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Forward-looking and Incentive-compatible Operational Risk Capital Framework[1]

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Abstract

The Advanced Measurement Approach (AMA) to operational risk capital is vulnerable to gaming, complex, and lacks comparability. The Standardized Measurement Approach (SMA) to operational risk capital lacks risk sensitivity and is unlikely to be appropriately conservative for US banks. An alternative framework is proposed that addresses the weaknesses of these approaches by relying on an incentive-compatible mechanism to elicit forward-looking projections of loss exposure.

JEL Classification: G21, G28, G32

Keywords: Banking Regulation, Operational Risk, Regulatory Capital, Incentive Compatibility

1 – Introduction

Operational risk comprises a large portion of US banks' capital requirements, accounting for 27% of risk-weighted assets (RWA) in December 2015. However, designing an operational risk capital framework has proved challenging for the Basel Committee on Banking Supervision (BCBS) and US banking regulators. Basel II's Advanced Measurement Approach (AMA) is now seen by many regulators and industry practitioners as unnecessarily complex and not providing enough value to business decisions. Also, regulators worry that AMA capital lacks comparability across banks and countries. Thus, to improve simplicity and comparability, the BCBS proposed an alternative framework, the Standardized Measurement Approach (SMA), wherein operational risk capital calculation would be fully standardized according to a regulatory formula. However, industry practitioners have criticized the SMA for lack of risk sensitivity and excessive calibration.

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This paper puts forward a set of properties that an ideal capital framework should meet: appropriate conservatism, robustness to gaming, risk sensitivity, comparability, stability, simplicity, and usefulness to risk management and advancement of risk quantification. The AMA and the SMA are evaluated relative to these properties, and both are deemed to have significant flaws. The AMA's main flaws are its vulnerability to gaming, lack of comparability, and complexity. The SMA's main flaws are its lack of risk sensitivity, particularly due to its lack of forward-looking perspective, and its possible lack of appropriate conservativeness, as a watering down of the previous SMA proposal may be needed to reach an international agreement.

An alternative framework is proposed, the Forward-looking and Incentive-compatible Approach (FIA), which uses an incentive-compatible capital calculation mechanism to meet the seven desired properties. The FIA combines a backward-looking component, aimed to guarantee a minimum level of conservatism and comparability, with a forward-looking component based on banks loss projections, aimed to enhance risk sensitivity. The incentive-compatibility of the mechanism guarantees the framework is robust to gaming, thus allowing appropriate conservatism and risk sensitivity to be combined. The proposal is kept as simple as possible to achieve the other desired properties.

The remainder of the paper is organized as follows: Section 2 describes the properties of an ideal capital framework; Section 3 evaluates the AMA framework; Section 4 evaluates the SMA framework; Section 5 proposes and evaluates the FIA for operational risk capital; finally, Section 6 concludes.

2 – Properties of an ideal capital framework

This section discusses seven properties of an ideal capital framework. These properties are interlinked but not synonymous, and deserve a separate treatment. In some cases, achieving one of the properties may be in tension with another property (e.g., risk sensitivity and simplicity). I loosely ordered the properties by what I believe should be their priority for supervisors.

Appropriate conservatism – The primary goal of capital regulation is contributing to the safety and soundness of banks by ensuring capital adequacy. The BCBS defines the principle of capital adequacy as "*The supervisor sets prudent and appropriate capital adequacy requirements for banks that reflect the risks undertaken by, and presented by, a bank in the context of the markets and macroeconomic conditions in which it operates. The supervisor defines the components of capital, bearing in mind their ability to absorb losses. At least for internationally active banks, capital requirements are not less than the applicable Basel standards*" (BCBS 2012). Unfortunately, what constitutes "prudent and appropriate" is difficult to establish and cannot be separated from judgement. Some academics and regulators argue that capital requirements, particularly for large and complex banks, should be meaningfully more conservative (Admati and Hellwig 2014, Hoenig 2015, Federal Reserve Bank of Minneapolis 2016, Tarullo 2016, Firestone et al. 2017). Other academics and most bankers contend that excessive capital requirements reduce bank profitability, hinder lending, and reduce economic growth (Diamond and Rajan 2000, Van den Heuvel 2008, Elliott 2013, Dimon 2017).

