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Empirical Approximation of the ES-VaR: Evidence from Emerging and Frontier Stock Markets during Turmoil

Aproximación empírica del VaR y ES-VaR: evidencia de mercados emergentes y de frontera durante períodos de turbulencia

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Abstract

After releasing the Basel III Capital Accord with enhanced Minimum Capital Requirements (MCR) based on Value-at-Risk (VaR), the Basel Committee embarked on a revision of the risk measures employed and, in this sense, it proposed the introduction of Expected Shortfall (ES) to replace VaR in a bid to remedy VaR's glitches. The current article features a review of ES, specially emphasising the impact that the application of ES would exert on MCR in times of great market stress. The empirical analysis performed determines that 97.50% could constitute the confidence level for ES-based MCR that accomplishes the Basel Committee's mandate —therefore equating VaR's and ES's MCR— and recommends several changes in the level of the fixed factors in the Basel Committee's MCR formulas in order to calibrate outcomes. Furthermore, it suggests a likely course of action —abiding by Basel regulations— to remedy the inconsistencies underlying the capital buffers. Finally, it hints at the adequacy of Basel II Capital Accord subject to the utilisation of the right model to compute the risk metric embedded in the MCR formulae and, conversely, points at the knee-jerk reaction of the Basel Committee at the time of enacting the Basel III mandates.

JEL classification: G18, G28.

Key words: *Expected Shortfall, Value-at-Risk, Basel Capital Requirements, Extreme Value Theory.*

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Resumen

Luego de publicar el Acuerdo de Capital de Basilea III, que incluye mayores Requerimientos Mínimos de Capital (MCR) basados en el Valor-en-Riesgo (VaR), el Comité de Basilea encaró una revisión de las métricas de riesgo empleadas y, en tal sentido, propuso la introducción del Déficit Esperado (ES) para reemplazar el VaR en un intento de remediar las valencias del VaR. El presente artículo expone una evaluación de ES, enfatizando especialmente el impacto que la aplicación de ES tendrá sobre los MCR en tiempos de *stress* en los mercados. El análisis empírico determina que el nivel de confianza a aplicar a ES para lograr el mandato del Comité de Basilea consistente en igualar los MCR derivados del VaR con aquellos de ES es 97.50%. Adicionalmente, el estudio recomienda algunos cambios en el nivel de los parámetros fijos existentes en las fórmulas que determinan los MCR necesarios para calibrar los resultados. Además, se sugiere un curso de acción —dentro de las regulaciones de Basilea— para remediar las inconsistencias que subyacen a las reservas de capital. Finalmente, se apunta que, en caso de emplearse el modelo adecuado para computar la medida de riesgo utilizada para calcular los MCR, el Acuerdo de Capital de Basilea II podría haber resultado adecuado, hecho que indicaría una sobre-reacción del Comité de Basilea al momento de la promulgación de Basilea III.

Classification JEL: G18, G28.

Palabras clave: Valor en Riesgo, Valor en Riesgo condicional, pérdida esperada, requerimientos de capital, Basilea III.

Introduction

Since the 1996 Amendment to the Basel I Capital Accord (BCBS, 1996), Value-at-Risk (VaR) has become the official risk measure to quantify market risks. Its inclusion in the Basel II Capital Accord appeared a sensible move given the inability of the former mandate to deal with the challenges posed by many notorious collapses (Jorion (1996)).

As any market risk metric, VaR has advantages and disadvantages. Although it constitutes a simple universal probabilistic measure to describe the magnitude of the likely losses on the portfolio (Linsmeier and Pearson (1996)), its inability to inform the size of the potential losses (Dowd (2005)) and, most notably, its failure to achieve the status of 'coherence' devised by Artzner *et al*. (1999) underline its snags.

The improvements brought about by Basel II materialised in the introduction of VaR revealed themselves powerless to fend off the devastating effects of the subprime crisis of 2007-2008. Consequently, the Basel Committee of Banking Supervision (BCBS) enacted the third Basel Capital Accord (Basel III) that contained a series of novelties concerning the trading book, among which the addition of the stressed VaR (sVaR) component to the VaR-based Minimum Capital Requirements (MCR) formula plays an outstanding role. Even though the new standard fostered the constitution of higher and of better quality capital buffers, Rossignolo, Fethi and Shaban (2012a, 2012b) pointed out that the laxity contained in Basel Capital Accords may give rise to moral hazard by —inadvertently— enticing the use of inaccurate VaR schemes.

With Basel III still under implementation, the BCBS commissioned a full revision of the risk measurement for the trading book. Not surprisingly, it placed strong emphasis on VaR shortcomings and evinced Expected Shortfall (ES) as the alternative to replace VaR. Unfortunately, though highlighting its virtues juxtaposed to VaR's snags, the BCBS avoided carrying out a quantitative comparison between ES and VaR for capital constitution objectives, which may have informed the extent of the improvements susceptible of being attained in the wake of ES application. Furthermore, the adoption of ES instead of VaR posed some methodological problems of which the selection of an appropriate confidence level (which, according to BCBS's directives, ought to equate VaR's and ES's MCR) and the determination of the right multiplication factors in the MCR formula susceptible to yield reasonable regulatory capital levels are only a few. Additionally, the task of finding sensible answers to the problems appears hampered by the interrelation existing between VaR and ES, to the extent that, at the time of enacting its Revision to the Market Risk Framework (BCBS (2012)), the BCBS has only indicated that, in the first place, the confidence level for ES must be 97.50% and, in the second place, the capital levels arising from VaR should be similar to those deriving from ES, albeit failing to precise on which grounds those conclusions were attained.

The paper unfolds as follows. Section 1 shows the motivations and expected contributions, Section 2 summarises the theoretical environment behind VaR and ES, emphasising VaR's pitfalls that encumbered ES; Section 3 synthesises Basel II and Basel III frameworks regarding MCR for the existing metric (VaR) and its likely replacement; Section 4 details the Methodology employed to compute ES while Section 5 exhibits the outcome of the Backtesting exercise for the three confidence levels tested and the corresponding MCR based on ES and in comparison with those deriving from VaR. Finally, Section 6 stages a sensitivity analysis gauging the performance of ES in Basel II and Basel III mandates as well as its comparison with VaR's behaviour whereas the last section presents some overall closing remarks regarding the whole ES exercise.

1. Motivation and expected contribution

The motivation of the current article resides in shedding light on two of the most controversial aspects of the application of ES as a market risk metric: the confidence level and the equivalence of VaR and ES capital requirements, eventually one of the founding blocks of the latest revision to the market risk framework. For that purpose, using a sample of Emerging and Frontier stock markets and the subprime crisis of 2007-2008 as the empirical scenario, the paper proposes a methodology that determines 97.50% as the approximate confidence level which enables VaR and ES to deliver approximately equal MCR, developing, in this fashion, a technique that may be employed to understand the rationale behind the new regulations, enacted without major explanations. Furthermore, in light of the aforementioned results, the study ventures to analyse the multiplication factors embedded in the MCR expression based on ES instead of VaR, additionally concluding that the adoption of ES as the official market risk metric would in principle allow banks to operate under the old Basel II, this way avoiding the application of the Basel III specifications. Finally, the analysis presents credible evidence that the usage of leptokurtic models —mainly those based on Extreme Value Theory— could have mitigated the extent of the precision disincentives implicit in Basel Capital Accords (Basel II and Basel III) and contributed to align the banks' accuracy enticements and the supervisors' objectives.

2. Theoretical background. Concepts and definitions

2.1. Value-at-Risk definition

McNeil, Frey and Embrechts (2005) define the Value-at-Risk of a portfolio of multiple or single assets at the confidence level α as the smallest number l such that the probability that loss L exceeds l is no greater than (1 – α):

$$VaR(\alpha) = \inf\{l \in R : P(L > l) \leq (1-\alpha)\} = \inf\{l \in R : F_L(l) \geq \alpha\} \qquad (1)$$

This risk measure informs the amount of the monetary loss that will only be exceeded α% of the time in the next k-trading days. More specifically, Linsmeier and Pearson (1996) state that, at a given point in time, VaR_{t+1} describes the risk in the tails of the conditional distribution of losses over a one-day horizon: it expresses the maximum loss in the value of exposures due to adverse market movements that will not be exceeded within a pre-specified coverage probability α if portfolios are held static during a certain period of time *t*, thus making: $\Pr(r_{t+1}<VaR_{t+1})=\alpha$ in terms of relative returns.[1] Therefore:

$$VaR(\alpha)_{t+1} = \sigma_{t+1}\ F^{-1}(\alpha) \tag{2}$$

where:

σ_{t+1} = volatility of the loss distribution function *F* according to the scheme utilised

$F^{-1}(\alpha)$ = inverse of the loss distribution function, i.e., α-quantile of *F*

2.2. Advantages and disadvantages of VaR

2.2.1. Advantages of VaR

Beder (1995: 12) synthesises in a single sentence VaR's greatest merit: "VaR enables a firm to determine which businesses offer the greatest expected return at the least expense of risk", afterwards highlighting its prowess to track, control and manage market risks. In this line, Linsmeier and Pearson (1996: 3) label VaR as a simple way to describe the magnitude of the likely losses on the portfolio.

The definition in 2.1 implies some attractions worth of being singled out:[2]

i) VaR is a measure susceptible of being applied to any kind of assets and positions, thus enabling the comparison of risks across diverse assets;

ii) VaR indicates a probability associated with a certain loss amount, instead of other measures which do not convey a likelihood assessment (e.g. CAPM);

iii) VaR is easily understood and transparently expressed in units of measure.

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1 Hence, VaR requires the estimation of a quantile of the distribution of profits and losses.

2 Dowd (2005) gives specific names for the patterns enunciated. Hence, VaR is a common, aggregate, holistic, probabilistic and expressed in units risk measure.

Stemming from the aforementioned points, VaR has many other uses beyond the typical market risk quantification which undoubtedly helped the surge in its popularity. For instance, within the scope of the company:

i) Var information is often employed to set the overall risk target (Dowd (1988));
ii) VaR may aid in the optimal allocation of resources and in setting the limits to risk-taking (Dowd (1998));
iii) VaR might also determine the remuneration rules for traders, rewarding those who deliver the highest return per VaR unit (Dowd (1999));
iv) VaR may set the guidelines for hedging decisions (Dembo (1997));
v) VaR could constitute the founding block of any credit or operational risk technique (JP Morgan (1996), BCBS (2004, 2006));

where as from a regulatory point of view:

i) VaR is currently applied to determine the market risk MCR demanded by the BCBS (BCBS (2006, 2010));
ii) VaR is to be specifically disclosed by institutions operating under the framework of the BCBS (BCBS (2006, 2010));
iii) VaR is often employed to estimate the probability of distress in Capital Strength ratios (Dowd (1998)).

2.2.2. *Disadvantages of VaR*

Linsmeier and Pearson (1996) stress that, albeit representing a quality step evaluated against previous risk quantification measures, VaR cannot be regarded as a panacea. In this vein, despite its magnetism, VaR can simultaneously be dangerous. As early as 1995 Beder raised concerns about the fact that the multiplicity of schemes —each one with its respective assumption— to calculate VaR could render significant differences in the results and, perhaps more relevantly, in the MCR level at a time when BCBS was planning to introduce the VaR-based-IMA in the Basel Capital Accord as a result of the Market Risk Amendment of 1996 (Jorion (1996)). Moreover, Dowd (2005) cites Marshall and Siegel (1997) casting doubts on the implementation risks faced by VaR models.

Additionally, Danielsson and Zigrand (2001) are sceptical about tight VaR regulations. They reason that risk modelling affects the distribution of risks, thus rendering risk as an endogenous element instead of an exogenous variable. Therefore, as current directives demand VaR measures, market participants are urged to execute similar trading strategies which change the distributional properties of risk, particularly in crisis times. When markets crash, as all actors deploy the same stratagems, they will reduce their positions by virtue of VaR-based models, shrinking liquidity and exacerbating the scope of the crisis.

Furthermore, VaR as a risk measure portrays much deeper structural deficiencies and, in this vein, Danielsson (2002) points out three major snags. Firstly, it fails to indicate the size of the potential losses beyond the threshold; secondly, it fails to achieve coherence and thirdly, its dependence on a single quantile renders easy its manipulation with specially devised strategies, thus nesting a moral hazard problem. More specifically,

i) The size of potential losses beyond VaR

In other words, this means its inability to fully capture the tail risk because VaR only states the riskiness of a position considering the likelihood but not the magnitude of losses beyond a certain confidence level, their expected value (Artzner *et al*. (1999)). Dowd (2005) stresses that two positions can eventually report the same VaR but have very different risk exposures. Other measures like the Tail Conditional Expectation (TCE) or Expected Shortfall (ES) can address that challenge.

ii) Coherence

Artzner *et al*. (1997, 1999) proposed a framework to assess every risk measure consisting of four axioms to be complied with: monotonicity, positive homogeneity. translational invariance and subadditivity. The first three are conditions intended to discard embarrassing results while the fourth one reveals itself as the most relevant; in this light, VaR fails to show that the diversification, at the very least, does not increase risks. Additionally, subadditivity conveys more than a theoretical property as it may give rise to several unpleasant practical implications:

- It implies that widespread risks create a residual risk which existence had not been recorded before;
- Non-additive risk measures might motivate traders in organised exchanges to break up their accounts, therefore reducing their margin requirements;

- Capital requirements set on the basis of non-subadditive risk measurements may tempt banks to break themselves up to reduce the capital demands;
- The perfectly correlated sum of risks could no longer be employed as a conservative estimate of the exposure faced.

Acerbi (2002) underlines that uses of VaR should be restricted to its quantile condition, hence warning against its extended application as a sound risk measure.

iii) Moral hazard and VaR manipulation

Danielsson (2002) and Ahn *et al*. (1999) mark the feasibility to devise permitted trading strategies in order to enhance profits and report —albeit not decrease— a smaller VaR value. The use of options would enable the bank to artificially diminish its VaR and report a lower VaR number to regulators courtesy of the official focus on a single quantile. Other measures that comprise the evaluation of the whole distribution beyond VaR quantile do not allow these tricks.[3]

2.3. Expected Shortfall: *an alternative coherent risk measure*

Academics and regulators have identified the lack of coherence (i.e., failure to comply with subadditivity) and the absence of information about losses beyond the established quantile the most important deficiencies of VaR as a risk measure. Therefore, it would be desirable that any new risk measure should retain the benefits of VaR while, at the same time, avoid its snags. In this line, Dowd (2005) affirms that those schemes ought to represent functions of the quantiles of the P&L distribution rather than a single and isolated quantile. In this vein, the financial literature proposes the ES as a natural substitute for VaR, which appears endorsed by BCBS (2012).

