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Basel IV and the structural relationship between SA and IMA

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Abstract

The current paper aims at ascertaining the massive overhaul of the Trading Book or Basel IV, comparing the capital requirements of the Standardized and Internal Models Approaches in market crisis context. Throughout an integral sequential analysis encompassing every step of both regimes –including several specifications for the latter-, the study finds that the radical revamp achieves its main objective: raising capital for market risks. Simultaneously, the Standardized Approach appears favored, establishing a high floor as a credible fall-back and penalizing the Internal Models with complex structures and stringent validation tests. With the general purpose apparently attained, it would be wise to review the whole process and grant some flexibility to local supervisors in its application. The investigation was focused on Mexican stock markets during Covid-19, and it is understood that extending it to more countries could bolster the results. The present article ranks among the first to study the effects of Basel IV and highlights some of its flaws, particularly the probably excessive capital levels and the crackdown on Internal Models, which could dent profits, restrict innovation and shrink credit.

JEL Classification: C53, F37, F38, G01, G18, G28.

Keywords: Basel IV, Capital Requirements, Standardized Approach, Internal Models Approach.

Basilea IV y la relación estructural entre SA e IMA

Resumen

El artículo evalúa la profunda revisión del Libro de Negociación o Basilea IV comparando los requerimientos de capital de los Enfoques Estandarizado y de Modelos Internos en un contexto de crisis de mercado. Mediante un análisis integral secuencial abarcando cada paso de los dos regímenes –incluyendo varias especificaciones para el segundo-, el estudio halla que la modificación radical consigue su objetivo principal: la elevación del capital para riesgos de mercado. Simultáneamente, el Enfoque Estandarizado aparece favorecido estableciendo un piso alto como respaldo creíble y los Modelos Internos son penalizados con estructuras complejas y tests de validación restrictivos. Con el propósito general aparentemente logrado, sería razonable efectuar una exploración del proceso general y conceder mayor flexibilización a los supervisores locales para su aplicación. La investigación se concentró en los mercados accionaros mexicanos durante el Covid-19, y se entiende que la extensión a más países podría reforzar los resultados. Este artículo se sitúa entre los primeros en estudiar los efectos de Basilea IV y resalta algunas de sus falencias, particularmente los niveles de capital probablemente excesivos y la campaña contra los Modelos Internos, lo cual podría mellar las ganancias, restringir la innovación y reducir el crédito.

Clasificación JEL: C53, F37, F38, G01, G18, G28.

Palabras clave: Basilea IV, Requerimientos de Capital, Enfoque Estandarizado, Enfoque de Modelos Internos.

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1. Introduction

One of the main missions of the Basel Committee of Banking Supervision (BCBS), incorporated in its Tableer, is to set the standards for the prudential regulation and supervision of banks. In general terms, it expects full implementation of its standards by its members and their internationally active banks, albeit BCBS standards constitute minimum requirements and its members may evaluate to go beyond them.

BCBS's guidance comes in waves, usually in response to big financial crises, as was the case for Basel I, Basel II and Basel III[2][3]. In this instance, it appears that the BCBS detected may flaws in the current Capital Accord, and decided to correct it enacting an entire overhaul of the market risk framework, both for the Standardized and the Internal Models Approaches (SA and IMA respectively). The initial glance at the new set of specifications determines that the Minimum Capital Requirements (MCR) will undoubtedly rise, but although the BCBS intended to counter the argument stating that the changes would only exert a minimal impact in the overall capital requirements, further analysis shows that the new market risk rules will heavily affect banks with significant investment activities.

However, many organizations like the Global Financial Markets Association (GFMA), the Institute of International Finance (IIF) and the International Swaps and Derivatives Association (ISDA) challenged the BCBS and stressed that the rules may have a negative impact on banks' capital market activities and reduce market liquidity

It is relevant to analyze the effect that the new regulations could exert on the banks' capital levels emphasizing one of the most volatile markets, i.e. the stock market. The article focuses on Mexico, the second largest Latin American economy, with the motivation fueled by the fact that Mexican banks have not participated in the Quantitative Impact Studies (QIS) carried out by the BCBS that defined the final structure of the schemes and the value of the respective parameters. Furthermore, in consideration of the fact that the relationship between SA and IMA was completely revamped and banks using the latter must also compute the former, it is imperative to evaluate whether the latest version of the IMA could be the right one and, additionally, if the incentives to develop modelling innovations are aligned with the final outcome or, on the contrary, if the BCBS seems to be pushing institutions to utilize the SA. The study is carried out hypothesizing that Basel IV entails a profound change in the relationship between SA and IMA with a tilt towards the former in view of the intricate network of validation tests for the latter that, alongside the output floor, severely hampers the election of the latter, particularly during periods of heightened market volatility.

The paper unfolds as follows. Section 2 briefly introduces the incoming Standardized and Internal Models Approaches; Section 3 sketches the literature review; Section 4 outlines the Methodology; Section 5 describes the Results and, finally, Section 6 synthetizes the conclusions and implications.

[2] An interesting synthetic review to the main elements of Basel IV may be found in Zirkler et. al. (2021).
[3] Langthaler and Lederer (2022) question the 'Basel IV' denomination on the grounds that the series of reforms still belong to the finalisation of the Basel iii standards launched in 2016, notwithstanding which the majority of the financial literature backs the change in view of the sweeping nature of the reforms.

2. Introduction to the SA and IMA

2.1. The new Standardized Approach

The revamped SA, reflective of BCBS's bid to balance the increased risk sensitivity against granularity complexity and its respective capital requirement, boils down to the simple sum of three components: i) the Capital Requirement (CR) computed under the sensitivities-based method, ii) the Default Risk Capital Requirement (DRC), and iii) the Residual Risk add-on (RRAO). Those elements possess the following characteristics:

a) *The Capital Requirement (CR) under the sensitivities method*
Arguably the most relevant factor in the formula, it is calculated adding three delta, vega and curvature risk measures:
a.1) *Delta (DCR)*: related to the sensitivities of the instrument to regulatory risk factors bearing corresponding risk weights;
a.2) *Vega (VCR)*: based on sensitivities of the instrument to vega risk factors (i.e., options) bearing corresponding risk weights;
a.3) *Curvature (CCR)*: designed to grab the material risks uncaptured by DCR for changes in the price of an option, computed using three stress scenarios comprising upward and downward shocks to each and every regulatory factors with the corresponding risk weights.

In order to calculate the overall Capital Requirement, the risk-weighted sensitivities are added employing pre-specified correlation parameters that acknowledge diversification across risk factors. Furthermore, banks also ought to assess the changes in correlations during periods of financial stress by means of three different scenarios for the prescribed correlation parameters.

b) *The Default Risk Capital Requirement*
For those instruments subject to credit risk, the DRC is introduced to capture the jump-to-default (JTD) risk overlooked by the sensitivities-based method with limited hedging.

c) *The Residual Risk Add-On*
As set out by the BCBS, the RRAO is included to capture all those complex risks that the design of the SA is unable to detect[4].

[4] The RRAO encompasses instruments with exotic underlying, or subject to vega or curvature risks, complex pay-offs and positions falling under the correlation trading portfolio. The BCBS (2019) outlays a non-exhaustive list including instruments with gap risk, correlation risk (options) and behavioural risk. Given the scope of the current article, RRAO will be excluded.

2.1.2. Minimum capital requirements and calculation

Requirement under the sensitivities method

It describes the sensitivities of financial assets to the prescribed set of risk factors:

i) General Interest Rate Risk (GIRR);
ii) Credit-spread risk (CSR) non-securitizations;
iii) CSR securitizations (non-correlation trading portfolio, or non-CTP);
iv) CSR securitizations (correlation trading portfolio, or CTP);
v) Equity risk (ER);
vi) Commodity risk (CR);
vii) Foreign exchange risk (FR)

For the purposes of ER, it is important to highlight the following elements, as defined by the BCBS (2019):

i) *Risk factor*: any variable, i.e., the equity price, that influence the value of the instrument (equity);
ii) *Risk Bucket* or simply bucket: the set of risk factors grouped together by a common thread;
iii) *Risk position*: exposure to a corresponding risk factor;
iv) *Risk capital requirement*: the quantity of capital that banks ought to reserve as a reflection of the risks taken; it must be computed initially as an aggregation of positions at the bucket level and afterwards across buckets within a risk class.

On the grounds of the objectives of the current paper, i.e., equity risk with no derivatives attached, the exposures here presented will only be subject to Delta risk, therefore omitting Vega and Curvature risks and, furthermore RRAO. Additionally, for ER, the equity delta risk factors are all equity spot prices.

The SA requires that the notional positions should be allocated into predefined risk buckets, which are determined according to variables like the type of economy (developed or emerging), and also categorical parameters such as industry sector or credit quality with unclassified exposures allotted in a 'residual' risk bucket (Table 2.1).

Table 2.1 Buckets and Risk weights for delta sensitivities

Bucket No.	Market Capitalisation	Economy	Sector	Risk Weight
1	Large	Emerging	Consumer goods and services, transportation and storage, administrative support, service activities, healthcare, utilities	55%
2	Large	Emerging	Telecommunications, industrials	60%
3	Large	Emerging	Basic materials, energy, agriculture, manufacturing, mining, quarrying	45%
4	Large	Emerging	Financials incuding givernent-backed financials, real estate activities, technology	55%
5	Large	Advanced	Consumer goods and services, transportation and storage, administrative support, service activities, healthcare, utilities	30%
6	Large	Advanced	Telecommunications, industrials	35%
7	Large	Advanced	Basic materials, energy, agriculture, manufacturing, mining, quarrying	40%
8	Large	Advanced	Financials incuding givernent-backed financials, real estate activities, technology	50%
9	Small	Emerging	All sectors described under buckets 1, 2, 3 and 4	70%
10	Small	Advanced	All sectors described under buckets 5, 6, 7 and 8	50%
11	Other sector			70%
12	Large market cap. Advanced equity indices (non-sector specific)			15%
13	Other equity indices (non-sector specific)			25%

Source: BCBS (2019)

After being allocated and aggregated into each risk bucket, positions are risk-weighted and correlated employing the standard values provided by the BCBS (2019). It is also noteworthy that the new risk-oriented SA envisions hedging and diversification, firstly because long and short positions in the same asset are allowed to offset and, secondly, because a series of correlation parameters are to be applied within and across risk buckets. This is called the step-by-step approach and requires the sequence below:

i) Determination of the individual sensitivities
For delta equity spot, the sensitivity is equal to the change in the market value of the instrument *i* (*Vi*) as a result of a change of 1% in the market value of equity *k* (*EQk*), per unit of change:

$$s_k = \frac{V_i\,(1.01\,EQ_k) - V_i\,(EQ_k)}{0.01} \quad (1)$$

Remarkably, s_k allows offsetting between long and short positions.

ii) Calculation of the weighted sensitivities WS_k as the product of the individual (net) sensitivities:

$$WS_k = RW_k s_k \quad (2)$$

where RW_k strands for the Risk Weight, analogous to a standalone capital requirement indicated in Table 2.1.

iii) Determination of the risk position for bucket b, K_b, as a result of the aggregation of the weighted sensitivities within each risk bucket, correlated employing the prescribed correlation parameter ρ_{kl}, and establishing a null floor if weighted sensitivities are negative:

$$K_b = \sqrt{\max\left(0, \sum_{k=1}^{n} WS_k^2 + \sum_{k=1}^{n} \sum_{k>l}^{n} \rho_{kl} WS_k WS_l\right)} \quad (3)$$

iv) Determination of the Delta Risk Capital, DRC, carried out aggregating the risk positions across the risk buckets, utilising the respective correlation parameter Υ_{bc}:

$$DRC = \sqrt{\sum_{b=1}^{n} K_b^2 + \sum_{b=1}^{n} \sum_{c>b}^{n} \gamma_{bc} S_b S_c} \quad (4)$$

where $S_p = \sum_{k=1}^{n} WS_k$ for bucket p and in case the overall sum under the root square becomes negative, the following alternative specifications apply:

$$S_p = \max\left[\min\left(\sum_{k=1}^{n} WS_k, K_b\right), -K_b\right] \quad (5)$$

for all risk factors in bucket b.

