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Synergies and challenges in the implementation of Basel IV regulations

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Executive Summary

Due to the need for all European banks to comply with the upcoming regulatory frameworks issued by BCBS and ISDA authorities, the authors decided to analyze three of the most impacting regulations for the bank Risk IT function. The recent regulatory need to have a more risk-sensitive framework translated into the design of quite refined methodologies also for standardized approaches: considering the sensitivity-based common approach, the authors chose to focus on the FRTB-SBM, SIMM and SA-CVA regulations and to give a representation of the workflow needed for the metric calculation. The article has the intention to find all relevant similarities and synergies, both on a methodological and technical point of view, that can be exploited by banks, as well as to warn against some challenges that can arise from their implementation.

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Synergies and challenges in the implementation of Basel IV regulations

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IN this article we want to give a better understanding of the latest regulations, published by the Basel Committee and ISDA, that will impact the Capital Requirement calculation for all banks. We decided to focus on FRTB–SBM, SIMM and SA–CVA regulations because they have to be implemented in the forthcoming years, their implementation will require a relevant computational effort, especially small and medium-sized banks will face the most significant challenges, and finally but not for importance, because they share some important common features.
In the first chapter we give a brief overview of the regulatory framework of the above capital requirements, with the specific rules and definition of the product perimeter affected by the new rules. The second chapter is dedicated to the comparison of the three workflows, that have been split in three main phases, following the general wisdom: risk factor identification, net sensitivities calculation and metrics calculation.
Our aim is to highlight possible challenges that banks will have to cope with in the compliance with the new regulations and also to find some synergies across the three frameworks that can be exploited during the implementation phase.

1. Description of the regulations

In this chapter we outline, for each regulation, the framework proposed by the regulators. More specifically we focus on workflows, perimeters, inputs and results that distinguish the different prudential rules.

1.1 Overview of FRTB-SBM capital charge

The **Sensitivity Based Method** (SBM) is one of the three new market risk frameworks introduced by the Basel Committee on Banking Supervision (BCBS) in January 2016 [3]. This framework focuses on the market risk (Trading Book PL due to the change in market prices) and it is based on the aggregation of net sensitivities of the risk factors the bank is exposed to.

The other two charges that complete the *FRTB Standardised Approach* framework are the **Default Risk Charge** (introduced to capture pure default risk and Jump–to–Default exposure) and the **Residual Risk Add–On** (additional risk charge for exotic underlying risk and other residual risks not included in SBM and DRC). Banks can also create their own internal model for capital requirement calculation by following the *FRTB-Internal Model Approach* framework.

With respect to Basel II.5 rules, the revised SBM aims to be a more risk–sensitive approach in order to give a credible fallback for trading desks not eligible for IMA and an appropriate standard

* At the time of the writing of this article, the authors were working for Iason Consulting.

for banks that don't implement an internal model.

In the SBM framework there are three Risk Charges that need to be computed and summed up in order to calculate the final Capital Requirement:

1. **Delta**: risk measure calculated for all instruments in the Trading Book based on the price sensitivity to a change in the derivative underlying;

2. **Vega**: risk measure calculated for all instruments with optionality based on the price sensitivity to a change in the derivative implied volatility;

3. **Curvature**: risk measure calculated for all instruments with optionality that takes into consideration the incremental risk not captured by Delta Risk Charge based on two stressed scenarios.

More specifically, all the instruments whose payoff cannot be written as a linear function of the underlying or instruments with optionality are subject to Vega and Curvature Risk Charge (e.g. call, put, cap, floor, swaption, barrier/convertibility/prepayment option . . .). The optionality might impact also RRAO framework.

Net sensitivities for each Risk Charge are divided into 7 Risk Classes and grouped into buckets by common features. Risk Classes are the usual asset classes and, according to FRTB naming convention, they are: General Interest Rate Risk (GIRR), Credit Spread Risk for non securitization (CSR non-sec), Credit Spread Risk for securitization (CSR sec), Credit Spread Risk for securitization and correlation trading portfolio (CSR sec CTP), Equity Risk, Commodity Risk and FX Risk. A synthetic picture is reported in Figure 4.

After the risk factor identification and association, the calculated metrics have to be aggregated and an hedging benefit is recognized in this process: sensitivities are multiplied with a Risk Weight and aggregated with two correlation matrices given by the regulator. The first aggregation involves the sensitivities within the same bucket and the second aggregation takes in to account different buckets of a single Risk Charge. Figure 1 represents all the steps of the workflow with a specific focus on the first bucket of IR Delta; other buckets and risk charges follow a similar workflow.

Furthermore, with the calculation of three Capital Requirements, the risk that correlation between assets may change during a financial crisis must be taken into consideration. For this reason Delta, Vega and Curvature are based on different correlation scenarios: the first scenario is defined as the regulatory prescribed correlation matrices, in the second scenario the prescribed correlations are multiplied by a factor of 0.75 and in the third scenario the prescribed correlations are multiplied by a factor of 1.25 capped at 100%.

The Basel Committee issued on March 2018 [5] a draft revision of the Standardised Approach for FRTB-SBM, in this paper the Committee wants to share the revisions that will impact FRTB-SBM regulation version of 2017. Enhancements involve FX liquid pairs, methodology for calculating low correlation scenario matrix and Curvature Risk Charge calculation.
Concerning FX liquid pairs, triangulation of liquid pairs can be considered itself a liquid pair in the FX Risk Class; for example USD/EUR and USD/BRL are in the list of liquid pairs so also the triangulation EUR/BRL is considered a liquid pair too.
The Basel Committee proposed a new methodology for calculating the low correlation scenario because it observed that, for risk factors that have high correlations with no regard to market conditions, the low correlation scenario tends to underestimate the empirical correlation.
Curvature Risk Charge calculation has been changed in order to improve the following two aspects: the cliff effect (an abrupt increase in the capital charge that happens if both up and down stress scenarios are negative, due to the alternative specifications that banks must apply) and the approach to apply stressed scenarios (the capital requirement will not be calculated on the worst stressed scenario because it can lead to two financial instruments very closely related having the capital requirement calculated on opposite stressed scenarios).