ES constitutes one of the alternatives capable of overcoming VaR's theoretical deficiencies. According to McNeil, Frey and Embrechts (2005), it represents a risk measure that supplies information about the tails of the distribution in depth. Hence, instead of sticking to a confidence level α, ES

3 The scheme involves writing a call with a strike price right below the correct VaR and purchasing a put with its strike price right above the desired VaR, taking care in fixing equal absolute differences. Thus, the intended effect is instantaneously achieved and the reported VaR is reduced (Danielsson (2002)).

averages VaR for those probability levels ζ such that $\zeta \geq \alpha$, thus making $ES_\alpha \geq VaR_\alpha$ for identical probability levels. Formally,

$$ES_\alpha = \frac{1}{1-\alpha}\int_\alpha^1 q_\zeta \, d\zeta \tag{3}$$

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

$$ES_\alpha = \frac{1}{1-\alpha}\int_\alpha^1 VaR_\zeta \, d\zeta \tag{4}$$

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:

$$ES_\alpha = \frac{E[L; L \geq q_\alpha(L)]}{1-\alpha} = E(L \mid L \geq VaR_\alpha) \tag{5}$$

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)):

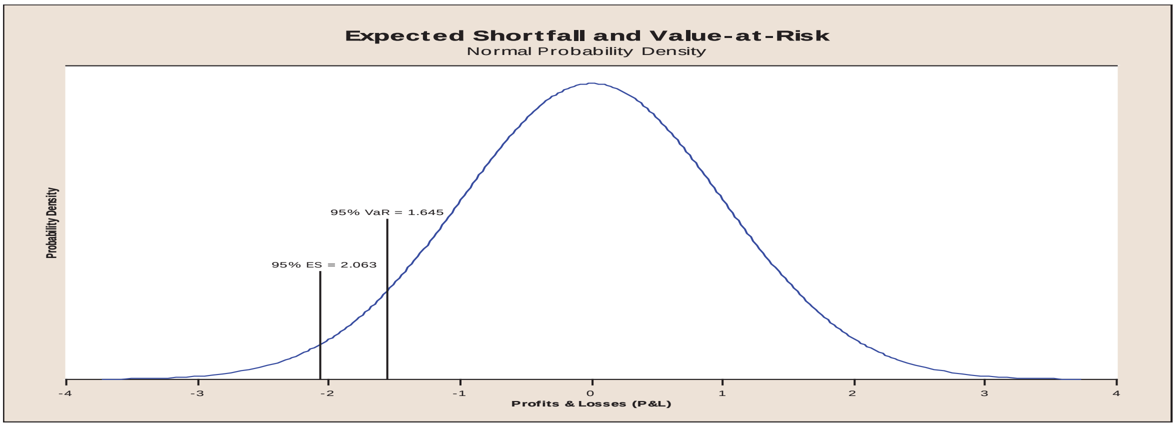
$$ES_\alpha = \frac{1}{1-\alpha}\{E[L; L \geq q_\alpha] + q_\alpha [1-\alpha - P(L \geq q_\alpha)]\} \tag{6}$$

When the distribution is discrete, ES is calculated employing the natural estimator and discrete equivalent, i.e., the average of the *w* greatest losses exceeding VaR:

$$ES_\alpha = \frac{\sum_{i=1}^{w} L_i}{w} \tag{7}$$

ES becomes an attractive risk measure by means of retaining VaR conceptual simplicity and easiness of implementation and complying with the four axioms of coherence. Likewise, it conveys more precise information about the distribution of losses than VaR, because in addition to the threshold value that represents the quantile-based VaR, it delivers the amount of likely losses in the event of adverse market movements. Graph 1 illustrates that difference between VaR and ES: while VaR focuses on a single quantile (employing a standard Normal distribution, the 95% VaR equals 1.645), ES gauges the average of all the quantiles exceeding VaR (under analogous assumptions, 2.063). Consequently, ES delivers a figure more than 25% over VaR which would undoubtedly render higher capital requirements were this measure utilised. By construction, any conditional VaR measure like ES can never be less than the pertaining VaR, and the difference between ES and the respective VaR depends on the fatness of the tail: the heavier the tail, the greater the gap.

Graph 1. *ES and VaR illustration*



Note: P&L density portrayed using a standard Normal distribution

3. *Regulatory frameworks: Basel II and Basel III for VaR and ES*

3.1. The Basel II Capital Accord Minimum Capital Requirements

In 1996 the BCBS issued an Amendment to incorporate a specific treatment for market risks, largely overlooked in Basel I Capital Accord and eventually included in Basel II Capital Accord.[4] This adjustment allows institutions to employ the Internal Model Approach (IMA) to determine their market risk Minimum Capital Requirements (MCR) by their own VaR estimates, which in turn derive from their respective VaR models. Risk-capital charges result from:[5]

$$MCR_{t+1} = \max\left(\frac{m_c}{60}\sum_{i=1}^{60} VaR(99\%)_{t-i+1} \;\; ; VaR(99\%)_t\right) \tag{8}$$

i.e., the maximum between the previous day's VaR and the average of the last 60 daily VaRs increased by the multiplier[6] $m_c=3(1+k)$ and $k \in [0; 1]$ according to the result of Backtesting. BCBS demands VaR estimation to observe the following quantitative requirements:

a) Daily-basis estimation;
b) Confidence level α set at 99%;
c) One-year minimum sample extension with quarterly or more frequent updates;
d) No specific models prescribed: banks are free to adopt their own schemes;
e) Regular Backtesting and Stress Testing programme for validation purposes.[7]

3.1.1. Backtesting

It constitutes a statistical technique to assess the quality of the risk measurement specifications, which involves the comparison between the

4 BCBS (1996, 2006).

5 BCBS demands the use of a 10-day holding period through the square-root-of-time rule. However, the present research will omit the specification and work with a 1-day holding period instead. See Section 5.

6 mc will be, at minimum, 3. Although BCBS does not enlighten its derivation, Stahl (1997) and Danielsson et al. (2001) provide a statistical explanation. This value can sometimes be so conservative that any incentives to develop an accurate model by achieving k=0 might be quickly overshadowed.

7 The focus of the present article is restricted to Backtesting. BCBS (1996, 2006, 2009), Jorion (1996), Penza and Bansal (2001), Christoffersen (2003), Dowd (1998, 2005), JP Morgan (1996) and Osteirrischische Nationalbank (1999), just to name a few, cater for basic concepts and extensive treatment of stress testing.

daily VaR forecast with the actual losses.[8] Albeit the assumptions behind VaR calculations may be labelled incoherent (Artzner *et al.* (1997, 1999), Acerbi and Tasche (2002)), it is useful to evaluate whether the model is capable of capturing the trading volatility. Backtesting procedure entails counting the number of times that losses exceed VaR estimates in approximately 250 trading days. McNeil, Frey and Embrechts (2005) use the indicator function:

$$I_{t+1} = I_{\{L_{t+1} > VaR_{t+1}(\alpha)\}} = \begin{cases} 1 & \text{if } L_{t+1} > VaR_{t+1}(\alpha) \\ 0 & \text{otherwise} \end{cases}$$

where:

I_t	=	indicator function accumulating the excessions, exceptions or violations behaving like outcomes of iid Bernoulli trials with success probability 1-α;
L_{t+1}	=	realised loss for period *t+1*;
$VaR_{t+1}(\alpha)$	=	conditional VaR estimates for *t+1*

BCBS proposes a three-zone —Green, Yellow and Red— layout to classify VaR models:[9]

Backtesting results determine the extent of capital surcharge through the value of the scaling factor *k* as the quantity of exceptions in a sample of 250 trading days is transformed into a number indicating the increase in the multiplier to be applied to m_c (Table 2). BCBS establishes that the beginning of each zone is marked by the points where the cumulative probability of a Bernoulli distribution with 99% success probability reaches 95% for the Yellow Zone (5 exceptions) and 99.99% for the Red one (10 or more violations) respectively. Given that five excessions represent a 98% coverage for 250 observations, it would be necessary to enhance the multiplier by 40% to restore the coverage to the 99% demanded (supposing that returns

8 "...the backtesting framework ...involves the use of risk measures calibrated to a one-day holding period". (BCBS (2006: 312).

9 This categorisation is designed to balance the probabilities of Error I: erroneous rejection of accurate models and Error II: incorrect acceptance of inaccurate models. BCBS (2004, 2006).

follow a Normal distribution and the scaling factor m_c=3).[10,11] However, although it is possible for *k* in (8) to achieve nullity (Green Zone), Danielsson, Hartmann and de Vries (1998) remark that m_c assuming a minimum of 3 in (8) conspires against the development of accurate models. Given that m_c is calculated as in (8) in the current regulatory framework, the present article will unfold according to the respective procedures.

Table 1. Backtesting zones. Definition and characteristics

Zone	Definition	Characteristics
Green	Outcomes consistent with low probability of Error II	- Number of exceptions between 0 and 4 - No capital surcharge, *k* = 0
Yellow	Results uncertain and compatible with either precise or inaccurate models	- Number of exceptions between 5 and 9 - Strong suggestion of imprecise specifications, particularly as number of exceptions grow - Capital penalties increase with number of violations - Capital charges determined to return model to a 99% coverage - Encourages sharpness to keep penalties low
Red	Presumption of inaccurate model	- Number of excessions equal or greater than 10 - *k* increased to 1 immediately - Subsequent model invalidation

Source: Prepared by author.

3.2. Basel III Capital Accord

The trading sessions following Lehman Brothers' bankruptcy triggered unusual losses of such magnitude that financial institutions found their capital buffers unquestionably insufficient to match those deficits. Though these market movements were of a weird nature, BCBS (2009) partly blamed

10 The quotient between the 99% and 98% cumulative normal distribution amounts to 1.14 which, for a scaling factor of 3represents a 40% increase in the base level. In effect, for five exceptions 1-5/250=0.98 and $3*\Phi^{-1}(0.99)/\Phi^{-1}(0.98) - 3 \sim 0.40$ assuming normality. Hence, *k*=0.40 or 40%. The surcharges for α=99% and the alternative values α = 97.50% and α = 95% tried are shown in Table 2 below.

11 Table 2.

the previous Amendment of 1996 for failing to grab some key extreme risks[12] occurred during the turmoil. Additionally, some national regulators increased the pressure on BCBS demanding tougher measures to avoid further embarrassing bailouts at the expense of taxpayers. The Financial Services Authority (2009) issued an influential report which highlighted some deficiencies of the VaR approach that may have provoked, among other equally important reasons, the insolvency of several firms. In particular, it is mentioned that most VaR models are unable to capture fat-tail risks: "Short-term observation periods plus assumption of Normal distribution can lead to large underestimation of probability of extreme losses" (FSA, (2009:23)).[13]

To tackle this specific issue, while maintaining the Basel II methodology,[14] BCBS proposed the introduction of a stressed VaR (sVaR) metric to increase MCR. Its calculation complies with the same guidelines that current VaR (Section 3.1) though the dataset must belong to a "…continuous 12-month period of significant financial stress…" (BCBS (2009:14)), i.e., when market movements would have inflicted great losses on the banks.

The stricter daily capital demands reflect in sVaR added to VaR:

$$MCR_{t+1} = \max\left(\frac{m_c}{60} \sum_{i=1}^{60} VaR\,(99\%)_{\;t-i+1} ; VaR\,(99\%)_{\;t} \right) + \qquad (9)$$

$$\max\left(\frac{m_s}{60} \sum_{i=1}^{60} sVaR\,(99\%)_{\;t-i+1} ; sVaR\,(99\%)_{\;t} \right)$$

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12 The emphasis is also laid on default and migration risk, among others (BCBS (2009)). These measures lie beyond the scope of the study, which will be restricted to the introduction of the stressed VaR.

13 FSA highlights the procyclicality that emerges using observation periods as short as one year: falls in confidence raise volatilities, which vanish liquidity and increase volatility even more. (FSA (2009)).

14 Some slight variations regarding the data updating scheme are also put forward. (BCBS (2009)).

where:

m_c	=	multiplier for VaR (Section 3.1);
$-sVaR(99\%)_t$	=	99% sVaR for day t;
m_s	=	multiplier for sVaR

with $m_s=3(1+k)$ and k is derived from Backtesting results for VaR (not for sVaR).

As $k \in [0; 1]$ institutions are encouraged to develop precise VaR models in order to keep $k \approx 0$ and avoid penalties to establish MCR.

Besides strengthening MCR by means of the sVaR component in the MCR formula, Basel III focuses on reinforcing the protection against periods of acute economic and financial strain through two additional layers to be placed on top of MCR:[15] Capital Conservation Buffer (CCB) and Countercyclical Capital Buffer (CyCB).[16] However, technically speaking, Basel III innovations stem from the introduction of the sVaR to calculate MCR, as both CCB and CyCB constitute supplementary capital layers with fixed and externally determined proportions respectively. Therefore, the scope of the present article will be limited to the performance of the VaR-based IMA approach, either in its VaR version or in the ES adaptation.

3.3. Expected Shortfall: a likely change of tack

BCBS has been for the first time pondering the prospect of phasing out VaR as a measure of market risk and, although the idea appears far from crystalising, there are encouraging signs in the acknowledgment of VaR's failures. Accordingly, it has proposed ES and Spectral Risk Measures (SRM) as probable alternatives, where the former is the most widespread risk metric after VaR. Given this BCBS declaration, the paper focuses on ES as a potential VaR successor.

BCBS (2011) correctly asseverates that ES overcomes three VaR snags. In the first place, it conveys a notion about the severity of losses beyond the VaR threshold (a property especially relevant for regulators, who are concerned about these losses); secondly, it complies with the axioms of coherence

[15] Andersen (2011) finds substantial evidence of the cyclicality in Basel II and suggests a different risk-weighting scheme to circumscribe that shortfall.

[16] Stolz and Wedow (2011) illustrate the performance of countercyclical capital buffers for Germany.

devised by Artzner *et al*. (1997, 1999), particularly with subadditivity and thirdly, it spans all the confidence levels beyond the one selected to perform VaR, therefore softening the effect that a selection of a specific confidence level may bring about for risk management.

In spite of the advantages above mentioned, the challenge of developing an appropriate method to backtest ES estimates reveals itself daunting and more complicated than backtesting VaR. In an interesting review on market risk measurements, BCBS (2011) points out some topics regarding the assessment of ES estimates:

a) The typical Backtesting procedure employed in Basel II and Basel III keeps their low power (Christoffersen (2003)), and might need a correction to account for the size of the exceptions;
b) It might be desirable to transform the realised losses (represented by VaR excessions) into a forecasted loss distribution to further backtest the transformed sample (Berkowitz (2001)). Furthermore, Kerkhof and Melenberg (2004) postulate that ES should be computed on the squared losses and backtested afterwards;
c) Kerkhof and Melenberg (2004) suggest that the fixed multiplication factor mc should take a different value were ES to be applied instead of VaR.[17]

Among the uncertainty in the design of an appropriate Backtesting procedure involving ES and the ensuing MCR expression using the new risk measure, the BCBS also seems concerned about the significant amount of information that banks would be urged to gather, process and disclose. Unfortunately, given that the BCBS lacks of any appropriate procedure to test ES and the embryo stage in its application, the current paper will restrict itself to the traditional Backtesting.

4. Methodology

The current article is largely grounded on the approach stated in BCBS(2009), albeit substituting VaR for ES as the risk measure. Therefore, using an identical sample of Emerging markets (Brazil, Hungary, India,

[17] The level of the multiplication factor mc had already been objected by Danielsson (2002). Kerkhof and Melenberg (2004) obviously did not analyse the fixed multiple ms of Basel.

Czech Republic, Indonesia and Malaysia) and Frontier markets (Argentina, Lithuania, Tunisia and Croatia),[18] ES is computed on a daily basis with a classic Backtesting performed, where the quantity of actual losses on the portfolio are assessed against ES forecasts.

Backtesting results are in turn employed to calculate MCR in both Basel II and Basel III specifications, replacing VaR for ES in (8) and (9). A subsequent analysis of the impact of adopting ES is carried out under Basel II and Basel III frameworks, evaluating whether the expressions determining the MCR could be maintained, especially stressing the fixed multiples m_c and m_s in the light a sensitivity analysis performed using ES. It is acknowledged that, in light of the reflections in 3.3, the approach might not square the theoretical facts but, at the same time, it is important to recognise that given that no optimal appraisal has been hitherto devised, the present investigation could provide evidence to develop a more adequate Backtesting and ensuing MCR structures.

ES estimation and assessment will adopt the current BCBS's mandates for VaR-based IMA:

— Daily time series belonging to the blue-chip indices of the aforementioned countries retrieved from Thomson Reuters® starting on January/2000 and ending on December/2008;
— Daily time horizon, hence excluding the 'squared root of time rule' (Danielsson (2002) and Danielsson and Zigrand (2006) to avoid the extrinsic increase of ES estimations employing arbitrary multiples;
— One-tailed ES estimations on the left end of the distribution (i.e., long positions);
— Sample term spans more than 1000 daily observations (Christoffersen (2003) and Dowd (2005)) while forecast one includes the financial crisis unraveled in September-October 2008.[19]

Expressions (4) and (5) imply that ES represents the average of the losses overcoming VaR at a certain confidence level α, thus In this respect, Kerkhof and Melenberg (2004) suggest that, given that regulators would demand roughly the same amount of capital irrespective of the risk measure in use,

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18 *In order to categorise the markets the study follows the FTSE Global Equity Index Series Country Classification, March 2015 update. (FTSE (2015)).*

19 *Alternatively, Section 5.4.3. uses year 2007 as Backtesting period in order to add robustness to the analysis.*

ES would need a lower confidence level to reach VaR buffers ES(α') ≥ VaR(α) with α'<α. Accordingly, the present study calculates ES using alternative confidence levels: 95%, 97.50% and 99% to assess the approximate levels of capital delivered employing the MCR formulas for Basel II and Basel III in relation with the 2008 crisis.[20]

The present article compares the ES estimates in the context of the subprime calamity employing GARCH and EGARCH Conditional Volatility models featuring the Normal distribution and the most accurate model, EVT, where the parameters of both GARCH and EGARCH specifications are obtained using Maximum Likelihood (ML) (Christoffersen (2003), Alexander (2008)). According to McNeil, Frey and Embrechts (2005), for α ϵ (0, 1), when the loss distribution is Normal, ES is calculated as follows:

$$ES_{t+1}(\alpha) = \mu_t + \sigma_t \frac{\phi[\Phi^{-1}(\alpha)]}{1-\alpha} \qquad (10)^{21}$$

Given that for the samples considered μt ≈ 0, (4.1) becomes:

$$ES_{t+1}(\alpha) = \sigma_t \frac{\phi[\Phi^{-1}(\alpha)]}{1-\alpha} \qquad (11)$$

where:

ϕ	=	density of the standard normal distribution
ϕ	=	distribution function of the standard normal distribution
σ_t	=	conditional volatility obtained via GARCH and EGARCH models

In the case of EVT through Peaks Over Threshold (POT), recalling that the Generalised Pareto Distribution (GPD) quantile with confidence level α reads:

$$G^{-1}(\alpha) = u + \frac{\hat{\beta}}{\hat{\xi}} \left[\left(\frac{1-\alpha}{w/n}\right)^{-\hat{\xi}} - 1 \right] \qquad (12)$$

20 Kerkhof and Melenberg (2004) warn against the comparison between VaR and ES capital levels, stating the inadequateness of that practice in view of the different assumptions carried by both risk measures.