In order to address the variation in the correlation parameters during market crises, the above steps must be performed three times, each one corresponding to a different correlation scenario on the specified values for the parameter embodying the correlation factor between risk factors within a bucket (ρ_{kl}) and the correlation across buckets in the same risk class (Υ_{bc}) with institutions applying the highest capital requirement arising from each scenario:

a) The 'medium correlations' scenario where the values of ρ_{kl} and Υ_{bc} are the prescribed ones in Tables 2.2 and 2.3 below;

Table 2.2. Correlation parameters within risk buckets

Bucket No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Correlation	15%	15%	15%	15%	25%	25%	25%	25%	7.50%	12.50%	0%	80%	80%

Source: Author's elaboration from BCBS (2019)

Table 2.3. Correlation parameters across risk buckets (%)

Bucket No.	1 - 9	1 - 13	1 - 11	1 - 10	11	12
1 - 9	15%					
11		0%				
12			45%			
13				45%	0%	75%

Source: Author's elaboration from BCBS (2019)

b) The 'high correlations' scenario requires values in a) increased 1.25 times subject to a 100% cap;
c) The 'low correlations' scenario replaces the figures exposed by the ones deriving from the expressions below:

$$\rho_{kl}^{low} = \max(2 * \rho_{kl} - 100\%; 75\% * \rho_{kl}) \quad (6)$$

$$\gamma_{kl}^{low} = \max(2 * \gamma_{kl} - 100\%; 75\% * \gamma_{kl}) \quad (7)$$

where ρ_{kl}^{low} and γ_{kl}^{low} denote the correlation parameters deriving from the low correlation scenario within and across buckets in the same risk class

The correlation parameter for bucket 11 is set at 0% given that:

$$K_{b\,(Other\ bucket)} = \sum_{k=1}^{n} |WS_k| \quad (8)$$

Finally, "large" market capitalization is defined as market capitalization equal to or in excess of USD 2bn –on a global or international basis-.

2.1.3. The Capital Requirement under the Default Risk

The DRC is intended to capture the JTD risk surging from credit shocks that is omitted from the sensitivities approach (delta risk) above explained. It recognizes offsetting and partial hedging to capture the benefits of positions in the same issuer and short exposures respectively.

It begins with the calculation of the gross JTD risk positions and computed separately for long and short positions. It is defined as a credit exposure that ends in a loss in case of a default and expressed as a function of the Loss Given Default (LGD), the notional amount or face value and the cumulative profit and loss (P&L) already sustained on the (net) position:

$$JTD(long) = \max(LGD\ x\ notional + P\&L; 0) \quad (9)$$

$$JTD(short) = \min(LGD\ x\ notional + P\&L; 0) \quad (10)$$

For equities, LGD is 100% which makes the market value the basis to compute JTD.

To compute the DRC, the BCBS nominated three exposure buckets: corporates, sovereigns and sub-sovereigns, given that the hedging relationship between net long and net short positions is estimated within a bucket. Furthermore, the capital requirement acknowledges the hedging relationship between long and net short positions by means of the Hedge Benefit Ratio (HBR) in the following fashion:

$$HBR = \frac{\sum netJTD_{long}}{\sum netJTD_{long} + \sum |netJTD_{short}|} \quad (11)$$

where all net JTD, long or short, are unweighted and summed across credit rating bands.

The weighted net JTD, i.e., the DRC for each bucket, uses default risk weights by credit quality category in accordance with Table 2.4, which determine the DRC for the respective bucket *b*:

$$DRC_b = \max\left[\left(\sum^{n}_{\substack{i=1 \\ i\in long}} RW_i\, JTD_i\right) - HBR\left(\sum^{n}_{\substack{i=1 \\ i\in short}} RW_i |netJTD_i|\right); 0\right] \quad (12)$$

Notably, hedging across buckets is not allowed and the total DRC across buckets is the simple sum of the individual DRCs.

Table 2.4 Default risk weights by credit quality category

Credit Rating	AAA	AA	A	BBB	BB	B	CCC	Defaulted	Unrated
DRW	0.50%	2.00%	3.00%	6.00%	15.00%	30.00%	50.00%	100.00%	15.00%

Source: BCBS (2019)

2.2. The new Internal Models Approach

2.2.1. The model

The new Capital Accord introduces two groundbreaking points in comparison with its predecessors:

a) *Substitution of VaR (Value-at-Risk) for ES (Expected Shortfall)*: given the conceptual problems presented by VaR as a risk metric (Artzner et. al. (1999) and McNeil, Frey and Embrechts (2005), Danielsson and Zigrand (2006), among others), ES constitutes the official market risk measure for the IMA, calculated at 97.50% confidence level. Therefore, the replacement also signifies the demise of the 99% in favor of the 97.50%[5];
b) *Calibration to stressed conditions*: The BCBS postulates the adoption of an "indirect" approach to compute the ES over the observational period. Hence, in order to bridge the difficulties that the identification of a strained period could pose in terms of data availability for the full set of risk factors, banks should specify a reduced set of risk factors relevant for their portfolios for which a relatively long history of observations is available. Although banks are allowed to

[5] More precisely, the VaR at 99% will not be employed for capital determination purposes; its usage is restricted to the validation stage of the IMA.

select the appropriate factors for their respective portfolios, the BCBS requires them to explain a pre-specified percentage of the full variation of the ES model[6]. Using that reduced set of factors, ES is calibrated to the most severe 12-month stressed term available over the observation period and afterwards scaled up by the ratio of the current ES employing the full set of risk factors to the current ES utilizing the reduced set of risk factors. Consequently, the risk capital calculation features the following expression:

$$ES = ES_{R,S} \, x \, \frac{ES_{F,C}}{ES_{R,C}} \qquad (13)$$

where:

ES : Expected Shortfall for risk capital purposes

$ES_{R,S}$: Expected Shortfall using the reduced set of risk factors calculated over the stressed period

$ES_{F,C}$: Expected Shortfall using the full set of risk factors based on the current (most recent 12-month) observation period

$ES_{R,C}$: Expected Shortfall using the reduced set of risk factors based on the current (most recent 12-month) observation period

Once the bank has determined the eligible trading desks subject to the IMA, and provided it abides by the qualitative standards set by the BCBS (BCBS (2013))[7], the calculation of any model must contemplate a series of quantitative requirements[8]:

a) 97.50% one-tailed ES computed on a daily basis for regulatory capital purposes, both for the trading desks and firm-wide portfolios;
b) ES calibrated to a period of stress according to the "indirect" approach materialized in (1), with a sufficiently long sample for the reduced set of risk factors[9];
c) ES_{RS} estimated over the 12-month strained period in which the relevant portfolio experiences the greatest loss, and its data sets, alongside those supporting ES_{FC} and ES_{RC} updated at lea1st once every three months or whenever market prices exhibit substantial variations;
d) Consistent with the VaR-based antecessors, BCBS does not prescribe a specific ES model for Basel IV, as long as the bank's technique captures all the material risks and passes the model validation standards (Section 2.2.2);
e) Analogous to Basel II and Basel III, banks must constitute a daily capital minimum requirement (MCR_t) expressed as[10]:

[6] That percentage remains to be defined (BCBS (2013)).
[7] The qualitative demands refer, in broad terms, to the constitution of risk management calculation and control units, audit procedures and assessment tests (BCBS (2013)).
[8] The BCBS states some additional provisions regarding liquidity shocks. However, they lie outside the reach of the present paper.
[9] The length of the observation period is yet to be specified after subsequent Quantitative Impact Study (QIS), though the BCBS appears to be suggesting at least ten (10) years of history.
[10] The formula also comprises other components like the capital charge for positions subject to default risk and the capital charge for risk factors deemed unmodellable. However, they are purposefully skipped as they lie beyond the scope of the article. The interest reader may recur to BCBS (2013).

$$MCR_t = max\left(IMCC_{t-1}; \, m_c \, IMCC_{avg}\right) \tag{14}$$

$$\text{where } m_c = 1.5\,(1+k) \tag{15}$$

and

$IMCC_{t-1}$: capital charge generated by the IMA for the previous day (t-1)

$IMCC_{avg}$: average of the daily capital charges generated by the IMA for the preceding 60 days

m_c : multiplication factor subject to an absolute minimum of 1.5, which could be increased by the supervisory authority to reflect a qualitative add on.

k : add-on factor related to the ex-post performance of the model

It is important to state that in order to determine the value of k, banks must perform Backtesting following Basel II and Basel III for the full set of risk factors (using VaR_{FC})[11].

2.2.2. Model validation standards

Assuming the institution achieves the regulator's approval or passes Step 1 above, the evaluation of the eligibility of the trading desks demands a tough process involving[12]:

a) *Backtesting*: it demands the comparison of the desk's daily static VaR at 99% percentile applying at least one-year of the most recent data against the portfolio's actual P&L. The procedure is analogous to Basel II and Basel III, though the penalization scheme reads as in Table 2.5:

Table 2.5. Backtesting Zone and Backtesting add-on

Exceptions	Zone	Add-on
0 - 4	Green	0.00%
5	Amber	13.33%
6	Amber	17.33%
7	Amber	22.00%
9	Amber	25.33%
9	Amber	29.00%
10 or more	Red	100.00%

Source: Author's elaboration from BCBS (2019)

[11] BCBS (2006, 2009).

[12] The BCBS also proposes fourth criteria to assess the IMA applied, called "model independent risk assessment tool" involving the desk-level, ES-based MCR, the size of the exposure and a threshold, which is yet to be specified.

b) *Profts and Losses Attribution Tests (PLAT):* carried out at trading-desk levels, they are designed to evaluate the model's valuation engine, comparing the real P&L with the model's ones, via two test metrics:
b.1) Spearman correlation metric (r_s): rank correlation between the real P&L (RTPL) and the model generated P&L (HPL):

$$r_s = \frac{cov(R_{HPL}, R_{RTPL})}{\sigma_{R_{HPL}}, x\, \sigma_{R_{PTPL}},} \tag{16}$$

r_s requires the construction of a time series of ranks based on the size of the P&L (RHPL), starting with the lowest value in the HPL time series and the corresponding time series of ranks based on the size of RTPL, with $\sigma_{R_{HPL}},$ and $\sigma_{R_{PTPL}},$ being the standard deviation of both time series.

b.2) Kolmogorov-Smirnov test metric (KS): For any value of RTPL and HPL, their empirical cumulative distributions are the product of 0.004 and the number of RTPL observations less or equal to the specified RTPL and HPL respectively. KS is, then, the largest absolute difference observed between RTPL and HPL at any P&L value.

The Sperman and KS tests are evaluated using the thresholds enunciated in Table 2.6. If a trading desk belongs to the PLA Red zone, it becomes ineligible for market risk capital requirements determination using IMA and must resort to SA until its model produces outcomes in the PLA Green zone and it satisfies the required backtesting exceptions over the past twelve months. However, if it is in the Amber zone, it is subject to a capital surcharge in the form of:

$$Capital\ surcharge = k * \max(0; SA - IMA) \tag{17}$$

where:

$$k = 0.5 * \frac{\sum_{i \in A} SA_i}{\sum_{i \in G,A} SA_i} \tag{18}$$

with
SAi : Standardized capital requirement for trading desk i
i Є A : trading desks in the amber zone
i Є G,A : trading desks in the green zone or amber zone

Table 2.6. PLA test thresholds

PLA test thresholds	Spearman correlation	KS test
Amber zone	0.8	0,09 (p-value = 0,264)
Red Zone	0.7	0,12 (p-value = 0,055)
Green zone	> 0,7	< 0,09

Source: Author's elaboration from BCBS (2019)

Therefore, the total capital requirement under IMA becomes the sum of (14) and (17) when the trading desk situates in the amber zone:

$$MCR_t = max(IMCC_{t-1}; m_c IMCC_{avg}) + k * \max(0; SA - IMA) \tag{19}$$

and (14) is maintained provided it belongs to the green zone. Red zone determines the immediate use of SA.

