The impact of the Fundamental Review of the Trading Book:

A preliminary assessment on a stylized portfolio

Chiara Pederzoli, University of Milano Bicocca and CEFIN

Costanza Torricelli, University of Modena and Reggio Emilia, CEFIN and CeRP

Abstract

The aim of this paper is to gauge the impact in terms of capital requirements against market risk of the Fundamental Review of the Trading Book (FRTB). To this end we take a stylized portfolio sensible to the risk factors mostly affected by the review and we gauge the impact of the new regulation both under the Standard Approach (SA) and the Internal Model Approach (IMA). Our results provide an order of magnitude of the increase across the two regulations and the two approaches (SA and IMA), and disentangle the expected increase implied by the FRTB in its main effects both for the SA and IMA approach.

Keywords: trading portfolio, VaR, stressed VaR, Expected shortfall, bank regulation

JEL: E30, E44, G01, G10, G28

April 2019

Acknowledgments: The authors are very grateful to Andrea Lusetti and Simone Venturelli for excellent research assistance, the discussant Pedro Verissimo and participants to the Portuguese Finance Network 2018 (Lisbon) for helpful comments and suggestions. Usual caveat apply.

1. INTRODUCTION

Following the Great Financial Crisis of 2007-2009 the need of a revision of bank capital regulation became apparent and the Basel Committee on Banking Supervision (BCBS) reacted with a series of reforms to the so-called Basel 2 regulation. Specifically in 2011 a first reform to the market risk framework, known as Basel 2.5, was published (BCBS, 2011a). However it immediately appeared insufficient to grant bank resiliency from the market risk perspective, and the Committee issued a series of three consultative documents (BCBS, 2012, 2013, 2014b) aimed to set a new discipline of market risk known as the Fundamental Review of the Trading Book (FRTB). A comprehensive version of the document was published in January 2016 (BCBS, 2016a). After further consultation in 2018, the final FRTB document was published in 2019 (BCBS, 2019) and is to be enforced in 2022. The new market risk framework formalizes five main key enhancements. As for the *internal models-approach (IMA),* the revision concerns both a more rigorous *model approval process* (specifically profit and loss attribution test) and a *shift from Value-at-Risk (VaR) to Expected Shortfall (ES) as measure of risk under stress*, whereby the latter help to ensure capturing "tail risk" and capital adequacy during periods of significant financial market stress. As for the *standardised approach (SA)*, the revision makes it sufficiently risk-sensitive to serve as a credible fall-back to the IMA providing at the same time an appropriate standard for banks that do not require a sophisticated treatment for market risk. A fourth area concerns the *incorporation of the risk of market illiquidity*, since different liquidity horizons are incorporated into the revised SA and IMA to mitigate liquidity risk across asset markets and a limit to the diversification benefit is also introduced. These replace the static 10-day horizon assumed for all traded instruments under VaR in the current framework. Finally, a *more objective boundary between the trading book and banking book* is introduced to reduce regulatory arbitrage between banking and trading books.

To the end of the present paper we recall the main novelties introduced by the FRTB. As for the SA, the capital charge results from the sum of three main components: the *Sensitivities-based Method* (SbM), the *Default Risk Charge* (DRC) and the *Residual Risk Add-On* (RRAO). The SbM is the main and most complex component calclulated by aggregating three risk measures: delta, based on sensitivities of a bank's trading book to regulatory delta risk factors; vega, based on sensitivities to regulatory vega risk factors; curvature, which captures the incremental risk not captured by the delta risk of price changes in the value of an option. The DRC captures the jump-to-default risk for the whole trading portfolio. The RRAO accounts for market risks not being captured in the standardised approach.

For banks adopting internal IMA, main changes are:

• the risk metrics: the current sum of VaR (10 day-1%) and *stressed*-VaR (s-VaR) over 12 months of significant losses, has to be replaced by ES, expected loss when loss greater than a 97.5% VaR calibrated over a 12 months stress period;

• the liquidity horizons: the current VaR based requirements are rescaled based on a 10-day horizon, whereas ES has to be adjusted on the basis of liquidity horizons, which differ according to the types of risk factors that impact the portfolio;

• the limits to benefits from diversification: while VaR is currently calculated at the portfolio level, ES is calculated on sub-sets of risk factors too:, in order to limit the "benefits of diversification", the capital charge is calculated as an average of the "diversifiable" and "non diversifiable" ES;

• the risk of default: outside securitisations, the principles of Basel 2.5 have been preserved, but the Incremental Risk Charge (IRC) has been replaced by a Default Risk Charge (DRC). The DRC excludes the migration risk but introduces a lower bound for PDs and extends its application to the equity.