21 McNeil, Frey and Embrechts (2005) provide a proof of the statement.

where:

G	=	GPD characterised by ξ and σ
u	=	threshold (GPD starting point)
ξ	=	tail index parameter
β	=	scale parameter
w	=	quantity of observations above the threshold u
n	=	sample length

It is important to emphasise that the parameters of the GPD are estimated via the Method of Moments (MM), as indicated in Reiss and Thomas (2007) after applying POT (Coles (2001)).

The VaR quantile is given by:

$$VaR_{t+1}(\alpha) = \sigma_{t+1}\, G^{-1}(\alpha) \qquad (13)$$

Assuming that, for financial applications, ξ < 1 (Reiss and Thomas (2007) and Coles (2001)), McNeil, Frey and Embrechts (2005) calculate the associated ES as:

$$ES_{t+1}(\alpha) = \sigma_{t+1}\, \frac{1}{1-\alpha} \int_{\alpha}^{1} q_x F\, dx = \sigma_{t+1} \left[\frac{VaR_{t+1}(\alpha)}{1-\xi} + \frac{\beta - \xi\, u}{1-\xi} \right] \qquad (14)$$

and:

q_x F	=	quantile of the distribution F
σ_t	=	conditional volatility obtained via GARCH-Normal technique

The assessment of capital levels is carried out at 95%, 97.50% and 99% confidence levels using Basel II and Basel III frameworks albeit employing ES instead of VaR. Therefore, in (1) and (2), the expression becomes, for Basel II:

$$MCR_{t+1}^{ES} = \max\left(\frac{m_c}{60} \sum_{i=1}^{60} ES(\alpha\%)_{t-i+1} \;\; ; ES(\alpha\%)_t \right) \qquad (15)$$

whilst in the case of Basel III:

$$MCR_{t+1}^{ES} = \max\left(\frac{m_c}{60}\sum_{i=1}^{60} cES\ (\alpha\%)\ _{t-i+1}\ ;\ cES\ (\alpha\%)\ _t\right) + \qquad (16)$$

$$\max\left(\frac{m_s}{60}\sum_{i=1}^{60} sES\ (\alpha\%)\ _{t-i+1}\ ;\ sES\ (\alpha\%)\ _t\right)$$

where:

MCR^{ES}_{t+1} = Minimum Capital Requirement for day t+1 employing ES

α = confidence level, adopting 95%, 97.50% and 99%

and m_c and m_s conserve their previous meanings.

Usage of confidence levels other than the official 99% entails the reconfiguration of the Backtesting zones and, in this sense, Table 2 shows the thresholds and the corresponding surcharges under Basel II and Basel III obtained employing the procedure in Basel II (BCBS (2004, 2006)) compared to the 99% values, (see Table 2).

5. *Results: Backtesting and bank capital*

5.1. Backtesting for α=99%

As it may be deduced from (5) to (7), ES delivers higher estimations than VaR for the same confidence level, even using presumably inaccurate models featuring the Normal density. In effect, the Backtesting exercise portrayed in Tables 3 and 4 shows that both Normal specifications fall in the Red Zone only in Lithuania (Table 3 Columns [2]-[3] and Table 4 Columns [1]-[2]) results in Red outcomes while using VaR in Indonesia, Lithuania and Croatia, GARCH-N in China and EGARCH-N in Hungary. Furthermore, the panorama looks more satisfactory under ES as Brazil, India, Malaysia, China and Argentina improve their performance stepping into the Green category. Additionally, the quantity of exceptions under Normal models are found in the expected value between 2 and 3 (Table 3- Column [1]) in Brazil, India and China (3), and Hungary, Malaysia and Argentina (4) for the GARCH scheme, while the respective EGARCH result are India and Argentina (3) and Malay-

Table 2. Backtesting zones redefined

Exceptions [1]	Zone α=99% [2]	Increase in scaling factor α=99% [3]	Zone α=97.50% [4]	Increase in scaling factor α=97.50% [5]	Zone α=95% [6]	Increase in scaling factor α=95% [7]
0	Green	0%	Green	0%	Green	0%
1	Green	0%	Green	0%	Green	0%
2	Green	0%	Green	0%	Green	0%
3	Green	0%	Green	0%	Green	0%
4	Green	0%	Green	0%	Green	0%
5	Yellow	40%	Green	0%	Green	0%
6	Yellow	50%	Green	0%	Green	0%
7	Yellow	65%	Yellow	8%	Green	0%
8	Yellow	75%	Yellow	17%	Green	0%
9	Yellow	85%	Yellow	27%	Green	0%
10	Red	100%	Yellow	36%	Green	0%
11	Red	100%	Yellow	45%	Green	0%
12	Red	100%	Yellow	53%	Green	0%
13	Red	100%	Yellow	62%	Yellow	4%
14	Red	100%	Yellow	79%	Yellow	10%
15	Red	100%	Yellow	78%	Yellow	17%
16	Red	100%	Yellow	86%	Yellow	24%
17	Red	100%	Yellow	94%	Yellow	31%
18	Red	100%	Red	100%	Yellow	38%
19	Red	100%	Red	100%	Yellow	44%
20	Red	100%	Red	100%	Yellow	51%
21	Red	100%	Red	100%	Yellow	58%
22	Red	100%	Red	100%	Yellow	65%
23	Red	100%	Red	100%	Yellow	71%
24	Red	100%	Red	100%	Yellow	78%
25	Red	100%	Red	100%	Yellow	85%
26	Red	100%	Red	100%	Yellow	92%
27	Red	100%	Red	100%	Red	100%

Note: A horizontal line separates Green, Yellow and Red Zones for each confidence level.

Source: Prepared by author.

sia and China (4) (Table 3 Columns [2]-[3]). On the other hand, EVT performs according to expectations given by the precedent set for VaR: there are no exceptions in any market, which hints at the elevated ensuing capital levels (Table 3 Column [4] and Table 4 Column [3]).

Table 4 also conveys the notion that the GARCH model slightly edges its counterpart given that 4 out of 11 markets receive Backtesting penalties against 6 in EGARCH (Table 4 Columns [1]-[2]). Moreover, only in Croatia does EGARCH records fewer exceptions (7 compared to 9), consequently translating into a lower surcharge 65% *vs* 85%. Apparently, ES under Normal density works better in Emerging markets, given that, both representations deliver two Yellow Zones (Tunisia and Croatia) and a Red one (Lithuania) in Frontier stock exchanges, featuring Argentina only in the Green one. Finally, EVT does not bear any penalty derived from its Backtesting performance (Table 4 Column [3]).

5.2. Backtesting for α=97.50%

Despite the more relaxed framework in terms of the quantity of exceptions deployed in Table 2, the overall picture looks a bit more compromised when α=97.50%. EVT reveals again as the top performer with a quantity of exceptions way below the expected number of 6 for every market, reflected in an impeccable record of null surcharges albeit in five occasions the number of exceptions is one (Table 3 Columns [5] and [8] and Table 4 Column [8]).

The image does not look so rosy for the remaining models, given that only three countries (Czech Republic, Malaysia and Argentina) and two markets (India and Malaysia) that gained the Green status for GARCH and EGARCH representations, respectively. The rest of the markets fall in the intermediate Yellow section except for Lithuania in the EGARCH specification (Red). The relationships elicited in Chart 3 Columns [6]-[7] and Chart 4 Columns [4]-[5]- imply heavy penalties for GARCH in Lithuania (86%), Indonesia (62%), Croatia (45%) and China (36%) while for EGARCH the greatest penalties are suffered in Indonesia (53%), Croatia (45%), Hungary (36%) and Brazil (27%). In overall terms, EGARCH appears to behave slightly better than GARCH (despite Lithuania) although the advantage does not seem conclusive enough.

5.3. Backtesting for α=95%

Because of the particular procedure used by BCBS to estimate Backtesting zones and its ensuing penalties, the Yellow line starts at 12 exceptions and

Table 3
Backtesting results
Quantity and proportion of exceptions in the forecast period

Line	Model Index	α=99% Expected Number [1]	α=99% GARCH Normal [2]	α=99% EGARCH Normal [3]	α=99% EVT-POT [4]	α=97.50% Expected Number [5]	α=97.50% GARCH Normal [6]	α=97.50% EGARCH Normal [7]	α=97.50% EVT-POT [8]	α=95% Expected Number [9]	α=95% GARCH Normal [10]	α=95% EGARCH Normal [11]	α=95% EVT-POT [12]
1	Brazil	2/1.00%	3/1.20%	6/2.41%	0/0.00%	6/2.50%	8/3.21%	9/3.61%	1/0.40%	12/5.00%	10/4.02%	11/4.42%	5/2.01%
2	Hungary	3/1.00%	4/1.59%	8/3.19%	0/0.00%	6/2.50%	7/2.79%	10/3.98%	0/0.00%	13/5.00%	13/5.18%	14/5.58%	0/0.00%
3	India	2/1.00%	3/1.23%	3/1.23%	0/0.00%	6/2.50%	8/3.28%	6/2.46%	1/0.41%	12/5.00%	9/3.69%	11/4.51%	15/6.15%
4	Cz. Rep.	3/1.00%	5/1.98%	6/2.38%	0/0.00%	6/2.50%	5/1.98%	8/3.17%	0/0.00%	13/5.00%	11/4.37%	12/4.76%	0/0.00%
5	Indonesia	2/1.00%	8/3.31%	8/3.31%	0/0.00%	6/2.50%	13/5.37%	12/4.96%	1/0.41%	12/5.00%	17/7.02%	19/7.85%	4/1.65%
6	Malaysia	2/1.00%	4/1.62%	4/1.62%	0/0.00%	6/2.50%	6/2.43%	6/2.43%	1/0.40%	12/5.00%	8/3.24%	7/2.83%	1/0.40%
7	China	2/1.00%	3/1.22%	4/1.63%	0/0.00%	6/2.50%	10/4.07%	7/2.85%	0/0.00%	12/5.00%	14/5.69%	15/6.10%	1/0.41%
8	Argentina	2/1.00%	4/1.61%	3/1.21%	0/0.00%	6/2.50%	6/2.42%	7/2.82%	0/0.00%	12/5.00%	10/4.03%	8/3.23%	10/4.03%
9	Lithuania	2/1.00%	13/5.35%	13/5.35%	0/0.00%	6/2.50%	16/6.58%	18/7.41%	0/0.00%	12/5.00%	19/7.82%	21/8.64%	2/0.82%
10	Tunisia	2/1.00%	6/2.44%	6/2.44%	0/0.00%	6/2.50%	8/3.25%	8/3.25%	1/0.41%	12/5.00%	11/4.47%	11/4.47%	6/2.44%
11	Croatia	2/1.00%	9/3.61%	7/2.81%	0/0.00%	6/2.50%	11/4.42%	11/4.42%	0/0.00%	12/5.00%	13/5.22%	12/4.82%	5/2.01%

Source: Prepared by author.

Table 4
Backtesting results
The Three-zone Approach – Increase in scaling factor k

Line	Model Index	α=99% GARCH Normal [1]	α=99% EGARCH Normal [2]	α=99% EVT-POT [3]	α=97.50% GARCH Normal [4]	α=97.50% EGARCH Normal [5]	α=97.50% EVT-POT [6]	α=95% GARCH Normal [7]	α=95% EGARCH Normal [8]	α=95% EVT-POT [9]
1	Brazil	Green/0%	Yellow/50%	Green/0%	Yellow/17%	Yellow/27%	Green/0%	Green/0%	Yellow/10%	Green/0%
2	Hungary	Green/0%	Yellow/75%	Green/0%	Yellow/8%	Yellow/36%	Green/0%	Yellow/4%	Yellow/10%	Green/0%
3	India	Green/0%	Green/0%	Green/0%	Yellow/17%	Green/0%	Green/0%	Green/0%	Green/0%	Yellow/17%
4	Cz. Rep.	Yellow/40%	Yellow/50%	Green/0%	Green/0%	Yellow/17%	Green/0%	Green/0%	Green/0%	Green/0%
5	Indonesia	Yellow/75%	Yellow/75%	Green/0%	Yellow/62%	Yellow/53%	Green/0%	Yellow/31%	Yellow/44%	Green/0%
6	Malaysia	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
7	China	Green/0%	Green/0%	Green/0%	Yellow/36%	Yellow/8%	Green/0%	Yellow/10%	Yellow/17%	Green/0%
8	Argentina	Green/0%	Green/0%	Green/0%	Green/0%	Yellow/8%	Green/0%	Green/0%	Green/0%	Green/0%
9	Lithuania	Red/100%	Red/100%	Green/0%	Yellow/86%	Red/100%	Green/0%	Yellow/44%	Yellow/58%	Green/0%
10	Tunisia	Yellow/50%	Yellow/50%	Green/0%	Yellow/17%	Yellow/17%	Green/0%	Green/0%	Green/0%	Green/0%
11	Croatia	Yellow/85%	Yellow/65%	Green/0%	Yellow/45%	Yellow/45%	Green/0%	Yellow/4%	Green/0%	Green/0%

Source:Prepared by author.

ends at 26 violations of the corresponding ES (Table 2–Columns [6]-[7]). Therefore, the performance of the GARCH and EGARCH models turns out practically alike as they deliver four Yellow zones in the same stock exchanges (Hungary, Indonesia, China and Lithuania) and seven Greens in the rest (Table 3 Columns [10]-[11] and Table 4 Columns [7]-[8]).

The performance of EVT clearly worsens in line with the diminution of the confidence level. In this sense, even though it passes the test with flying colours, the outcome delivers a considerable number of violations in Argentina (10) and India (15), the latter belonging to the Yellow Zone (Table 3 Column [12] and Table 4 Column [9]).

Table 4 also shows that the penalties envisaged are significant in Lithuania (58% for EGARCH and 44% for its counterpart respectively) and Indonesia (44% and 31% respectively) for both Normal models while the remaining Yellow Zones are below 17% (EGARCH) and 10% (GARCH). The aforementioned values mark that the GARCH representation obtains, in all the stock exchanges, less capital surcharges (Table 4 Columns [7]-[8]. Finally, EVT incurs in a penalty for the first time: 17% in India (Table 4 Column [9]).

5.4. Expected Shortfall and Basel regulations

The outcome of the ES-based MCR appears very much influenced by the peculiarities of the formula (15): the average 60-day ES enhanced by the multiplication factor m_c (currently equal to 3) and the add-on coefficient depending on Backtesting results (k).