This paper does not aim to identify the appropriate level of conservatism for operational risk capital. But the ensuing sections discuss how the AMA, the SMA, and my proposed framework compare across this critical dimension.

Robustness to gaming – To maximize return on equity, banks have incentive to minimize equity financing (Repullo 2004, Admati and Hellwig 2014, International Monetary Fund 2014). So, banks generally undertake "capital minimization" schemes within what is allowed by regulations and supervisory practices (Jones 2000, Acharya et al. 2014, Marriathasan and Merrouche 2014, Rajan et al. 2015). A capital framework is more gameable the less well established are estimation methodologies and the more judgement is involved in the estimation process. A fully standardized framework, particularly if relying on well specified accounting quantities, is likely more robust to gaming than a framework that relies on banks' internal models, particularly if the type of model to use is unspecified in the regulation.

A minimum degree of robustness to gaming is necessary to guarantee that a framework is appropriately conservative. Nevertheless, a framework may allow for some gaming and still be appropriately conservative if it includes mechanisms limiting how low capital can be (e.g., standardized floors). Also, the inherent vulnerability of a framework to gaming can be compensated by active supervisory monitoring of estimation practices; however, such active supervisory engagement increases supervisory burden. Robustness to gaming does not, on its own, guarantee appropriate conservatism because a framework that is robust to gaming can be calibrated to varying degrees of conservatism.

Risk sensitivity – Risk sensitivity concerns whether the capital framework appropriately distinguishes among levels of exposure. Within a risk sensitive framework, banks with higher risk exposure face higher capital requirements than banks with lower risk exposure. True risk sensitivity requires capital to be held before exposure materializes. A framework that requires capital to increase only after large losses occur is reactive, not truly risk sensitive.

The BCBS distinguishes between two aspects of risk sensitivity (BCBS 2013): ex-ante risk sensitivity, which implies that exposures with different characteristics are separately assessed within the framework; and ex-post risk sensitivity, which means that the standard can accurately differentiate in advance among exposures. Ex-ante risk sensitivity is tied to granularity, while ex-post risk sensitivity relates to model accuracy. Despite BCBS's somewhat confusing terminology, "ex-post risk sensitivity" is the more important concern and synonymous to how I defined risk sensitivity in the previous paragraph.

Risk sensitivity and conservatism are interlinked. The more risk sensitive a capital framework is, the less aggregate industry capital is required to achieve a desired average degree of conservatism for individual banks. Conversely, a high capital to assets ratio is not a guarantee of capital adequacy if capital does not sufficiently correlate with risk.

In theory, more granularity should allow for more risk sensitivity; however, increased granularity can increase model complexity and fragility, as well as gaming opportunities. Limiting gaming opportunities typically requires reduction of granularity (e.g., supervisory prescribed data segmentation). Whether such limitations increase or decrease risk sensitivity depends on the situation.

An additional benefit of enhanced risk sensitivity are the resulting incentives for risk minimization. Given banks incentive to minimize capital, a framework that accurately tracks risk will produce stronger incentives to minimize risk. To maximize these incentives, when a bank is able to reduce or eliminate a source of exposure, the bank should be able to reduce the capital requirement associated with such exposure.

Comparability – Capital comparability means that banks with similar exposure should have similar capital requirements (BCBS 2013). Thus, the concept of capital comparability directly ties to conservatism and risk sensitivity. Comparability implies that the same level of conservatism relative to risk should apply to all banks. Capital comparability is important to supervisors, as it guarantees a consistent degree of conservatism, and to banks, as a level-playing field is critical to enable market competition.