The last changes prescribed by the regulation are different risk weight that have to be applied to GIRR sensitivities. In this draft there are also two open points for the Curvature Risk Charge concerning how to avoid the double counting for FX Curvature Risk and the possibility not to apply stressed scenarios at bucket level but at 'sector' level, where sectors are specific subsets of buckets.

1.2 Overview of SIMM

The **Standard Initial Margin Model** (SIMM) is the new model for calculating the initial margin for non–cleared OTC derivatives, published by ISDA in December 2017 [6]. This new model is aimed to update the previous recommendations issued on March 2015 by the Working Group on Margin Requirements composed by BCBS and IOSCO [2], where they proposed two alternative methods for the calculation of the Initial Margin: the Standard Approach Schedule or an approved Initial Margin Internal Model. As well as FRTB–SBM, also SIMM uses sensitivities as inputs for the aggregation formulae and it recognizes some hedging and diversification benefits.

The purpose of these models is to set common and minimum standards for Margin Requirements for non-centrally cleared OTC derivatives that are supposed to be subject to higher capital requirements after 2007 financial crisis. Margin requirements are divided in two types: Variation and Initial Margins.
Variation Margin is a variable margin payment made by the Out-of-The-Money counterparty to the In-The-Money counterparty in order to protect the ITM counterparty from an unexpected loss due to a default of the OTM counterparty. With this protection against the default of the OTM counterparty, the ITM counterparty will be able to replace his positions without any loss. Collateral has to be posted on a daily frequency and it is the difference between the Mark-to-Market of the netting set adjusted by the haircut and the Variation Margin already posted. Mark-to-Market of the netting set is the sum of the Mark-to-Market of the trades (the cost of replacing the trade at current market prices) with a single counterparty that are subject to a legally enforceable bilateral netting agreement. Eligible collateral can be cash or non-cash assets (gold, government/corporate bond or equity) according to regulation. Posted collateral can be reused, re-hypothecated and it doesn't need to be segregated.
Initial Margin protects the non-defaulting counterparty against losses that may occur if replacement costs of the instruments are higher than the Variation Margin posted. This losses will happen if the Mark-to-Market of the netting set of the non-defaulting counterparty has increased since the last posting of Variation Margin and if there is a timing delay between the default and the actual closing out of the netting set. The closing out of the netting set is the claim of the non-defaulted counterparty based on the net value of all the trades. A sound model for Initial Margin must be able to estimate a distribution of losses due to future changes in the value of the Mark-to-Market of the netting set and the collateral during the Margin Period of Risk (the time between the last Variation Margin collateral posting and the closing out of the position). This model should also take into consideration the volatility of the Mark-to-Market and the possible impacts that the default may have on liquidity and other market risk factors. Initial Margin posting is a two-way collateral and follows a 'defaulter pays' principle: each counterparty post to the other a given collateral; in case of default of one institution, the other counterparty will receive back the collateral posted. The collateral received plus the collateral already held will be used in order to cover the losses that may occur. Collateral posted can be cash or non-cash assets but it must guarantee an immediate access to the non-defaulting counterparty, so it can't be reused or re-hypothecated.

The workflow of the SIMM metric is similar to SBM's one and can be divided into the same logical steps: risk factor identification, metric calculation and metric aggregation.

In the case of SIMM, 6 Risk Classes are identified: Interest Rate, Credit Qualifying, Credit non Qualifying, Equity, Commodity, FX. As for FRTB-SBM, these Risk Classes have the purpose of identifying and classifying relevant risk factors. In addition, a further level of classification is introduced with the purpose of assigning each trade to a single asset class. To this end, four Product Classes are identified: RatesFX, Credit, Equity or Commodity. Within each product class, the six risk classes take their component risks only from trades of that product class, e.g. Interest Rate risks for equity derivatives (associated to Equity product class) will be kept separated from Interest Rate risks for IRS derivatives (associated to RatesFX product class). Inside each risk class, trades are classified into buckets following common features. In Figure 4 there is a recap of Risk Classes with associated metadata, risk weights and correlations, while the aggregation workflow is summarized in Figure 2.

After the association of metadata to risk factors, net sensitivities for each trade are calculated for **Delta**, **Vega**, **Curvature** and **Base Correlation** Margin:

- All trades are subject to Delta Margin in order to capture the linear sensitivity to a change in the derivative underlying;
- Option–based derivatives or instruments subject to optionality are subject to additional Vega Margin and Curvature Margin, those requirements take in consideration the linear and non-linear sensitivity to a change in the implied volatility of the option;
- Instruments that are influenced by correlation between defaults of different credits within an index (e.g CDO tranches) are also subject to Base Correlation Margin (in the SIMM framework, the Base Correlation Margin is applicable only to Credit Qualifying risk class).

Net sensitivities are scaled with a risk weight and a concentration factor before starting the double aggregation: the first aggregation involves sensitivities for the same bucket and the second aggregation involves buckets for the same Delta/Vega/Curv/BaseCorr Margin for one risk class; both aggregations use correlation matrices prescribed by the regulator.
The Initial Margin for a single risk class is the simple summation of the specific Delta/ Vega/ Curv/ BaseCorr Margins. The six Initial Margins (one for every risk class) must be aggregated by using a third correlation matrix in order to calculate SIMM for each single product class.
The simple summation of the four product class SIMMs gives the final SIMM. An additional margin can be incorporated for notional–based add–ons for specified products and/or multipliers to the individual product class SIMM Margins.

1.3 Overview of SA-CVA capital charge

The **Credit Value Adjustment** (CVA) is the adjustment of the fair value of derivatives[2] and securities financing transactions (STFs) in order to take into account the downgrade of the counterparty quality and the shifts in relevant market risk factors[3]. Since the introduction of Basel III a bank is in fact obliged to set apart capital for the risk of market-to-market losses in the expected counterparty risk of the OTC derivatives which, together with the SFTs, are the target of the regulatory framework of the CVA.
The Basel Committee in 2015 [4] started an important review of the CVA risk framework which has been finalized in December 2017 [1] with the publication of the new Basel III standards. This updated version suggests a new approach for CVA capital charge that is more consistent with the revised framework for market risk (FRTB), whose application will be enforced starting from January 1st, 2022 for both of the aforementioned regulations[4].