3. Literature review

In view of the recent enactment of the latest regulations, the academic literature on the subject is not very profuse, and, in that sense, supervisory agencies and professional bodies provide the bulk of the references.

Magnus et. al. (2017), from the Directorate-General for Internal Policies (IPOL) in 2017 sketched a review of the main characteristics of the road to Basel IV which reflects the main patterns of the previous Basel Accords, their pitfalls, and the solutions intended to address them. Particularizing on the capital floor and considering that Basel III still broadly maintains Basel I framework the authors highlight that, at the moment of reviewing Basel III's capital output, the incumbent configuration did not tackle, among other issues, the following ones: the use of low capital levels to boost financial leverage, the unexpected large losses in low capital portfolios and the lack of market confidence in capital floors. These aspects, alongside the interaction between the input data, the output floors and the leverage ratio were to be addressed and finally configured after a comprehensive QIS (BCBS (2016a)). Regarding the capital floors, Neisen (2016) hypothesized the five objectives that Basel IV's capital floors should accomplish: i) ensure that the capital level across banking system does not fall below a certain level; ii) mitigate IMA's model risk and measurement error; iii) enhance the comparability of capital outcomes across banks; iv) reduce the variation in capital ratios across banks due to bank-specific models assumptions, and v) diminish the incentives for exploitation of internal models. However, it cautions that given that the new floor will replace the existing Basel I complemented with the extrinsic ratios in Basel III, the relationship with the IMA must be carefully analyzed. On this regard, Neisen and Schutlte-Mattler (2021) pioneer a method to soften the impact of the SA inversely, i.e., adjusting the composition of the portfolio instead of working on the specifications. Therefore, it would be possible to optimize the capital allocation if the business model included, additionally, the internal risk appetite and the cost of capital in the pricing model.

Koch et. al. (2017) concentrate on the expected capital impact, albeit for the European banking industry, mentioning that banks with significant trading books will bear the brunt of the new market risk framework, adding that those institutions that do not meet the general criteria and the qualitative and quantitative standards would suffer a substantial blow given that they should move from an IMA to the new SA. Furthermore, their study highlights the different impact magnitudes citing that Sweden, Denmark, Belgium and the Netherlands will suffer the greatest shock, followed by Germany, France, Spain and the UK according to the phase-in provisions of Basel IV. On the other hand, they remark that in contrast to the European perspective, the US would result less affected on the grounds that the Federal Reserve has already adopted a 100% Standardized capital floor under Section 171 of the Dodd-Frank Act (United States of America in Congress assembled (2010)). Buberkoku (2023) performs a study for the Turkish stock market and foreign exchange market using only two variants of IMA (FHS and EVT) and ascertained that Basel IV regulations may increase capital requirements for those risks. Notwithstanding the importance of those articles, the scope is circumscribed to Europe, with Latin America and many other regions lying outside its reach.

Jackson (2016) makes a point about the complexity of the SA regarding the calculation of the risk sensitivities, the DRC and the RRAO, mentioning that earlier estimations show that banks with large investment operations would face very large increases in capital requirements. The author concludes that Basel IV will have a considerable effect on the total capital required by some banks, furthermore cautioning about the implementation of the SA in view of its highly prescriptive nature and the difficulty in the enhancement to current data, data attributes and processes in banks.

Dankenbring et. al. (2016) stress that, while Basel III primarily focused on the numerator of the MCR ratio, Basel IV overtly aimed at the denominator of the capital ratio, i.e., the calculation of credit, market and operational risk exposures. Furthermore, they pour doubts on the final outcome of Basel IV underlying that the effect of the new wave of regulations will exceed banks' capital, funding, implementation costs and risk sensitivity as all those factors will exert downward pressure on profitability, simultaneously raising questions about the viability and sustainability of their business models. On this line, Leake et. al. (2015) regard investment banking as likely to be more affected than retail banking because the trading book is targeted directly, warning that the proposals, leverage ratio, liquidity requirements, large exposure limits, clearing and initial margins requirements are additional challenges for the (already) besieged investment banking business model. Finally, the authors alert that those banks may need to ponder whether their ROI (Return on Investment) will be viable in the long term. Accordingly, Oyetade et.al. (2023) carry out a study of the effects of Basel IV on simulated balance sheets of selected African banks and suggest that new Basel IV regulation would presage a negative impact on –at least- their short-term performance, albeit warning about the high uncertainty of an unapplied policy.

There is, then, a schism between BCBS, on the one hand, and the academics and practitioners on the other in the treatment of SA. While the former hails the approach for reducing the complexity, mimic the risks and enhance the comparability, the latter group brands the SA as almost inadequate to calculate MCR (Gaumert and Kemmer (2015)) because of its inability to capture risks, simultaneously proposing few measures to bolster the confidence in the IMA, albeit theoretically circumscribing to the Basel IV boundaries.

Some academics questioned some aspects of the route taken by the BCBS in the application of ES. Among the most innovative, Ahelejbey et. al. (2021) propose the Extreme Downside Hedge (EDH) and the Extreme Downside Correlation (EDC), by means of which they discover that assets can be clustered into "givers" and "receivers" of tail risk –though for the cryptocurrency market-, simultaneously criticizing Basel IV's failure to address systemic risk and Fang et. al. (2023) put forward a method to take into account and forecast systemic risk and, furthermore, backtest it. Other authors venture beyond the official ES-based IMA and advocate for the adoption of other risk measures like the Expectiles Risk Measure (ERM), like Tsvetelin et. al. (2023), casting doubts on the non-elicitability of ES, which is the main reason why Backtesting in Basel IV is grounded on VaR, and

Burzoni et. al. (2022) refine ES introducing a set of convex risk measures controlling the expected losses associated with different sectors of the tail distribution.

Another point of conflict is the validation criteria set out in Basel IV, triggered by the lack of elicitability of ES. The financial literature has come up with numerous alternatives like the traditional Acerbi and Szekely (2014), Constanzino and Curran (2018), Emmer et. al. (2015), Moldenhauer and Pitera (2019) Righi and Ceretta (2015) and the more recent ones in Bayer and Dimitriadis (2022) via a combined regression featuring VaR and ES, Marcin and Schmid (2022) with an ingenious and efficient way to curb the backtesting shortcomings rooted in VaR, ES and ERM or Molina Muñoz et. al. (2022) through an innovative combination of EVT and Gram-Charlier distributions. However, all the aforementioned proofs were overlooked by BCBS in an attempt to simplify matters and, accordingly, the new normative only contains a series of tests based on backtesting VaR.

The present paper contributes to the literature body going beyond to show that, even for simple exposures like stock portfolios in the Mexican market, the SA does not properly reflect the true risk; on the contrary, it obliges banks to constitute unnecessarily high capital levels. Consequently, it should not be considered a ‘credible fallback solution’ to IMA as both the official IMA and simpler alternatives related to it can still provide adequate coverage without freezing funds unproductively.

4. Methodology

The study is carried out on Mexico, one of the major economies in Latin America. As of 15/01/2020, every company quoting on the S&P BMV/IPC (Standard & Poor’s Bolsa Mexicana de Valores / Indice de Precios y Cotizaciones) is classified in accordance with the scheme of risk buckets in Table 2.1, bearing in mind that BCBS considers Mexico a developed country given that it belongs to the TLAC alongside USA and Canada. The data set is then split into two periods for parameter estimation (BCBS (2019)) and evaluation of market risk forecasts (one year minimum), thus complying with Basel indications, as in Mapa (2003) and Hansen and Lunde (2005). The first one spans ten years, from 15/01/2010 to 15/01/2020, again abiding by BCBS’s requirements (BCBS (2019)), while the second comprises the following year, i.e., from 16/01/2020 to 15/01/2021, for general evaluation and backtesting procedures[13]. Primary data about stock prices was previously retrieved from Refinitiv® and converted into inputs via logarithmic returns. Using the sample of the initial 10 years, and companies are ranked in descending order in terms of 1) volatility (using beta with reference to S&P BMV/IPC, highest beta first), and 2) market capitalization (highest market capitalization first, valued as of 15/01/2020). For every set, the first five companies corresponding to each risk bucket are selected and market cap weighted, thus making, at this stage, two portfolios of twenty assets each[14]. Additionally, subsets of portfolios in each category are constructed deleting the last three and four companies and reweighing the remaining components. Hence, briefly stated, the exercise deals with six portfolios calculated with the general criteria explained in Table 4.1, with Table 4.2 informing their precise composition[15].

[13] The choice of the sample and test periods corresponds to the initiation of the pandemic, according to the WHO declared a global health emergency.
[14] Some risk buckets do not encompass 5 assets; hence some portfolios may possess less than 20 assets.
[15] Appendix A.

Portfolios 1 to 6 have then, its MCRs calculated via SA (Section 2.1) and IMA (Section 2.2). For the former, HBR = 1 (11) as only long positions are used and DRC (12) is obtained employing the latest credit rating available at the start of 2020 (Refinitiv ®). For the latter, given that BCBS does not require a specific VaR model, several approaches are employed[16]: Historical Simulation (HS), Filtered Historical Simulation (FHS) and Conditional Volatility (CV) via GARCH-Normal, GARCH-t(d), EGARCH-Normal, EGARCH-t(d) and Extreme Value Theory (EVT). HS values are obtained through rolling windows; CV and FHS (GARCH-EGARCH) via Maximum Likelihood (ML), and FHS through Quasi-ML with GARCH-Normal, GARCH-t(d), EGARCH-Normal and EGARCH-t(d) specifications to generate the distribution of Standardized residuals. EVT follows the Peaks-Over-Thresholds (POT) approach with the Method of Moments (MM) applied to obtain Generalized Pareto Distribution (GPD) parameters after GARCH pre-whitening (McNeil, Frey and Embrechts (2005) and Embrechts, Klüppelberg and Mikosch (1997)). However, in order to circumscribe the scope of the analysis and avoid masking artificial capital increases, EVT, i.e. the model that performs best without Backtesting penalties in the evaluation period is selected for ES and VaR calculations throughout the process. Additionally, again complying with BCBS (2019), S&P BMV/IPC is the reduced factor (RS) contemplated in (13), as it reasonably drives the behavior of the six portfolios[17]. IMA calculations follows two different strands: the first one closely resembles the official approach exposed in Section 2.3., while the second one suppresses the reduced factor modelling, simply computing:

$$ES = ES_{FC} \tag{20}$$

with the model validation standards in Section 2.2.1.

SA and both IMA variants are further calculated for every day of the evaluation period, and several parameters computed as a means to ascertain the respective capital levels, stability and relative slack compared to the losses experienced by the base portfolios. Finally, the relationship between both IMAs and SA is calculated to gauge the latter as a credible capital floor in view of the scheme proposed by BCBS (2019).

Table 4.1. Portfolios – General criteria

Criterion	Set 1	Set 2
Main criterion	High volatility (beta)	Market capitalization
Weigts	Market capitalization	Market capitalization
Portfolios	P1: 20 assets (5 per bucket) P3: 10 assets (2 per bucket) P5: 4 assets (1 per bucket)	P1: 20 assets (5 per bucket) P3: 10 assets (2 per bucket) P5: 4 assets (1 per bucket)

Source: Author's elaboration

[16] Appendix B.
[17] In terms of the initial BCBS's (2016b) Capital Requirements for Market Risk BCBS's, the R^2 between the portfolios's and the S&P BMV/IPC´s log return series is at least, 75% for each one (available upon request).