Standardized approaches for capital use inputs in the same way, which is a form of comparability; however, whether such approaches truly meet the ideal of comparability set out by the BCBS depends on how correlated their inputs are with risk. Meanwhile, internal model approaches, particularly when modeling methodologies are unspecified, are unlikely to result in comparable capital requirements across banks. Vulnerability to gaming typically hurts comparability, as banks enjoy different degrees of success in minimizing capital requirements.

Stability – Volatility of capital requirements is costly for banks, and so the capital framework should not result in unjustified swings in capital (Peura and Keppo 2006, Heid 2007). When exposure changes, capital should change; but when exposure remains unchanged, capital should not experience swings. Thus, stability is directly tied to risk sensitivity.

Banks can minimize capital volatility by holding capital buffers above minimum regulatory requirements. In my view, stability is important but ranks below appropriate conservatism and robustness to gaming. Improving stability should not serve as an excuse to reduce the safety and soundness of the framework.

Simplicity – The BCBS set simplicity as a key goal of its latest round regulatory capital reforms (BCBS 2013). Simplicity is enhanced when requirements are simple to explain and understand, inputs are few and captured in normal accounting and risk management systems, and estimation methodologies avoid advanced mathematical and statistical concepts and are easily verifiable by third-parties. Typically, simplicity enhances robustness to gaming and facilitates comparability.

Simplicity is in tension with granularity because, all else equal, increases in granularity reduce simplicity. Whether simplicity detracts from risk sensitivity depends on the degree of true risk differences across different exposure segments, on the availability of granular data, and on the performance of advanced estimation techniques applied to particular risks. Additional granularity and mathematical sophistication do not always improve model performance (Aikman et al. 2014, Lever et al. 2016). But in certain circumstances granularity and advanced estimation techniques are justified, and avoiding them would result in overly simplistic capital requirements.[2]

In my view, simplicity is a worthwhile goal on its own, but should be subordinate to the other properties aforementioned. When simplifying the framework enhances robustness to gaming and comparability, without meaningfully reducing risk sensitivity, such simplification should be adopted. But risk sensitivity should not be severely compromised to achieve simplicity.

Usefulness to banks' risk management and advancement of risk quantification – Ideally, the capital framework's outputs and processes should be useful to inform business decisions related to pricing risk and other risk management processes. To this effect, the Basel II framework introduced the concept of the "use test," which consists in assessing whether capital internal models were being used for other risk management purposes. Generally, framework outputs are more useful to banks' risk management processes the more they are tailored to banks' risk specificities (Hinchcliffe 2016).

In addition, the ideal framework should foster the development of new quantification tools, risk management processes, and knowledge about risks. Ideally, the capital framework contributes to a better understanding of risk by banks, regulators, and other market participants.

[2] For example, a framework that required the same risk weights for treasury bonds and junk bonds would be ignoring real differences in risk. Similarly, simple models that assume linearity, stationarity, or normality can perform much worse than more complex models that relax these assumptions when these assumptions are not met.

3 – Advanced Measurement Approach

The Basel II framework includes the AMA as a model-based option to set minimum operational risk capital requirements (BCBS 2006). US regulators went beyond the BCBS and required large, internationally active US banks to calculate operational risk RWA according to the AMA (Department of the Treasury et al. 2007). The AMA requires banks to estimate the 99.9th percentile of the annual operational loss distribution. But the Basel text is silent on how this estimation should take place and, thus, in theory banks are provided full flexibility. Banks are required to use internal loss data, external loss data, scenario analysis, and business environment and internal control factors (BEICFs) in their operational risk measurement system, but the BCBS did not set standards defining how these data elements should be combined.

Top US regulators have expressed interest in standardizing RWA requirements (Tarullo 2012) or doing away with risk-weighting completely (Hoenig 2013). In the case of the AMA, US banks also appear content to let internal models go (American Bankers Association 2016, The Clearing House et al. 2016, and The Risk Management Association 2016).