In order to be authorized to apply the SA method, banks need to meet some eligibility criteria: the ability to model exposure and to calculate CVA and CVA-sensitivities to the relevant market risk factors, the presence of a robust methodology to approximate the credit spreads for illiquid counterparties, and the existence of a dedicated CVA desk responsible of CVA risk management and hedging.

The frequency of the capital charge calculation is at least monthly and on demand. The framework of the final revision could be summed up in three main directions:

[2]Except the derivatives transacted directly with a qualified central counterparty.

[3]The market risk factors sensitivity has been introduced by the Basel Committee in the paper "Basel III: Finalizing post-crisis reforms", Dec, 2017.

[4]In the first consultative paper, the BCBS suggests three different frameworks: the internal model approach (IMA-CVA), the standardized approach (SA-CVA) and the basic approach (BA-CVA) for all those banks who don't match the eligibility conditions for the first methods. Since the IMA-CVA has been removed by the BCBS in a consultative paper published in 2016, the SA-CVA is the most refined method a bank can adopt.

1. **Enhance risk sensitivities** taking into account also the underlying market risk factors in the exposure component and its associated hedges;

2. **Strengthen robustness** removing the possibility of using an internal model and leaving space to only three alternatives in the CVA capital charge computation: SA-CVA, BA-CVA and a less computational intensive method for all the banks which have an aggregated notional amount of non-centrally cleared derivatives less than or equal to 100 billion which consists in setting the CVA bank capital equal to 100% of the bank's capital requirement for CCR.

3. **Improve consistency** with the revised FRTB framework.

In order to have the supervisor approval to use the SA-CVA for the capital charge, the CVA must be calculated at a counterparty level as the expectation of the future loss resulting from the default of the counterparty assuming that the bank itself is default-free (therefore, only unilateral CVA is considered in contrast to Accounting CVA) and, furthermore, it must be calculated making use of the following inputs:

- The term structure of market-implied PD;
- The market-consensus ELGD[5];
- The path of discounted future exposures[6]

Regarding the calculation of the capital charge, the main principles that banks strictly have to follow are:

- The use of six asset classes (Interest rate, Foreign Exchange, Counterparty Credit Spreads, Reference Credit Spread, Equity, Commodities);
- To perform the sum of the delta and vega (for which the Counterparty Credit Spread is not taken into account) risk calculated for the entire CVA book in order to have the overall CVA capital requirement;
- In case of index hedging instruments, the calculation of the sensitivities to all risk factors upon which the index depends, is mandatory

The SA-CVA uses as input the sensitivity of regulatory CVA to both counterparty credit spreads and market risk factors.

Six risk asset classes are defined as relevant: Interest Rate (IR), Foreign Exchange (FX), Counterparty Credit Spreads, Reference Credit Spread, Equity and Commodity. Details for the risk factor mapping and associated metadata for each asset class are defined in Figure 4. **Delta** and **Vega** sensitivities have to be calculated for these risk classe. The capital requirement for delta risk is given by the sum of the delta capital requirements for all the six asset classes. The capital requirement for vega risk is given by the sum of the vega requirements for only five asset classes (Counterparty credit spread is excluded).

The workflow can be summed up in the following steps. Net sensitivities for each Risk Charge are divided into 6 Risk Classes and grouped into buckets according to the features of the risk taken into account. After risk factors identification and association, the calculated metrics have to be aggregated as explained in Figure 3 and an hedging benefit is recognized to the CVA portfolio only for those products who respect the eligibility criteria. The Delta and Vega sensitivities are multiplied for a Risk Weight, which is usually different for each bucket; after that, they are aggregated taking into account, first, intra-bucket correlation parameters and, then, across-bucket correlations set by the regulators.

[5] The same used for credit spreads risk-neutral default probabilities

[6] Computed as the pricing of the derivatives transactions related to that counterparty based on simulated paths for their relevant market risk factors