Table 4.2 Portfolio composition and details

Portfolio 1	Equity name	Sector	Size	Bucket No.	Weights
	Grupo Bimbo	Consumer, Utilities	Large	5	4.54%
	Puerto Liverpool	Consumer, Utilities	Large	5	3.86%
	Arca Continental	Consumer, Utilities	Large	5	5.12%
	Grupo Aeroportua	Consumer, Utilities	Large	5	9.13%
	GAP Mexico	Consumer, Utilities	Large	5	3.95%
	America Movil	Telecommunications, Industrials	Large	6	27.59%
	IEnova	Telecommunications, Industrials	Large	6	12.01%
	Alfa	Telecommunications, Industrials	Large	6	2.14%
	Pinfra	Telecommunications, Industrials	Small	10	0.70%
	Megacable	Telecommunications, Industrials	Large	6	3.33%
	Nemak Mexico	Basic Materials, Energy	Large	7	2.61%
	Grupo Mexico	Basic Materials, Energy	Large	7	1.18%
	Grup Fin Inbursa	Financial, Technology	Large	8	3.99%
	Gentera	Financial, Technology	Large	8	9.39%
	Regional	Financial, Technology	Large	8	3.93%
	Grupo Banorte	Financial, Technology	Large	8	1.39%
	BanSantander MX	Financial, Technology	Large	8	5.16%
Portfolio 2	**Equity name**	**Sector**	**Size**	**Bucket No.**	**Weights**
	Grupo Aeroportua	Consumer, Utilities	Large	5	9.08%
	Arca Continental	Consumer, Utilities	Large	5	5.08%
	Grupo Elektra	Consumer, Utilities	Large	5	4.59%
	Grupo Bimbo	Consumer, Utilities	Large	5	4.51%
	GAP Mexico	Consumer, Utilities	Large	5	3.92%
	Alfa	Telecommunications, Industrials	Large	6	27.42%
	America Movil	Telecommunications, Industrials	Large	6	11.93%
	Megacable	Telecommunications, Industrials	Large	6	3.31%
	Televisa	Telecommunications, Industrials	Large	6	2.13%
	IEnova	Telecommunications, Industrials	Small	10	0.69%
	Nemak Mexico	Basic Materials, Energy	Large	7	2.59%
	Alpek	Basic Materials, Energy	Small	10	1.05%
	Gentera	Financial, Technology	Large	8	9.33%
	BanSantander MX	Financial, Technology	Large	8	5.13%
	Grup Fin Inbursa	Financial, Technology	Large	8	3.96%
	Regional	Financial, Technology	Large	8	3.90%
	Grupo Banorte	Financial, Technology	Large	8	1.38%

Table 4.2 (cont.) Portfolio composition and details

Portfolio 3	Equity name	Sector	Size	Bucket No.	Weights
	Grupo Bimbo	Consumer, Utilities	Large	5	6.97%
	Puerto Liverpool	Consumer, Utilities	Large	5	5.92%
	America Movil	Telecommunications, Industrials	Large	6	42.35%
	IEnova	Telecommunications, Industrials	Large	6	18.43%
	Nemak Mexico	Basic Materials, Energy	Large	7	4.00%
	Grupo Mexico	Basic Materials, Energy	Large	7	1.81%
	Grup Fin Inbursa	Financial, Technology	Large	8	6.12%
	Gentera	Financial, Technology	Large	8	14.41%
Portfolio 4	**Equity name**	**Sector**	**Size**	**Bucket No.**	**Weights**
	Grupo Aeroportua	Consumer, Utilities	Large	5	12.68%
	Arca Continental	Consumer, Utilities	Large	5	7.10%
	Alfa	Telecommunications, Industrials	Large	6	38.29%
	America Movil	Telecommunications, Industrials	Large	6	16.66%
	Nemak Mexico	Basic Materials, Energy	Large	7	3.62%
	Alpek	Basic Materials, Energy	Small	10	1.46%
	Gentera	Financial, Technology	Large	8	13.04%
	BanSantander MX	Financial, Technology	Large	8	7.16%
Portfolio 5	**Equity name**	**Sector**	**Size**	**Bucket No.**	**Weights**
	Grupo Bimbo	Consumer, Utilities	Large	5	11.73%
	America Movil	Telecommunications, Industrials	Large	6	71.25%
	Nemak Mexico	Basic Materials, Energy	Large	7	6.73%
	Grup Fin Inbursa	Financial, Technology	Large	8	10.30%
Portfolio 6	**Equity name**	**Sector**	**Size**	**Bucket No.**	**Weights**
	Grupo Aeroportua	Consumer, Utilities	Large	5	18.75%
	Alfa	Telecommunications, Industrials	Large	6	56.63%
	Nemak Mexico	Basic Materials, Energy	Large	7	5.35%
	Gentera	Financial, Technology	Large	8	19.28%

Source: Author's elaboration

5. Results

Tables 5.1, 5.2 and 5.3 picture an overview of the kind of movement that the pandemic brought about on the portfolios, most notably the increase in standard deviation, skewness and kurtosis, which alongside the growth in the tails of the distribution, indicate that the distributions of all the portfolios became more leptokurtic than the sample period. This fact, that appears more marked in P5 and P6, is indeed a foregone conclusion given the diversification present in more granulated portfolios. Aprioristically, this point would pave the way for models featuring a special treatment of the extremes, thus the expected result for EVT in Backtesting.

Some interesting elements appear in Table 5.4, which breaks down the components of SA. The high correlation regime gives the maximum MCR for every portfolio, with an increase in the region of 10% with reference to the 'normal' case, which is one of the innovations of the new SA (Table 5.4, Column [5]). HBR = 1 makes the portfolios bear the full brunt of DRC given the absence of offsetting short positions to net. Although it appears strange, the behavior of the DRC is not closely related with diversification as it depends on the credit rating of the weightier allocations[18]. The total MCR, ranges from 39% and 41% for P1 and P2 respectively, to 1%-2% more for P3, P4, P5 and P6, slightly ascending where the quantity of assets (and the diversification benefit) is reduced.

Rossignolo, Fethi and Shaban (2013) introduced the LCR, a simple measure of the extent of capital coverage of the trading desk. In this sense, Table 5.4 Column [12] shows that SA in Basel IV provides more than 5.4 times the largest loss of the backtesting period, indeed a substantial amount that banks ought to immobilize as a result of the new regulations and high threshold to be attained by IMA.

From the tables below, it could be deduced that the behavior of the portfolios became more extreme in the forecast period as the volatility of the portfolios (as measured by the standard deviation) of the distributions increased. Predictably, the kurtosis and the negative skew also augmented -particularly for the intermediate portfolios- on the grounds of the weights gained by the most volatile bucket, i.e., bucket 5. Strangely enough, the S&P BMV/IPC saw the kurtosis reverted, mainly due to the fall in the capitalization of its most volatile components.

Table 5.1 Basic statistics sample period

Parameter	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	S&P BMV/IPC
Observations	2513	2513	2513	2513	2513	2513	2513
Mean	0.00032	0.00030	0.00043	0.00034	0.00063	0.00044	0.00013
Variance	0.00003	0.00003	0.00006	0.00004	0.00011	0.00006	0.00008
Std. Dev.	0.00587	0.00568	0.00796	0.00671	0.01040	0.00778	0.00902
Maximum	0.02425	0.02349	0.03332	0.02742	0.04230	0.03361	0.04167
Minimum	-0.04427	-0.04514	-0.05858	-0.05112	-0.07066	-0.05278	-0.06062
Skewness	-0.31363	-0.38219	-0.29592	-0.30069	-0.04262	-0.02569	-0.42418
Kurtosis	3.05035	3.53896	2.88559	3.00188	2.05885	2.09405	3.50759
q(0,0001)	-0.04215	-0.04273	-0.05654	-0.04862	-0.06459	-0.04749	-0.06044
q(0,01)	-0.01140	-0.01121	-0.01574	-0.01342	-0.02010	-0.01522	-0.01884
q(0,025)	-0.00923	-0.00897	-0.01245	-0.01034	-0.01655	-0.01214	-0.01389
q(0,05)	-0.00923	-0.00897	-0.01245	-0.01034	-0.01655	-0.01214	-0.01389
q(0,10)	-0.00652	-0.00623	-0.00885	-0.00762	-0.01199	-0.00905	-0.01040
q(0,90)	0.00713	0.00688	0.00985	0.00840	0.01307	0.00970	0.01018
q(0,95)	0.00966	0.00942	0.01314	0.01108	0.01845	0.01381	0.01406
q(0,9750)	0.01171	0.01162	0.01653	0.01396	0.02270	0.01721	0.01808

[18] For instance, P5 is composed by Grupo Bimbo (12%, Aa2), America Movil (71%, AAA), Nemak Mexico (7%, AA) and Grupo Financiero Inbursa (10%, AAA), which, weighted, contribute with less than 1%. On the contrary, P3 dilutes those good credit ratings and adds Ienova (14%, BBB) and Gentera (15%, N/A) which, evidently, suffer penalization for the poor (or absence of) credit qualifications.

q(0,99)	0.01517	0.01480	0.02052	0.01756	0.02773	0.02131	0.02367
q(0,9999)	0.02421	0.02310	0.03214	0.02678	0.04174	0.03323	0.04006

Source: Author's elaboration

Table 5.2 Basis statistics forecast period

Parameter	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	S&P BMV/IPC
Observations	253	253	253	253	253	253	253
Mean	-0.00020	-0.00019	-0.00031	-0.00027	-0.00064	-0.00045	0.00010
Variance	0.00016	0.00014	0.00025	0.00017	0.00034	0.00018	0.00025
Std. Dev.	0.01277	0.01198	0.01576	0.01316	0.01854	0.01346	0.01571
Maximum	0.03612	0.03420	0.05121	0.04651	0.05774	0.04317	0.04744
Minimum	-0.07340	-0.07021	-0.09367	-0.07814	-0.09387	-0.06560	-0.06638
Skewness	-0.91633	-0.92514	-0.88068	-0.86393	-0.53409	-0.49532	-0.46856
Kurtosis	4.95555	5.24203	5.35800	5.55522	2.53231	2.22147	1.93529
q(0,0001)	-0.07267	-0.06948	-0.09283	-0.07749	-0.09286	-0.06499	-0.06609
q(0,01)	-0.02469	-0.02323	-0.03113	-0.02566	-0.03835	-0.02816	-0.03378
q(0,025)	-0.01754	-0.01768	-0.02292	-0.01917	-0.03088	-0.02243	-0.02523
q(0,05)	-0.01754	-0.01768	-0.02292	-0.01917	-0.03088	-0.02243	-0.02523
q(0,10)	-0.01352	-0.01230	-0.01739	-0.01469	-0.02311	-0.01574	-0.01708
q(0,90)	0.01453	0.01333	0.01772	0.01482	0.02156	0.01604	0.01891
q(0,95)	0.01871	0.01817	0.02345	0.01887	0.02743	0.02015	0.02482
q(0,9750)	0.01632	0.01602	0.01972	0.01601	0.02450	0.01909	0.02225
q(0,99)	0.02847	0.02672	0.03682	0.02897	0.04165	0.02886	0.03875
q(0,9999)	0.03610	0.03418	0.05095	0.04619	0.05751	0.04293	0.04723

Source: Author's elaboration

Table 5.3 Relative variations sample vs forecast periods

Parameter	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	S&P BMV/IPC
Observations							
Mean	-164.20%	-164.73%	-172.11%	-179.40%	-201.45%	-203.43%	-25.18%
Variance	374.09%	344.66%	292.24%	285.32%	217.88%	199.08%	203.33%
Std. Dev.	117.74%	110.87%	98.05%	96.30%	78.29%	72.94%	74.16%
Maximum	48.93%	45.61%	53.68%	69.65%	36.50%	28.47%	13.84%
Minimum	65.78%	55.53%	59.91%	52.87%	32.84%	24.29%	9.50%
Skewness	192.17%	142.06%	197.61%	187.32%	1153.06%	1828.17%	10.46%
Kurtosis	62.46%	48.12%	85.68%	85.06%	23.00%	6.08%	-44.83%
q(0,0001)	72.42%	62.62%	64.19%	59.38%	43.76%	36.86%	9.36%
q(0,01)	116.60%	107.27%	97.76%	91.20%	90.83%	85.03%	79.33%
q(0,025)	89.95%	97.15%	84.15%	85.48%	86.63%	84.75%	81.54%
q(0,05)	89.95%	97.15%	84.15%	85.48%	86.63%	84.75%	81.54%
q(0,10)	107.44%	97.37%	96.53%	92.84%	92.72%	73.99%	64.22%
q(0,90)	103.75%	93.77%	79.95%	76.31%	65.03%	65.37%	85.66%

q(0,95)	93.68%	92.81%	78.44%	70.26%	48.72%	45.91%	76.52%
q(0,9750)	39.37%	37.80%	19.31%	14.75%	7.94%	10.90%	23.09%
q(0,99)	87.72%	80.57%	79.45%	64.98%	50.20%	35.47%	63.71%
q(0,9999)	49.09%	48.01%	58.54%	72.50%	37.79%	29.19%	17.90%

