for further validation stages. On the other hand, the overall picture for FHS and CV hints at the former one prevailing, given that it fares better than its counterpart.

Within the FHS, the GARCH specification delivers more precision than its exponential counterpart as only two portfolios are invalidated and the remaining ones pick between 50% and 85% surcharges compared to ten in the red zone. CV, on the other hand, displays more heterogeneous behaviour, with a couple of green zones among an overall redder panorama, particularly regarding the EGARCH (100% rejections for the normal variant and one green zone and three yellow ones for the student-t one). CV/GARCH exhibits more resilience, with five portfolios discarded and the rest bearing penalties for the normal specification, while the student-t improves yielding three approvals, nine surcharges and two rejections. The highly leptokurtic EVT reveals itself as the most reliable model avoiding any kind of punishment.

Classic Backtesting narrows the quantity of models to be selected, but the plight for IMA appears worsened once stage two-step a is performed. Table 5 reports the quantity of exceptions recorded in the second string of Backtesting at 99% and 97.50% according to Section 3.2.2. For simplicity, Table 5 also depicts the full outcome of stages 1 and 2 (restricted to the first step, i.e., Backtesting), from where it emerges that only EVT passes the validation criteria comfortably whereas the remaining techniques manage to put relatively decent outcome.[17] FHS's performance seems slightly better than CV's with scattered approvals for the Exponential GARCH normal and student-t variants and few disqualifications for GARCHs against numerous rejections for both autoregressive models and only four nods for EGARCH student-t. Step b of Stage II does not prove as restrictive as it may have been surmised. Accordingly, Table 6 displays the result of P&LAT1 and P&LAT2[18], where it might be noticed that these proofs have not produced any noticeable impact on the situation of the models. In effect, Table 7 depicts the overall assessment of the evaluation procedure that broadly coincides with the Backtesting indicated in Table 4. Nevertheless, even though a number of representations could, in principle, obtain the regulator's authorisation to be employed for the determination of *CRC*, a joint analysis of Tables 4 and 7 reveals that only the EVT specification passes the tests outstandingly across all the Sets and the corresponding portfolios, to the point that it still avoids penalisation under the classic Backtesting. Consequently, the ensuing analysis will only feature EVT as the IMA representation against which SA is to be contrasted considering, moreover, that its *CRC* levels shall not be distorted by the addons envisaged by Backtesting. The outcome makes a twofold contribution to the (scant) financial literature regarding Basel 3.5: in the first place, it provides evidence of the very stringent validation methodology susceptible of being put into practice, whereas in the second place it hints at a kind of bias against the IMA in consideration that only ultra-heavy tailed models could in principle pass the multi-stage criteria. Additionally, it seems to imply that the relationship between the SA and IMA (or, specifically, the techniques that overcome the validation procedure) could end up altered as SA will also represent a fall-back to IMA.

The evaluation process formally concludes with the analysis of the SRF used to compute the ES_{RS}, i.e., the ES utilising the reduced set of factors throughout the stressed period mentioned in (3), (8) and (9). As indicated in Section 4, the indices TRJCRB and TRJCRBNETR are employed to mimic the movements of the portfolios, with the selection boiling down to the one yielding the highest R^2. Acknowledging that the BCBS has not hitherto ventured to establish a threshold for the value of R^2, Table 8 exposes the sets, portfolios, indices and the respective coefficients of determination.[19]

5.2 The CRC levels and the relationship between IMA and SA

The *CRC* arising from the different IMA are displayed in Table 9, from where it surges that frequently the most accurate specification (EVT) delivers higher capital levels than many other techniques penalised under Backtesting (Table 4), again hinting at the presence of the inconsistencies underlined by Rossignolo et al. (2013).[20] For example, Table 9 column [10] indicates that, for Set B, EVT ends up constituting 16.09% and 26.48% against 13.49% and 19.76% of CV/GARCH-t (Column [7]), for portfolios A and B respectively, even after corresponding extra capital charges of 65% and 50%. Furthermore, the situation for Set C appears more dramatic, since EVT delivers 63.10% and 72%, while CV/GARCH-t yields 21.42% and 24.49% (portfolios A and B respectively), despite suffering 65% surcharge in each case. Unfortunately, EVT still fares worse than the second-best CV GARCH student-t in a handful of additional instances where the latter suffers high surcharges (65% to 85%). Consequently, the results show that the BCBS has not amended these inconsistencies in Basel 3.5, which may hamper the effectiveness of the IMA as in Basel III, adding more woes for this avenue when computing capital requirements.

In absolute terms, EVT does not yield excessive *CRC*. In fact, Table 9 column [10] conveys the idea that, save from sets A and C where the figures seem abysmal, the value fluctuates from 14.84% to 26.48%, which suggests that EVT may not, after all, embody disproportionate amounts of capital. Acknowledging the difficulty in ascertaining the appropriate level of equity base, the figures contained in Table 9 suggest that the utility of EVT as a proper technique to deal with abnormal adverse market movements (McNeil, 1998) is enhanced by the aprioristically adequate (i.e., not so excessive) coverage delivered by its *CRC*, finding not comprehensively underlined by academics. However, that advantage looks dizzy when the relationship between SA and IMA is brought into play (overlooked by the literature), even after the restrictive test process required for IMA filters only super leptokurtic models (EVT).