Below, the AMA is evaluated according to the seven properties of an ideal capital framework.

Appropriate conservatism – The degree of conservatism of AMA models was the result of a prolonged supervisory process, involving the Federal Reserve System, the Office of the Comptroller of the Currency (OCC), and the Federal Deposit Insurance Corporation (FDIC). To approve AMA models, the supervisory agencies had to agree to their appropriateness. Curti et al. (2016) evaluated the conservatism of AMA capital figures and found that they cover the largest loss year for all banks and the 99.9th percentile from empirical bootstrapping LDA models for most banks. Nevertheless, given that the largest loss year and empirical bootstrapping benchmarks are based in ten to fifteen years of data and that large, infrequent losses dominate operational loss exposure, the AMA capital to loss benchmark ratios of the banks in the lower range imply that these banks are likely far short of the 99.9th percentile of the annual loss distribution.

Robustness to gaming – Basel II internal modeling requirements have been criticized by regulators and academics for offering banks opportunity to game capital requirements (Blum 2008, Tarullo 2008, BCBS 2013, Hoenig and Morris 2013, Mariathasan and Merrouche 2014, Plosser and Santos 2014, Admati 2016). This problem is particularly acute within the AMA framework for two reasons: the lack of modeling standards in the Basel text and the extreme uncertainty associated with estimates of the 99.9th percentile of the annual operational loss distribution.

Researchers have documented the large degree of uncertainty associated with models of the 99.9th percentile of operational loss distributions (Mignola and Ugoccioni 2006, Nešlehová et al. 2006, Cope et al. 2009, Opdyke and Cavallo 2012, Ames et al. 2015). Even in best case theoretical examples, where the correct distributional family is assumed to be known, 99.9th percentile estimates suffer from large uncertainty due to parameter uncertainty; in practical applications, the uncertainty is much worse because parameter uncertainty is compounded by distributional or model uncertainty. The correct distribution to apply to operational losses is not known, and different options with similar goodness-of-fit statistics often lead to large differences in capital estimates.

US regulators have tried to minimize the gaming opportunities presented by the AMA framework through guidance and supervisory activities. Given scenario analysis' subjective nature and banks' lack of incentive to properly measure exposure, the use of scenario analysis to lower AMA estimates was explicitly discouraged in 2011 guidance (Board of Governors of the Federal Reserve System et al. 2011). Similarly, this guidance recommended that the magnitude of BEICF-based adjustments to model outputs should be limited. Taken together, these recommendations illustrate US regulators' preference that AMA models be based in loss data, both internal and external. 2014 AMA guidance moved further in this direction by focusing on standards for application of the loss distribution approach (LDA), a type of loss data model for the operational loss distribution (Board of Governors of the Federal Reserve System 2014). In addition, this guidance recommended that external loss data not be used lower model estimates and that the "empirical bootstrap" – a simplified LDA model – be used to benchmark AMA capital estimates.[3] However, despite these regulatory efforts to narrow AMA modeling standards, estimates still suffer from large uncertainty, particularly model uncertainty, which opens them to manipulation and gaming.

Risk sensitivity – The Basel AMA framework offers banks the opportunity to develop models for the 99.9th percentile of the annual loss distribution unencumbered from regulatory directives. In theory, such flexible framework offers the possibility to tailor models to banks' particular exposures, and thus maximizes the potential for development of risk sensitive models. However, as discussed above, banks have incentive to minimize capital requirements and, thus, it is unclear whether AMA's flexibility truly fosters risk sensitivity.