Source: Author's elaboration

Table 5.4 The Standardized Approach

Portfolio	**ERC correlation regime**				**HBR**	**Default**	**ERC**	**Variation**	**Variation**	**Maximum**	**LCR**
	Normal	**High**	**Low**	**Var (H/N)**		**Risk Capital**	**Total**	**DRC / [5]**	**DRC / [2]**	**loss**	
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**
Portfolio 1	31.43%	34.63%	27.86%	10.19%	1.00	4.68%	39.31%	13.52%	14.90%	7.34%	5.36
Portfolio 2	31.43%	34.63%	27.86%	10.18%	1.00	6.28%	40.91%	18.14%	19.99%	7.02%	5.83
Portfolio 3	34.72%	38.41%	30.59%	10.62%	1.00	4.19%	42.60%	10.92%	12.08%	9.37%	4.55
Portfolio 4	33.06%	36.52%	29.20%	10.45%	1.00	6.04%	42.56%	16.54%	18.27%	7.81%	5.45
Portfolio 5	37.93%	42.12%	33.22%	11.04%	1.00	0.78%	42.90%	1.84%	2.05%	9.39%	4.57
Portfolio 6	33.45%	36.97%	29.53%	10.50%	1.00	6.96%	43.93%	18.82%	20.80%	6.56%	6.70
Average							**42.03%**				**5.41**

Source: Author's elaboration

Table 5.5 The Internal Models Approach – Backtesting penalties

Portfolio	**Historical**	**Filtered Historical Simulation**				**Conditional Volatility**				**EVT - POT**	**Linear**	
	Simulation	**GARCH-N**	**GARCH-t**	**EGARCH-N**	**EGARCH-t**	**GARCH-N**	**GARCH-t**	**EGARCH-N**	**EGARCH-t**		**Normal**	**t**
[1]	**[2]**	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
Portfolio 1	100.00%	22.00%	22.00%	28.00%	28.00%	100.00%	22.00%	100.00%	28.00%	0.00%	100.00%	100.00%
Portfolio 2	100.00%	22.00%	17.33%	100.00%	28.00%	100.00%	25.33%	100.00%	100.00%	0.00%	100.00%	100.00%
Portfolio 3	100.00%	22.00%	22.00%	100.00%	100.00%	100.00%	28.00%	100.00%	25.33%	0.00%	100.00%	100.00%
Portfolio 4	100.00%	25.33%	25.33%	100.00%	100.00%	100.00%	28.00%	100.00%	100.00%	0.00%	100.00%	28.00%
Portfolio 5	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	28.00%	0.00%	100.00%	100.00%
Portfolio 6	100.00%	28.00%	28.00%	100.00%	100.00%	100.00%	25.33%	100.00%	28.00%	0.00%	100.00%	100.00%

Note: color of cell indicates Backtesting zone: green, amber or red.

Source: Author's elaboration

Section 4 mentioned that EVT was the specification selected to perform the rest of the study, based on the evidence deployed in Table 5.5, as, in effect, it is the only one capable of avoiding Backtesting penalties in the evaluation period. The performance stems from the very foundations of the Theory of Extremes at the time of dealing with huge variations between the sample and evaluation periods. As for the rest of the techniques, it does not seem possible to extract definite conclusions about their behavior, bar from the unsuitability of Historical Simulation and linear models. In terms of the traditional VaR Backtesting, FHS and CV deliver somewhat mixed results, with GARCH variants faring slightly better than EGARCH counterparts in FHS category (Columns [3] to [6]) and GARCH-t and EGARCH-t in FHS (Columns [7] to [10]), which appears to signal the relative preeminence of the specification for the FHS and the distributional assumption for CV. Therefore, it would not seem sensible to apply any other model than EVT, as their performance across the board implies[19].

Table 5.6 depicts the capital levels at the start of the evaluation period. A simple look shows that both specifications do not suffer Backtesting penalties (Table 5.6 Columns [3] to and [13] to [15]), hence their capital values are not in principle deemed to be distorted by those surcharges. Furthermore, the fact that both Spearman and Kolmogorov-Smirnov tests fall into the Green Zone translates in the absence of the surcharge envisaged in (17) and (18) for both variants (Table 5.6 Columns [6] to [7] and [16] to [17]). The comparison between the Basel IV model and the Simplified specification in terms of the capital levels brings about a handful of implications and, in this sense, a first glance at Columns [11] and [21] shows that the official formula nearly triples its alternative due to the stressed calibration, thus taking the LCR to levels in excess of 4.65 in contrast to the figure of the more limited approach, 1.82. Consequently, both models provide coverage against the significant market slumps recorded after the pandemic, albeit the alternative in (20) would appear somewhat tight, with only 82% to spare.

Table 5.7 deals with the concept of the capital floor, in terms of the comparison between SA, the official IMA and the Simplified Specification. As Columns [4] and [6] convey, the average coverage[20] of the capital floor established by the SA reaches 88% in the case of the official IMA, descending to 27% for the Simplified Specification. The table also shows another option, i.e., a very straightforward adaptation of (20), increasing the 1.5 multiple in (15) to 3 and embedding it. This latest option delivers encouraging results, as the capital levels raise to 22% bringing the floor coverage to 53%. Given the timetable established by the BCBS (2020), by means of which IMA must meet SA levels by 50% in 2023, 55% in 2024, 60% in 2025, 65% in 2026, 70% in 2027 and 72.50% in 2028, the official specification would be granted approval since 2023, the Simplified Specification could not surpass the minimum threshold and the Alternative specification may remain in line for the year 2023 and in need to raise the game onwards.

Table 5.8 deploys the average, standard deviation, average surplus (as the difference between portfolio returns and the respective MCR), the average floor coverage (in relation with the SA) and its standard deviation. Across the board, the official model nearly doubles the Simplified technique, again mainly due to the stressed calibration of the reduced factors (S&P BMV/IPC). However, the flip side of the increased capital is its instability as long as the quantity of assets is reduced (the standard

[19] Appendix C.
[20] The author acknowledges the inconvenience of the averages; hence, it is only included for illustrative purposes given the apparent parity among the different portfolios.

deviation raises from 2.73% and 2.61% to 7.06% and 5.31% for P1 and P2 respectively (Table 5.8 Column [2] against [10] and [4} against [12], second line), in turn deriving from the ES_{FC} (i.e., a portfolio of 4 assets each) as the rest of the factors of (13) remain unaltered; conversely, the path for simple ES does not appear spiky as the diversification decreases (Table 5.8 Columns [3], [5], [7], [9], [11] and [13], second line). The average capital surplus reflects the modelling nature, with maximum and minimum values of around 43% and 26% (Table 5.8 Columns [10] and [8] respectively) versus 23% and 13% (Table 5.8 Columns [11] and [5] respectively)[21].

Finally, the proportion of floor coverage also delivers interesting implications given that, once more, the official specification shows satisfactory levels albeit with rising instability as diversification erodes, whereas the Simplified system appears relatively more stable showcasing lesser coverage levels. This is, in turn, a relevant derivation because it hints that much more simple models can provide capital levels enough to withstand crises of considerable magnitudes but would still be disallowed by the regulatory authorities.

[21] Appendix D.

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Table 5.6 Minimum capital requirements as of 15/01/2020

Portfolio	Maximum loss	Basel IV specification										Simplified specification									
		Backtesting Zone (I)	Backtesting Zone (II.a)	Backtesting Zone (II.b)	Spearman Zone	KS Zone	Surcharge k	Capital level	DRC	Total Capital	LCR	Backtesting Zone	Backtesting Zone (II.a)	Backtesting Zone (II.b)	Spearman Zone	KS Zone	Surcharge k	Capital level	DRC	Total Capital	LCR
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**	**[14]**	**[15]**	**[16]**	**[17]**	**[18]**	**[19]**	**[20]**	**[21]**	**[22]**
Portfolio 1	7.34%	Green	Green	Green	Green	Green	0.00%	26.32%	2.70%	29.02%	3.95	Green	Green	Green	Green	Green	0.00%	8.76%	2.70%	11.46%	1.56
Portfolio 2	7.02%	Green	Green	Green	Green	Green	0.00%	25.50%	2.60%	28.10%	4.00	Green	Green	Green	Green	Green	0.00%	8.49%	2.60%	11.09%	1.58
Portfolio 3	9.37%	Green	Green	Green	Green	Green	0.00%	41.07%	3.31%	44.37%	4.74	Green	Green	Green	Green	Green	0.00%	13.67%	3.31%	16.98%	1.81
Portfolio 4	7.81%	Green	Green	Green	Green	Green	0.00%	29.30%	2.98%	32.27%	4.13	Green	Green	Green	Green	Green	0.00%	9.75%	2.98%	12.73%	1.63
Portfolio 5	9.39%	Green	Green	Green	Green	Green	0.00%	46.12%	4.08%	50.20%	5.35	Green	Green	Green	Green	Green	0.00%	15.35%	4.08%	19.43%	2.07
Portfolio 6	6.56%	Green	Green	Green	Green	Green	0.00%	34.18%	3.55%	37.73%	5.75	Green	Green	Green	Green	Green	0.00%	11.38%	3.55%	14.93%	2.28
Average								**33.75%**	**3.20%**	**36.95%**	**4.65**							**11.23%**	**3.20%**	**14.44%**	**1.82**

Source: Author’s elaboration

Table 5.7 The capital floors (% of the SA)

Portfolio	Standardised Approach	Basel IV IMA		Simplified specification		Alternative specification	
		Capital level	Floor coverage	Capital level	Floor coverage	Capital level	Floor coverage
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Portfolio 1	39.31%	29.02%	73.81%	8.76%	22.29%	17.52%	44.58%
Portfolio 2	40.91%	28.10%	68.69%	8.49%	20.75%	16.98%	41.50%
Portfolio 3	42.60%	44.37%	104.16%	13.67%	32.09%	27.34%	64.18%
Portfolio 4	42.56%	32.27%	75.84%	9.75%	22.92%	19.51%	45.83%
Portfolio 5	42.90%	50.20%	117.03%	15.35%	35.79%	30.71%	71.59%
Portfolio 6	43.93%	37.73%	85.90%	11.38%	25.90%	22.76%	51.81%
Average	**42.03%**	**36.95%**	**87.57%**	**11.23%**	**26.62%**	**22.47%**	**53.25%**

Source: Author’s elaboration

Table 5.8 Dynamic behavior

Metric	Portfolio 1		Portfolio 2		Portfolio 3		Portfolio 4		Portfolio 5		Portfolio 6	
	Basel IV	**Simplified**	Basel IV	**Simplified**	Basel IV	**Simplified**	Basel IV	**Simplified**	Basel IV	**Simplified**	Basel IV	**Simplified**
[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**
Average	29.71%	14.47%	27.66%	13.33%	38.04%	19.66%	26.81%	13.83%	43.98%	24.28%	32.66%	18.19%
Std. Dev.	2.73%	4.01%	2.61%	3.51%	5.46%	4.21%	4.54%	3.23%	7.06%	3.16%	5.31%	2.11%
Avg. Surplus	28.67%	13.54%	26.63%	12.60%	36.76%	18.13%	26.03%	12.70%	42.86%	22.72%	31.99%	17.03%
Avg. Floor cov.	75.58%	36.80%	67.61%	32.58%	89.29%	46.15%	63.00%	32.49%	102.52%	56.60%	76.14%	42.40%
SD Floor cov.	6.96%	10.20%	6.38%	8.57%	12.82%	9.88%	10.67%	7.58%	16.45%	7.36%	12.39%	4.91%

Source: Author’s elaboration

6. Conclusions

In the very words of the BCBS, Basel IV has been enacted to remedy many flaws of Basel III, principally around four axes: the trading book/banking book boundary, the measurement of risk of market illiquidity, enhancement of the robustness and risk sensitivity of the SA and finally, improvement of the capture and capitalization against tail risk. The paper could –completely achieving the objectives stated- carry out the complete cycle of MCR determination for the Mexican stock market and the results confirmed the initial hypothesis, given that the relationship between SA and IMA looks completely transformed. However, the bias towards the former appears clearer and on the other hand, the adoption of the latter may be hampered by the inherent complexity in its construction and the stringent validation criteria, the extent of which is pushed forward during market crises. Hence, in consideration of the outcomes, and even acknowledging that equity risk is only one of the main risks mentioned, the BCBS certainly seems to have achieved its aims, albeit at a potentially high cost which, at least, should merit a review.