Table 4 Stage 1 steps a and b – Backtesting: quantity of exceptions and penalties at 99%

Set portfolio	*HS*	*FHS GARCH-N*	*FHS GARCH-t*	*FHS EGARCH-N*	*FHS EGARCH-t*	*CV GARCH-N*	*CV GARCH-t*	*CV EGARCH-N*	*CV EGARCH-t*	*EVT POT*	*Linear normal*	*Linear t*
Set A/P1	12–100%	7–65%	7–65%	10–100%	10–100%	11–100%	7–75%	14–100%	11–100%	2–0%	15–100%	13–100%
Set A/P2	18–100%	8–75%	6–50%	18–100%	8–75%	9–85%	4–0%	25–100%	7–75%	0–0%	18–100%	17–100%
Set B/P1	12–100%	7–65%	7–65%	12–100%	14–100%	9–85%	7–75%	11–100%	10–100%	0–0%	15–100%	13–100%
Set B/P2	18–100%	8–75%	7–65%	12–100%	11–100%	6–50%	6–50%	13–100%	8–75%	0–0%	18–100%	17–100%
Set C/P1	10–100%	8–75%	8–75%	9–85%	9–85%	9–85%	7–75%	11–100%	9–85%	0–0%	15–100%	10–100%
Set C/P2	14–100%	6–50%	6–50%	9–85%	9–85%	7–75%	7–75%	16–100%	13–100%	0–0%	19–100%	15–100%
Set D/P1	11–100%	6–50%	6–50%	12–100%	4–0%	5–40%	4–0%	16–100%	3–0%	1–0%	16–100%	9–85%
Set D/P2	10–100%	6–50%	6–50%	11–100%	4–0%	5–40%	4–0%	14–100%	3–0%	0–0%	13–100%	9–85%
Set E/P1	12–100%	11–100%	10–100%	13–100%	14–100%	16–100%	11–100%	17–100%	12–100%	3–0%	20–100%	16–100%
Set E/P2	14–100%	6–50%	6–50%	6–50%	6–50%	13–100%	8–75%	15–100%	10–100%	0–0%	19–100%	17–100%
Set F/P1	23–100%	13–100%	12–100%	21–100%	24–100%	15–100%	10–100%	24–100%	25–100%	1–0%	25–100%	22–100%
Set F/P2	20–100%	7–65%	8–75%	9–85%	10–100%	8–75%	7–75%	12–100%	11–100%	0–0%	26–100%	20–100%
Set G/P1	16–100%	9–85%	8–75%	11–100%	10–100%	13–100%	9–85%	16–100%	13–100%	1–0%	24–100%	19–100%
Set G/P2	16–100%	8–75%	8–75%	12–100%	12–100%	9–85%	9–85%	16–100%	11–100%	0–0%	20–100%	17–100%

Note: Quantity of exceptions and penalties separated by hyphen.

Table 5 Stage 1 step b – Backtesting at 99% and 97.50% and Backtesting outcome

Set portfolio	*HS*	*FHS GARCH-N*	*FHS GARCH-t*	*FHS EGARCH-N*	*FHS EGARCH-t*	*CV GARCH-N*	*CV GARCH-t*	*CV EGARCH-N*	*CV EGARCH-t*	*EVT POT*	*Linear normal*	*Linear t*
Set A/P1	12-12-I	7-7-I	7-7-I	10-10-I	10-10-I	11-11-I	7-7-I	14-14-S	11-11-I	2-0-I	15-15-S	13-13-S
Set A/P2	18-18-S	8-8-I	6-6-I	18-18-S	8-8-I	9-9-I	4-4-I	25-25-S	7-7-I	0-0-I	18-18-S	17-17-S
Set B/P1	12-12-I	7-7-I	7-7-I	12-12-I	14-14-S	9-9-I	7-7-I	11-11-I	10-10-I	0-0-I	15-15-S	13-13-S
Set B/P2	18-18-S	8-8-I	7-7-I	12-12-I	11-11-I	6-6-I	6-6-I	13-13-S	8-8-I	0-0-I	18-18-S	17-17-S
Set C/P1	10-10-I	8-8-I	8-8-I	9-9-I	9-9-I	9-9-I	7-7-I	11-11-I	9-9-I	0-0-I	15-15-S	10-10-I
Set C/P2	14-14-S	6-6-I	6-6-I	9-9-I	9-9-I	7-7-I	7-7-I	16-16-S	13-13-S	0-0-I	19-19-S	15-15-S
Set D/P1	11-11-I	6-6-I	6-6-I	12-12-I	4-4-I	5-5-I	4-4-I	16-16-S	3-3-I	1-0-I	16-16-S	9-9-I
Set D/P2	10-10-I	6-6-I	6-6-I	11-11-I	4-4-I	5-5-I	4-4-I	14-14-S	3-3-I	0-0-I	13-13-S	9-9-I
Set E/P1	12-12-I	11-11-I	10-10-I	13-13-S	14-14-S	16-16-S	11-11-I	17-17-S	12-12-I	3-0-I	20-20-S	16-16-S
Set E/P2	14-14-S	6-6-I	6-6-I	6-6-I	6-6-I	13-13-S	8-8-I	15-15-S	10-10-I	0-0-I	19-19-S	17-17-S
Set F/P1	23-23-S	13-13-S	12-12-I	21-21-S	24-24-S	15-15-S	10-10-I	24-24-S	25-25-S	1-0-I	25-25-S	22-22-S
Set F/P2	20-20-S	7-7-I	8-8-I	9-9-I	10-10-I	8-8-I	7-7-I	12-12-S	11-11-I	0-0-I	26-26-S	20-20-S
Set G/P1	16-16-S	9-9-I	8-8-I	11-11-I	10-10-I	13-13-S	9-9-I	16-16-S	13-13-S	1-0-I	24-24-S	19-19-S
Set G/P2	16-16-S	8-8-I	8-8-I	12-12-I	12-10-I	9-9-I	9-9-I	16-16-S	11-11-I	0-0-I	20-20-S	17-17-S

Note: Quantity of exceptions at 99%, 97.50% and backtesting outcome separated by hyphen. 'I' and 'S' denote 'IMA' and 'SA' respectively.