5.4.1. Expected Shortfall and Basel II

Table 5 (Lines 1 to 3), deploys the MCR under Basel II directives employing ES instead of VaR at 99%. In this sense, the straightforward relationship ES(α) ≥ VaR(α) is distorted by the application of the Backtesting penalties in the VaR version. The full extent of the difference, however, is reflected in the amounts of MCR delivered by EVT (Table 5 Line 4) which are unaffected by Backtesting charges, thus delivering MCR(ES) larger than MCR(VaR). Acknowledging that EVT gives a MCR(VaR) higher than any other specification and the definition of ES, MCR(ES) under EVT would in principle seem too high even to withstand a 2008-style crisis.[22] As aforementioned, the relationship between VaR and ES becomes fuzzy in view of the Backtesting results in the

22 In this sense, the MCR for Hungary seems utterly excessive.

VaR version (Table 5 Lines 1 to 3 and 10 to 12): setting aside the Red Zones for each category (Lithuania for ES and Indonesia, Lithuania and Croatia —both GARCH and EGARCH— and Hungary —EGARCH— for VaR), MCR(VaR) almost always exceeds MCR(ES) due to the significant Backtesting penalty for VaR (only Czech Republic for the GARCH alternative delivers MCR(VaR) < MCR(ES), possibly owing to the 50% surcharge in GARCH-VaR). In the ES configuration, the difference between the MCR obtained from EVT and those from the Normal models (Table 5 Lines 1 to 3) proves massive despite the penalties laid upon the Gaussian schemes, thus enhancing the accuracy disincentive.

Table 5 —Lines 4 to 6— shows that the confidence level α=97.50% delivers lower MCR, albeit the new penalties for the Yellow Zone blur the real extent of the difference with the α=99% exercise, consequently turning the EVT representation that falls in the Green bucket into the yardstick to assess the absolute MCR. However, it is possible to draw certain parallelisms crossing the information displayed in Tables 3, 4 and 5. Utilising GARCH-Normal, penalties in the order of 8% (Hungary) and 17% (Brazil and Hungary) recorded in the Yellow Zone[23] would equate MCR in the Green Zone at 99%. On the other hand, employing EGARCH-Normal, Argentina could initially confirm that a Backtesting penalty of 8% equates a 99% Green Zone with a 97.50% Yellow Zone through a Gaussian model. Unfortunately, the results do not permit to gauge the approximate penalty that equals the MCR between two Yellow Zones, because the multiples must be much bigger when α=97.50%. EVT delivers values always greater than any Normal specification and coincides with the 99% case even in the presence of Backtesting penalties although the difference appears somewhat shrunk due to the reduction in the confidence level. Therefore, the issue of the moral hazard continues hovering in the background and seems intricate to resolved.

Lines 7 to 9 in Table 5 display the MCR using α=95%. As expected, the values are smaller compared to the other confidence levels to the point that, in many markets such as Tunisia and Argentina[24] the capital buffers might not result high enough to forestall a repetition of a 2008 crisis (the highest

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[23] The observation could extend to China, as the surcharge in the Yellow Zone when α = 97.50% is 36%.

[24] It is interesting to observe the decreasing in the leptokurtic effect in the GPD as both GARCH and EGARCH schemes give higher MCR than in the EVT.

Table 5
Basel II Minimum Capital Requirements via ES (cES)

Line	Model Index	Brazil	Hungary	India	Czech Republic	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
1	GARCH-N 99%	33.77%	31.58%	28.10%	52.07%	38.74%	12.09%	22.22%	14.55%	25.86%	10.83%	30.79%
2	EGARCH-N 99%	38.71%	40.33%	24.11%	42.54%	31.18%	12.08%	22.08%	14.80%	22.50%	9.07%	29.07%
3	EVT-POT 99%	65.07%	115.02%	49.31%	63.56%	65.86%	45.84%	67.08%	33.95%	45.03%	18.94%	42.85%
4	GARCH-N 97.5%	34.66%	29.91%	28.84%	32.62%	31.45%	10.60%	26.51%	12.76%	21.10%	7.41%	21.17%
5	EGARCH-N 97.5%	28.75%	27.49%	21.15%	29.11%	23.91%	10.59%	20.91%	14.02%	19.74%	6.20%	22.41%
6	EVT-POT 97.5%	45.24%	75.41%	31.54%	46.19%	41.15%	31.26%	45.94%	19.94%	29.96%	11.93%	29.12%
7	GARCH-N 95%	26.14%	25.42%	21.75%	28.78%	22.44%	9.36%	18.92%	11.26%	14.41%	5.59%	13.40%
8	EGARCH-N 95%	19.97%	19.62%	18.66%	21.95%	19.86%	9.35%	19.99%	11.46%	13.76%	4.68%	13.63%
9	EVT-POT 95%	32.07%	48.31%	22.96%	35.44%	24.63%	21.82%	32.10%	10.53%	20.36%	7.08%	20.75%
10	VaR-GARCH	51.59%	45.48%	42.92%	48.69%	38.64%	15.83%	38.80%	19.05%	22.57%	11.03%	29.05%
11	VaR-EGARCH	41.67%	40.23%	31.57%	43.32%	31.11%	15.81%	33.72%	21.32%	19.64%	9.23%	30.75%
12	VaR-EVT-POT	41.80%	39.08%	28.56%	42.36%	36.96%	28.49%	42.06%	17.60%	26.94%	10.88%	25.97%
13	Variation 99%	55.68%	194.35%	72.61%	50.07%	78.18%	60.92%	59.49%	92.90%	67.17%	74.05%	64.99%
14	Variation 97.50%	8.25%	92.98%	10.42%	9.04%	11.34%	9.74%	9.22%	13.28%	11.23%	9.57%	12.15%
15	Variation 95%	-23.26%	23.64%	-19.63%	-16.34%	-33.36%	-23.41%	-23.69%	-40.18%	-24.42%	-34.99%	-20.09%

Note: Lines 13 to 15 portray the relative variation between ES at 99%, 97.50% and 95% and VaR at 99%.
Figures in bold letters indicate specifications belonging to the Red Zone in the respective Backtesting configurations both for ES and VaR exercises.

Source: Prepared by author.

amounts being 7.08% via EVT and 11.46% through EGARCH). In view of the more relaxed set of penalties dictated by Table 2 Columns [6] and [7], and the particular shape of the GPD, the distance between EVT and the Gaussian models appears compressed, hence softening the disincentives to apply the accurate representations and, despite its recurrence, the gap between EVT and GARCH/EGARCH ends somewhat trimmed.[25] Consequently, for example, excluding the abnormal value in Hungary, Indonesia records 24.60% (EVT-Green Zone) against 19.86% (EGARCH-Yellow Zone with 44% surcharge) and China 32.10% (EVT-Green) versus 18.92% (GARCH-Yellow with 10% penalty). An interesting feature is highlighted in lines 13 to 15 in Table 5, which depict the relative difference between EVT —eventually the most accurate technique given it pertains to the Green Zone—[26] and the EVT-VaR at 99%[27] considering the three confidence levels of the present paper: 99%, 97.50% and 95%. In effect, setting aside Hungary, a striking similarity between VaR at 99% and ES at 97.50% may be spotted: even though ES records higher MCR, the differences situate between 8.25% (Brazil) and 13.28% (Argentina), thus hinting at some sort of 'equivalence' in the confidence levels in terms of the two risk measures.

5.4.2. Expected Shortfall and Basel III

The calculation of the Stressed Minimum Capital Requirements via ES (sES) concurs with that of the base ES for Basel II, except for the fact that it must be carried out over a 12-month continuous period wreaking havoc on the financial position of the company. Considering the 60-day average and the penalties envisaged for poor Backtesting performance stated in formula 9, EVT again delivers the greatest sES factor at 99%, 97.50% or 95%[28] (Table 6, Lines 1 to 3, 4 to 6 and 7 to 9 respectively).

The figures stated in Table 6 suggest that the capital cushion to be added to Basel II requisites might appear relatively excessive for an accurate model like EVT at 99%; in this vein, line 3 depicts cases like Argentina (65%),

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25 The example compares the highest (EVT) and the lowest MCR, where the former belongs to the Green bucket whereas the latter falls into the Yellow Zone.

26 EVT always falls in the Green Zone except for India at α=95%, where it suffers a 17% penalty.

27 For ease of comparison, VaR values calculated in Rossignolo, Fethi and Shaban (2012b) are reported on lines 10 to 12 belonging to Chart 5.

28 Exception made of Argentina at 95% where the three specifications give roughly similar results: GARCH=21.44%, EGARCH=20.47% and EVT=20.04%.

Table 6
Basel III – Stressed Minimum Capital Requirements via ES (sES)

Line	Model Index	Brazil	Hungary	India	Czech Republic	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
1	GARCH-N 99%	13.82%	9.31%	11.63%	16.56%	21.37%	12.08%	12.62%	27.70%	**14.22%**	5.06%	16.05%
2	EGARCH-N 99%	24.19%	18.11%	12.85%	17.66%	21.41%	11.61%	12.77%	26.45%	**15.12%**	5.16%	13.46%
3	EVT-POT 99%	26.62%	33.93%	20.41%	20.21%	36.33%	45.82%	38.10%	64.63%	24.76%	8.85%	22.33%
4	GARCH-N 97.5%	14.18%	8.82%	11.94%	10.37%	17.35%	10.60%	15.06%	24.30%	11.60%	3.46%	11.03%
5	EGARCH-N 97.5%	17.97%	12.35%	11.27%	12.08%	16.42%	10.19%	12.10%	25.06%	**13.27%**	3.53%	10.37%
6	EVT-POT 97.5%	18.51%	22.25%	13.06%	14.69%	22.70%	31.24%	26.09%	37.96%	16.48%	5.57%	15.18%
7	GARCH-N 95%	10.70%	7.50%	9.00%	9.15%	12.38%	9.35%	10.75%	21.44%	7.92%	2.61%	6.98%
8	EGARCH-N 95%	12.48%	8.81%	9.95%	9.11%	13.63%	8.99%	11.56%	20.47%	9.25%	2.66%	6.31%
9	EVT-POT 95%	13.12%	14.25%	9.50%	11.27%	13.59%	21.81%	18.23%	20.04%	11.20%	3.30%	10.82%
10	VaR-GARCH	21.11%	13.42%	17.77%	15.48%	**21.32%**	15.82%	**23.76%**	36.27%	**12.41%**	5.15%	**15.14%**
11	VaR-EGARCH	26.05%	**18.07%**	16.83%	17.98%	**21.36%**	15.20%	20.76%	38.10%	**13.20%**	5.26%	**14.24%**
12	VaR-EVT-POT	17.10%	11.53%	11.83%	13.47%	20.39%	28.47%	25.76%	33.50%	14.81%	5.08%	13.54%
13	Variation 99%	55.68%	194.35%	72.61%	50.07%	78.18%	60.92%	47.92%	92.90%	67.17%	74.05%	64.99%
14	Variation 97.50%	8.25%	92.98%	10.42%	9.04%	11.34%	9.74%	1.30%	13.28%	11.23%	9.57%	12.15%
15	Variation 95%	-23.26%	23.64%	-19.63%	-16.34%	-33.36%	-23.41%	-29.22%	-40.18%	-24.42%	-34.99%	-20.09%

Note: Lines 13 to 15 portray the relative variation between ES at 99%, 97.50% and 95% and VaR at 99%.
Figures in bold letters indicate specifications belonging to the Red Zone in the respective Backtesting configurations both for ES and VaR exercises.

Source: Prepared by author.

Malaysia (46%), China (38%) or Indonesia (36%) while the remaining models —either in the Green or Yellow zones— exhibit much moderate increments. The scenario looks more even as the confidence level decreases: notwithstanding the presence of moral hazard, the difference is substantially reduced. For example, when α=97.50% (Table 6, Lines 4 to 6), the sES from EVT (always in the Green Zone) exceeds the respective Gaussian models in the Yellow Zone in Brazil, Hungary, India, Czech Republic, Indonesia, China, Argentina, Lithuania, Tunisia and Croatia whereas if α=95% the situation does not strike as utterly unfair as it only emerges in Indonesia, China, Lithuania and Croatia (Table 6, Lines 7 to 9). Repeating the procedure in 6.4.1, it is illustrative to evaluate the relative variation between ES at 99%, 97.50% and 95% and the 99% VaR computed through EVT for both risk measures[29] (Lines 10 to 12 in Table 6): excluding the case of Hungary, amounts of ES at 97.50% report noticeably similar percentages to those of VaR at 99% and situate in the interval [1.30% (China); 13.28% (Argentina)].

The aforementioned considerations are reflected in Table 7, which displays the total capital charge for Basel III (16). In general terms,[30] full MCR exhibits a direct relationship with the confidence level though in many occasions it ends up distorted by the penalties envisaged by Backtesting and the different starting points for the Backtesting zones (for instance, in Hungary GARCH-99% belonging to the Green bracket yields 41% whilst when α=97.50% it receives a an 8% penalty and still gives 39% —Table 7, Lines 1 and 4—). For every set of confidence thresholds, the global picture indicates that EVT —quite understandably— delivers the highest MCR (except in Argentina where it ranks third) while the remaining specifications do not show significant differences that may merit any pecking order. Finally, lines 10 to 15, which portray the EVT-VaR MCR in Rossignolo, Fethi and Shaban (2012b) and the relative difference with the EVT-ES MCR at the respective confidence levels confirm that EVT at 97.50% gives approximately similar values to EVT-VaR at 99% (Table 7 Lines 6, 12 and 14), eventually the sharpest model throughout both papers.

The above analysis that portrayed the equivalence of VaR and EVT through MCR could be verified equating formulas (2) and (10), and (13) and (14), for the Standard Normal and EVT configurations respectively, where α'

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29 The analysis is performed employing EVT as the most accurate technique.

30 The regularity is to be observed when models fall into the Green Zone in each confidence level.

Table 7
Basel III Minimum Capital Requirements via ES: MCR = MCR(cES) + MCR(sES)

Line	Model Index	Brazil	Hungary	India	Czech Republic	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
1	GARCH-N 99%	47.59%	40.89%	39.73%	68.62%	60.11%	24.17%	34.85%	42.25%	**40.08%**	15.88%	46.83%
2	EGARCH-N 99%	62.90%	58.45%	36.96%	60.20%	52.59%	23.69%	34.84%	41.26%	**37.63%**	14.23%	42.52%
3	EVT-POT 99%	91.69%	148.95%	69.72%	83.78%	102.18%	91.66%	105.18%	98.58%	69.79%	27.79%	65.18%
4	GARCH-N 97.5%	48.84%	38.74%	40.77%	43.00%	48.81%	21.20%	41.57%	37.06%	32.70%	10.87%	32.20%
5	EGARCH-N 97.5%	46.72%	39.84%	32.42%	41.19%	40.33%	20.78%	33.01%	39.08%	**33.00%**	9.74%	32.78%
6	EVT-POT 97.5%	63.75%	97.66%	44.60%	60.87%	63.85%	62.51%	72.03%	57.89%	46.44%	17.50%	44.30%
7	GARCH-N 95%	36.83%	32.91%	30.75%	37.94%	34.82%	18.71%	29.67%	32.70%	22.34%	8.20%	20.38%
8	EGARCH-N 95%	32.46%	28.43%	28.61%	31.06%	33.49%	18.34%	31.55%	31.93%	23.00%	7.34%	19.95%
9	EVT-POT 95%	45.20%	62.56%	32.46%	46.71%	38.22%	43.62%	50.33%	30.57%	31.56%	10.38%	31.57%
10	VaR-GARCH	72.70%	58.89%	60.69%	64.18%	**59.96%**	31.65%	62.56%	55.32%	**34.99%**	16.18%	**44.19%**
11	VaR-EGARCH	67.72%	**58.30%**	48.40%	61.30%	**52.46%**	31.02%	54.48%	59.42%	**32.84%**	14.49%	**44.99%**
12	VaR-EVT-POT	58.90%	50.60%	40.39%	55.83%	57.35%	56.96%	67.82%	51.11%	41.75%	15.97%	39.50%
13	Variation 99%	55.68%	194.35%	72.61%	50.07%	78.18%	60.92%	55.10%	92.90%	67.17%	74.05%	64.99%
14	Variation 97.50%	8.25%	92.98%	10.42%	9.04%	11.34%	9.74%	6.21%	13.28%	11.23%	9.57%	12.15%
15	Variation 95%	-23.26%	23.64%	-19.63%	-16.34%	-33.36%	-23.41%	-25.79%	-40.18%	-24.42%	-34.99%	-20.09%

Note: Lines 13 to 15 portray the relative variation between ES at 99%, 97.50% and 95% and VaR at 99%.

Figures in bold letters indicate specifications belonging to the Red Zone in the respective Backtesting configurations both for ES and VaR exercises.