As for the consequences of FRTB in terms of increased capital requirements, an interim impact analysis was offered in (BCBS, 2015), which presented a second assessment on the capital impact of the FRTB. Based on a sample of 44 banks, the capital requirement under the proposed internally-modelled approaches is 54% higher than under current internally-modelled approaches. Based on a sample of only 9 banks that provided complete data on both the revised standardised and internal model approaches, capital requirements under the standardised approach are 2 to 3 times higher than the internally modelled approaches. To be stressed that the report refers to review in the consultative documents (BCBC 2012, 2013) and the comparison was with respect to the market risk capital framework in BCBS (2009a, b). Moreover, the results presented in the report are based on parameter values set at the time the Quantitative Impact Study (QIS) was undertaken, and "It does not reflect any subsequent revisions to either the internal model-based approach or standardised approach"(BCBS, 2015, page 3).

The forthcoming implementation of the FRTB has fostered a debate among academics, consultants and, more generally, in the banking industry (e..g. Farag 2017, Masera, 2016), and the discussion has been also framed within the context of a general upgrade from Basel 3 to Basel 4 (e.g. Magnus et al. 2017).

Against this backdrop the aim of this paper is to gauge, both from the SA and IMA perspective, the impact in term of capital requirements against market risk of the final version of the FRTB (BCBS, 2019), with respect to the current regulation (BCBS, 2011a). Given that realistic trading portfolios differ according to the specificity of each bank, we do not aim to a precise quantitative measurement. Rather our analyses has two main objectives: to gauge the order of magnitude of the increase across the two regulations and the two approaches, and to disentangle the expected increase implied by the FRTB in its main effects both for the SA and IMA approach. To this end we take a stylized portfolio sensible to the risk factors mostly impacted by the review and we compare capital requirements under the two regulations and across the SA and IMA perspective. Estimates of the various metrics (VaR, sVaR and ES) are based on historical simulation, which is the mostly used approach in the banking industry (EBA 2017).

The paper is structured as follows. Section 2 recalls the main feature of the FRTB under the two approaches (SA and IMA). Section 3 describes the portfolio and the dataset, while Section 4 presents results on capital charges and capital requirements. Section 5 provides a comparison across the two regulations and the two approaches. Last Section concludes with a discussion of results and possible implications.

2. THE CAPITAL REQUIREMENT UNDER THE FRTB

2.1 **Standardized approach**

The capital charge results from the sum of three main components: the *Sensitivities-based Method* (SbM), the *Default Risk Charge* (DRC), the *Residual Risk Add-On* (RRAO).The SbM is calculated by aggregating three risk sensitivities: delta, vega, and curvature. The curvature captures the incremental risk not captured by the delta risk of price changes in the value of an option. Delta, vega and curvature can be see in relation to the greeks of options (delta, vega and gamma respectively).

The delta and the vega charges are calculated following the same steps and the same aggregation formula. Each risk measure has to be estimated according to each risk factor, which have to be mapped into 7 macro classes selected by the regulator: the general interest rate risk (GIRR), the credit spread risk (CSR) for the non securitized exposures, the credit spread risk in the securitized exposures in or out of the correlation trading portfolio, the equity risk, the commodity risk and the foreign exchange risk. To make the estimation issue clearer let us take a few of the most common sensitivities. For example delta GIRR, is a risk factor defined over two dimensions: a risk-free curve for each currency in which interest-rate sensitive assets are denominated, and the so called vertices to which the delta risk factors are assigned (3-6 months, 1-2-3-5-10-15-20-30 years). To take another example let us consider the delta CSR of non-securitized assets, where the two dimensions are the credit spread curve of the issuer (of Bond and CDS) and the vertices to which the delta risk factors are assigned (6 months, 1-3-5-10 years). Finally, the delta equity risk factors are all the equity spot prices. Moreover, all instruments with optionality require the computation of vega and curvature. For example, considering an option on equity, the vega equity risk factors are the the implied volatilities of options that reference the equity spot prices as underlyings. The equity curvature risk factors are again all the underlying equity spot prices.