Table 6 Profits and losses attribution tests I and II

Set portfolio	*HS*	*FHS GARCH-N*	*FHS GARCH-t*	*FHS EGARCH-N*	*FHS EGARCH-t*	*CV GARCH-N*	*CV GARCH-t*	*CV EGARCH-N*	*CV EGARCH-t*	*EVT POT*	*Linear normal*	*Linear t*
Set A/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set A/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set B/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set B/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set C/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set C/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set D/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set D/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set E/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set E/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set F/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set F/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set G/P1	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I
Set G/P2	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I	I-I

Note: Profits and losses attribution tests I and II outcome separated by hyphen. 'I' denotes 'IMA'.

Table 7 Complete evaluation process – stages 1 and 2 overall results

Set portfolio	*HS*	*FHS GARCH-N*	*FHS GARCH-t*	*FHS EGARCH-N*	*FHS EGARCH-t*	*CV GARCH-N*	*CV GARCH-t*	*CV EGARCH-N*	*CV EGARCH-t*	*EVT POT*	*Linear normal*	*Linear t*
Set A/P1	S	I	I	S	S	S	I	S	S	I	S	S
Set A/P2	S	I	I	S	I	I	I	S	I	I	S	S
Set B/P1	S	I	I	S	S	I	I	S	S	I	S	S
Set B/P2	S	I	I	S	S	I	I	S	I	I	S	S
Set C/P1	S	I	I	I	I	I	I	S	I	I	S	S
Set C/P2	S	I	I	I	I	I	I	S	S	I	S	S
Set D/P1	S	I	I	S	I	I	I	S	I	I	S	I
Set D/P2	S	I	I	S	I	I	I	S	I	I	S	I
Set E/P1	S	S	S	S	S	S	S	S	S	I	S	S
Set E/P2	S	I	I	I	I	S	I	S	S	I	S	S
Set F/P1	S	S	S	S	S	S	S	S	S	I	S	S
Set F/P2	S	I	I	I	S	I	I	S	S	I	S	S
Set G/P1	S	I	I	S	S	S	I	S	S	I	S	S
Set G/P2	S	I	I	S	S	I	I	S	S	I	S	S

The fact that SA establishes a flo or to *CRC* clearly complicates the matters. Table 9 column [13] exhibits the values given by the SA, and a quick comparison with the most accurate model – EVT – indicates that in half of the examples it situates below the minimum percentage established by the SA (highlighted in bold letters) and, excluding a few outliers (Sets A and C), the remaining portfolios deliver roughly levelled amounts of equity, with the exceedance percentages ranging from 2.22% to 8.88%. Furthermore, BCBS's goals are clearly depicted in Table 10, which compares the *CRC* derived from Basel III and Basel 3.5 specifications employing the most precise IMA – EVT – and the SA. While, on average terms, Basel 3.5 reports a 33% decrease in the capital requirement for IMA –notably due to the scrap of the sVaR term, it sees a rise of 37% in the figures belonging to the SA – stemming from the demise of the 18% flat rate and its replacement for the more risk-oriented methodology. The overall scenario, then, comprises an average decrease in the *CRC* yielded by IMA against an increase in the values of those delivered by SA that effectively elevates the floor that SA is expected to establish, therefore availing the objectives pursued by the BCBS. While this constitutes a desired outcome, the study also marks that it was reached at the expense of severely restraining the quantity of Internal Models available to operate in consideration of the tough three stage validation scheme, possibly bringing about potential inconsistencies in the prospective Basel 3.5. This otherwise important point has already been mentioned by Rossignolo et al. (2013) for Basel III, and the current study would rank among the first ones in raising it for Basel 3.5.

Table 8 Specification of risk factors

Set/portfolio	*Index*	R^2
Set A/P1	TRJCRB	62.16%
Set A/P2	TRJCRB	34.79%
Set B/P1	TRJCRBNETR	58.68%
Set B/P2	TRJCRBNETR	60.44%
Set C/P1	TRJCRB	36.61%
Set C/P2	TRJCRB	32.50%
Set D/P1	TRJCRBNETR	23.85%
Set D/P2	TRJCRBNETR	22.65%
Set E/P1	TRJCRBNETR	29.25%
Set E/P2	TRJCRBNETR	39.06%
Set F/P1	TRJCRB	49.55%
Set F/P2	TRJCRB	42.56%
Set G/P1	TRJCRB	55.98%
Set G/P2	TRJCRB	38.56%

Up to the present stage, the evidence gathered shows that, for commodity exposures, the BCBS managed to augment the capital base arising from SA and diminish that surging from the several IMA compared to the existing Basel III. Even though in absolute terms the levels might appear strong, the following section attempts to assess it more precisely using a real test.