Source: Prepared by author.

denotes the new confidence level for ES. In effect, in the case of the Normal distribution, the outcome is independent of the volatility model employed:

$$VaR_{t+1}(\alpha) = ES_{t+1}(\alpha') \qquad (17)$$

$$\Phi^{-1}(\alpha) = \frac{\phi[\Phi^{-1}(\alpha')]}{1-\alpha'}$$

where the approximate value that allows the equivalence is 97.42%. Analogously, the exercise for EVT shows:

$$VaR_{t+1}(\alpha) = ES_{t+1}(\alpha') \qquad (18)$$

$$VaR(\alpha') = G^{-1}(\alpha)(1-\xi) - \beta + \xi\, u$$

and, solving for α', gives the values included in Table 13 Column [1]. Incidentally, in order to reinforce the empirical outcome, Table 13 Column [2] displays the confidence levels that approximates VaR(α) and ES(α') applying a purely empirical model like Historical Simulation (again free from any volatility assumption) which, brushing off all the disadvantages that its use brings about, may also ratify that VaR(99%) is approximately equivalent to ES(97.50%).

5.4.3. Extending Backtesting: the power of EVT

The robustness of EVT for capital constitution purposes may result in replicating the analysis, above mentioned, by employing a different Backtesting period. In effect, it is interesting to observe the behaviour of the specifications reestimating the parameters and performing Backtesting in 2007 and keeping the crisis year of 2008 for the stressed ES, analogously to 5.1. to 5.4. above.

In this vein, Table 13 provides the outcome of the Backtesting for the three confidence levels 99%, 97.50% and 95% applying the usual models GARCH-N, EGARCH-N and EVT-POT, Table 14 reports the capital surcharge as a consequence of the values taken by the multiplier *k*, and Table 15 displays the MCR arising from the exercise, much in the same fashion than

Table 8
$VaR\ (\alpha) \approx ES(\alpha')$ – – Approximate confidence levels

Index	Brazil	Hungary	India	Czech Republic	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
Standard Normal	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%	97.42%
EVT-POT	97.23%	97.38%	97.52%	97.48%	97.47%	97.54%	97.42%	97.52%	97.67%	97.49%	97.67%
Hist. Simul.	97.54%	97.58%	97.53%	97.48%	97.32%	97.57%	97.47%	97.57%	97.60%	97.40%	97.41%

Note: Standard Normal confidence levels are coincident for all countries given that the distribution is the same for all of them.

Source: Prepared by author.

Table 9
Backtesting results
Quantity and proportion of exceptions in 2007

Line	Model Index	α=99% Expected Number [1]	α=99% GARCH Normal [2]	α=99% EGARCH Normal [3]	α=99% EVT-POT [4]	α=97.50% Expected Number [5]	α=97.50% GARCH Normal [6]	α=97.50% EGARCH Normal [7]	α=97.50% EVT-POT [8]	α=95% Expected Number [9]	α=95% GARCH Normal [10]	α=95% EGARCH Normal [11]	α=95% EVT-POT [12]
1	Brazil	2/1.00%	3/1.22%	3/1.22%	0/0.00%	6/2.50%	5/2.04%	4/1.63%	1/0.41%	12/5.00%	6/2.45%	7/2.86%	3/1.22%
2	Hungary	3/1.00%	3/1.00%	4/1.59%	0/0.00%	6/2.50%	4/1.63%	5/2.04%	0/0.00%	13/5.00%	7/2.86%	8/3.27%	0/0.00%
3	India	2/1.00%	2/1.00%	2/1.00%	0/0.00%	6/2.50%	6/2.50%	4/1.63%	0/0.00%	12/5.00%	6/2.45%	7/2.86%	7/2.86%
4	Cz. Rep.	3/1.00%	4/1.59%	5/1.98%	0/0.00%	6/2.50%	4/1.63%	7/2.86%	1/0.41%	13/5.00%	5/2.04%	6/2.45%	0/0.00%
5	Indonesia	2/1.00%	6/2.48%	6/2.48%	0/0.00%	6/2.50%	6/2.45%	7/2.86%	0/0.00%	12/5.00%	13/5.31%	14/5.71%	2/0.82%
6	Malaysia	2/1.00%	2/1.00%	3/1.21%	0/0.00%	6/2.50%	4/1.63%	4/1.63%	0/0.00%	12/5.00%	5/2.04%	5/2.04%	1/0.41%
7	China	2/1.00%	3/1.22%	3/1.22%	0/0.00%	6/2.50%	6/2.45%	3/1.22%	1/0.41%	12/5.00%	10/4.08%	11/4.49%	2/0.82%
8	Argentina	2/1.00%	3/1.21%	3/1.21%	0/0.00%	6/2.50%	5/2.04%	6/2.45%	1/0.41%	12/5.00%	7/2.86%	6/2.45%	8/3.27%
9	Lithuania	2/1.00%	8/3.29%	10/4.12%	0/0.00%	6/2.50%	10/4.08%	11/4.49%	0/0.00%	12/5.00%	15/6.12%	17/6.94%	1/0.41%
10	Tunisia	2/1.00%	4/1.63%	5/2.03%	0/0.00%	6/2.50%	7/2.86%	6/2.45%	1/0.41%	12/5.00%	9/3.67%	10/4.08%	3/1.22%
11	Croatia	2/1.00%	6/2.45%	6/2.41%	0/0.00%	6/2.50%	8/3.27%	9/3.67%	1/0.41%	12/5.00%	8/3.27%	9/3.67%	2/0.82%

Source: Prepared by author.

Table 10
Bac-ng results
The Three-zone Approach – Increase in scaling factor k

Line	Model Index	α=99% GARCH Normal [1]	α=99% EGARCH Normal [2]	α=99% EVT-POT [3]	α=97.50% GARCH Normal [4]	α=97.50% EGARCH Normal [5]	α=97.50% EVT-POT [6]	α=95% GARCH Normal [7]	α=97.50% EGARCH Normal [8]	α=97.50% EVT-POT [9]
1	Brazil	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
2	Hungary	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
3	India	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
4	Cz. Rep.	Green/0%	Yellow/40%	Green/0%	Green/0%	Yellow/8%	Green/0%	Green/0%	Green/0%	Green/0%
5	Indonesia	Yellow/50%	Yellow/50%	Green/0%	Green/0%	Yellow/8%	Green/0%	Yellow/4%	Yellow/10%	Green/0%
6	Malaysia	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
7	China	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
8	Argentina	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
9	Lithuania	Yellow/75%	Red/100%	Green/0%	Yellow/36%	Yellow/45%	Green/0%	Yellow/17%	Yellow/31%	Green/0%
10	Tunisia	Green/0%	Yellow/40%	Green/0%	Yellow/8%	Green/0%	Green/0%	Green/0%	Green/0%	Green/0%
11	Croatia	Yellow/50%	Yellow/50%	Green/0%	Yellow/17%	Yellow/27%	Green/0%	Green/0%	Green/0%	Green/0%

Source: Prepared by author.

Table 11
Basel II Minimum Capital Requirements via ES (cES)

Index	Model Index	Brazil	Hungary	India	Czech Republic	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
1	GARCH2-N 99%	12,95%	12,58%	11,01%	20,16%	14,80%	4,70%	8,87%	5,63%	10,07%	4,20%	12,32%
2	EGARCH-N 99%	18,06%	40,33%	24,11%	42,54%	31,18%	12,08%	22,08%	14,80%	**22,50%**	9,07%	29,07%
3	EVT-POT 99%	30,07%	51,99%	22,71%	29,77%	30,53%	21,44%	30,01%	15,14%	21,14%	8,54%	19,16%
4	GARCH-N 97.5%	13,99%	11,85%	11,33%	12,87%	12,26%	4,19%	10,13%	5,07%	8,50%	2,94%	8,17%
5	EGARCH-N 97.5%	13,05%	13,13%	9,68%	13,40%	10,61%	4,87%	9,96%	6,81%	9,21%	2,90%	10,27%
6	EVT-POT 97.5%	20,31%	34,84%	14,01%	21,92%	18,93%	13,97%	21,31%	9,11%	13,75%	5,29%	12,81%
7	GARCH-N 95%	10,71%	9,50%	8,24%	11,46%	8,37%	3,51%	7,80%	4,19%	5,78%	2,24%	5,33%
8	EGARCH-N 95%	8,84%	8,91%	8,25%	10,18%	9,36%	4,47%	9,05%	5,22%	6,44%	2,06%	6,43%
9	EVT-POT 95%	14,51%	22,81%	10,78%	15,58%	10,68%	10,16%	14,92%	4,92%	8,84%	3,13%	9,28%
10	VaR-GARCH	19,78%	18,11%	16,81%	18,85%	14,76%	6,15%	15,48%	7,37%	8,79%	4,28%	11,62%
11	VaR-EGARCH	19,44%	19,09%	14,59%	19,84%	14,57%	7,52%	15,54%	9,54%	9,24%	4,30%	14,10%
12	VaR-EVT-POT	19,32%	17,66%	13,16%	19,84%	17,13%	13,33%	18,82%	7,85%	12,65%	4,91%	11,61%
13	Variation 99%	55,68%	194,32%	72,61%	50,07%	78,18%	60,92%	59,49%	92,90%	67,17%	74,05%	64,99%
14	Variation 97.50%	5,16%	97,26%	6,46%	10,49%	10,48%	4,81%	13,26%	16,06%	8,70%	7,84%	10,29%
15	Variation 95%	-24,90%	29,14%	-18,08%	-21,43%	-37,64%	-23,78%	-20,71%	-37,31%	-30,10%	-36,33%	-20,13%

Source: Prepared by author.

Table 12

Basel III Minimum Capital Requirements via ES: MCR = MCR(cES) + MCR(sES)

Line	Model Index	Brazil	Hungary	India Republic	Czech	Indonesia	Malaysia	China	Argentina	Lithuania	Tunisia	Croatia
1	GARCH-N 99%	47.59%	40.89%	39.73%	68.62%	60.11%	24.17%	34.85%	42.25%	40.08%	15.88%	46.83%
2	EGARCH-N 99%	62.90%	58.45%	36.96%	60.20%	52.59%	23.69%	34.84%	41.26%	**37.63%**	14.23%	42.52%
3	EVT-POT 99%	91.69%	148.95%	69.72%	83.78%	102.18%	91.66%	105.18%	98.58%	69.79%	27.79%	65.18%
4	GARCH-N 97.5%	48.84%	38.74%	40.77%	43.00%	48.81%	21.20%	41.57%	37.06%	32.70%	10.87%	32.20%
5	EGARCH-N 97.5%	46.72%	39.84%	32.42%	41.19%	40.33%	20.78%	33.01%	39.08%	33.00%	9.74%	32.78%
6	EVT-POT 97.5%	63.75%	97.66%	44.60%	60.87%	63.85%	62.51%	72.03%	57.89%	46.44%	17.50%	44.30%
7	GARCH-N 95%	36.83%	32.91%	30.75%	37.94%	34.82%	18.71%	29.67%	32.70%	22.34%	8.20%	20.38%
8	EGARCH-N 95%	32.46%	28.43%	28.61%	31.06%	33.49%	18.34%	31.55%	31.93%	23.00%	7.34%	19.95%
9	EVT-POT 95%	45.20%	62.56%	32.46%	46.71%	38.22%	43.62%	50.33%	30.57%	31.56%	10.38%	31.57%
10	VaR-GARCH	72.70%	58.89%	60.69%	64.18%	59.96%	31.65%	62.56%	55.32%	34.99%	16.18%	44.19%
11	VaR-EGARCH	67.72%	58.30%	48.40%	61.30%	52.46%	31.02%	54.48%	59.42%	32.84%	14.49%	44.99%
12	VaR-EVT-POT	58.90%	50.60%	40.39%	55.83%	57.35%	56.96%	67.82%	51.11%	41.75%	15.97%	39.50%
13	Variation 99%	55.68%	194.35%	72.61%	50.07%	78.18%	60.92%	55.10%	92.90%	67.17%	74.05%	64.99%
14	Variation 97.50%	8.25%	92.98%	10.42%	9.04%	11.34%	9.74%	6.21%	13.28%	11.23%	9.57%	12.15%
15	Variation 95%	-23.26%	23.64%	-19.63%	-16.34%	-33.36%	-23.41%	-25.79%	-40.18%	-24.42%	-34.99%	-20.09%

Note: Lines 13 to 15 portray the relative variation between ES at 99%, 97.50% and 95% and VaR at 99%.
Figures in bold letters indicate specifications belonging to the Red Zone in the respective Backtesting configurations for both ES and VaR exercises.

Source: Prepared by author.

Tables 3, 4 and 5 above. Further addition of Table 6 —which contains the capital supplement arising from the stressed period (eventually unaltered given that it stems from the strained term)—, determines the total MCR pictured in Table 16. Understandably enough, the models reveal an overall improvement in performance (in view of the fact that volatility was not the common factor in stock markets) reflected in the quantity of Green Zones recorded for the three confidence levels. For instance, if α=99%, GARCH-N manages to step in the Green Zone from the Yellow one in Czech Republic and Tunisia, and from Red to Yellow in Lithuania and reduce the amount of penalties in Croatia and Indonesia (still belonging to the intermediate Zone). On the other hand, analogous improvements are reported by EGARCH-N in Brazil and Hungary, with surcharges of the Yellow Zone brought down in Czech Republic, Indonesia, Tunisia and Croatia. A similar assessment could be made in the event of α=97.50%, with GARCH-N stepping up in all countries but Czech Republic, Malaysia and Argentina (already in Green Zone), whereas in the rest of the countries reductions in penalties are obtained. EGARCH-N, concurrently, presents an improvement in Brazil, Hungary, China, Argentina and Tunisia, and amid decreases in penalties in the rest of the markets (including trading a Red for a Yellow Zone in Lithuania). α=95% reinforces the empirical evaluation arising from the previous confidence levels, because both Normal specifications deliver two Yellow Zones (although extra charges are substantially reduced). Finally, EVT-POT manages to yield an unstained performance with all Green Zones (even correcting the situation in India, for α=95%).

It is acknowledged that the fact that EVT coming unscathed from every Backtesting exercise translates into higher MCR (Table 16), although their levels are decreased compared with those of 2008 as the test period. It is up to the local and supranational regulators, then, to legislate on the adequacy of the specifications and the corresponding MCR, although the aforementioned outcomes are clearly not to be neglected.

6. Basel II and Basel III MCR revisited in light of ES

Rooting in the Backtesting result from Section 5.1 to 5.3, this Chapter provides a reassessment of the MCR formulas (15) and (16) belonging to Basel II and Basel III respectively applying EVT-POT —eventually the most accurate representation— through a sensitivity analysis aimed at ascertaining the adequacy of the multiples m_c and m_s computed at the three alternative confidence levels 99%, 97.50% and 95%.

6.1. Basel II and Basel III capital buffers in numbers

Basel II regulations entail a coverage of more than three times the size of the heaviest loss in 2008 —except in Argentina, where the coverage amounts to 2.62 times— (Table 13 Column [1]), which translate into deficits averaging 65% in Emerging markets —Hungary leading with an astonishing 100%— and 35% in Frontier stock exchanges-highest value for Lithuania, 45%- (Table 13 Column [2]). These amounts represent a substantial increase from the VaR estimations —reported on Columns [1] and [2] in Table 14— in the region of 76% for Emerging markets and 73% in Frontier ones (average figures). The introduction of the sES accomplishes its objective toughening the MCR given that the former quantities are increased to more than 7 times the greatest loss of the forecast period (average values 8.84 and 7.28 in Emerging and Frontier markets respectively), representing average daily shortfalls of about 91% and 65% in each case (Table 13 Columns [3] and [4]). Compared with Basel III VaR values, ES records an augmentation of more than 65% and furthermore, in relative terms, the sES factor lifts. MCR in more than 64% in Emerging markets and 76% in Frontier ones (again, average values reported on Columns [3] to [4] in Table 14).

When the confidence level is brought down to 97.50%, the values are, again, strikingly similar to those of VaR at 99%. In fact, under the Basel II framework, the maximum loss coverage amounts to —in average values— 3.97 in Emerging markets and 2.72 in the Frontier ones (compared to 3.29 and 2.44 respectively in the VaR exercise), whereas adding the sES as in Basel III the figures increase by 50% and 72% to reach 5.93 and 4.67. Translating the above mentioned multiples into losses, ES would withstand daily red outcomes of 45% and 23% in Basel II and 66% and 42% in Basel III (Emerging and Frontier stock exchanges respectively) (Table 13 Columns [5] to [8]). The resemblance with the maximum daily loss matched by VaR at 99%, both for Basel II and Basel III, is displayed in Table 14 Columns [5] and [6] respectively, with increases in the region of 20%-22% for Emerging markets and 12% for Frontier ones.