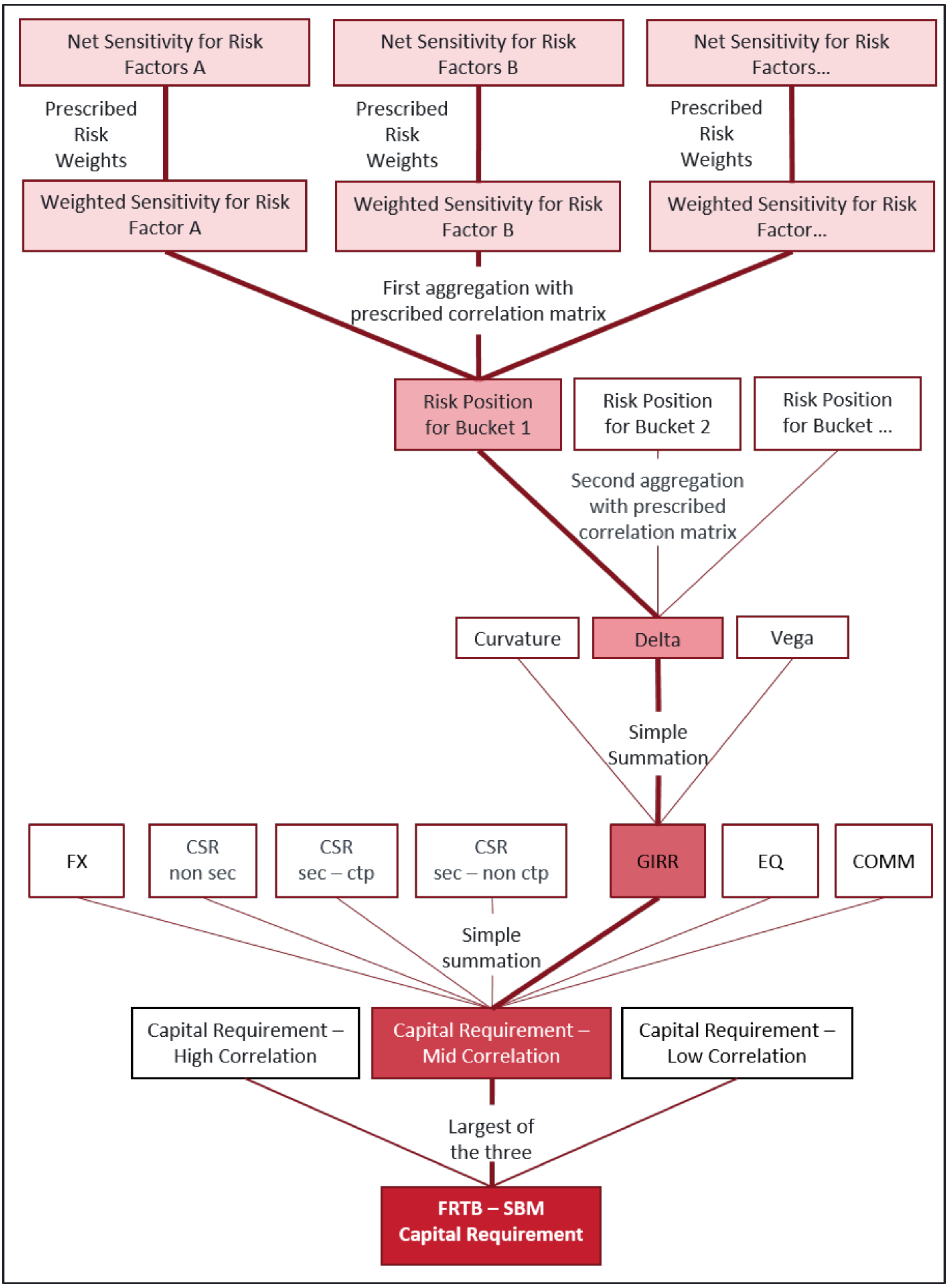

FIGURE 1: We here provide a graphic description of the workflow representing the various steps needed to calculate the final capital requirement according to the FRTB-SBM regulation. The focus has been put on the IR Delta, but the process is analogous for the other Risk Types.

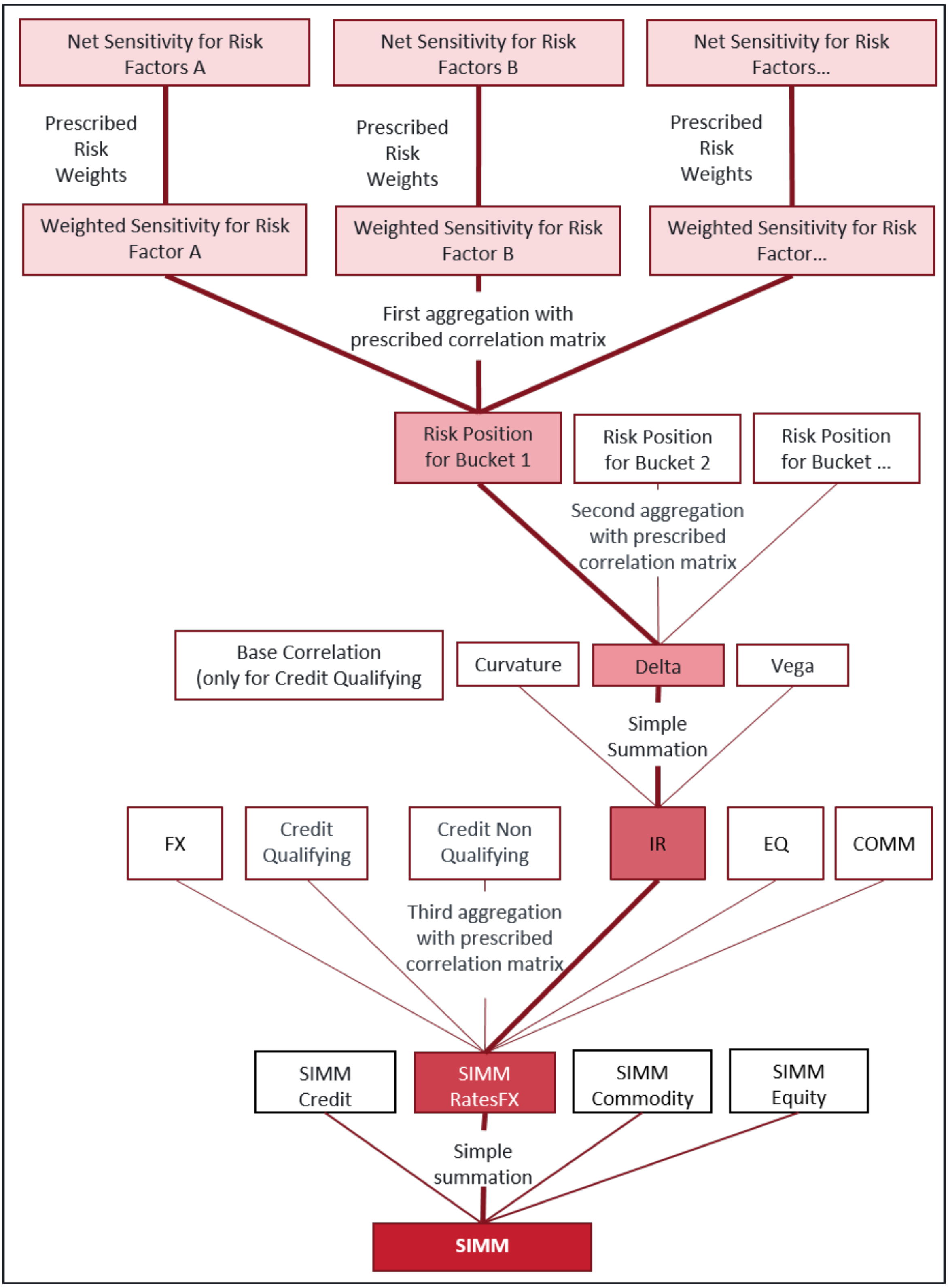

FIGURE 2: In this Figure we provide a graphic description of the workflow of the SIMM aggregation. The focus is on the Bucket 1 of the IR Delta, but the process is analogous for other buckets and risk charges.