The SA looks completely revamped, with a logical attempt to embed risk via the classification in risk buckets, the correlation coefficients and regimes and the sensitivities method. However, the outcome poses interesting questions because, in principle, the output floor looks somewhat elevated as it would provide coverage many times the highest loss of the backtesting period. Although ultimately it is a matter of empirical assessment, the scheme appears orientated to be computed using stressed values, with the standalone capital requirement (risk weights) already delivering sizeable cushions and, on top of this, a questionable correlation matrix rooting in an arguable sector classification. Admittedly, both the individual risk weights and the correlation within and among the risk buckets play a very important part at the time of increasing the threshold, which is augmented by the inclusion of the DRC. It is clear that the rigidness of the approach pushed the BCBS to introduce a credit risk element in market risk measurements (the deterioration of the credit standards is not reflected in the whole scheme) and, time and again, the flexibilization of the coefficients would appear healthy. Ultimately, it boils down to empirical verification whether their relaxation and adaptation to the different market moments could bring about a softening of the floor, but everything may point in that direction.

In view of the outcomes, the IMA has suffered an important crackdown by the BCBS, and its reflections blaming the models for its poor performance in the event of the major subprime crisis do reveal its beliefs. Not only has it increased the market risk estimates by substituting VaR for ES –fact logical from a theoretical point of view – but it has made life harder by imposing stringent and complex validating criteria which leaves in practical terms highly leptokurtic specifications like those rooted in the theory of extremes one of the few capable of overcoming them. This consequently translates into elevated minimum capital requirements which, besides enacting a sizeable coverage, may still fall behind the levels demanded by the SA. Delving into the mechanics of the formula, it is useful to compare it to the yardstick represented by the Simplified model, and it is clear that the stressed calibration of the reduced factor ES raises the level of MCR. The results convey that even though the plain vanilla technique provides sufficient coverage against relatively major market slumps, the presence of the strained factor increases the output, and a detailed assessment would elucidate whether the removal of the stressed calibration and the utilization of an enhanced variant (i.e., increasing the fixed multiple but still keeping the leptokurtic modelling) would be enough to provide coverage in stressed times, but, initially, the results should encourage a likely path forward.

The BCBS attained its aims at the time of raising the MCR, albeit at the expense of cornering the IMA (formulation, validation criteria and high capital floor) and enabling a relatively inflexible SA. True as it may be, this facilitates the comparison across jurisdictions and the harmonization of standards, but in principle would stifle the financial innovation, increase the cost of capital, decrease profit measures like ROA or ROI and shrink banking credit.

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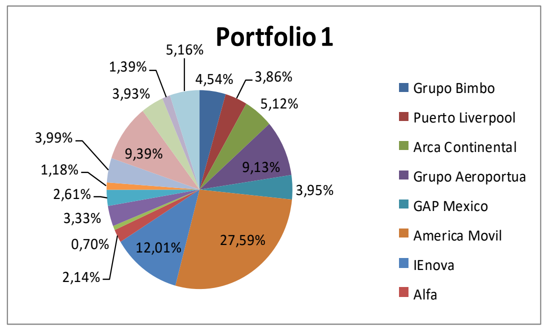
Appendix A. Portfolio composition

The current Appendix portrays a graphical representation of the portfolios involved.

Portfolio 1

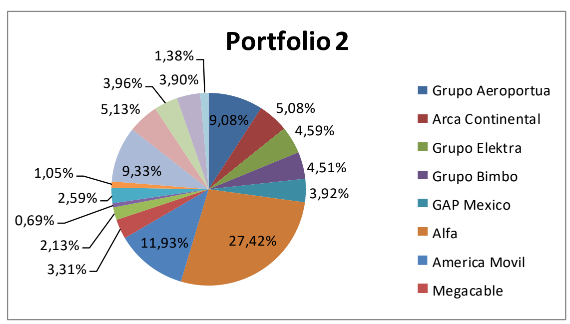
Stock	Bucket	Weight
Grupo Bimbo	5	4,54%
Puerto Liverpool	5	3,86%
Arca Continental	5	5,12%
Grupo Aeroportua	5	9,13%
GAP Mexico	5	3,95%
America Movil	6	27,59%
IEnova	6	12,01%
Alfa	6	2,14%
Pinfra	6	0,70%
Megacable	6	3,33%
Nemak Mexico	7	2,61%
Grupo Mexico	7	1,18%
Grup Fin Inbursa	8	3,99%
Gentera	8	9,39%
Regional	8	3,93%
Grupo Banorte	8	1,39%
BanSantander MX	8	5,16%



Source: Author's own elaboration (table and figure)

Portfolio 2

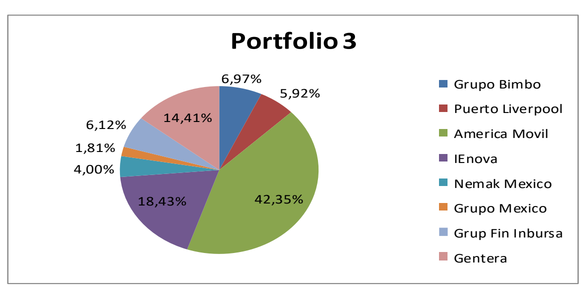
Stock	Bucket	Weight
Grupo Aeroportua	5	9,08%
Arca Continental	5	5,08%
Grupo Elektra	5	4,59%
Grupo Bimbo	5	4,51%
GAP Mexico	5	3,92%
Alfa	6	27,42%
America Movil	6	11,93%
Megacable	6	3,31%
Televisa	6	2,13%
IEnova	6	0,69%
Nemak Mexico	7	2,59%
Alpek	7	1,05%
Gentera	8	9,33%
BanSantander MX	8	5,13%
Grup Fin Inbursa	8	3,96%
Regional	8	3,90%
Grupo Banorte	8	1,38%



Source: Author's own elaboration (table and figure)

Portfolio 3

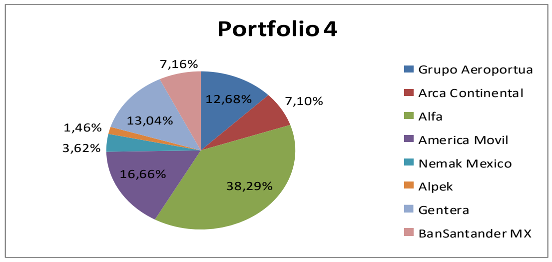
Stock	Bucket	Weight
Grupo Bimbo	5	6,97%
Puerto Liverpool	5	5,92%
America Movil	6	42,35%
IEnova	6	18,43%
Nemak Mexico	7	4,00%
Grupo Mexico	7	1,81%
Grup Fin Inbursa	8	6,12%
Gentera	8	14,41%



Source: Author's own elaboration (table and figure)

Portfolio 4

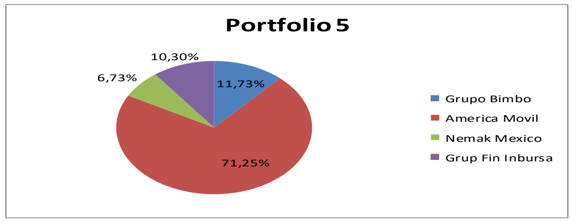
Stock	Bucket	Weight
Grupo Aeroportua	5	12,68%
Arca Continental	5	7,10%
Alfa	6	38,29%
America Movil	6	16,66%
Nemak Mexico	7	3,62%
Alpek	7	1,46%
Gentera	8	13,04%
BanSantander MX	8	7,16%



Source: Author's own elaboration (table and figure)

Portfolio 5

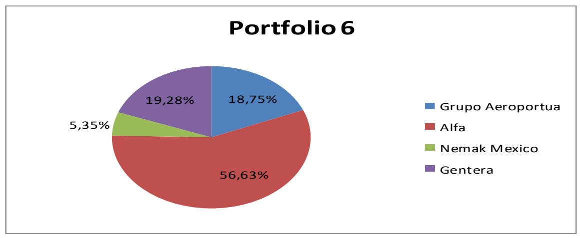
Stock	Bucket	Weight
Grupo Bimbo	5	11,73%
America Movil	6	71,25%
Nemak Mexico	7	6,73%
Grup Fin Inbursa	8	10,30%



Source: Author's own elaboration (table and figure)

Portfolio 6

Stock	Bucket	Weight
Grupo Aeroportua	5	18,75%
Alfa	6	56,63%
Nemak Mexico	7	5,35%
Gentera	8	19,28%



Source: Author's own elaboration (table and figure)

Appendix B. General formulae

The present Appendix synthesizes the general formulae used to obtain the appropriate risk measures.

ES constitutes one of the alternatives capable of overcoming VaR's theoretical deficiencies. According to McNeil, Frey and Embrechts (2005), ES represents a risk measure providing information about the tails of the distribution in depth. Specifically, instead of sticking to a particular confidence level α, the underlying idea boils down to average the VaR for those probability levels ζ such that $\zeta \geq \alpha$, thus making $ES_\alpha \geq VaR_\alpha$ for identical probability levels. Formally,

$$ES_\alpha = \frac{1}{1-\alpha}\int_\alpha^1 q_\zeta \, d\zeta \tag{A.1}$$

where q_ζ is the quantile function corresponding to the return distribution, thus relating ES and VaR in an analogous fashion:

$$ES_{\alpha} = \frac{1}{1-\alpha}\int_{\alpha}^{1} VaR_{\zeta}\, d\zeta \tag{A.2}$$

Additionally, for continuous loss distributions, a more intuitive, easily comprehended interpretation asserts that ES is equal to the expected loss incurred provided VaR is exceeded, i.e., the average of the losses exceeding VaR:

$$ES_{\alpha} = \frac{E[L; L \geq q_{\alpha}(L)]}{1-\alpha} = E(L | L \geq VaR_{\alpha}) \tag{A.3}$$

for an integrable loss L (McNeil, Frey and Embrechts (2005)). This expression does not hold for discontinuous loss distributions, in which case the formula below applies (Acerbi and Tasche (2002)):

$$ES_{\alpha} = \frac{1}{1-\alpha}\{E[L; L \geq q_{\alpha}] + q_{\alpha}[1-\alpha - P(L \geq q_{\alpha})]\} \tag{A.4}$$

When the distribution is discrete, ES is calculated employing the natural estimator and discrete equivalent of (2.23), i.e., the average of the w losses greater than VaR:

$$ES_{\alpha} = \frac{\sum_{i=1}^{w} L_i}{w} \tag{A.5}$$

Given that ES could be expressed in terms of VaR, it seems appropriate to analyse VaR functions for every specification used. Therefore,

$$VaR_{t+1}(\alpha/) = \sigma_{t+1}\, F^{-1}(1-\alpha) \tag{A.6}$$

where:
σ_{t+1} : volatility forecast derived from any volatility model;
$F^{-1}(\alpha)$: inverse of the cumulative density function of the empirical distribution of the standardised residuals, i.e., α-quantile of F
Hence:

a. Historical Simulation Model

$$VaR_{t+1}^{HS}(\alpha) = Q_{\alpha}(r_t, r_{t-1,} r_{t-2,\dots,} r_{t-1+n}) \tag{A.7}$$

where VaR_{t+1}^{HS} refers to the Value-at-Risk level using Historical Simulation and Q_{α} denotes the α-quantile of the n previous returns states the Value-at-Risk for time $t+1$ at the confidence level α.