Regulators have attempted to limit model variation through guidance (Board of Governors of the Federal Reserve System 2014, European Banking Authority 2015) and supervisory action. Whether such limitations have reduced or enhanced risk sensitivity is an empirical question that

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[3] The empirical bootstrap is a simplified LDA model where the historical loss severity distribution is used as the severity distribution, instead of the common approach of using a parametric severity distribution.

has not been addressed. Nevertheless, industry practitioners have criticized the focus on past internal losses and advocated that models would be more risk sensitive if forward-looking data elements, such as scenario analysis, could be more freely used within the AMA framework (Meek 2014, Ames et al. 2015). Likely there is some merit to these claims; but, within the current framework, regulators have limited tools to ensure conservatism and comparability and, thus, have nudged banks towards a uniform modeling approach, the LDA, even when this approach may not be the most appropriate for certain exposures.

Also, given the focus on past internal and external losses, the AMA framework as implemented in the US does not allow banks to quickly manage the capital requirement associated with operational risk. When a bank introduces new risk controls, diminishes business volume, or even completely exits a business, regulators insist that past losses, particularly large legal losses, should not be removed from the LDA models used by banks (Board of Governors of the Federal Reserve System 2014). Due to this regulatory stance, such risk reduction measures result in capital decreasing only gradually, as new losses fail to materialize, rather than immediately, as banks would prefer. This regulatory stance is justified by concerns with residual exposure and bias in estimation,[4] but it does have the side effect of reducing banks' ability to decrease their capital quickly after reducing risk and, thus, somewhat reduces banks incentives to improve operational risk controls and minimize risk (Ames et al. 2015, Mignola et al. 2016).

The greatest challenge in assessing the risk sensitivity of AMA models relates to the framework's goal of protecting from the 99.9th percentile of annual loss distribution. Appropriately testing whether AMA models are properly calibrated would require thousands of years of data for each bank.

Comparability – The modeling flexibility afforded to banks by the AMA framework can lead to large capital variability across banks with similar exposure. US regulators have attempted to curb this variability through guidance and supervisory activity. The benchmarking analysis of Curti et al. (2016) shows that these efforts have enjoyed some success. Ratios of AMA capital to total assets range from .7% to 1.6%, while ratios of AMA capital to the empirical bootstrap benchmark range from 0.8 to 3.0. Such variation is still large, but may be justified, particularly the variation relative to total assets, given differences in risk across banks. Absent supervisory guidance and continuous supervision of capital models, variation across banks would likely be much more dramatic.

[4] If losses from exited businesses are completely excluded upon exit but losses from an entered businesses are only introduced slowly as they accrue, LDA models are likely to be downward biased.

While a degree of comparability of AMA capital requirements in the US has been achieved through the supervisory process, large differences remain internationally. Banks in other countries have typically relied much more on scenario analysis (Marlin 2016), and such differences in methodology have led to meaningfully different AMA capital figures. Attesting this international lack of comparability is the very different impact of adopting the SMA – which uses a fixed formula based on the income statement and losses – for banks in different countries. AMA banks in European countries would experience much larger capital increases than their US counterparts (Hegarty 2016).

Stability – As was mentioned in the robustness to gaming paragraphs, AMA capital estimates obtained through the LDA suffer from large uncertainty. Estimating a tail percentile such as the 99.9^{th} suffers from large uncertainty in any context (Danielsson 2002). For operational risk, the uncertainty is compounded by the predominance of large, infrequent losses on exposure estimates (Cope et al. 2009, Opdyke and Cavallo 2012). When a banks model relies primarily on internal losses, a new large loss can have large effects on capital requirements. Perhaps more perversely, sometimes changes in the number of losses close to the loss collection threshold can have large impacts on estimates of the 99.9^{th} percentile too due to challenges associated with truncated estimation (Opdyke and Cavallo 2012).

Reliance on external losses can alleviate instability. However, due to the extreme tail estimated, models often still change considerably due to new large losses suffered by other banks. Such changes are difficult to justify internally for bank modelers. Also, reliance on external data may meaningfully reduce risk sensitivity when exposure varies across the industry. Reliance on scenario analysis can also improve stability, as the data used on these models is created by bank staff. However, there is no good way within the AMA framework to guarantee that scenario analysis outputs are appropriately conservative given banks' incentive to minimize equity financing.