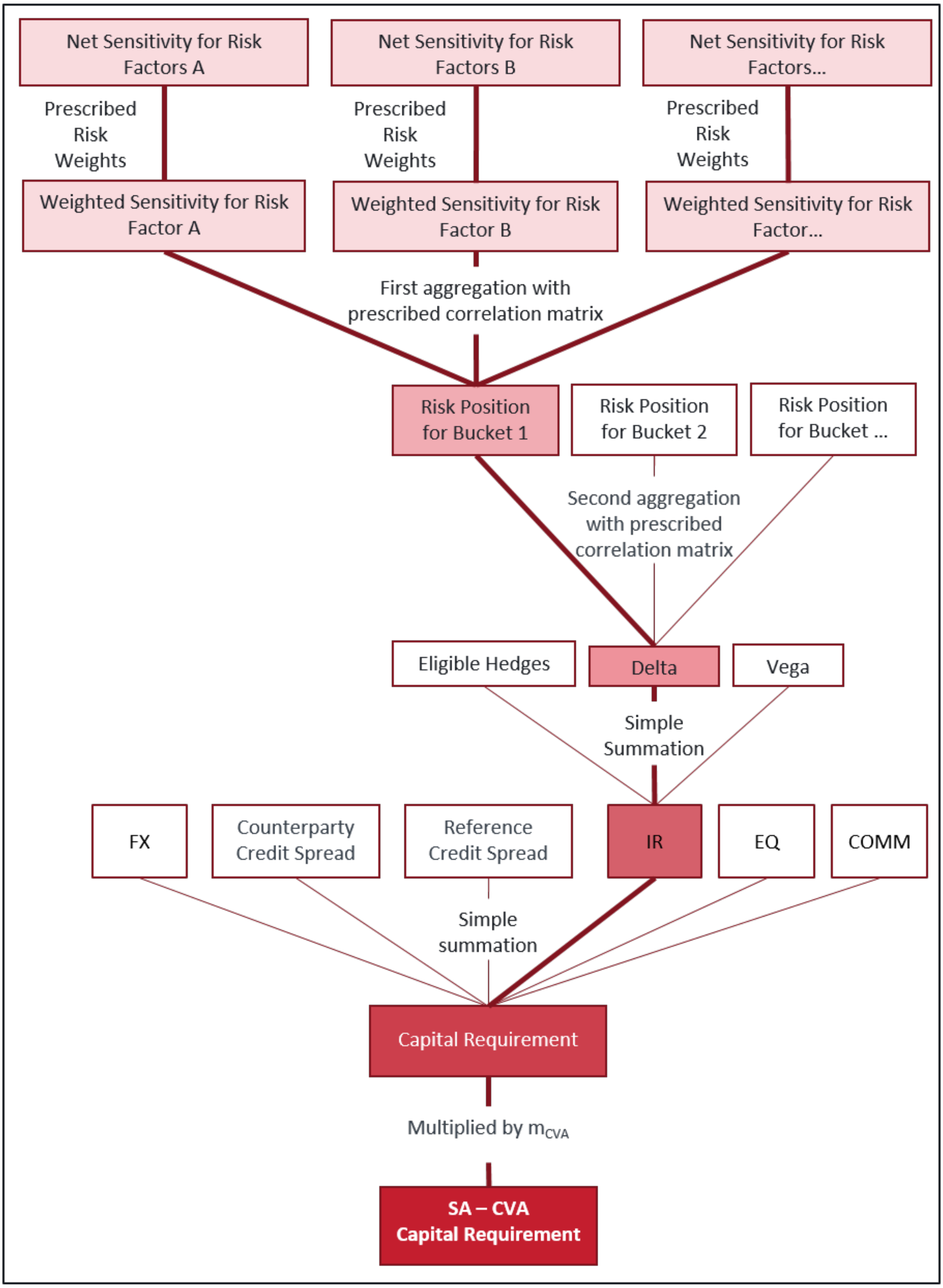

FIGURE 3: In this Figure we provide a graphic description of the workflow of the CVA aggregation. The focus is on the Bucket 1 of the IR Delta, but the process is analogous for other buckets and risk charges.

Risk Type	SIMM	FRTB-SBM	SA-CVA
Interest Rate	• *Curve Type*: zero curve, inflation or basis • *Tenor* (vertex for sensitivity granularity) • 12 verteces + Inflation + CCS basis • *Currency* for bucket allocation	• *Curve Type*: zero curve, inflation or basis • *Tenor* (vertex for sensitivity granularity) • 10 verteces + Inflation + CCS basis • *Currency* for bucket allocation	• *Curve Type*: zero curve, inflation • *Tenor* (vertex for sensitivity granularity) • 5 verteces (only for 7 ccy) + Inflation • *Currency* for bucket allocation
Credit	**Credit Qualifying(no-sec + sec CTP):** • issuer/seniority pair • 5 verteces • 12 buckets + residual o *Issuer (no-sec) / Underlying Issuer (sec) Credit Quality*: IG or HY/NR o *Issuer (no-sec) / Underlying Issuer (sec) Sector* **Credit Not-Qualifying (sec no-CTP)** • issuer/tranche pair • 5 verteces • 2 buckets + residual o Tranche Credit Quality: IG or HY/NR o Possible Tranche Sector: RMBS or CMBS	**CSR (no-securitisation):** • issuer • 5 verteces • 16 buckets o *Issuer Credit Quality*: IG or HY o *Issuer Sector*: Industry Sector **CSR (securitisation CTP):** • underlying issuer • 5 verteces • same buckets of CSR no-sec for underlying issuer **CSR (Securitisation no-CTP):** • tranche • 5 verteces • 25 buckets o Tranche Credit Quality: IG or HY/NR o Tranche Sector: RMBS, ABS, CMBS,CLO	**Counterparty credit spread** • Counterparty name • 5 verteces • 7 buckets o *Sector*: Industry Sector **Reference credit spread** • Reference name (issuer) • 15 buckets o *Issuer Credit Quality*: IG or HY o *Issuer Sector*: Industry Sector
Equity	• *Equity price* • 10 buckets + "Indexes, ETFs, Funds"+"Volatility Indeces" o *Market Cap*: Large or Small o *Economy*: Emerging or Advanced o *Sector*	• *Equity price* and *Equity Repo rate* • 10 buckets + Other sector o *Market Cap*: Large or Small o *Economy*: Emerging or Advanced o *Sector*	• *Equity price* • 11 buckets o *Market Cap*: Large or Small o *Economy*: Emerging or Advanced o *Sector*
Commodity	• *Commodity price* • 16 buckets + "Indeces" o Commodity Typology	• *Commodity price* • *Contract grade* • *Delivery location* • 11 verteces for instrument maturity • 11 buckets o Commodity Typology	• *Commodity price* • 11 buckets o Commodity Typology
Forex	• All *ccy pair* with reporting ccy	• All *ccy pair* with reporting ccy	• All *ccy pair* with reporting ccy