Table 9 Basel 3.5 *CRC* levels

Set portfolio	*HS [1]*	*FHS GARCH-N [2]*	*FHSGARCH-t [3]*	*FHS EGARCH-N [4]*	*FHSE GARCH-t [5]*	*CV GARCH-N [6]*	*CV GARCH-t [7]*	*CV EGARCH-N [8]*	*CV EGARCH-t [9]*	*EVT POT [10]*	*Linear normal [11]*	*Linear t [12]*	*SA [13]*
Set A/P1	12.15%	15.09%	15.06%	16.39%	16.12%	21.19%	14.27%	23.84%	17.49%	40.08%	14.52%	16.55%	20.58%
Set A/P2	14.76%	23.85%	20.50%	21.25%	23.90%	30.19%	13.91%	24.13%	26.03%	61.73%	15.81%	17.09%	24.28%
Set B/P1	9.65%	8.12%	7.68%	10.18%	10.73%	9.20%	13.49%	11.13%	15.38%	*16.09%*	10.67%	11.74%	25.12%
Set B/P2	11.73%	8.38%	8.42%	12.22%	12.13%	15.15%	19.76%	14.02%	21.03%	26.48%	11.62%	12.12%	25.91%
Set C/P1	19.11%	25.34%	23.93%	30.04%	28.53%	30.86%	21.42%	49.47%	29.11%	63.10%	20.86%	22.49%	20.78%
Set C/P2	19.16%	25.76%	24.62%	29.12%	28.75%	31.40%	24.49%	43.83%	31.63%	72.00%	19.29%	21.76%	18.62%
Set D/P1	10.29%	6.51%	6.23%	9.11%	5.86%	8.19%	7.57%	10.19%	9.82%	*19.27%*	11.42%	10.73%	36.86%
Set D/P2	9.87%	6.56%	6.01%	8.55%	5.89%	8.07%	7.50%	10.04%	9.89%	*18.98%*	11.21%	10.53%	35.41%
Set E/P1	15.34%	10.01%	10.20%	12.72%	13.20%	10.47%	16.46%	12.45%	18.94%	*17.24%*	13.28%	14.44%	21.66%
Set E/P2	15.07%	11.86%	11.90%	12.44%	14.39%	15.44%	19.97%	15.74%	24.86%	*25.43%*	13.54%	14.75%	27.14%
Set F/P1	11.70%	10.52%	10.58%	11.19%	8.93%	9.01%	15.04%	7.73%	10.50%	*14.84%*	9.95%	10.88%	24.45%
Set F/P2	12.03%	10.71%	10.74%	12.28%	12.10%	10.16%	13.70%	9.92%	14.15%	*19.12%*	10.18%	11.92%	25.03%
Set G/P1	12.74%	14.14%	13.23%	14.85%	13.69%	12.07%	17.60%	9.78%	15.84%	*19.88%*	10.68%	11.59%	20.58%
Set G/P2	13.49%	12.58%	12.50%	14.08%	13.61%	11.65%	17.55%	9.44%	14.58%	20.74%	10.91%	11.89%	19.05%

Table 10 Basel III vs. Basel 3.5 *CRC* levels – IMA-EVT and SA

Set portfolio	*IMA-EVT Basel III*	*IMA-EVT Basel 3.5*	*IMA-EVT % variation*	*SA Basel III*	*SA Basel 3.5*	*SA% variation*
Set A/P1	21.99%	40.08%	82.25%	18.00%	20.58%	14.31%
Set A/P2	36.72%	61.73%	68.11%	18.00%	24.28%	34.91%
Set B/P1	47.38%	16.09%	–66.04%	18.00%	25.12%	39.55%
Set B/P2	79.92%	26.48%	–66.87%	18.00%	25.91%	43.92%
Set C/P1	102.87%	63.10%	–38.66%	18.00%	20.78%	15.42%
Set C/P2	60.21%	72.00%	19.58%	18.00%	18.62%	3.47%
Set D/P1	23.75%	19.27%	–18.86%	18.00%	36.86%	104.77%
Set D/P2	23.73%	18.98%	–20.02%	18.00%	35.41%	96.71%
Set E/P1	26.83%	17.24%	–35.75%	18.00%	21.66%	20.31%
Set E/P2	43.99%	25.43%	–42.19%	18.00%	27.14%	50.76%
Set F/P1	39.57%	14.84%	–62.50%	18.00%	24.45%	35.83%
Set F/P2	59.91%	19.12%	–68.09%	18.00%	25.03%	39.06%
Set G/P1	39.53%	19.88%	–49.72%	18.00%	20.58%	14.31%
Set G/P2	42.98%	20.74%	–51.74%	18.00%	19.05%	5.84%
Average	46.38%	31.07%	–33.02%	18.00%	24.67%	37.08%
Std. deviation	23.03%	19.83%		0.00%	5.53%	

5.3 *The sufficiency of CRC levels*

One of the ways to quantify the sufficiency of the *CRC* could root in the evaluation of the coverage they provide against the stressed period when the portfolio sustained the heaviest loss in terms of the *LCR* put forward by Rossignolo et al. (2013). Table 11 informs the 2008 shortfall in column [1], whereas columns [2]–[3] and [4]–[5] exhibit the *CRC* and *LCR* delivered by the IMA's EVT and SA respectively and, in this vein, figures on columns [3] and [5] are pretty descriptive of the amount of extra capital that the banks are demanded to constitute. For EVT, setting aside the outliers (sets A and C), *LCR* values range from a minimum of 146% to a maximum of 332%, while the boundaries for SA are 191% and 614%.[21] In spite of the fact that neither the apparition nor the magnitude of 'black swans' can be ruled out (Taleb, 2007), the aforementioned quantities could mark, generally, that the BCBS attained the declared overarching objective of higher capital requirements but, on the other hand, it may signal that banks might be freezing funds unnecessarily instead of allocating them to more productive projects. In order to remedy or, at least, ameliorate those glitches, the ensuing Section proposes a relatively direct route, thus contributing to existing bodies of knowledge with a forthright solution within Basel 3.5 framework.