b. Filtered Historical Simulation Models

GARCH (Bollerslev (1986)) and EGARCH (Nelson (1991)) volatility models with both Normal and Student-t distributions constitute the combinations under FHS framework. Hence, formula (3.59) may be further specified considering these four possibilities:

b.1) $$VaR_{t+1}^{FHS-GN}(\alpha) = \sigma_{t+1}^{G} F^{-1}(\alpha) \quad \text{(A.8)}$$
b.2) $$VaR_{t+1}^{FHS-Gt}(\alpha) = \sigma_{t+1}^{G} F^{-1}(\alpha) \quad \text{(A.9)}$$
b.3) $$VaR_{t+1}^{FHS-EN}(\alpha) = \sigma_{t+1}^{E} F^{-1}(\alpha) \quad \text{(A.10)}$$
b.4) $$VaR_{t+1}^{FHS-Et}(\alpha) = \sigma_{t+1}^{E} F^{-1}(\alpha) \quad \text{(A.11)}$$

where VaR_{t+1}^{FHS-XY} denotes the Value-at-Risk number corresponding to the Filtered Historical Simulation scheme using the model "*X*" (GARCH or EGARCH) with the distribution "*Y*" appended (Normal or Student-t). The superscript "*G*" or "*E*" refers to the GARCH or EGARCH representation employed to obtain the volatility forecast for the day t+1 respectively whereas the symbols "*N*" and "t" stand for Normal and Student-t distributions respectively. Finally, the symbol F^{-1} indicates the inverse of the standardised empirical distribution using the model provided.

c. Conditional Volatility Models

According to Section 3.5, GARCH and EGARCH volatility models with both Normal and Student-t distributions constitute the combinations under the CV framework. Hence, formula (3.64) may be further specified considering those four possibilities:

c.1) $$VaR_{t+1}^{CV-GN}(\alpha) = \sigma_{t+1}^{G} \Phi^{-1}(\alpha) \quad \text{(A.12)}$$
c.2) $$VaR_{t+1}^{CV-Gt}(\alpha) = \sigma_{t+1}^{G} t^{-1}(\alpha) \quad \text{(A.13)}$$
c.3) $$VaR_{t+1}^{CV-EN}(\alpha) = \sigma_{t+1}^{E} \Phi^{-1}(\alpha) \quad \text{(A.14)}$$
c.4) $$VaR_{t+1}^{CV-Et}(\alpha) = \sigma_{t+1}^{E} t^{-1}(\alpha) \quad \text{(A.15)}$$

where VaR_{t+1}^{CV-XY} denotes the Value-at-Risk number corresponding to the Conditional Volatility scheme using the model "*X*" (GARCH or EGARCH) with the distribution "*Y*" appended (Normal or Student-t). Additionally, the superscript "*G*" or "*E*" refers to the GARCH or EGARCH representations employed to obtain the volatility forecast for the day $t+1$ respectively whereas the symbols "*N*" and "t" stand for Normal and Student-t distributions respectively. Finally, the symbols Φ^{-1} and t^{-1} indicate the inverse of the cumulative Normal or Student-t distributions respectively.

d. Extreme Value Theory Model

The expression of the relevant α-quantile is computed by:

$$\hat{F}^{-1}(\alpha) = u + \frac{\hat{\sigma}}{\hat{\xi}}\left[\left(\frac{1-\alpha}{k/n}\right)^{-\hat{\xi}} - 1\right] \tag{A.16}$$

where u, σ and ξ denote the threshold, standard deviation and shape parameters respectively and k and n the number of extremes above the threshold and total number of extreme respectively and the superscript ^ (hat) the estimator symbol.

Following McNeil, Frey and Embrechts (2005) and Fernandez (2003) who advocate the use of the GARCH-Normal combination as the model to forecast volatility and standardise the residuals to feed the Generalised Pareto Distribution adjustment.

e. Linear Models

e.1) $$VaR_{t+1}^{L-N}(\alpha) = \sigma_{t+1}^{L}\Phi^{-1}(\alpha) \tag{A.17}$$

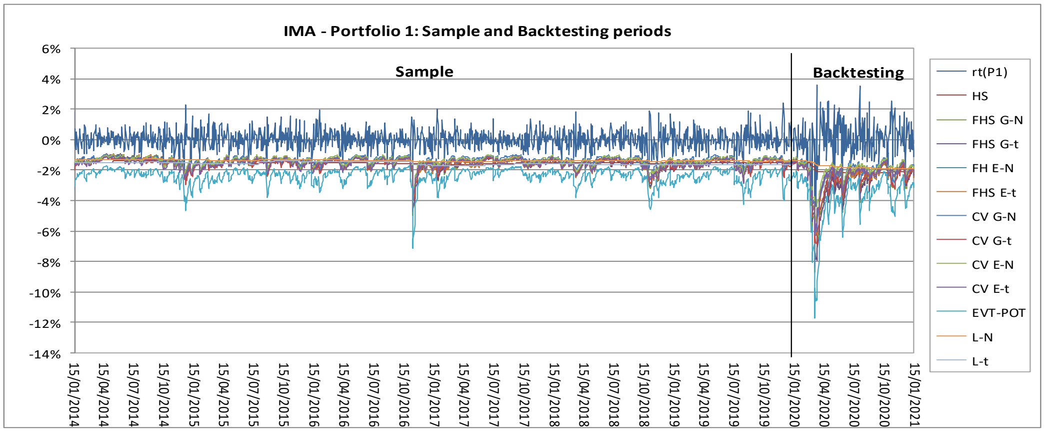
e.2) $$VaR_{t+1}^{L-t}(\alpha) = \sigma_{t+1}^{L}t^{-1}(\alpha) \tag{A.18}$$

where the superscript L stands for Linear (i.e., Standard Deviation) and letters N and t and the symbols Φ^{-1} and t^{-1} conserve the informed meaning.

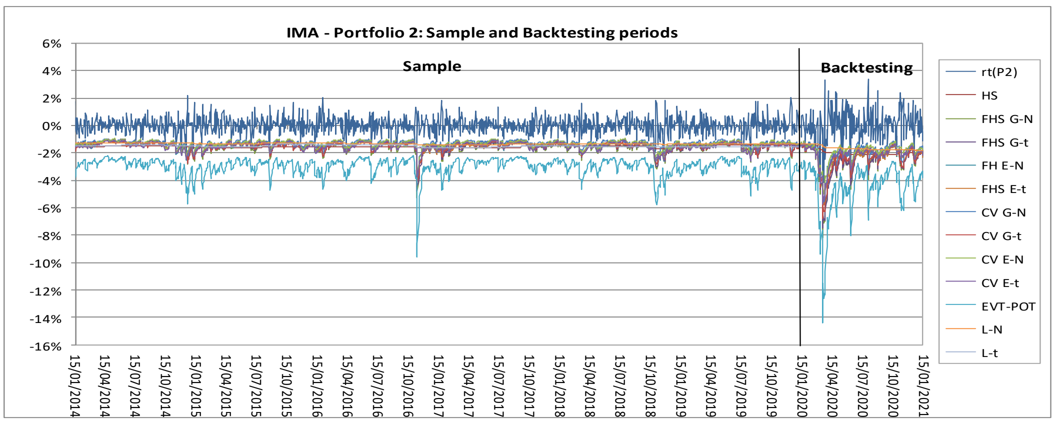
Appendix C. Internal Models Approach: Backtesting

The present Appendix displays the graphical behavior of the models employed compared with the portfolio series during Backtesting. The graphs are divided in two sections separated by a vertical black line indicating the division between the sample and backtesting periods, and it is crucial to remark that, as mentioned in Section 2.2.2, the test requires the usage of VaR models (not ES) to count the number of violations and subsequently determine the penalties.

The dark blue line denotes the portfolio return series, where it the increase in volatility derived from the Covid-19 is patent. Furthermore, it may be appreciated how the EVT specification represented by the light blue line reacts to market movements and at all times its estimated VaRs avoid any exception and consequently emerge unscathed. It is also clear that linear models and HS react slowly to volatility spikes, which eventually grant their exclusion whereas the remaining techniques deliver mixed outcomes.



Source: Author's elaboration



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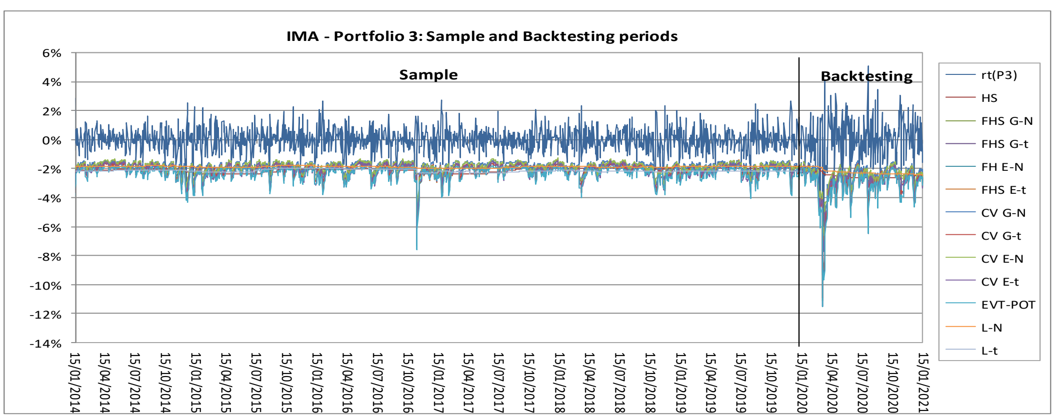

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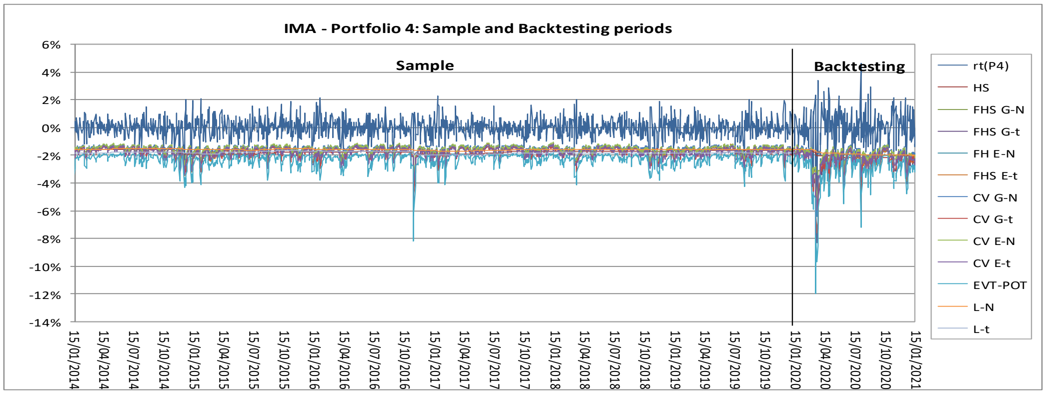