At 95% ES delivers figures roughly equal or even smaller than VaR at 99%. Table 13 Columns [9] to [12] reports that, in Basel II terms, the average MCR for Emerging and Frontier ones reach 2.71 and 1.76 times the heaviest

Table 13
Loss Coverage and Maximum Daily Loss – Basel II and Basel III at α = 99%, 97.50% and 95%

Index LCR MDL	Basel II Loss Coverage [1]	α=99% Max. daily loss [2]	Basel III Loss Coverage [3]	α=99% Max. daily loss [4]	Basel II Loss Coverage [5]	α=97.5% Max. daily loss [6]	Basel III Loss Coverage [7]	α=97.5% Max. daily loss [8]	Basel II Loss Coverage [9]	α=95% Max. daily loss [10]	Basel III Loss Coverage [11]	α=95% Max. daily loss [12]
Brazil	5.38	65.07%	7.58	91.69%	3.74	45.24%	5.27	63.75%	2.65	32.07%	3.74	45.20%
Hungary	8.92	100.00%	11.56	100.00%	5.85	75.41%	7.58	97.66%	3.75	48.31%	4.85	62.56%
India	4.25	49.31%	6.01	69.72%	2.72	31.54%	3.84	44.60%	1.98	22.96%	2.80	32.46%
Czech Rep	3.93	63.56%	5.18	83.78%	2.85	46.19%	3.76	60.87%	2.19	35.44%	2.89	46.71%
Indonesia	6.01	65.86%	9.33	100.00%	3.76	41.15%	5.83	63.85%	2.25	24.63%	3.49	38.22%
Malaysia	4.59	45.84%	9.19	91.66%	3.13	31.26%	6.26	62.51%	2.19	21.82%	4.37	43.62%
China	8.34	67.08%	13.08	100.00%	5.71	45.94%	8.95	72.03%	3.99	32.10%	6.26	50.33%
Avg.Emg.	**5.92**	**65.25%**	**8.84**	**90.98%**	**3.97**	**45.25%**	**5.93**	**66.47%**	**2.71**	**31.05%**	**4.06**	**45.59%**
Argentina	2.62	33.95%	7.61	98.58%	1.54	19.94%	4.47	57.89%	0.81	10.53%	2.36	30.57%
Lithuania	6.39	45.03%	9.91	69.79%	4.25	29.96%	6.59	46.44%	2.89	20.36%	4.48	31.56%
Tunisia	3.79	18.94%	5.55	27.79%	2.38	11.93%	3.50	17.50%	1.41	7.08%	2.07	10.38%
Croatia	3.98	42.85%	6.06	65.18%	2.71	29.12%	4.12	44.30%	1.93	20.75%	2.93	31.57%
Avg.Ftier.	**4.19**	**35.19%**	**7.28**	**65.34%**	**2.72**	**22.74%**	**4.67**	**41.53%**	**1.76**	**14.68%**	**2.96**	**26.02%**

Note: Above values obtained through EVT-POT. Loss Coverage = MCR(VaR) / Maximum Loss Forecast Period

Source: Prepared by author.

Table 14

Maximum Daily Loss – Variation between ES- and VaR-based values in Basel II and Basel III

Index MDL	Basel II Var α=99% [1]	Basel III Var. α=99% [2]	Basel II Es α=99% [3]	Basel III Es α=99% [4]	Basel II Es α=97.50% [5]	Basel III Es α=97.50% [6]	Basel II Es α=95% [7]	Basel III Es α=95% [8]
Brazil	41.80%	58.90%	55.68%	55.68%	8.25%	8.25%	-23.26%	-23.26%
Hungary	39.08%	50.60%	155.91%	97.61%	92.98%	92.98%	23.64%	23.64%
India	28.56%	40.39%	72.61%	72.61%	10.42%	10.42%	-19.63%	-19.63%
Czech Rep	42.36%	55.83%	50.07%	50.07%	9.04%	9.04%	-16.34%	-16.34%
Indonesia	36.96%	57.35%	78.18%	74.37%	11.34%	11.34%	-33.36%	-33.36%
Malaysia	28.49%	56.96%	60.92%	60.92%	9.74%	9.74%	-23.41%	-23.41%
China	42.06%	67.82%	59.49%	47.46%	9.22%	6.21%	-23.69%	-25.79%
Avg.Emg.	**37.04%**	**55.41%**	**76.13%**	**64.20%**	**22.15%**	**19.96%**	**-16.19%**	**-17.72%**
Argentina	17.60%	51.11%	92.90%	92.90%	13.28%	13.28%	-40.18%	-40.18%
Lithuania	26.94%	41.75%	67.17%	67.17%	11.23%	11.23%	-24.42%	-24.42%
Tunisia	10.88%	15.97%	74.05%	74.05%	9.57%	9.57%	-34.99%	-34.99%
Croatia	25.97%	39.50%	64.99%	64.99%	12.15%	12.15%	-20.09%	-20.09%
Avg.Ftier.	**20.35%**	**37.08%**	**72.96%**	**76.19%**	**11.75%**	**12.00%**	**-27.86%**	**-29.83%**

Note: Above values obtained through EVT-POT. *Loss Coverage = MCR(VaR) / Maximum Loss Forecast Period.*

Source: Prepared by author.

loss in the forecast period, raising them to 4.06 (+50%) and 2.96 (+68%) after the addition of the sES factor. These numbers amount to daily losses of 31% and 15% for Emerging and Frontier markets in Basel II and 46% and 26% when Basel III is considered. The comparison with the VaR example in Rossignolo, Fethi and Shaban (2012b) informs a decrease of 16% and 28% in Basel II (Emerging and Frontier markets respectively), with the gap augmenting to 18% and 30% in Basel III (Table 14 Columns [7] and [8]).

6.2. A sensitivity analysis to assess m_c and m_s using ES

The present section exhibits a sensitivity analysis[31] designed to show the effects of the adoption of different multiples m_c and m_s on the Maximum Daily Loss —which constitutes an alternative way to express the MCR— forestalled employing EVT and alternative confidence levels α=99%, α=97.50% and α=95%.[32]

At 99% the MCR result is relatively high: considering that under Basel II the MCR amount to 67% and 35% for Emerging and Frontier markets, a daily LCR in excess of 4 represents a huge amount of capital unproductively immobilised. The introduction of the stressed component in Basel III contributes to the suboptimisation observed in Basel II as it delivers 99% and 65% —LCR greater than 8 for both sets of stock exchanges—. Were the BCBS to stick to this enormous confidence level even applying ES, it would be advisable to select another combination of the fixed multiples and, in this sense, the figures suggest that values up to m_c=1.5 / m_s= 1 (excluding m_c=1) should be enough to withstand massive crises. For instance, under Basel II, m_c=1.5 (Maximum daily loss in the region of 33% and 18% representing LCR of 3 and 2.5 for Emerging markets) delivers high MCR, whilst if Basel III is to be applied, mixes like m_c=1 / m_s=0.5 or m_c=1 / m_s=1 cover more than a daily loss of 30% for Emerging markets (3 times the heaviest loss in the 2008 crisis) whereas the corresponding values for Frontier stock exchan-

[31] For the sake of readability, the amounts are expressed in average terms for Emerging and Frontier markets unless otherwise stated.

[32] The Tables are intended to report the Maximum Daily Loss and the corresponding Loss Coverage Ratio (LCR) for each α. Due to space constraints and in light of its bearing on the final result, only the results corresponding to α = 97.50% will be displayed notwithstanding which the remaining Tables belonging to the confidence levels α = 99% and α = 95% are available upon requirement.

ges situate in the region of daily 26% and 3.50 LCR. Finally, a first glance at the ES estimates compared to the VaR-based ones in Rossignolo, Fethi and Shaban (2012b) would point to an approximate equivalence between m_c(VaR)=3 and m_c(ES)=2 in Basel II framework, while in terms of Basel III the correspondence could be fixed at m_c(VaR)=m_s(VaR)=3 and m_c(ES)=2 and m_s(ES)=1.5.

Tables 15 and 16 reproduce the analysis at α=97.50%, where it may be appreciated a certain relaxation of the amounts.[33] Basel II specifications would entail MCR in the order of 45% (LCR>4) and 22% (LCR>3) for Emerging and Frontier markets respectively (Lines 33 in Tables 15 and 16) while Basel III delivers 74% and 45% (LCR>6 in both groups) (Lines 48 in Tables 15 and 16), indeed huge values even for a 2008-style plight. Consequently, were the BCBS to apply formulas 5.6 and 5.7 to determine the MCR through ES, the multiples m_c and m_s should be drastically reduced. For instance, Lines 4 to 19 (Charts 15 and 16) could supply a buffer to fend off a 30% and 15% Maximum Daily Loss for Emerging and Frontier markets respectively which translates into more than 2 times the greatest shortfall of the forecast period.[34] It is deemed that MCR in excess of those aforementioned would, again, freeze considerable money which could be diverted to more productive uses. Finally, the performance of m_c(ES)=2.5 at 97.50% might be equated to Basel II VaR at 99% (2.5≤m_c<3), while the approximate equivalence for Basel III may be found on Lines 39 (m_c=3, m_s=2.5).

On the contrary, as the confidence level keeps diminishing, the multiplication factors are in urgent need of being increased in order to achieve similar results to the higher alphas. LCR consistently over 2 are obtained, which is tantamount to expressing a Maximum Daily Loss coverage of 23% and 14% in Emerging and Frontier market respectively

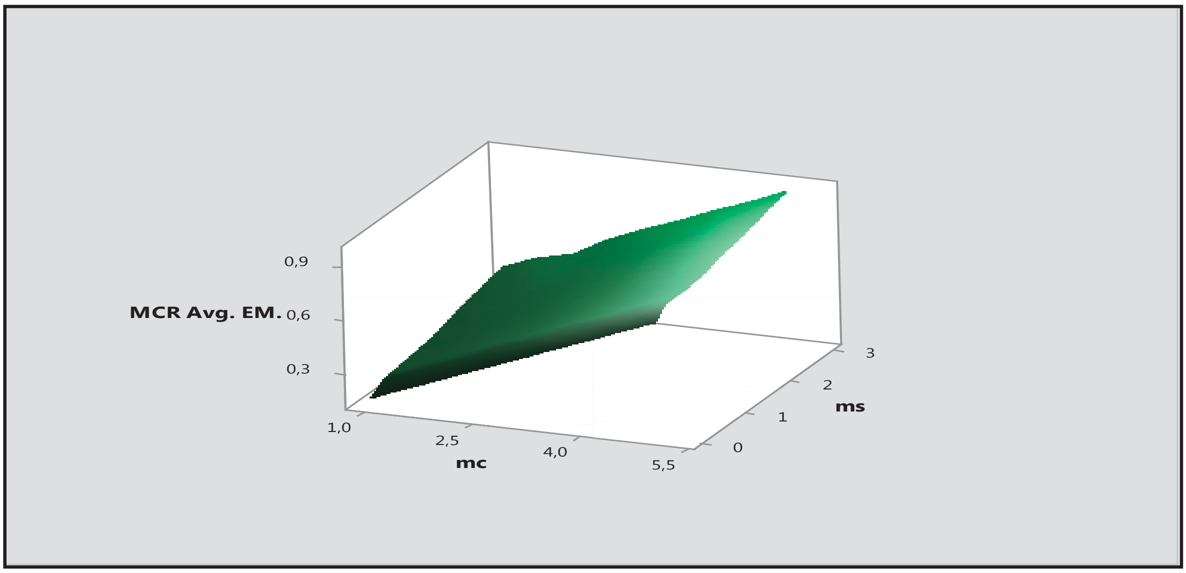
33 Graphs 2 and 3 illustrate the sensibility of the Average Emerging and Average Frontier markets MCR to the different values of m_c and m_s, whereas Graphs 4 and 5 portray the sensibility of the Average Emerging and Average Frontier markets LCR to variations in mc and ms as expressed in Charts 15 and 16 respectively. Space considerations prevent the inclusion of the surfaces belonging to the individual countries, which remain available upon request.

34 Exception made for lines 9 in Charts 15 and 16 where, for m_c=1.5 in Frontier markets, the average maximum daily loss amounts to 11.37% (LCR = 1.59).

35 It is acknowledged the need to make an exception in the cases of Basel II when m_c=2 and m_c=2.5 because, in the case of Frontier markets, the capital buffer would not be enough to match shortfalls in the region of 1.39 and 1.74 times the greatest loss of the forecast period.

from m_c=m_s=1.5.[35] Finally, VaR-based Basel II Maximum daily losses covered reveal roughly equivalent to ES-MCR at 95% when m_c=4, while the task of finding a feasible equivalence for Basel III becomes uphill because of the

Graph 2
Sensitivity analysis – Average MCR Emerging Markets



Graph 3
Sensitivity analysis – Average MCR Frontier Markets

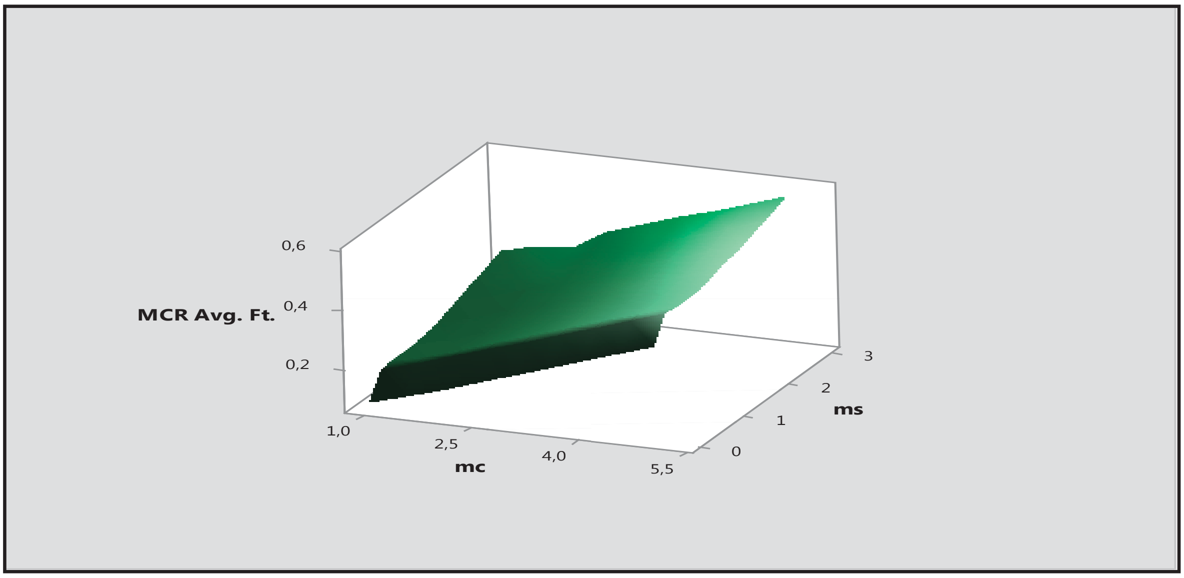


Table 15
Sensitivity Analysis-Total MCR with varying scaling factors m_c and m_s at α = 97.50%