FIGURE 4: *In this figure we compare the mapping of the risk factors for the three frameworks.*

2. Comparison between FRTB – SBM, SA – CVA and SIMM capital charges

The aim of the second chapter is to compare the three regulations described above, in order to identify the synergies and the challenges that a bank has to cope with during the implementation phase. The first common feature among all the regulations is that the workflow can be split into three steps which share the same logic: risk factors identification, net sensitivities calculation and metrics aggregation. The first phase has the highest level of synergies, while the second one presents the most important challenges for the implementation of the regulations. It has to be highlighted that in FRTB–SBM and SA–CVA schemes there is the possibility for small banks or banks with a smaller trading activity, to opt for a reduced regulation.
In the following paragraphs, we will highlight synergies and challenges among FRTB–SBM, SA–CVA and SIMM regulations, for each one of the above mentioned phases.

2.1 Risk Factor Identification

We identify the two following relevant synergies:

1. Regulatory workflow is common as the banks must always identify the Risk Factors and associate metadata to them in order to implement the bucket classification;

2. The hierarchy used for the risk factor classification has a common structure among regulations.

The first synergy concerns the **common workflow**, for which the bank must be able to:

- Identify the set of Risk Factors to which it's exposed;
- Isolate the specific perimeter involved for each regulation:
  - The entire Trading Book and the Commodity/FX positions of the Banking Book for FRTB–SBM;
  - All the non–centrally cleared derivatives, SFTs and CVA eligible hedges for SA–CVA;
  - All the non–cleared OTC derivatives for SIMM;
- Associate metadata in order to classify the Risk Factors into individual buckets.

Some peculiarities are:

- In the SA–CVA framework, the bank must estimate the credit spreads for illiquid counterparties from quoted spreads;
- In the SIMM framework the bank has also to associate single trades of each Product Class to the Risk Classes that affect the trade.

The second synergy involves the **hierarchy of the classification**, which, generally speaking, is structured in the classical five risk macro–areas: Interest rate risk, Credit risk, Equity risk, Commodity risk and FX risk. However, some differences are present at the detail level. The most relevant difference regards the Credit macro–area:

- In the FRTB–SBM, Credit risk is divided in three areas, namely CSR non securitisation, CSR securitisasion non correlated portfolio and CSR securitisation correlated trading portfolio;
- In the case of CVA, the sub-areas of Credit risk are counterparty credit spread (the credit spread for the derivative's counterparty) and reference credit spread (the credit spread that drives the market value of the derivative);
- In the SIMM case, the division is similar to the FRTB–SBM one and the areas are Credit Qualifying (approximately CSR non securitization + securitization correlation portfolio) and Credit Non Qualifying (approximately CSR securitization non correlation trading portfolio).

FRTB-SBM framework prescribes the highest level of granularity because the perimeter impacted is the widest of the three regulations. Furthermore, Supervisors usually force banks to provide a deeper disclosure on market risk exposure and trading activities as it is one of the most common and relevant financial risks that might deteriorate solvency of the institution. On the contrary, SA-CVA has the lowest level of granularity because it implies the highest computational effort.
Let's now investigate, for each Risk Class, which are the similarities concerning the association of metadata to Delta risk factors among all the regulations.

Interest Rate

Risk factors for Interest Rate risk are defined as some specific pillars (called **vertices**) of the risk-free yield curves and have to be associated with two metadata: the **type of the curve** (inflation, Cross–Currency Basis or zero curve) and the **currency** of the curve. However, the required granularity of risk factors is different for the three regulations. In the FRTB–SBM framework, inflation and CCB curves are considered flat, while the zero curves must have ten vertices: 0.25y, 0.5y, 1y, 2y, 3y, 5y, 10y, 15y, 20y and 30y. In the CVA framework, flat inflation curves and the five vertices 1y, 2y, 5y, 10y, 30y for the zero curves are considered (Cross Currency Basis curves are not relevant in this framework). For the SIMM regulation, as in the FRTB-SBM, there are flat inflation and CCB curves, but in addition there are twelve vertices for the zero curves: 2w, 1m, 3m, 6m, 1y, 2y, 3y, 5y, 10y, 15y, 20y and 30y.

Credit

Credit macro–area is the one that shows the highest level of differences, especially in the perimeter of the regulations: FRTB–SBM and SIMM prescribe a specific Risk Class for complex credit derivatives (e.g. resecuritizations, nth–to–default, ABS, . . .) while SA-CVA has one single framework for all credit derivatives. Nevertheless, CVA framework takes into consideration both the credit spreads of the counterparty and of the underlying of the credit derivative. For all of the three regulations, risk factors are represented by the credit spreads of the underlying curves (in case of credit plain derivatives and securitisations) or of the tranches (in the case of complex derivatives). The metadata that have to be associated to those risk factors are **credit quality** (Investment Grade or High Yield/Non Rated), **industry sector** of the issuer and **five vertices** of the credit curve (0.5y, 1y, 3y, 5y, 10y for FRTB–SBM and SA-CVA for counterparty credit spreads and 1y, 2y, 3y, 5y, 10y for SIMM.). There are also different rules for the risk factor identification in case the credit derivative is a securitisation or a plain one. Credit quality is not a relevant metadata for counterparty credit spread in the SA-CVA framework.

Equity

For the Equity macro – area, risk factors are represented by equity prices and – in the FRTB–SBM framework – also by repo rates. The metadata used for Equity products are the **size** (large or small, accordingly to the market capitalization threshold of USD 2 billion), the **region** (emerging market or advanced economies) and four **sectors** (this differentiation holds only for those equity Risk Factors classified in the 'large' size). FRTB–SBM and CVA frameworks have also a residual bucket for non classifiable risk factors, while SIMM framework has no residual bucket but two other buckets named 'Indexes, Funds, ETFs' and 'Volatility Indexes'.