Moreover each sensitivity (e.g. delta GIRR, delta CSR, delta Equity) is further composed according to the so-called buckets: e.g. for delta GIRR each currency is a bucket, for delta Equity buckets are defined in terms of size and sector (see Table 9 BCBS 2019)9.

Once the sensitivities s_k are estimated for each risk factor k, they are weighted using weights RW_k, provided by the regulator so as to obtain the weighted sensitivity WS_k.

$$\mathrm{WS_k} = \mathrm{RW_k s_k}$$

For example, in the case of delta Equity, the risk weights differ according to 13 buckets (Table 10 BCBS 2019).

The sensitivities thus obtained for each risk factor *k*, are aggregated using the correlations ρ_{kl} for risk factors *k* and *l* defined by the regulator to the risk poistion for each *bucket*, K_b:[1]

$$K_b = \sqrt{\sum_k WS_k^2 + \sum_k \sum_{k \neq l} \rho_{kl} WS_k WS_l}$$

The final aggregation is across *buckets*, using the buckets' correlations γ_{bc}, provided by the regulator to obtain the risk charge:

$$Risk\ Charge = \sqrt{\sum_b K_b^2 + \sum_b \sum_{c \neq b} \gamma_{bc} S_b S_c}$$

Where $S_b = \Sigma_k WS_k$ and $S_c = \Sigma_k WS_k$ for all risk factors in *bucket b and c respectively.* [2]

The computation of the curvature component follows a different procedure: it consists in the application of two stress scenarios corresponding to a positive and a negative shock.

We need first of all calculate the *net curvature sensitivity* of instruments for each risk factor associated. For each risk factor the two shocks are applied and the relative variation in the instrument value is calculated: the highest loss is taken as risk charge. Then the curvature risk exposures are aggregated for each bucket using regulatory defined correlation indexes. The final charge for curvature risk is obtained by aggregation over buckets. To account for the risk that correlations may increase or decrease in periods of financial stress, three risk charge figures must be calculated for each risk class based on three different scenarios where correlation indexes are multiplied by 1,25, 1 and 0,75 to represent high, median and low correlation respectively. We refer to BCBS (2019) for the details.

[1] The quantity within the square root is floored to zero.

[2] If the quantity within the square root is negative an alternative specification is given by the regualtor (CBBS, 2019).

[3] The observation period must span back at least to include 2007

If the quantity within the square root is negative an alternative specification is given by the regualtor (CBBS, 2019).

2.2 **The Internal Model approach**

The FRTB substantially changes the calculation of the capital requirements, whereby two are the main innovations:

1. the metrics used for calculation, from VaR 99% to ES 97,5% ;
2. the time horizon considered, from the standard 10 days horizon to different horizons consistent with the liquidity of asset classes.

The FRTB does not impose any specific model to estimate ES, as well as for VaR estimation under the current regulation. As for the time horizon the innovation is actually two-fold: while under the current regulation the 10-days ahead VaR can be computed from the one-day ahead VaR multiplied by the square root of time rule, the FRTB explicitly asks to consider 10-day variations in building the P&L distribution. A square root adjustment is then applied to account for longer liquidity horizons as follows:

$$ES = \sqrt{(ES_{10})^2 + \sum_{j\geq 2}\left(ES_{10}(j)\sqrt{\frac{LH_j - LH_{j-1}}{10}}\right)^2} \qquad (1)$$

where:

ES_{10} = portfolio expected shortfall over a 10 days horizon;

LH_j = liquidity horizon for risk factors in class j, as defined in Table 1 and 2.

$ES_{10}(j)$ = expected shortfall computed with respect to shocks in the risk factors with liquidity horizon at least as long as LH_j only.

The ES in (1) must be calibrated over a 12-month period of stress, which is to be selected over a longer horizon[3] according to the largest portfolio losses. In order to choose the stress period, banks are allowed to use a reduced set of risk factors: to account for this the FRTB applies a further correction on (1), which has no impact if all the risk factors are considered.

[3] The observation period must span back at least to include 2007.