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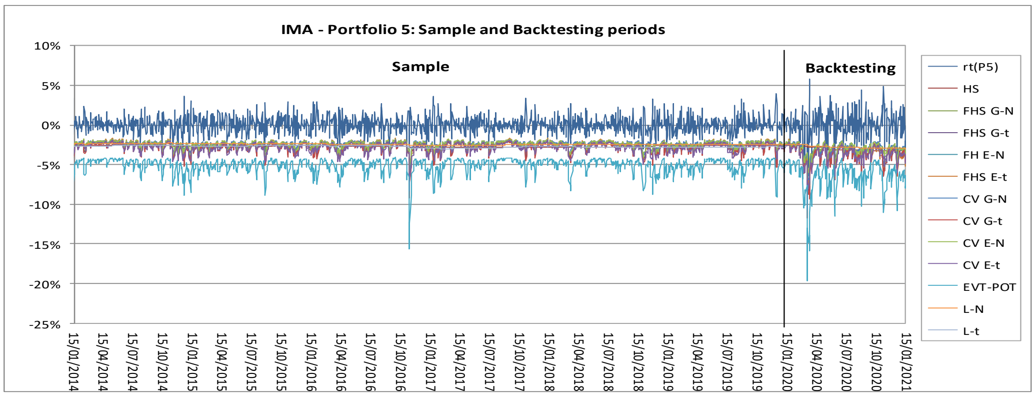

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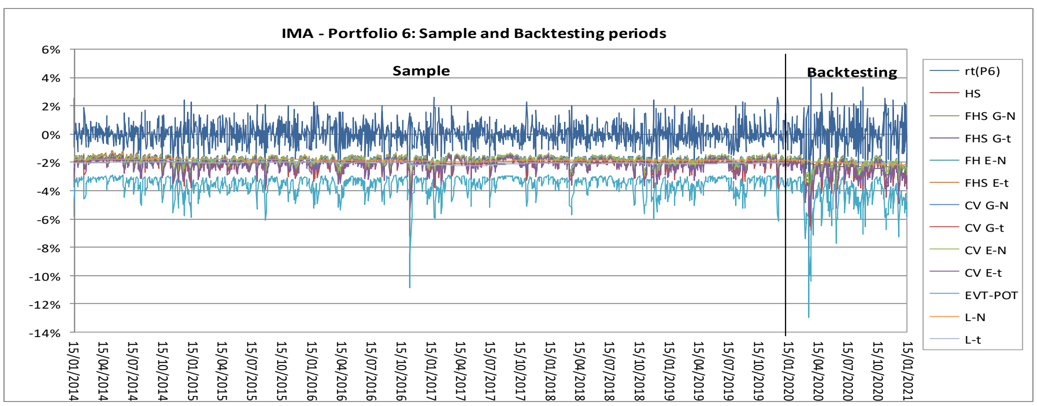

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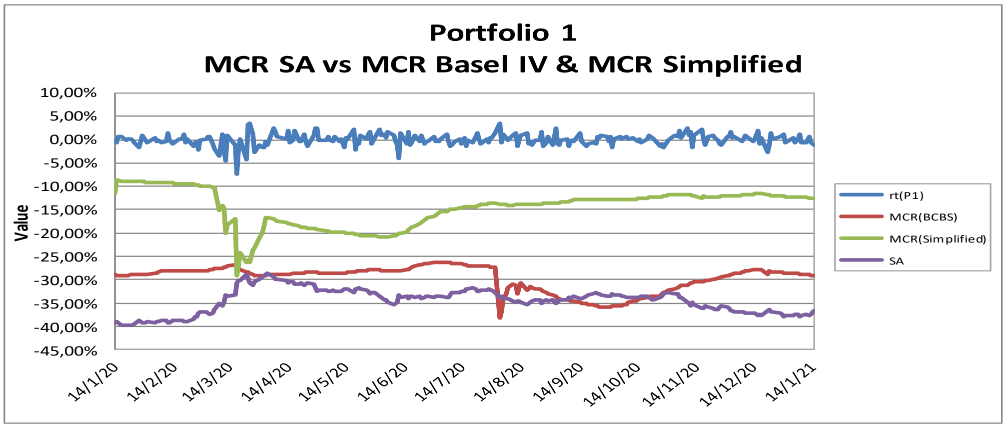
Appendix D. Dymamic behavior of MCR: SA vs IMA(BCBS) vs IMA(Simplified)

The following graphs picture the performance of the MCR calculated via SA and IMA according to the BCBS mandate and the simplified formula (20). In all the portfolios the behavior is consistent: substantial capital increase for MCR's SA and IMA(BCBS) and high output floor set by the former, level that can only be attained by means of a highly leptokurtic model like EVT, and, for some portfolios like P3 and P5, IMA(BCBS) exceeds SA. Furthermore, the yardstick constituted by the simplified model seems capable of delivering adequate capital base for market crises and react more quickly to volatility.



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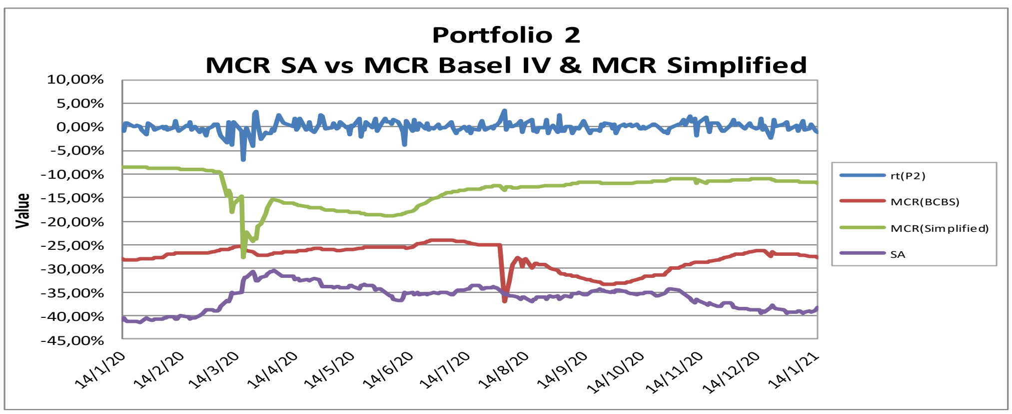

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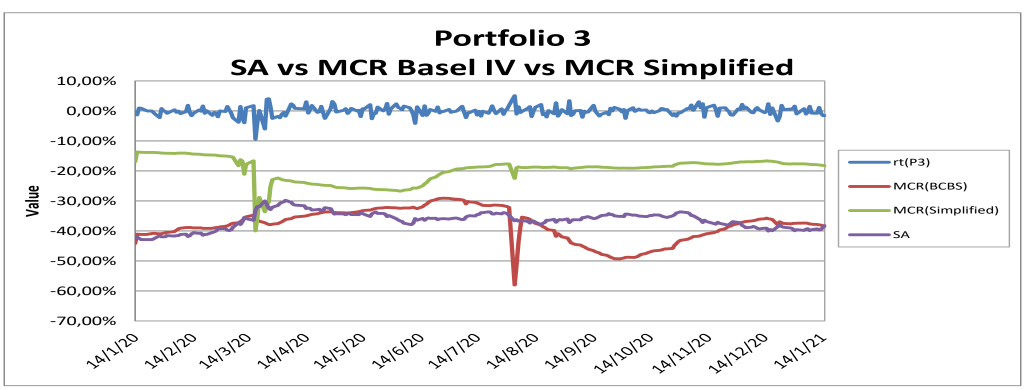

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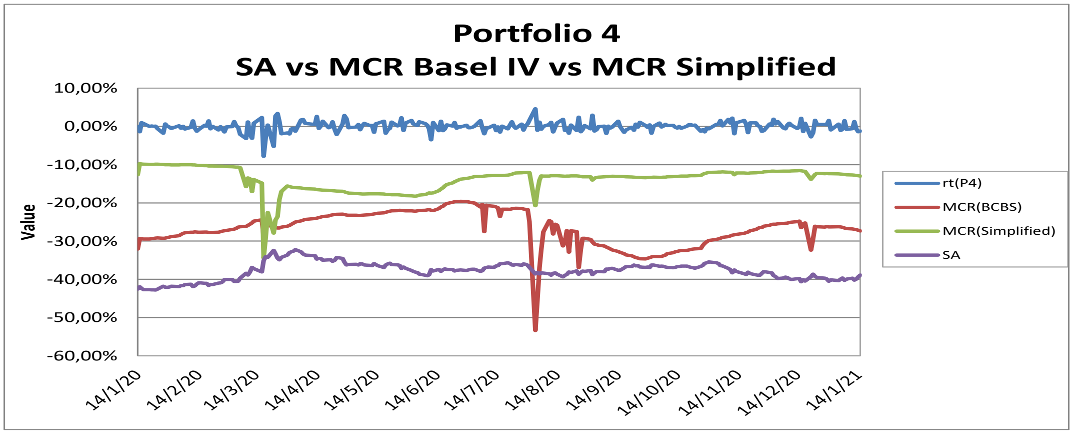

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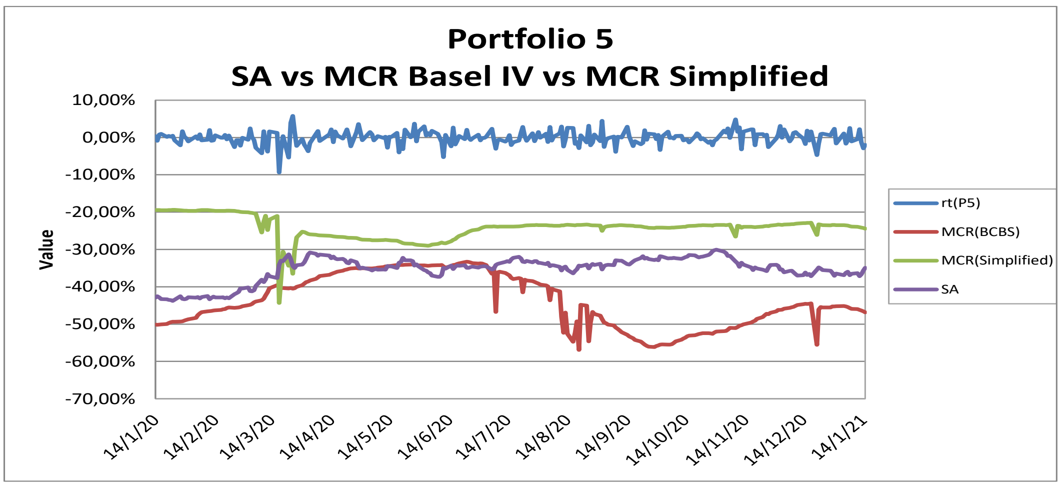

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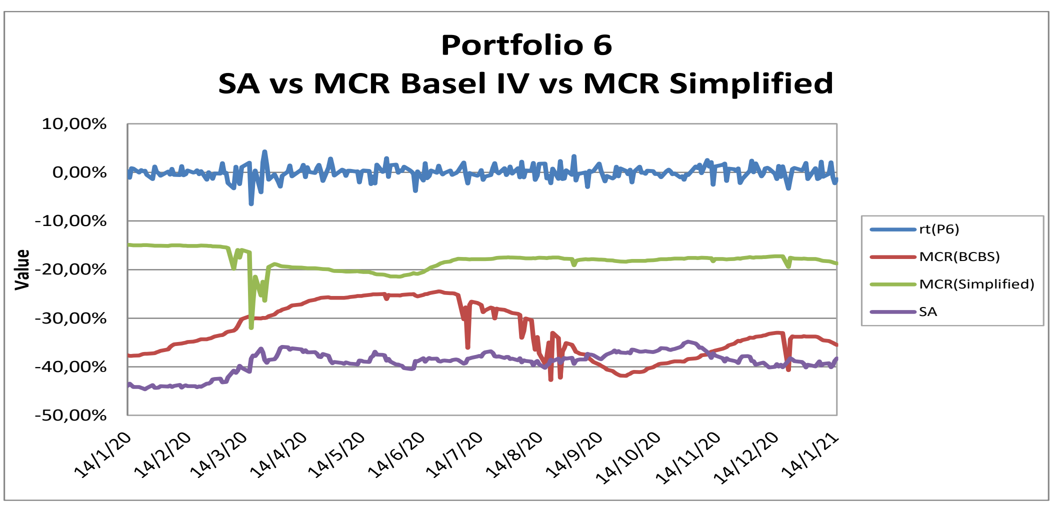

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