Simplicity – The AMA framework does not require models to be complicated. Moreover, the LDA approach used by all US AMA banks is conceptually simple. Nevertheless, to achieve their competing goals – capital minimization, capital stability, and enough goodness of fit to convince supervisors that models are appropriate – most bank modelers have devised fairly complex model selection procedures and have explored a variety of estimation approaches, some requiring advanced or non-standard mathematical techniques (Mignola et al. 2016). Also, the techniques used to combine units of measure while accounting for diversification tend to be fairly sophisticated.[5] Finally, techniques used to combine different data sources (e.g., internal loss data, external loss data, scenario analysis) tend to be creative and sometimes fairly complicated.

[5] Units of measure are the modeling units to which the LDA is applied in estimating operational loss exposure.

Overall, the AMA estimation process is seen as complex by non-specialist regulators and banks' management. In justification of their SMA proposal, the BCBS concluded that AMA is inherently complex (BCBS 2016).

Usefulness to risk management and advancement of quantification – By incentivizing banks to collect loss data, analyze external data, undertake scenario analysis, and develop business, environment and control factors, the AMA framework set the stage for an increased focus on operational risk management and for the development of risk quantification tools. As a consequence, the industry made significant progress in these areas (Chapelle et al. 2016). Nevertheless, bankers and other industry practitioners argue that AMA models themselves have limited usefulness beyond regulatory capital calculation (Hinchliffe 2016). Such limited usefulness is likely due to the primordial focus on modeling from past losses and on the estimation of the 99.9th percentile. The reliance on past losses diminishes the dynamism of models when exposure changes and, particularly, limits the use of modeling techniques that do not fully account for past loss experience but may be more appropriate than LDA models to model particular risks. Furthermore, the 99.9th percentile is such an extreme tail event that it has limited usefulness for pricing risk and other day-to-day risk management within banks. Also, the competing goals banks have while developing AMA models (i.e., pleasing regulators while minimizing capital) do not foster the development of models that are truly useful for understanding risk.

4 – Standardized Measurement Approach

In March 2016, the BCBS proposed a new operational risk capital framework, the Standardized Measurement Approach or SMA (BCBS 2016). This framework aims to replace all Basel II operational risk capital approaches, including the AMA. The SMA standardizes capital calculation by applying a regulatory formula to banks' historical financial statements and internal operational losses. The framework uses two measures of exposure: the Loss Component, which corresponds to the sum of three average total loss metrics for the past ten years multiplied by regulatory scalars; and the BI Component, which results from multiplying the Business Indicator or BI (an income-based metric) by marginally increasing multipliers. After calculating these two metrics, capital requirements are calculated according to the formulas below:

$$SMA\ Capital = \begin{cases} BI\ Component, if\ BI \leq\ 1Bln \\ 110Mln + (BI\ Component - 110Mln) \cdot ILM, if\ BI > 1Bln \end{cases}$$

where ILM is given by

$$ILM = ln\left(exp(1) - 1 + \frac{Loss\ Component}{BI\ Component}\right)$$

Below, the SMA is evaluated according to the seven properties of an ideal capital framework and compared to the AMA:

Appropriate conservatism – The March 2016 SMA proposal would meaningfully increase operational risk capital requirements across the industry if adopted unchanged. This impact is illustrated by the analysis included in the Operational Riskdata eXchange Association's (ORX) comment letter to the SMA (Hegarty 2016). This analysis claims that the SMA would increase capital 33% for the median surveyed bank and 61% for the average surveyed bank relative to current approaches. However, such average and median estimates hide meaningful geographical differences. According to ORX's study, median and mean changes would be 2.9% and 1.3%, respectively, for US banks, while they would reach 63.5% and 79.6%, respectively, for European banks. Such differences in impact – which result from very different starting levels of capitalization relative to SMA's exposure metrics – have caused European banks to oppose the SMA more vocally than their American counterparts. Also, the European Commissioner for Financial Stability, Financial Services and Capital Markets Union, Valdis Dombrovskis, has publicly criticized the capital impact of last round of Basel reforms, including the SMA (Dombrovskis 2016).