Commodity

Commodity Risk Factors are represented by commodity spot prices for all the regulations. The metadata associated to the prices used in FRTB–SBM framework are **commodity contract grade** (the minimum accepted standard for the deliverable commodity), **delivery location**, **time to maturity** of the instrument (considered vertices are 0y, 0.25y, 0.5y, 1y, 2y, 3y, 5y, 10y, 15y, 20y and 30y) and **commodity typology** used for bucketization. This last metadata is common for all the regulations, but there are some differences in its granularity: CVA and FRTB–SBM have 10 different buckets plus a residual bucket, while SIMM prescribes an higher degree of granularity with 15 different buckets plus 'Indexes' and a residual bucket.

Forex

FX Risk Factors are all the **ccy pairs** between the domestic currency of the bank and the currency of the derivative. The pairs need to be associated to the list of liquid currencies (for FRTB–SBM) or to the high/medium/low volatility currencies (for SIMM). Currencies within this lists are allowed to compute a lower sensitivity in order to take into account for the lower liquidity risk. In addition to pairs cointained within the list, also triangulations of those pairs are allowed to the reduced capital requirement. For example, if USD/EUR and USD/BRL are in the list of liquid pairs so also the triangulation EUR/BRL is considered a liquid pair too.

Vega Risk factors

Vega risk factors are the implied volatilities that enter in the pricing models of the instruments, SA-CVA also takes into account volatilities used for the risk factor path generation. Bucket classification is similar to Delta risk factor's one, so also the metadata that have to be associated to Vega risk factors is similar.

2.2 Net Sensitivities Calculation

For a bank, this phase is the most challenging one; the calculation of the metrics must be compliant to prescribed bumps and formulas, furthermore the risk IT engine should be upgraded in order to handle properly higher computational burden and increased number of data with respect to past regulations.
The most relevant issues come from the implementation of all the different metrics calculations, and from the enhancement of the methodologies and Risk IT technologies used in this part of the regulatory process. Challenges may come from the following aspects:

- A full sensitivity calculation workflow must be in place; in case banks don't have it already they have to build a new one or, in case it's already present, an upgrade of the risk engine may become necessary.
- Sensitivities coming from different Legal Entities or Front Offices need to be collected in a single repository.
- Data management has to be improved in order to handle data flows containing sensitivities and metadata with an high degree of granularity.
- According to the SIMM regulation, since banks have multiple choices regarding the shift that has to be applied to risk factors, they should opt for the methodology that allows them to have the most appropriate representation of the risks they are subject to;
- CVA Vega is always material so it has to be calculated in all cases and it takes into account a wider range of volatilities used in the models, including the ones used for the generation of simulated risk factors paths.

All of these issues will bring a relevant effort if a dedicated Risk engine is still not present in the bank's skeleton, but also banks with an upgraded Risk IT area may have to enhance their methodologies in order to be fully compliant with different regulations.

Concerning the calculation of the metrics there are substantial differences in the type and the formulae of the sensitivities that have to be calculated, the principal differences are summarized in Figure 5. Let's now examine separately the three frameworks.

FRTB-SBM

For FRTB–SBM the metrics that have to be calculated are Delta, Vega and Curvature.
Delta risk is the difference between the shocked market value of the derivative and the current market value. Prescribed shocks are always upward bumps of 1bp (for interest rate curves, credit spreads and equity repo rates) or of 100bp (for equity spot prices, commodity prices and FX pairs),

the difference then has to be rescaled for the applied bumps.
Vega risk is computed as the implied volatility multiplied for the first order sensitivity of the option/derivative to the implied volatility itself. Those measures are calculated by the bank's independent Risk Management internal function.
Curvature risk is based on a stressed upward and downward scenario of the risk factors. Delta effect has to be removed from these stressed difference in order to consider only the higher level of price sensitivity to the underlying. This metric is peculiar of FRTB-SBM and has no analogue in the other regulations. Moreover, it has been noted that it is more similar to a stress measure than to a true sensitivity (indeed it has a meaning close to the gamma but it is defined in a different way).

SA-CVA

In the SA-CVA framework, shifts are not applied to the market value of the singular derivatives (as it is for FRTB–SBM and SIMM), but they are applied to the CVA exposure to each counterparty. This characteristic makes heavier/tougher the computation of the CVA net sensitivities because it implies a re-simulation of the exposures; only for CVA hedges market value sensitivities have to be calculated.
SA-CVA framework requires only Delta and Vega sensitivities for aggregate CVA and for the eligible hedging instruments for a given risk factor. If an eligible hedging instrument is an index, banks have to calculate sensitivities for all the underlying risk factors of the index.
Delta sensitivity has to be calculated for Interest Rate, Counterparty Credit Spread, Reference Credit Spread, Equity, Commodity and FX risk factors. Metrics are calculated via the application of a shift of 1bp (for Interest rate and Credit Delta risk factors) or of 100bp (for Equity, Commodity and FX Delta risk factors). The difference between the CVA computed with the shifted risk factor with respect to the current CVA has then to be scaled for the bump applied. Banks can apply smaller shifts to risk factors if doing so they are more consistent with internal risk management calculations.
Vega sensitivity has to be calculated for all the volatilities used in the exposure calculation model, both for volatilities used in the generation of risk factor paths and the ones used in the pricing models. Vega sensitivities have always to be calculated, regardless of whether or not the portfolio includes some options. The formula is similar to Delta's one: a shift of 100bp has to be applied simultaneously to all the volatilities and also here the difference in the CVA has to be rescaled for the shift applied.

The smaller number of sensitivities required and the reduced granularity of risk factors (both in terms of buckets and vertices) is therefore balanced with a higher computational burden. In particular, standard bump and run techniques may reveal extremely expensive in the CVA context. Even though precise bumps are prescribed in the sensitivity definition, BCBS states that a bank may use smaller values of risk factors shifts if doing so is consistent with internal risk management calculations: this opens the possibility to use alternative methodologies aimed at avoiding the iteration of multiple MC simulations of EPE computations. The most popular method at this regard is AAD (Adjoint Algorithmic Differentiation) which can lead to impressive gains in terms of computational time. The drawback is that the risk architecture would typically need strong enhancements in order to handle these kinds of techniques.

SIMM

SIMM regulation requires the calculation of Delta, Vega, Curvature and Base Correlation sensitivities.

Delta risk is the difference of the shocked market value and the current one (as in FRTB–SBM framework): but shocks can be upward, downward or central of 1bp (for Interest Rate and Credit product asset classes) or of 100bp (for Equity, Commodity and FX product classes); if banks use one of those three shocks, the resulting difference is not scaled for the applied bump. Financial institutions can also go for an alternative option, that consist in using a reduced bump with a rescaling of the resulting difference.