Table 1 *Liquidity horizon in FRTB*

j	LH_j
1	10
2	20
3	40
4	60
5	120

Source: BCBS (2019)

Table 2: Liquidity horizons according to the risk factor category

Risk factor category	n	Risk factor category	n
Interest rate: specified currencies - EUR, USD, GBP, AUD, JPY, SEK, CAD and domestic currency of a bank	10	Equity price (small cap): volatility	60
Interest rate: – unspecified currencies	20	Equity: other types	60
Interest rate: volatility	60	FX rate: specified currency pairs[37]	10
Interest rate: other types	60	FX rate: currency pairs	20
Credit spread: sovereign (IG)	20	FX: volatility	40
Credit spread: sovereign (HY)	40	FX: other types	40
Credit spread: corporate (IG)	40	Energy and carbon emissions trading price	20
Credit spread: corporate (HY)	60	Precious metals and non-ferrous metals price	20
Credit spread: volatility	120	Other commodities price	60
Credit spread: other types	120	Energy and carbon emissions trading price: volatility	60
		Precious metals and non-ferrous metals price: volatility	60
Equity price (large cap)	10	Other commodities price: volatility	120
Equity price (small cap)	20	Commodity: other types	120
Equity price (large cap): volatility	20		

Source: BCBS (2019)

In addition to the global ES (henceforth diversifiable ES), banks must also calculate partial ES for each class of risk factors, which are summed up to calculate a non-diversifiable ES. The rationale is to neglect benefits deriving from diversification in a conservative perspective. The capital charge is then defined as the average of diversifiable and non-diversifiable ES.

An add-on for non-modellable risk factors is summed to the ES defined above. Both measures are calculated also as an average of the last 60 days, andAs it is the case under the current regulation the final capital charge is the highest of the current measures and the averages of the same relative to the last 60 days.[4]

A Default risk charge (DRC) must also be estimated, based on a VaR model, to account for potential losses deriving from an obligor's default. The DRC is again summed up to the above-defined charge to obtain the global capital requirement.

3. THE PORTFOLIO AND THE DATASET

In order to simplify the analysis and highlight main channels of the impact on capital requirements of the FRTB, the portfolio we set up is stylized yet representative since it captures the typical risk factors of a trading portfolio (interest rate, credit spread, equity and foreign exchange) and the associated liquidity horizon required by the review. Specifically, in order to highlight the effects of the change in regulation, we need to have the presence of risk factor whose liquidity horizon goes beyond the 10-day one that characterizes the current regulation. Furthermore, the portfolio taken allows capturing all the sensitivities introduced by the new SA. Specifically, assuming the viewpoint of a euro-centred bank, we take:

a)A high yield bond position, which is sensitive to both interest rate and credit spread risk;

b)Two equity positions, highly representative of the Italian equity market;

c)An at the money index option, which is sensitive to equity prices and volatility;

d)A foreign currency cash position, which is sensitive to the exchange rate.

[4] The average ES is actually multiplied by a factor dependent on the backtest outcome.

Table 3 reports the specific composition of the portfolio considered and its current value. [5]

Table 3: Portfolio's composition and value

Asset	*Description*	Position	Current value (€)	Weight
Bond Intesa San Paolo	Nominal value: 50.000€, Coupon 5%, Maturity: 23/09/2019, Rating: BB+	18	929.457 €	50,48%
Equity Eni	Unitary price: 16,34€	12.500	204.275 €	11,09%
Equity Unicredit	Unitary price: 12,43€	16.000	198.816 €	10,80%
Foreign currency (USD cash)	Exchange rate (EUR/USD): 1,1549	$500.000	432.950 €	23,51%
Call option on FTSE MIB	Moneyness ATM, Maturity: 15/03/2019	30	75.675 €	4,11%
Total			1.841.173 €	100,00%

We used Bloomberg as data provider, considering 2 October 2018 as reference date on which we estimate all the relevant risk metrics for the SA, and the period December 2007- December 2008 for the sVar and ES estimates of the IMA.

[5] Note that to simplify we have modeled interest rate risk on a single maturity. Moreover,we have not included any commodity position.

4. THE CALCULATION OF CAPITAL REQUIREMENTS UNDER SA AND IMA

In this Section we present the calculation of the capital requirement under the newly proposed regulation. We separately present the SA and the IMA approaches in Section 4.1 and 4.2 respectively. In Section 4.3 we propose a comparison of the two approaches. Along our analysis the DRC component is neglected.

4.1 **The capital charge under the SA**

In Table 4 we present the capital requirement deriving from the application of the proposed SA to the portfolio defined in Section 3.