Table 11 Basel 3.5 *LCR* and *CRC*

Set portfolio	*Maximum loss year 2008 [1]*	*IMA-EVT CRC [2]*	*IMA-EVT LCR [3]*	*SA CRC [3]*	*SA LCR [4]*
Set A/P1	–5.69%	40.08%	704.91%	20.58%	361.89%
Set A/P2	–7.07%	61.73%	872.61%	24.28%	343.25%
Set B/P1	–8.03%	16.09%	200.46%	25.12%	312.92%
Set B/P2	–10.55%	26.48%	251.09%	25.91%	245.65%
Set C/P1	–7.44%	63.10%	847.99%	20.78%	279.19%
Set C/P2	–5.77%	72.00%	1248.57%	18.62%	323.00%
Set D/P1	–6.18%	19.27%	311.74%	36.86%	596.25%
Set D/P2	–5.77%	18.98%	329.15%	35.41%	614.05%
Set E/P1	–6.18%	17.24%	279.18%	21.66%	350.69%
Set E/P2	–7.67%	25.43%	331.71%	27.14%	353.92%
Set F/P1	–9.59%	14.84%	154.70%	24.45%	254.90%
Set F/P2	–13.12%	19.12%	145.72%	25.03%	190.77%
Set G/P1	–9.22%	19.88%	215.50%	20.58%	223.07%
Set G/P2	–8.59%	20.74%	241.41%	19.05%	221.71%

5.4 A straightforward conduit

On the grounds of the somewhat disproportionate capital base that Basel 3.5 yields, the article postulates an alternative that may mitigate the impact of its application, yet within BCBS's framework. For that purpose, the proposal advocates that national regulators should become empowered to perform minor modifications to the BCBS's regulations that may help them tailor the capital mandates to their national markets.

The idea involves the inclusion of calibration parameters in the expressions delivering the *CRC*: sa in (2.2) for SA and m_s in (2.3) and m_c^* in (2.13) and (2.14) for IMA, intending to level SA with the most accurate IMA, simultaneously limiting disproportionately high capital levels. The modified formulas will, then, read as follows:

1 Standardised approach:

$$CRC^{SA*} = sa\left(\sqrt{\sum_{b=1}^{B} K_b^2 + \sum_{b=1}^{B} \sum_{c \neq b} \gamma_{bc} S_b S_c} + K_{\text{residual}}\right) \tag{15}$$

2 Internal models approach:

$$ES = m_s\left(ES_{R,S}\,\frac{ES_{F,C}}{ES_{R,C}}\right) \tag{16}$$

and

$$m_c = m_c^*(1+k) \tag{17}$$

which, after algebraic manipulations, yield a modified version of the IMA's *CRC* stated in (2.13):

$$CRC^{IMA*} = \max\left[IMCC_{t-1}; m_c * \left(IMCC_{avg}\right)\right] \quad (18)$$

Expressions (16) and (18)[22] will consequently be employed to produce new capital levels CRC^{SA*} and CRC^{IMA*} by varying the parameters *sa* and m_s and m_c^* respectively.

Table 12 panels A and B deploys an optimisation exercise designed to minimise the difference between SA and EVT-IMA across sets and portfolios –measured by RMSE and MAE[23] – changing one of the three parameters at a time. For instance, Table 12 Panel A states that, according to RMSE, setting m_c^* = 1.38 in (17), with sa = 1 (15) and m_s = 1 (16), it is possible to approximate SA and EVT-IMA, whereas, using MAE, m_c^* = 1.6124. The rest of the instances indicate a reduction in the variables: m_s = 0.4657 and 0.5438 and sa = 1.11 and 0.93722 for RMSE and MAE respectively, consequently conveying that m_c = 3 appears excessive, much like m_s = 1 whilst, on the other hand, *sa* would, at least, remain the same or slightly modified.

Table 12 The optimisation exercise

Panel A – root mean squared error (RMSE)				
Parameter	m_c^*	m_s	*sa*	*RMSE*
m_c^*	1.38162	1.00000	1.00000	0.18407
m_s	3.00000	0.46570	1.00000	0.18408
sa	3.00000	1.00000	1.11000	0.29229
Panel B – mean squared error (MSE)				
Parameter	m_c^*	m_s	*sa*	*MAE*
m_c^*	1.61000	1.00000	1.00000	0.40754
m_s	3.00000	0.54380	1.00000	0.40754
sa	3.00000	1.00000	0.93722	0.42848

Table 13 displays the (selected) outcome of a simulation exercise featuring the *LCR* and the *CRC* for IMA-EVT and SA allowing simultaneous variations of *sa*, m_c and m_s, and illustrating the wide range of combinations that national supervisors may have at hand when fixing those parameters to achieve their aims. Hence, acknowledging the limitations of the averages, m_c = 2.40, m_s = 0.88 and sa = 0.95 could provide a good starting point to level EVT-IMA and SA in view of the similar (average) values they yield for *LCR* and *CRC* (Table 13 columns [1] to [3]). Local supervisors could, then, relax the provisions of the BCBS regulations and, still within its framework but calibrating the factors, accommodate the *CRC* to their specific needs. This recipe could embody a relevant outcome as the ‘one size fits all’ regulation might be adapted to the patterns and characteristics of the domestic markets outlined by national supervisors, simultaneously avoiding the application of mandates generated with only a few countries in mind. This recipe could embody a relevant outcome as the ‘one size fits all’ regulation might be adapted to the patterns and characteristics of the domestic markets outlined by national supervisors, simultaneously avoiding the application of mandates generated with only a few countries in mind.