Vega risk factor calculation is similar to Delta one, with the only difference that the bump will be applied to the implied volatility of the instrument. Upward, downward, central or reduced shocks are allowed here too. Curvature risk charge takes into consideration the non–linear exposure to implied volatility changes (therefore it has a different meaning with respect to the Curvature defined in FRTB–SBM framework, which is focused on non–linear exposure to underlying changes as a stress scenario). As a consequence, sensitivities calculation is based on the Vega risk factors.

Base Correlation is the difference between the market value of the instrument and the market value of the instrument where the Base Correlation curve/surface of the risk factor – a given credit index family – is bumped of an upward factor of 100bp. This metric has to be calculated only for Credit Qualifying Risk Class.

Banks, in case of the calculation of Interest Rate Delta sensitivities, can choose between the following options:

- *upward*:
$$s_x = V(x + 1bp) - V(x)$$
- *downward*
$$s_x = V(x) - V(x - 1bp)$$
- *central*
$$s_x = V(x + 0.5bp) - V(x - 0.5bp)$$
- *reduced scaled*
$$s_x = \frac{V(x + \varepsilon 1bp) - V(x)}{\varepsilon}$$

where:

- s_x is the sensitivity to the risk factor x;
- $V(x)$ is the market value of the instrument, given the value of the risk factor x;
- ε is a scaling factor, $0 < |\varepsilon| < 1$.

This choice is not present in the two other frameworks, where only upward shifts are allowed[7]. Banks should make a deep study of the impact on the final capital requirement given by the use of different sensitivity formulae. In fact, option–based derivatives may have different sensitivities if an upward or downward shift is applied, due to the non linearity of their payoffs and the moneyness of the instrument will play a crucial impact on the choice of the most convenient formula to be used.

2.3 Metrics Aggregation

For all the three regulations, the third phase is based on the aggregation of the sensitivities according to predefined rules. The three frameworks share the same procedure, the only difference arise in the prescribed values of correlation matrices, in the risk weights and in other parameters (i.e. concentration factors, historical volatility ratios, ...) used in the aggregation of the exposures. As a common feature, by using correlation matrices for the aggregation of sensitivities, some hedging benefits are recognized in the calculation of the final Capital Requirement. An important peculiarity that characterizes SA-CVA is that, at the end of the metrics aggregations, the capital calculated has to be multiplied by a factor of 1.25 in order to compensate for the lower degree of granularity in the risk factor identification and the fact that only first order derivatives are taken into consideration. Table 1 recaps the differences among the three workflows with respect to the number of aggregations prescribed by the regulator and the other risks that have to be taken into consideration.

[7] In the case of SA-CVA, however, banks have the possibility to calculate smaller risk factor bumps than the prescribed amounts, as discussed above

Risk Type	SIMM	FRTB-SBM	SA-CVA
Delta Metrics			
Interest Rate	• Additive bump 1bp • Forward, backward, central, smaller shock difference • Rescale for bump only in smaller shock difference	• Additive bump 1bp • Only forward difference • Rescale for bump	• Additive bump 1bp or less • Absolute difference • Rescale for bump
Credit	• Additive bump 1bp • Forward, backward, central, smaller shock difference • Rescale for bump only in smaller shock difference	• Additive bump 1bp • Only forward difference • Rescale for bump	• Additive bump 1bp or less • Absolute difference • Rescale for bump
Equity	• Factor bump 1bp • Forward, backward, central, smaller shock difference • Rescale for bump only in smaller shock difference	• **Equity spot** o Factor bump 1% o Only forward difference o Rescale for bump • **Equity repo rate** o Additive bump 1bp o Only forward difference o Rescale for bump	• Factor bump 1% or less • Absolute difference • Rescale for bump
Commodity	• Factor bump 1bp • Forward, backward, central, smaller shock difference • Rescale for bump only in smaller shock difference	• Factor bump 1% • Only forward difference • Rescale for bump	• Factor bump 1% or less • Absolute difference • Rescale for bump
Forex	• Factor bump 1bp • Forward, backward, central, smaller shock difference • Rescale for bump only in smaller shock difference	• Factor bump 1% • Only forward difference • Rescale for bump	• Factor bump 1% or less • Absolute difference • Rescale for bump
Vega Metrics			
All	• Methodology and bump given	• Methodology and bump given	• Risk factors and option volatilities must be bumped. • No Vega for counterparty credit spreads
Curvature Metrics			
All	• Based on volatility	• Based on stress scenarios of risk factor and removal of delta component	• No Curvature

FIGURE 5: In this figure we compare the most important differences in the methods for calculating net sensitivities for the three frameworks.

	FRTB-SBM	CVA	SIMM
Number of aggregations	• Risk factors within the same bucket; • Buckets within the same risk class	• Risk factors within the same bucket; • Buckets within the same risk class.	• Risk factors within the same bucket; • Buckets within the same risk class; • Risk Classes within the same Product Class.
Other risks considered	Risk in a change of the correlation between instruments → 3 different sets of correlation matrices are prescribed: High/Medium/Low Correlation Scenario.	Model risk (losses due to a model that lacks of accuracy) → a multiplier is applied to the aggregated risk charge of each Risk Class.	Concentration risk in the Trading Book → a concentration risk factor is applied to weighted sensitivities before the start of the aggregation.

TABLE 1: In this table we highlight the major differences in the aggregation workflow across the three regulations.

3. Conclusion

In conclusion, the implementation of these regulations will force banks which still don't have in place a structured Risk workflow to handle some difficulties.
In our opinion the most important challenges will come from the sensitivities calculation, especially for SA–CVA because the CCR chain is usually less developed with respect to the market risk one due to the recent major focus on this topic by supervisory autorithies.
Taking into account all the synergies that arise from the implementation of the regulations (i.e. common workflow, risk factors and metadata) a bank should be able to enhance the actual Risk engine with a leaner process or to create a new one exploiting all the common features in the regulations and to avoid any duplication of procedures.
In 2019 banks will have to be compliant to SIMM framework; once the banks create a workflow for Risk Factor Identification, they should be able to adapt the same logic for the other two regulations in order to meet the deadline of 2022.

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