Table 4: Capital requirement components under the new SA

Components	Capital charge	Weights on the full capital requirement	Percentage on portfolio value
GIRR	26.966,20 €	3,78%	1,46%
EQUITY	512.144,74 €	71,88%	27,82%
FOREX	64.942,79 €	9,12%	3,53%
CSR	108.473,82 €	15,22%	5,89%
Total SbM[(1)]	712.527,55 €	100%	

(1) SbM = Sensitivities-based Method, equal to the sum of the capital charges for each risk class

The results show that the new SA implies a high capital requirement, which amounts to 38,7% of the portfolio's market value. Within the SbM the equity risk component emerges as the most impacting. In order to deepen the analysis, in Table 5 we report the decomposition of the equity charge among the three components: Delta, Vega and Curvature. The relevance of the Delta component is due to the long positions without hedging instruments.

Table 5: Decomposition of the equity risk charge

Equity components	Capital charge	Weights on the total capital charge	Percentage on portfolio value
Delta	468.820,04 €	91,54%	25,46%
Vega	43.324,70 €	8,46%	2,35%
Curvature	-	-	-
Total	512.144,74 €	100%	27,82%

4.2 The capital charge under the IMA

In this Section we compute the capital charge under the newly proposed IMA. Consistently with the regulation, we select a 12-month period of financial turbulence in order to estimate ES. The stress period, which registers the worst losses on the hypothetical portfolio, turns out to be the 252 days from 13/12/2007 to 12/12/2008 as expected. This period is then extended to enclose the specific *liquidity horizon* (LH) for each risk factor. Beyond the basic 10-days horizon, we have to account for a 60-day horizon for the credit spread in high yield corporate bond and a 20-day horizon for equity volatility impacting on the index option.

The portfolio P&L distribution, in line with the majority of banks (EBA 2017), is estimated by historical simulation.[6] Among the advantages of this non-parametric approach (e.g. O'Brien e Szerszen, 2014), the most valuable, above its simplicity, is the absence of distributional hypotheses: the joint distribution of the risk factors, which determines the distribution of the total P&L, is completely driven by historical data. The portfolio considered in this paper is affected by seven risk factors: one year risk free interest rate, credit spread, FTSE MIB price and volatility, Eni and Unicredit equity prices, EUR/USD exchange rate.

[6] An alternative to plain historical simulation is volatility weighted historical simulation (VWHS): Laurent e Omidi Firouzi (2017) discuss the use of this method in relation to the new regulation.

While the standard time horizon for both VaR and ES in the current and new regulation is 10 days, under the current regulation daily VaR can be transformed into 10-day VaR by the square root of time rule. By contrast, the new regulation under the FRTB requires a 10 days horizon to be considered in the estimation of ES. Therefore, while for VaR estimation a one day ahead P&L distribution can be considered, for the estimation of ES we need to build a 10 days ahead distribution. It is explicitly allowed to use overlapping observations to build the time series of changes in risk factors (BCBS 2019 33.4).

The portfolio is evaluated over all scenarios of risk factors variation, and the changes in value are considered: by ordering the hypothetical portfolio value changes a distribution of the portfolio 10 days P&L is obtained. Then both VaR and ES can be calculated just by choosing the desired confidence level. The FRTB then applies a liquidity horizon adjustment to the 10 days ES according to Table 1 as described in Section 2.

In order to understand the impact of the new regulation, we measure the capital requirement for the stylized portfolio described in Section 3 under the the FRTB. Before presenting the results, we list and discuss the hypotheses taken to calculate the capital requirement under the FRTB.

The first hypothesis, consistent with the simple structure of the portfolio, is that the full set of risk factors coincides with the reduced set: this implies no need for the adjustment mentioned in Section 2. [7] Secondly we only have modellable risk factors impacting the portfolio value and therefore the capital add-on for non-modellable risk factors is assumed to be zero. Third, since for our stylized portfolio the ES and SVaR remain constant, we consider the last values [8]and we neglect the multipliers

In order to determine the full ES-based charge (IMCC) as reported in Table 6, we need to calculate the average between the unconstrained ES (IMCC(C)) and the constrained ES (IMCC(Ci)): the latter is given by the sum of the ES for risk classes (equity, foreign exchange, credit spread and GIRR) and therefore neglects the

[7] This hypothesis amounts to assume the adjustment ratio equal to 1 in BCBS (2019), 33.6.