Table 13 Simulation analysis

Set portfolio appraisal	*IMA EVT m_c = 2.40 LCR [1]*	*IMA EVT m_s = 0.88 CRC [2]*	*SA sa = 0.95 LCR [3]*	*SA sa = 0.95 CRC [4]*	*IMA EVT m_c = 2.50 LCR [5]*	*IMA EVT m_s = 0.90 CRC [6]*	*SA sa = 0.98 LCR [7]*	*SA sa = 0.98 CRC [8]*	*IMA EVT m_c = 2.60 LCR [9]*	*IMA EVT m_s = 0.92 CRC [10]*	*SA sa = 1.01 LCR [11]*	*SA sa = 1.01 CRC [12]*
Set A/P1	9.5784	0.2821	6.8202	0.2009	10.2043	0.3006	7.3410	0.2162	10.8483	0.3195	7.9447	0.2340
Set A/P2	12.2231	0.4346	6.6685	0.2371	13.0218	0.4630	7.1777	0.2552	13.8436	0.4922	7.7681	0.2762
Set B/P1	1.7670	0.1133	3.8255	0.2453	1.8825	0.1207	4.1176	0.2640	2.0013	0.1283	4.4563	0.2857
Set B/P2	2.9984	0.1864	4.0685	0.2529	3.1943	0.1986	4.3792	0.2723	3.3959	0.2111	4.7393	0.2946
Set C/P1	14.1106	0.7330	3.9050	0.2029	15.0326	0.7809	4.2032	0.2183	15.9813	0.8302	4.5489	0.2363
Set C/P2	11.8551	0.5068	4.2534	0.1819	12.6297	0.5400	4.5783	0.1957	13.4268	0.5740	4.9548	0.2118
Set D/P1	3.7040	0.1357	9.8256	0.3599	3.9460	0.1445	10.5759	0.3874	4.1951	0.1537	11.4457	0.4192
Set D/P2	3.6781	0.1336	9.5166	0.3457	3.9184	0.1423	10.2434	0.3721	4.1657	0.1513	11.0858	0.4027
Set E/P1	2.4071	0.1214	4.1935	0.2114	2.5643	0.1293	4.5137	0.2276	2.7262	0.1375	4.8850	0.2463
Set E/P2	3.1658	0.1790	4.6847	0.2650	3.3726	0.1907	5.0424	0.2852	3.5855	0.2028	5.4571	0.3086
Set F/P1	2.1092	0.1045	4.8198	0.2387	2.2470	0.1113	5.1879	0.2570	2.3888	0.1183	5.6146	0.2781
Set F/P2	2.7408	0.1346	4.9765	0.2444	2.9199	0.1434	5.3565	0.2631	3.1042	0.1524	5.7971	0.2847
Set G/P1	3.2186	0.1399	4.6208	0.2009	3.4289	0.1491	4.9737	0.2162	3.6453	0.1585	5.3827	0.2340
Set G/P2	3.4406	0.1460	4.3825	0.1860	3.6654	0.1556	4.7172	0.2002	3.8968	0.1654	5.1051	0.2167
Average	5.4998	0.2394	5.4687	0.2409	5.8591	0.2550	5.8863	0.2593	6.2289	0.2711	6.3704	0.2806

Note: More results of the simulation analysis are available upon request.

6 Concluding remarks and policy implications

The latest BCBS's overhaul of Basel III has delivered a host of aspects to analyse, stemming from the restructuring of both the SA and IMA. While the jury is still out for the definitive results, the present study carried out on commodity markets enlightens a series of revealing consequences.

Initially, the transformation of the SA into a more risk-oriented approach appears very healthy particularly considering the snags of the former SA. Essentially, the fact that instead of a simple flat rate applied to the exposures the BCBS proposes a Markowitz's style appraisal would in principle reflect the risk embedded in the positions. However, the outcome hints at relatively invariant capital estimates due to the rigid structure of the correlation coefficients (both within the risk buckets and between the commodity exposures), eventually high enough to provide substantial coverage even in the occasion of massive market slumps.

On the other hand, the BCBS's appraisal to IMA allows two different readings. Firstly, the adoption of ES in lieu of VaR seems adequate regarding the disadvantages of the latter as a risk metric and, secondly, the results may indicate some problems arising from the stressed period pivot. Furthermore, the BCBS has adopted a very tough stance on IMA postulating restrictive validation proofs that virtually leaves highly leptokurtic models based on EVT as the only ones capable of attaining them.

Notwithstanding the fact that the BCBS's stringent criteria places IMA at a significant disadvantage with reference to its counterpart SA, and even making use of ultra heavy-tailed specifications like EVT, the interaction SA-IMA stipulates that SA effectively dictates the capital floor. However, the EVT-based IMA often manages to deliver lower equity levels, which gives rise to accuracy disincentives like in Basel II and Basel III (Rossignolo et al., (2012, 2013)).

In order to solve or at least soften the scale of the problems detected, the paper proposes a forthright methodology within the framework of Basel 3.5. The introduction of calibration parameters in the expressions that determine the *CRC*, both for the SA (parameter sa) and the IMA (parameters m_s and m_c) may basically change the appraisal, as the national regulators can fix their values at their discretion in accordance with the domestic panorama and perspectives, to the point of allowing the possibility to invert the approach and set the capital requirements around a certain predetermined *LCR*. Even though the estimated values as they appear in the article may be considered portfolio specific, this fact does not prevent them from being extended to more jurisdictions. In effect, the rationale behind the research states that the BCBS is bound to introduce those parameters in the official regulation, and, afterwards, the respective nations are free to ascertain their values after a careful and proper evaluation of the patterns of the portfolios and markets. In this fashion, the system of parameters could be tailored upwards to contain an upsurge of volatility, decreased to match periods of relative tranquillity or designed within fluctuation bands in order to circumscribe the procyclicality characteristic of capital requirements. Finally, national regulators ought to handle those coefficients with care, given that the adoption of erroneous figures could accentuate the natural tendency of capital to follow the economic and business cycle and, therefore apply a countercyclical stance but, at the same time, make sure that the resulting capital level is sufficient enough to provide protection for unexpected events that could wreak havoc on the reserves-base.