Line	mc/ms	Brazil	Hungary	India	Cz.Rp.	Indon.	Malay.	China	Arg.	Lit.	Tunisia	Croatia	Av.Em.	Av.Ft.
1	mc=1	0.1508	0.2514	0.1051	0.1540	0.1372	0.1042	0.1531	0.0766	0.0999	0.0398	0.1129	0.1508	0.0823
2	mc=1/ms=0	0.2463	0.3135	0.1858	0.1920	0.2091	0.1823	0.1531	0.2283	0.2203	0.0534	0.1621	0.2117	0.1660
3	mc=1/ms=0.5	0.2463	0.3135	0.1858	0.1920	0.2091	0.1823	0.1966	0.2283	0.2203	0.0534	0.1621	0.2180	0.1660
4	mc=1/ms=1	0.2463	0.3255	0.1858	0.2029	0.2128	0.2084	0.2401	0.2283	0.2203	0.0583	0.1635	0.2317	0.1676
5	mc=1/ms=1.5	0.2463	0.3626	0.1858	0.2274	0.2507	0.2604	0.2836	0.2664	0.2203	0.0676	0.1888	0.2595	0.1858
6	mc=1/ms=2	0.2742	0.3997	0.1922	0.2519	0.2885	0.3125	0.3271	0.3297	0.2203	0.0769	0.2141	0.2923	0.2103
7	mc=1/ms=2.5	0.3051	0.4367	0.2139	0.2763	0.3263	0.3646	0.3705	0.3929	0.2372	0.0862	0.2394	0.3277	0.2389
8	mc=1/ms=3	0.3359	0.4738	0.2357	0.3008	0.3642	0.4167	0.4140	0.4562	0.2646	0.0955	0.2647	0.3630	0.2703
9	mc=1.5	0.2262	0.3770	0.1577	0.2309	0.2058	0.1563	0.2297	0.0997	0.1498	0.0596	0.1456	0.2262	0.1137
10	mc=1.5/ms=0	0.3217	0.4392	0.2384	0.2690	0.2777	0.2344	0.2297	0.2514	0.2703	0.0733	0.1947	0.2872	0.1974
11	mc=1.5/ms=0.5	0.3217	0.4392	0.2384	0.2690	0.2777	0.2344	0.2732	0.2514	0.2703	0.0733	0.1947	0.2934	0.1974
12	mc=1.5/ms=1	0.3217	0.4512	0.2384	0.2799	0.2814	0.2605	0.3167	0.2514	0.2703	0.0782	0.1962	0.3071	0.1990
13	mc=1.5/ms=1.5	0.3217	0.4883	0.2384	0.3044	0.3193	0.3125	0.3601	0.2895	0.2703	0.0875	0.2215	0.3349	0.2172
14	mc=1.5/ms=2	0.3496	0.5254	0.2447	0.3288	0.3571	0.3646	0.4036	0.3527	0.2703	0.0968	0.2468	0.3677	0.2416
15	mc=1.5/ms=2.5	0.3805	0.5624	0.2665	0.3533	0.3949	0.4167	0.4471	0.4160	0.2871	0.1060	0.2721	0.4031	0.2703
16	mc=1.5/ms=3	0.4113	0.5995	0.2883	0.3778	0.4327	0.4688	0.4906	0.4792	0.3146	0.1153	0.2974	0.4384	0.3016
17	mc=2	0.3016	0.5027	0.2103	0.3079	0.2743	0.2084	0.3062	0.1329	0.1997	0.0795	0.1942	0.3016	0.1516
18	mc=2/ms=0	0.3971	0.5649	0.2910	0.3460	0.3463	0.2865	0.3062	0.2846	0.3202	0.0932	0.2433	0.3626	0.2353
19	mc=2/ms=0.5	0.3971	0.5649	0.2910	0.3460	0.3463	0.2865	0.3497	0.2846	0.3202	0.0932	0.2433	0.3688	0.2353
20	mc=2/ms=1	0.3971	0.5769	0.2910	0.3569	0.3500	0.3126	0.3932	0.2846	0.3202	0.0981	0.2447	0.3825	0.2369
21	mc=2/ms=1.5	0.3971	0.6140	0.2910	0.3814	0.3878	0.3646	0.4367	0.3227	0.3202	0.1074	0.2700	0.4104	0.2551
22	mc=2/ms=2	0.4250	0.6510	0.2973	0.4058	0.4257	0.4167	0.4802	0.3860	0.3202	0.1166	0.2953	0.4431	0.2795
23	mc=2/ms=2.5	0.4559	0.6881	0.3191	0.4303	0.4635	0.4688	0.5237	0.4492	0.3371	0.1259	0.3206	0.4785	0.3082
24	mc=2/ms=3	0.4559	0.6881	0.3191	0.4303	0.4635	0.4688	0.5237	0.4492	0.3371	0.1259	0.3206	0.4785	0.3082
25	mc=2.5	0.3770	0.6284	0.2628	0.3849	0.3429	0.2605	0.3828	0.1662	0.2497	0.0994	0.2427	0.3771	0.1895
26	mc=2.5/ms=0	0.4725	0.6906	0.3435	0.4230	0.4149	0.3386	0.3828	0.3178	0.3701	0.1131	0.2918	0.4380	0.2732
27	mc=2.5/ms=0.5	0.4725	0.6906	0.3435	0.4230	0.4149	0.3386	0.4263	0.3178	0.3701	0.1131	0.2918	0.4442	0.2732
28	mc=2.5/ms=1	0.4725	0.7026	0.3435	0.4339	0.4186	0.3647	0.4698	0.3178	0.3701	0.1179	0.2933	0.4579	0.2748
29	mc=2.5/ms=1.5	0.4725	0.7396	0.3435	0.4583	0.4564	0.4167	0.5133	0.3559	0.3701	0.1272	0.3186	0.4858	0.2930
30	mc=2.5/ms=2	0.5004	0.7767	0.3499	0.4828	0.4943	0.4688	0.5567	0.4192	0.3701	0.1365	0.3439	0.5185	0.3174
31	mc=2.5/ms=2.5	0.5313	0.8138	0.3716	0.5073	0.5321	0.5209	0.6002	0.4824	0.3870	0.1458	0.3692	0.5539	0.3461
32	mc=2.5/ms=3	0.5621	0.8509	0.3934	0.5318	0.5699	0.5730	0.6437	0.5457	0.4145	0.1551	0.3945	0.5893	0.3774
33	mc=3	0.4524	0.7541	0.3154	0.4619	0.4115	0.3126	0.4594	0.1994	0.2996	0.1193	0.2912	0.4525	0.2274
34	mc=3/ms=0	0.5479	0.8162	0.3961	0.5000	0.4835	0.3907	0.4594	0.3511	0.4201	0.1329	0.3404	0.5134	0.3111

35	mc=3/ms=0.5	0.5479	0.8162	0.3961	0.5000	0.4835	0.3907	0.5028	0.3511	0.4201	0.1329	0.3404	0.5196	0.3111
36	mc=3/ms=1	0.5479	0.8282	0.3961	0.5108	0.4872	0.4168	0.5463	0.3511	0.4201	0.1378	0.3418	0.5333	0.3127
37	mc=3/ms=1.5	0.5479	0.8653	0.3961	0.5353	0.5250	0.4688	0.5898	0.3892	0.4201	0.1471	0.3671	0.5612	0.3309
38	mc=3/ms=2	0.5758	0.9024	0.4024	0.5598	0.5628	0.5209	0.6333	0.4524	0.4201	0.1564	0.3924	0.5939	0.3553
39	mc=3/ms=2.5	0.6067	0.9395	0.4242	0.5843	0.6007	0.5730	0.6768	0.5157	0.4369	0.1657	0.4177	0.6293	0.3840
40	mc=3/ms=3	0.6375	0.9766	0.4460	0.6087	0.6385	0.6251	0.7203	0.5789	0.4644	0.1750	0.4430	0.6647	0.4153
41	mc=3.5	0.5278	0.8798	0.3680	0.5389	0.4801	0.3647	0.5359	0.2326	0.3496	0.1391	0.3398	0.5279	0.2653
42	mc=3.5/ms=0	0.6233	0.9419	0.4487	0.5769	0.5521	0.4428	0.5359	0.3843	0.4700	0.1528	0.3889	0.5888	0.3490
43	mc=3.5/ms=0.5	0.6233	0.9419	0.4487	0.5769	0.5521	0.4428	0.5794	0.3843	0.4700	0.1528	0.3889	0.5950	0.3490
44	mc=3.5/ms=1	0.6233	0.9539	0.4487	0.5878	0.5558	0.4689	0.6229	0.3843	0.4700	0.1577	0.3904	0.6087	0.3506
45	mc=3.5/ms=1.5	0.6233	0.9910	0.4487	0.6123	0.5936	0.5210	0.6664	0.4224	0.4700	0.1670	0.4157	0.6366	0.3688
46	mc=3.5/ms=2	0.6512	1.0281	0.4550	0.6368	0.6314	0.5730	0.7099	0.4856	0.4700	0.1763	0.4410	0.6693	0.3932
47	mc=3.5/ms=2.5	0.6821	1.0652	0.4768	0.6612	0.6693	0.6251	0.7534	0.5489	0.4869	0.1856	0.4663	0.7047	0.4219
48	mc=3.5/ms=3	0.7129	1.1022	0.4985	0.6857	0.7071	0.6772	0.7968	0.6122	0.5143	0.1948	0.4916	0.7401	0.4532
49	mc=4	0.6032	1.0055	0.4205	0.6158	0.5487	0.4168	0.6125	0.2658	0.3995	0.1590	0.3883	0.6033	0.3032
50	mc=4/ms=0	0.6987	1.0676	0.5012	0.6539	0.6206	0.4949	0.6125	0.4175	0.5199	0.1727	0.4374	0.6642	0.3869
51	mc=4/ms=0.5	0.6987	1.0676	0.5012	0.6539	0.6206	0.4949	0.6560	0.4175	0.5199	0.1727	0.4374	0.6704	0.3869
52	mc=4/ms=1	0.6987	1.0796	0.5012	0.6648	0.6243	0.5210	0.6995	0.4175	0.5199	0.1776	0.4389	0.6842	0.3885
53	mc=4/ms=1.5	0.6987	1.1167	0.5012	0.6893	0.6622	0.5731	0.7429	0.4556	0.5199	0.1869	0.4642	0.7120	0.4067
54	mc=4/ms=2	0.7266	1.1538	0.5076	0.7138	0.7000	0.6251	0.7864	0.5189	0.5199	0.1961	0.4895	0.7448	0.4311
55	mc=4/ms=2.5	0.7575	1.1908	0.5293	0.7382	0.7378	0.6772	0.8299	0.5821	0.5368	0.2054	0.5148	0.7801	0.4598
56	mc=4/ms=3	0.7884	1.2279	0.5511	0.7627	0.7757	0.7293	0.8734	0.6454	0.5643	0.2147	0.5401	0.8155	0.4911
57	mc=4.5	0.6786	1.1311	0.4731	0.6928	0.6173	0.4689	0.6890	0.2991	0.4494	0.1789	0.4368	0.6787	0.3411
58	mc=4.5/ms=0	0.7741	1.1933	0.5538	0.7309	0.6892	0.5470	0.6890	0.4508	0.5699	0.1926	0.4860	0.7396	0.4248
59	mc=4.5/ms=0.5	0.7741	1.1933	0.5538	0.7309	0.6892	0.5470	0.7325	0.4508	0.5699	0.1926	0.4860	0.7458	0.4248
60	mc=4.5/ms=1	0.7741	1.2053	0.5538	0.7418	0.6929	0.5731	0.7760	0.4508	0.5699	0.1975	0.4874	0.7596	0.4264
61	mc=4.5/ms=1.5	0.7741	1.2424	0.5538	0.7663	0.7308	0.6252	0.8195	0.4889	0.5699	0.2067	0.5127	0.7874	0.4446
62	mc=4.5/ms=2	0.8020	1.2794	0.5601	0.7907	0.7686	0.6772	0.8630	0.5521	0.5699	0.2160	0.5380	0.8202	0.4690
63	mc=4.5/ms=2.5	0.8329	1.3165	0.5819	0.8152	0.8064	0.7293	0.9065	0.6154	0.5867	0.2253	0.5633	0.8555	0.4977
64	mc=4.5/ms=3	0.8638	1.3536	0.6037	0.8397	0.8443	0.7814	0.9500	0.6786	0.6142	0.2346	0.5886	0.8909	0.5290
65	mc=5	0.7540	1.2568	0.5257	0.7698	0.6859	0.5210	0.7656	0.3323	0.4994	0.1988	0.4854	0.7541	0.3790
66	mc=5/ms=0	0.8495	1.3190	0.6064	0.8079	0.7578	0.5991	0.7656	0.4840	0.6198	0.2125	0.5345	0.8150	0.4627
67	mc=5/ms=0.5	0.8495	1.3190	0.6064	0.8079	0.7578	0.5991	0.8091	0.4840	0.6198	0.2125	0.5345	0.8212	0.4627
68	mc=5/ms=1	0.8495	1.3310	0.6064	0.8188	0.7615	0.6252	0.8526	0.4840	0.6198	0.2173	0.5360	0.8350	0.4643
69	mc=5/ms=1.5	0.8495	1.3681	0.6064	0.8432	0.7993	0.6773	0.8961	0.5221	0.6198	0.2266	0.5613	0.8628	0.4824
70	mc=5/ms=2	0.8775	1.4051	0.6127	0.8677	0.8372	0.7293	0.9395	0.5853	0.6198	0.2359	0.5866	0.8956	0.5069
71	mc=5/ms=2.5	0.9083	1.4422	0.6345	0.8922	0.8750	0.7814	0.9830	0.6486	0.6367	0.2452	0.6119	0.9309	0.5356
72	mc=5/ms=3	0.9392	1.4793	0.6562	0.9167	0.9128	0.8335	1.0265	0.7119	0.6641	0.2545	0.6372	0.9663	0.5669