[8] The Basel regulation requires for each metrics (VaR, sVaR, ES) to take the highest of the current value and the average of the last 60 days multiplied by a scaling factor as explained in Section 2.2.

benefits of diversification. To quantify the effect of diversification, in Table 6 we present the comparison between constrained and unconstrained ES: the IMCC(C) is lower than IMCC(Ci) as expected.

Table 6: Comparison between constrained and unconstrained ES

Risk measure	Capital charge	Percentage on portfolio value
ES diversifiable IMCC(C)	213.735,63 €	11,61%
ES not diversifiable IMCC(C_i)	245.823,04 €	13,35%
IMCC = Average ES	229.779,34 €	12,48%

A further analysis, along the line of Section 4.1, can be done by decomposing the constrained ES by risk class: from the results presented in Table 7, the equity class emerges as the most important for our portfolio.

Table 7: Decomposition of constrained ES

Risk class	Instruments	*Capital charge*	Percentage on portfolio value
ES EQUITY	Azioni, Opzione	162.020,47 €	8,80%
ES CSR	Bond	43.424,90 €	2,36%
ES FX	Valuta estera	38.360,84 €	2,08%
ES GIRR	Bond, Opzione	2.016,83 €	0,11%
IMCC(C_i)		245.823,04 €	13,35%

4.3 Comparison between IMA and SA

From the results presented in Section 4.1 and 4.2 it is evident that the IMA requirement is much lower than the SA one. In this Section we directly compare them. The result in Table 8 is sharp, consistently with Farag (2017), Hortin (2016) and Orgeldinger (2017). However, this very strong result is partly due to the chosen portfolio: we did not consider hedging positions, which allow reduction in the SA capital charge. The SA does not account at all for diversification.

Table 8: Comparison between SA and IMA capital charge under FRTB

Approach	*Capital charge*	Percentage on portfolio value	SA over IMA ratio
SA	712.527,55 €	38,7%	310,1%
IMA	229.779,34 €	12,48%	

Capital charges reported in Table 8 are directly comparable with the results presented in the QIS (BCBS 2015). In our work, the simple and transparent structure of the stylized portfolio allows to clearly quantify the impact of the new regulation on single risk factors. Actually the capital charge from SA in QIS is even higher then in our exampe; however, QIS was based on a previous version of the FRTB. In Table 9 the comparison is made by risk class: results are comparable with the QIS, with the exception of equity where the increase registered in QIS is more pronounced.

Table 9: SA - IMA comparison by risk class

Risk class	Capital charge SA (Percentage on portfolio value)	Capital charge IMA (Percentage on portfolio value)	SA/IMA ratio
GIRR	26.966,20 € (1,46%)	2.016,83 € (0,11%)	1337,06%
EQUITY	512.144,74 € (27,82%)	162.020,47 € (8,80%)	316,10%
CSR	108.473,82 € (5,89%)	43.424,90 € (2,36%)	249,80%
FOREX	64.942,79 € (3,53%)	38.360,84 € (2,08%)	169,29%

5. A COMPARISON OF CAPITAL REQUIREMENTS ACROSS REGULATIONS AND APPROACHES

In this Section capital charges for both SA and IMA under the current regulation (Basel 2.5) are calculated for comparison. Specifically, we first compare SA capital charges in Table 10 and then we spend some more space to discuss the IMA case.

Table 10 shows the variation of the capital requirement under SA moving from the current to the new regulation. The new total charge is more than three times the old one, and the most relevant changes come from the GIRR and equity risk classes.

Table 10: Changes in capital charges from current SA to new SA

Risk class	Requirement ante-FRTB	Requirement FRTB	Variation %
GIRR	6.506,20 €	26.966,20 €	314,47%
EQUITY	140.169,56 €	512.144,74 €	265,38%
FOREX	34.636,00 €	64.942,79 €	87,5%
CSR	74.356,56 €	108.473,82 €	45,88%
TOTAL	255.668,32 €	712,527,55	178,69%