Those variables will undoubtedly represent a flexible approximation to the constitution of *CRC*, also capable of aligning the precision motivations between the SA and the most accurate IMA, simultaneously including substantial coverage and reducing the associated immobilisation costs.

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Notes

1 Given that they still belong to the consultation period, the current paper will refer to it as Basel 3.5.

2 Appendix A.

3 Among many other contributors.

4 The definition of those risk buckets was carried out "…following a combination of statistical analysis and expert judgement…" [BCBS (2014), p.31]. Moreover, notional positions are assigned to risk buckets according to certain categorical variables such as credit quality and industry sector.

5 Different instruments relating to the same commodity are not permitted to offset.

6 Throughout the present paper expressions (1), (2), (3), (4), (7), (8), (9) and (12) is sourced from BCBS (2014) while (5), (6), (10), (11), (13) and (14) are based on BCBS (2014) information and own work.

7 The interested reader may recur to BCBS (1996) for a detailed enumeration of the characteristics included in Backtesting.

8 Real P&L exclude the impact of new transactions.

9 Actually, the ratio must deliver values in the range [0%; 20%].

10 BCBS enumerates four overall risk factors: general interest rate risk (GIRR), equity risk, commodity risk and foreign exchange risk.

11 On the grounds of space considerations, commodity prices are the only ones explained, whereas the remaining risk factors are summarised in Appendix B.

12 That refined approach could, for instance, need the modelling of the 'convenience yield' which reflects the possibility to reap benefits from the direct ownership of the physical commodity.

13 Notably the BCBS has only specified that the R^2 value should be 'high' and is bound to be determined in further quantitative impact studies (QIS).

14 Alternatively, ρ might have assumed any other value, because, on the grounds that there is only one risk factor, the outcome $IMCC = IMCC(C)$ will have been unaltered.

15 Actually, the MCR for IMA contemplates two additional factors, CU, denoting the capital charge for unapproved risk desks and IDR, representing the additional capital arising from the incremental default risk. Again, stemming from the approach of the present article, both of them will be discarded. However, even though they shall not be included, they ultimately reinforce the conclusions reached.

16 The broad commodity group or sector, stated in Table 1, is informed between brackets.

17 In the corresponding tables, 'IMA' denotes that the internal model is still allowed to be employed, whereas, on the contrary, 'SA' means that the specification should be discarded and the bank must resort to the SA instead.

18 For space restrictions, 'I' and 'S' denote those schemes that pass and fail the test respectively.

19 In general terms, it might be assumed that the indices deliver reasonably acceptable values of R^2 though, for instance, Set D and E/P1 could demand further adjustments to raise the R^2. However, the ambiguity in BCBS still allows some slack at the time of writing the paper.

20 The authors hinted at moral risk, albeit for Basel III configuration.

21 Although it should be borne in mind that, in many of those instances, the SA acts as a floor to the IMA CRC. For the sake of clarity, the analysis is carried out skipping that otherwise key lower limit.

22 The parameters m_s and m_c^* are embedded in formula (17).

23 RMSE and MAE stand for RMSE and mean absolute error respectively.

24 sa and m_s conserve the RMSE values.

Appendix A

A brief insight into EVT

EVT provides a theoretical justification to representing the ultimate quantiles of a distribution (i.e., 1% or less) as an alternative to its whole structure, thus playing the same essential role as the Central Limit Theorem performs when modelling sums of random variables. This section will supply some basic notions indispensable for the rest of the paper: for a detailed treatment and/ or some theoretical gaps the interested reader may refer to Embrechts et al. (1997), McNeil et al. (2005) or Reiss and Thomas (2007).

Of the two approaches to model extreme values, block maxima models (BMM) and POT, the current study favours the latter on the grounds of the inefficiency of the former arising from the disregard of the intermediate points contained in the block, a crucial fact in the relatively short emerging markets data series.

Supposing a sequence of iid returns (random variables) $X_1, X_2, \ldots, X_n$, which have an unknown marginal distribution function F, extreme events are defined as those values of X_t exceeding some high value u. The rest of this section enunciates theoretical support for the maximum, as long as the results for the minimum can be obtained from those of the maximum by transforming X_t into $-X_t$.

If X_0 is the right endpoint of the distribution F (finite or infinite), it follows that $X_0 = \sup\{X \in \Re : F(x) < 1\} \leq \infty$. Hence, a description of the stochastic behaviour of the excesses over the threshold u is given by the conditional probability:

$$F_u(y) = \Pr\{X - u \leq y \mid X > u\} = \frac{F(y+u) - F(u)}{1 - F(u)} \quad \text{[A1]}$$

Given that the threshold u is surpassed, $Fu(y)$ represents the probability that a loss exceeds the threshold u by an amount equal or less than y. Were the parent distribution F to be known, the distribution of the exceedances $Fu(y)$ would also be known; however, real exercises show the contrary thus obliging to estimate the distribution for high values above the threshold. Consequently, it is necessary to resort to the Balkema and de Haan (1974), Pickands (1975) Theorem, which broadly asserts:

Theorem 1 (Balkema and de Haan, 1974; Pickands, 1975): For a large class of underlying distribution functions F, it is possible to find a measurable function $\sigma(u)$, such that:

$$\lim_{u \to x_0} \sup_{0 \leq x \langle x_o - u} \left| F_u(y) - G_{\xi,\sigma(u)}(y) \right| = 0$$

if and only if F belongs to the maximum domain of attraction of the extreme value distribution H_ξ, i.e., $F \in \text{MDA}(H_\xi)$ with $\xi \in \Re$. As Coles (2001) states, the principal outcome is embodied in the theorem below:

Theorem 2: Supposing:

- $X_1, X_2, \ldots, X_n$ are a sequence of iid random variables with common *dfF*
- $M_n = \max\{X_1; X_2; \ldots; X_n\}$
- Any (arbitrary) term in the sequence of random variables X_i is denoted by X
- F complies with Fisher and Tippet (1928) theorem (Fisher and Tippet (1928));

Then, for large n, $\Pr\{M_n \leq H(z)\}$ with

$$H_\xi(z) = \begin{cases} \exp\left\{-\left[1 + \xi\left(\dfrac{z-\mu}{\sigma}\right)\right]^{-1/\xi}\right\} & \text{if } \xi \neq 0 \\ \exp\left(-e^{-z}\right) & \text{if } \xi = 0 \end{cases}$$

for some μ, $\sigma > 0$ and ξ. $H_\xi(z)$ is the distribution function of the generalised extreme value distribution (standard GEV), where ξ is known as the shape parameter and x must satisfy $1 + \xi z > 0$.

For large thresholds u, the distribution function of exceedances $(X - u)$, given that $X > u$, is given by the two-parameter limiting distribution function:

$$G_{\xi\sigma}(y) = \begin{cases} 1 - (1 + \xi y/\sigma)^{-1/\xi} & \text{if } \xi \neq 0 \\ 1 - \exp(-y/\sigma) & \text{if } \xi = 0 \end{cases}$$

as u increases, where $\sigma > 0$, and $x \geq 0$ when $\xi \geq 0$ and $0 \leq y \leq -\sigma/\xi$ when $\xi < 0$.

$G_{\xi,\sigma}(y)$ is the generalised Pareto distribution (GPD) family because it includes three other distributions according to the value of parameter ξ:

- $\xi > 0$: $G_{\xi,\sigma}(y)$ is the classic Pareto distribution
- $\xi = 0$: $G_{\xi,\sigma}(y)$ is the exponential distribution
- $\xi < 0$: $G_{\xi,\sigma}(y)$ is the short-tailed Pareto type II distribution.

which correspond to the Fréchet, Gumbel and Weibull extreme value distributions respectively. The GPD family can be enhanced if a location parameter μ is affixed, thus becoming $G_{\xi,\sigma}(y-\mu)$. Loosely speaking, both theorems mean that if block maxima M_n distribution is approximately described by H, then the approximate distribution of threshold excesses is given by G, belonging to the generalised Pareto family. Furthermore, the parameters of the GPD are univocally determined by those parameters of the associated GEV distribution of the block maxima (Coles, 2001).

Once the choice of the threshold u is made and the parameters of the GPD are estimated, it is necessary to obtain the expression to calculate the relevant VaR quantiles. From [5] and recalling $x = y + u$, an estimate for $F(x)$, for $x > u$ may be:

$$F(x) = [1 - F(u)]G_{\xi,\sigma(u)}(y) + F(u) \qquad \text{[A2]}$$

Considering k as the number of observations above the threshold u, $F(u)$ may easily be non-parametrically approximated by means of the simple empirical estimator

$$\hat{F}(u) = \frac{n-k}{n} \qquad \text{[A3]}$$

Plugging [A3] into [A1] it is possible to achieve an estimate for $F(x)$:

$$\hat{F}(x) = 1 - \frac{k}{n}\left[1 + \hat{\xi}\frac{(x-u)}{\hat{\sigma}}\right]^{-\frac{1}{\hat{\xi}}} \qquad \text{[A4]}$$

being estimates for ξ and σ respectively. For a level of confidence $\alpha > F(u)$, the VaR expression is computed by inverting $\hat{F}(x)$ and solving for x:

$$VaR(\alpha) = u + \frac{\hat{\sigma}}{\hat{\xi}}\left[\left(\frac{1-\alpha}{k/n}\right)^{-\hat{\xi}} - 1\right] \qquad \text{[A5]}$$

whereas the corresponding expression for *ES* becomes:

$$ES(\alpha) = \frac{VaR(\alpha)}{1-\xi} + \frac{\partial - \xi u}{1-\xi} \qquad \text{[A6]}$$

Appendix B

The SRF

As aforementioned in Section 3.2.4., the BCBS demands the enumeration of risk drivers for each of the risk factors enunciated in the proposal. The main body includes the provisions for commodity prices in view of its bearing on the topic of the paper and the present Appendix synthesises the principal characteristics for interest rates, exchange rates and equity prices.

1 *Interest rates*: it is necessary to model the yield curve employing one or several generally accepted approaches, for instance, using the estimation of forward rates with zero coupon yields. Furthermore, the yield curve should be divided in various maturity segments with a view to capturing the volatility of the interest rates along the yield curve, where there will be typically one risk factor for each maturity tranche. The Committee, moreover, demands that, in order to capture the material risks in the major currencies and markets, a minimum of six risk factors ought to be employed, although that quantity is ultimately dependent on the bank's trading strategy. Additionally, spread risk is required to incorporate separate risk factors so as to grasp the less than perfectly correlated movements between sovereign, sub-sovereign and other fixed-income securities or, alternatively, the difference between government rates at various points along the yield curve.

2 *Exchange rates (including gold)*: models should include risk factors belonging to the exchange rate between the domestic currency and each foreign currency in which the bank holds position, as any exposure in foreign currency will be expressed in local units.

3 *Equity prices*: at minimum, models should incorporate a risk factor able to capture market-wide movements – market index –, hence enabling the expression of individual securities or sector indices in their respective 'beta equivalents'. However, this does not preclude banks to develop more sophisticated approaches involving factors related to the volatility of the stocks and/ or risk factors corresponding to the various sectors of the equity market (industry, cyclical and non-cyclical sectors).