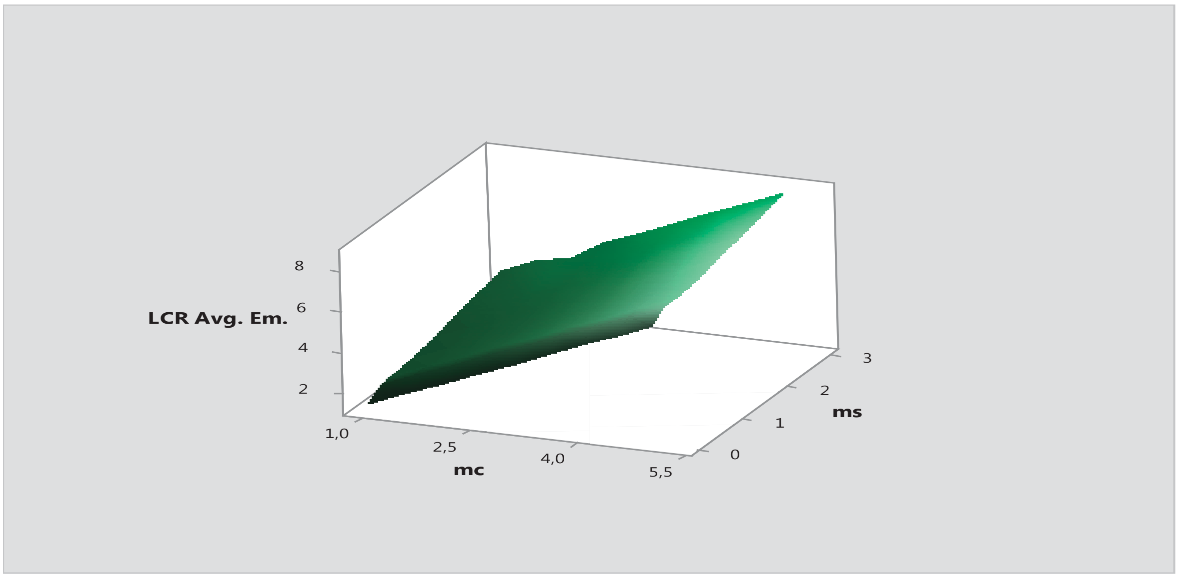
Table 16

Line	-mc/ms	Brazil	Hungary	India	Cz.Rp.	Indon.	Malay.	China	Arg.	Lit.	Tunisia	Croatia	Av.Em.	Av.Ft.
1	mc=1	1.25	1.95	0.91	2.48	0.85	0.95	1.11	0.95	0.92	0.56	2.26	1.35	1.17
2	mc=1/ms=0	2.04	2.43	1.60	3.09	1.29	1.66	1.11	2.84	2.03	0.76	3.24	1.89	2.22
3	mc=1/ms=0.5	2.04	2.43	1.60	3.09	1.29	1.66	1.42	2.84	2.03	0.76	3.24	1.93	2.22
4	mc=1/ms=1	2.04	2.53	1.60	3.27	1.31	1.90	1.73	2.84	2.03	0.83	3.27	2.05	2.24
5	mc=1/ms=1.5	2.04	2.81	1.60	3.66	1.55	2.38	2.05	3.31	2.03	0.96	3.77	2.30	2.52
6	mc=1/ms=2	2.27	3.10	1.66	4.05	1.78	2.85	2.36	4.10	2.03	1.09	4.28	2.58	2.87
7	mc=1/ms=2.5	2.52	3.39	1.84	4.45	2.02	3.33	2.67	4.88	2.18	1.22	4.79	2.89	3.27
8	mc=1/ms=3	2.78	3.68	2.03	4.84	2.25	3.80	2.99	5.67	2.44	1.35	5.29	3.20	3.69
9	mc=1.5	1.87	2.93	1.36	3.72	1.27	1.43	1.66	1.24	1.38	0.85	2.91	2.03	1.59
10	mc=1.5/ms=0	2.66	3.41	2.05	4.33	1.72	2.14	1.66	3.13	2.49	1.04	3.89	2.57	2.64
11	mc=1.5/ms=0.5	2.66	3.41	2.05	4.33	1.72	2.14	1.97	3.13	2.49	1.04	3.89	2.61	2.64
12	mc=1.5/ms=1	2.66	3.50	2.05	4.50	1.74	2.38	2.29	3.13	2.49	1.11	3.92	2.73	2.66
13	mc=1.5/ms=1.5	2.66	3.79	2.05	4.90	1.97	2.85	2.60	3.60	2.49	1.24	4.43	2.97	2.94
14	mc=1.5/ms=2	2.89	4.08	2.11	5.29	2.21	3.33	2.91	4.39	2.49	1.37	4.93	3.26	3.29
15	mc=1.5/ms=2.5	3.15	4.36	2.30	5.69	2.44	3.80	3.23	5.17	2.64	1.51	5.44	3.57	3.69
16	mc=1.5/ms=3	3.40	4.65	2.48	6.08	2.67	4.28	3.54	5.96	2.90	1.64	5.94	3.87	4.11
17	mc=2	2.49	3.90	1.81	4.95	1.69	1.90	2.21	1.65	1.84	1.13	3.88	2.71	2.13
18	mc=2/ms=0	3.28	4.38	2.51	5.57	2.14	2.62	2.21	3.54	2.95	1.32	4.86	3.24	3.17
19	mc=2/ms=0.5	3.28	4.38	2.51	5.57	2.14	2.62	2.52	3.54	2.95	1.32	4.86	3.29	3.17
20	mc=2/ms=1	3.28	4.48	2.51	5.74	2.16	2.85	2.84	3.54	2.95	1.39	4.89	3.41	3.19
21	mc=2/ms=1.5	3.28	4.76	2.51	6.14	2.40	3.33	3.15	4.01	2.95	1.52	5.40	3.65	3.47
22	mc=2/ms=2	3.51	5.05	2.56	6.53	2.63	3.80	3.47	4.80	2.95	1.66	5.90	3.94	3.83
23	mc=2/ms=2.5	3.77	5.34	2.75	6.92	2.86	4.28	3.78	5.58	3.10	1.79	6.41	4.24	4.22
24	mc=2/ms=3	3.77	5.34	2.75	6.92	2.86	4.28	3.78	5.58	3.10	1.79	6.41	4.24	4.22
25	mc=2.5	3.12	4.88	2.26	6.19	2.12	2.38	2.76	2.07	2.30	1.41	4.85	3.39	2.66
26	mc=2.5/ms=0	3.91	5.36	2.96	6.81	2.56	3.09	2.76	3.95	3.41	1.60	5.83	3.92	3.70
27	mc=2.5/ms=0.5	3.91	5.36	2.96	6.81	2.56	3.09	3.08	3.95	3.41	1.60	5.83	3.97	3.70
28	mc=2.5/ms=1	3.91	5.45	2.96	6.98	2.59	3.33	3.39	3.95	3.41	1.67	5.86	4.09	3.72
29	mc=2.5/ms=1.5	3.91	5.74	2.96	7.38	2.82	3.80	3.70	4.42	3.41	1.81	6.37	4.33	4.00
30	mc=2.5/ms=2	4.14	6.03	3.02	7.77	3.05	4.28	4.02	5.21	3.41	1.94	6.87	4.61	4.36
31	mc=2.5/ms=2.5	4.39	6.31	3.20	8.16	3.29	4.76	4.33	6.00	3.56	2.07	7.38	4.92	4.75
32	mc=2.5/ms=3	4.65	6.60	3.39	8.56	3.52	5.23	4.65	6.78	3.82	2.20	7.88	5.23	5.17
33	mc=3	3.74	5.85	2.72	7.43	2.54	2.85	3.32	2.48	2.76	1.69	5.82	4.06	3.19
34	mc=3/ms=0	4.53	6.33	3.41	8.04	2.99	3.57	3.32	4.36	3.87	1.89	6.80	4.60	4.23
35	mc=3/ms=0.5	4.53	6.33	3.41	8.04	2.99	3.57	3.63	4.36	3.87	1.89	6.80	4.64	4.23

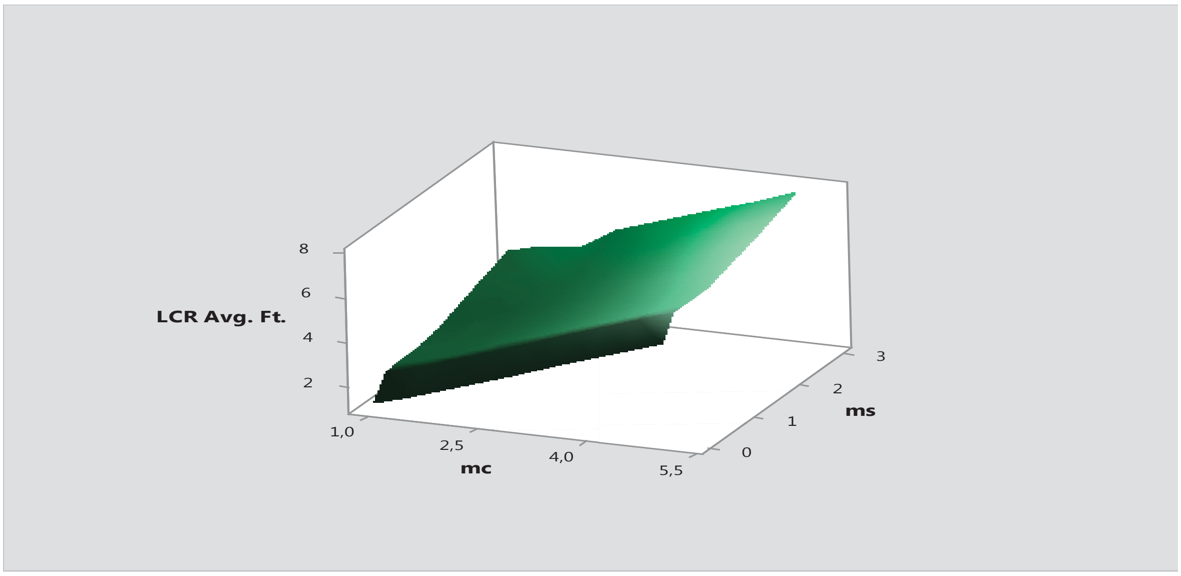
36	mc=3/ms=1	4.53	6.43	3.41	8.22	3.01	3.80	3.94	4.36	3.87	1.96	6.83	4.76	4.25
37	mc=3/ms=1.5	4.53	6.71	3.41	8.61	3.24	4.28	4.26	4.84	3.87	2.09	7.34	5.01	4.53
38	mc=3/ms=2	4.76	7.00	3.47	9.01	3.48	4.76	4.57	5.62	3.87	2.22	7.84	5.29	4.89
39	mc=3/ms=2.5	5.02	7.29	3.66	9.40	3.71	5.23	4.88	6.41	4.02	2.35	8.35	5.60	5.28
40	mc=3/ms=3	5.27	7.58	3.84	9.80	3.94	5.71	5.20	7.20	4.28	2.48	8.85	5.91	5.70
41	mc=3.5	4.36	6.83	3.17	8.67	2.97	3.33	3.87	2.89	3.22	1.97	6.79	4.74	3.72
42	mc=3.5/ms=0	5.15	7.31	3.87	9.28	3.41	4.04	3.87	4.78	4.33	2.17	7.77	5.28	4.76
43	mc=3.5/ms=0.5	5.15	7.31	3.87	9.28	3.41	4.04	4.18	4.78	4.33	2.17	7.77	5.32	4.76
44	mc=3.5/ms=1	5.15	7.40	3.87	9.46	3.43	4.28	4.50	4.78	4.33	2.24	7.80	5.44	4.79
45	mc=3.5/ms=1.5	5.15	7.69	3.87	9.85	3.67	4.76	4.81	5.25	4.33	2.37	8.31	5.68	5.06
46	mc=3.5/ms=2	5.38	7.98	3.92	10.25	3.90	5.23	5.12	6.04	4.33	2.50	8.81	5.97	5.42
47	mc=3.5/ms=2.5	5.64	8.26	4.11	10.64	4.13	5.71	5.44	6.82	4.48	2.63	9.32	6.28	5.81
48	mc=3.5/ms=3	5.89	8.55	4.30	11.03	4.37	6.18	5.75	7.61	4.74	2.77	9.82	6.58	6.23
49	mc=4	4.99	7.80	3.62	9.91	3.39	3.81	4.42	3.30	3.68	2.26	7.76	5.42	4.25
50	mc=4/ms=0	5.78	8.28	4.32	10.52	3.83	4.52	4.42	5.19	4.79	2.45	8.74	5.95	5.29
51	mc=4/ms=0.5	5.78	8.28	4.32	10.52	3.83	4.52	4.73	5.19	4.79	2.45	8.74	6.00	5.29
52	mc=4/ms=1	5.78	8.38	4.32	10.70	3.86	4.76	5.05	5.19	4.79	2.52	8.77	6.12	5.32
53	mc=4/ms=1.5	5.78	8.66	4.32	11.09	4.09	5.23	5.36	5.66	4.79	2.65	9.28	6.36	5.60
54	mc=4/ms=2	6.01	8.95	4.37	11.49	4.32	5.71	5.68	6.45	4.79	2.78	9.78	6.65	5.95
55	mc=4/ms=2.5	6.26	9.24	4.56	11.88	4.56	6.18	5.99	7.24	4.94	2.92	10.29	6.95	6.35
56	mc=4/ms=3	6.52	9.53	4.75	12.27	4.79	6.66	6.30	8.02	5.20	3.05	10.79	7.26	6.77
57	mc=4.5	5.61	8.78	4.08	11.15	3.81	4.28	4.97	3.72	4.14	2.54	8.73	6.10	4.78
58	mc=4.5/ms=0	6.40	9.26	4.77	11.76	4.26	4.99	4.97	5.60	5.25	2.73	9.71	6.63	5.82
59	mc=4.5/ms=0.5	6.40	9.26	4.77	11.76	4.26	4.99	5.29	5.60	5.25	2.73	9.71	6.68	5.82
60	mc=4.5/ms=1	6.40	9.35	4.77	11.94	4.28	5.23	5.60	5.60	5.25	2.80	9.74	6.80	5.85
61	mc=4.5/ms=1.5	6.40	9.64	4.77	12.33	4.51	5.71	5.91	6.08	5.25	2.93	10.25	7.04	6.13
62	mc=4.5/ms=2	6.63	9.93	4.83	12.72	4.75	6.18	6.23	6.86	5.25	3.07	10.75	7.32	6.48
63	mc=4.5/ms=2.5	6.89	10.21	5.01	13.12	4.98	6.66	6.54	7.65	5.40	3.20	11.26	7.63	6.88
64	mc=4.5/ms=3	7.14	10.50	5.20	13.51	5.22	7.13	6.86	8.44	5.65	3.33	11.76	7.94	7.30
65	mc=5	6.23	9.75	4.53	12.39	4.24	4.76	5.53	4.13	4.60	2.82	9.70	6.77	5.31
66	mc=5/ms=0	7.02	10.23	5.23	13.00	4.68	5.47	5.53	6.02	5.71	3.02	10.68	7.31	6.36
67	mc=5/ms=0.5	7.02	10.23	5.23	13.00	4.68	5.47	5.84	6.02	5.71	3.02	10.68	7.35	6.36
68	mc=5/ms=1	7.02	10.33	5.23	13.17	4.70	5.71	6.15	6.02	5.71	3.08	10.71	7.47	6.38
69	mc=5/ms=1.5	7.02	10.61	5.23	13.57	4.94	6.18	6.47	6.49	5.71	3.22	11.22	7.72	6.66
70	mc=5/ms=2	7.25	10.90	5.28	13.96	5.17	6.66	6.78	7.28	5.71	3.35	11.72	8.00	7.01
71	mc=5/ms=2.5	7.51	11.19	5.47	14.36	5.41	7.13	7.09	8.06	5.86	3.48	12.23	8.31	7.41
72	mc=5/ms=3	7.76	11.48	5.65	14.75	5.64	7.61	7.41	8.85	6.11	3.61	12.73	8.61	7.83

Sensitivity Analysis–Loss Coverage with varying scaling factors m_c and m_s at α = 97.50%

Graph 4
Sensitivity analysis – Average LCR Emerging Markets



Graph 5
Sensitivity analysis – Average LCR Frontier Markets



Source: Prepared by author

disparate values for EVT when the confidence level nears the centre of the distribution, notwithstanding which likely appraisals situate from line 63 onwards (m_c=4.5, m_s=2.5).

Conclusions

ES has been initially proposed by the BCBS in 2012 as a theoretically superior alternative to VaR and its usage may, in principle, overcome VaR's deficiencies as a risk measure. Given that the BCBS opened up a consultation period to calculate the MCR using ES instead of VaR, the current paper aims at providing an initial approach designed to ascertain the impact of the introduction of ES in the determination of MCR under Basel II and Basel III frameworks, comparing the performance of two widespread Normal models with an EVT-based one in the context of the 2007-2008 subprime crisis.

In the first place, with reference to the model assessment, the evidence collected appears conclusive enough to name EVT as the most precise model during steep market slumps, as its estimations fall in the Green Zone for the three confidence levels tried (Exception made of India at 95%, where it records 15 exceptions, meriting a 17% surcharge), whereas for the Normal representations any feasible ranking appears blurred by the wide variety of Backtesting penalties.

Regarding the VaR-ES pairing, considering the structural difference between the two risk measures, ES values will not be smaller than the corresponding VaR and, accordingly, any estimation of MCR must take into account the fact that the confidence level would need to be brought down from the current official 99% required for VaR to abide by the recommendation stated in BCBS (2012) referred to the equivalence of capital levels. Applying EVT, MCR (for both Basel II and Basel III configurations) report a substantial increase from the corresponding VaR figures at 99% and a significant diminution at 95%, simultaneously recording similar values at 97.50%. The result implies, then, that ES should be reduced to a confidence level in an entourage of 97.50% in order to avoid significant discontinuities were a change of regime to take place. The BCBS (2012) appears to have acknowledged this fact in its Consultative Document, though stopping short of indicating a confidence level.

Usage of ES in MCR equation also gives rise to a host of possible combinations of variables like the confidence level and the parameters of the formula, conceding inverse relationship between the values of the fixed multiples m_c —Basel II— and the tandem m_c-m_s in Basel III. The proofs gathered show that, with α=99% under Basel II structure, m_c=1.5 could provide adequate coverage against market crisis whilst using Basel III, m_c=m_s=1 would represent a satisfactory blend. If α=97.50%, m_c=2 and m_c=2 / m_s=0.5 might prevent a crash of considerable scale utilising Basel II and Basel III frameworks respectively whereas when α=95%, the factors m_c and m_s should grow to figures greater than those of both Capital Accords.

The study also sheds light on the approximate equivalences between the VaR and ES-based MCR for Basel II and Basel III. In this vein, under Basel II specifications, m_c equal to 2, 2.5 and 4 applying ES at 99%, 97.50% and 95% respectively yields similar values to m_c=3 using VaR while using Basel III provisions the mix could roughly situate in the region of m_c=2 / m_s=1.5, m_c=3 / m_s=2.5 and m_c=4 / m_s=2.5 when α=99%, 97.50% and 95% respectively.

It is imperative to continue studying the behaviour of ES in the context of MCR though there would be evidence that the confidence level ought to be decreased to percentages in an entourage of 97.50%. Furthermore, the study suggests that, provided an accurate model is employed, Basel III parameters m_c and m_s should appear excessive (yet unnecessary) for ES. BCBS ought to strike, then, a proper balance among the confidence level, the calibration of the appropriate parameters and the treatment dispensed to precise and inaccurate techniques in order to maintain the incentives to utilise sharp representations and dispel the chance of inaccuracy temptations.

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