As for the analysis of IMA, a first step of the analysis is to gauge the effect of the change in the metrics required by the FRTB. To this end we compare the current regulation measure (VaR and sVaR) to the new one (ES). While sVaR is estimated on the same stress period as ES, VaR is based on the last 12 months (i.e. 03/10/2017-02/10/2018). The results in Tables 11 underscore that the two measures referring to a "non normal" period (sVaR and ES) require quite different capital charges. Beyond the distribution of P&L[9], the differences can also be attributed to the adjustment for longer liquidity horizons introduced by the FRTB. Moreover, the difference can also be reconnected to different methodology used in historical simulation estimates of

[9] Under normality of risk factors and portfolio linearity (that is normality of the P&L distribution), the 99% VaR and the 97.5% ES approximately coincide. When the distribution is fat-tailed, ES exceeds VaR.

risk factors changes (daily changes for VaR vs. *overlapping period* for ES) and the time *scaling* approach used (square root rule for sVaR vs. ES over 10 days).

As a second step, Table 12 shows the comparison of the full capital charges.

Table 11: Comparison of risk metrics

Risk measure	Capital charge (partial)	Capital charge (full)	Percentage on portfolio value	Variation %
VaR	78.557,00 €	180.097,00 €	9,78%	18,68 %
sVaR	101.540,00 €			
ES	213.735,63 €		11,61%	

Table 12: Capital requirement under current and new IMA

Regulation adopted	Capital charge	Percentage on portfolio value	Variation %
Ante-FRTB	180.097,00 €	9,78%	27,59%
FRTB	229.779,34 €	12,48%	

Even neglecting the DRC component, the capital charge under the new regulation is significantly higher, consistently with the aim of the BCBS to strengthen the banking system in terms of capital.

5. DISCUSSION OF RESULTS AND CONCLUSIONS

Before summarizing our main results it is worth recalling three main objectives of the FRTB as for the IMA. First the reform is intended to more fully capture the so-called *tail risks* by substituting VaR-based metrics with the *Expected Shortfall*. Second, it wants to incorporate liquidity risk by introducing liquidity horizons that are differentiated according to the specific risk factor considered. Finally, by introducing constraints on the use of correlations between risk factors, the reform also targets a reduction in the regulatory diversification benefits.

The analysis presented in this paper aims to gauge, for both banks adopting internal and standard models, the impact of the final version of the FRTB with respect to the current regulation. Given that realistic trading portfolios differ according to the specificity of each bank, we do not mean to provide a quantitative measurement, but instead to disentangle the expected increase implied by the FRTB in different aspects. Specifically for IMA we consider three main effects related to: the Expected Shortfall metrics substituting Value at Risk, the introduction of liquidity risk, and the reduction in the diversification benefit.

To this end we have proposed an empirical analysis based on a stylized portfolio sensible to the risk factors mostly impacted by the review, i.e. equity, volatility, interest rate, credit spread and exchange rate. The simple portfolio allows to disentangle the impact of the new regulation in a transparent way among risk factors. Results of the analysis can be summed up as follows.

The newly proposed regulation implies an increase in capital requirements for both SA and IMA. Focusing on IMA, Table 11 highlights, *ceteris paribus*, the effect that can be attributed to the very same change in metrics from VaR plus sVar to ES. ES is implemented together with liquidity horizons, which are longer and different according to the risk factor considered: at this level we observe substantial increase in the capital charge due to the diversifiable ES. When, in a second step, we also account for the constraints on the diversification benefit (Table 12), we see an even more relevant increase in the capital charge. Therefore we can say that the objective of strengthening banks' capitalization is reached by means of a change in the metrics, reinforced by the reduction in diversification benefits.

We would like to conclude drawing the attention on the implications that the FRTB might have in terms of business strategies and trading book compositions. The very simple implementation we have proposed highlights data requirement issues mainly due the need to calibrate risk measures over different periods. The data issue is not limited at the IMA level, but it is relevant also for banks adopting the SA approach given the various sensitivities needed and the data quality requirements (Pugachevsky et al., 2017). Further it should be stressed that SA represents a "floor" for banks adopting IMA, thus doubling computational requirements associated to the reform. More generally, the FRTB might have strategic implications in terms of trading books, with a twist towards core assets that mainly contribute to profitability (Kancharla, 2016). In some cases we might even assist to a repricing of some assets in order to preserve profitability in the presence of a more capital-intensive system and a reduction of those structured products requiring more capital. Overall the FRTB should foster even tighter connections between the risk management and each single trading desk in order for traders to be totally aware of the impact of their strategy in terms of capital and ultimately on ROE (Kelly, 2016).

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