Due to the different capitalization starting points between the US and Europe, modifying the SMA to make it closer to capital neutral for European banks, while keeping the exposure metrics relatively unchanged, would necessarily require that the modified SMA meaningfully decrease operational risk capital requirements for US banks. Whether US policy makers would find such outcome desirable is an important question to follow.

Robustness to gaming – By applying a standardized formula to financial statement metrics and historical internal losses, the SMA eliminates banks' ability to game operational risk capital models. The potential sources of manipulation left are gaming of loss data – which is also a concern under the AMA – and gaming of financial statement data – which falls under the purview of accounting experts and auditors and, thus, represents a smaller gaming risk than internal models.

Risk sensitivity – Industry commenters have criticized the SMA's reliance on financial statement and historical internal loss data together with regulatory defined multipliers to measure operational loss exposure, as these simplified metrics do not fit banks' specific risk profiles. Also, the elimination of data elements such as scenario analysis or BEICFs from capital calculations are criticized for curtailing the forward-looking perspective of operational risk capital (American Bankers Association 2016, British Bankers Association 2016, European Banking Federation 2016, Mignola et al. 2016, Peters et al. 2016).

The sole reliance on financial statement metrics – which are unlikely to have a strong correlation with operational risk – plus past internal losses surely limits risk sensitivity relative to an approach that included other sources of information such as external losses or expert assessments. Nevertheless, for the reasons related to gaming explored in the AMA section, it is unclear whether the SMA is truly less risk sensitive than the AMA. Only empirical evidence could conclusively answer whether modeling flexibility plus potential for gaming leads to more risk sensitivity than a standardized calculation that is not gameable, but such empirical evidence is unlikely to ever be gathered for this particular case. What can be safely concluded is that a mechanism that allows for risk sensitive approaches to be used while curtailing gaming, would almost surely be more risk sensitive than the SMA.

Similar to the US implementation of the AMA, changes in risk controls cannot be immediately translated into decreases in capital requirements. Rather, average losses need to decrease before the loss portion of the capital calculation decreases. Nevertheless, the impact of large losses within the SMA is likely less long-lasting than under the AMA. The SMA prescribes that losses are used for ten years in the average loss calculation, while under the 2014 US AMA guidance, large losses should potentially be included in the severity distribution estimation forever, unless the bank can justify their exclusion. On top of that, changes in business mix are likely to affect the SMA faster than the AMA because such changes likely produce changes in the financial statement component of the SMA quickly, while they do not impact calculations in AMA models of US banks until they translate into changes in observed loss distributions. Overall, given how AMA models are implemented in the US, the SMA, despite being standardized and backward looking, may be quicker to adjust to changes is risk and thus produce more immediate incentives for risk control.

Comparability – A prime concern governing the latest round of changes to the capital framework proposed by the BCBS is comparability of capital requirements across banks and jurisdictions, and the SMA proposal is the prime example of this concern. The SMA applies a single formula to banks' financial statement metrics and internal loss history, and, as far as such metrics are comparably measured across banks and countries and as far as these measures and the BCBS formula appropriately capture risk, the SMA ensures perfect comparability. However, these caveats are significant. First, differences in data collection across banks can compromise comparability under the SMA (McConnell 2017). Should be noted though that, unless accounted for, such differences also compromise comparability under the AMA.

The more important challenge to SMA's comparability claims resides on whether the SMA truly measures risk. Comparability presupposes not similar level of capital in abstract, but similar level of capital relative to risk. If the BCBS's risk metrics and formula appropriately capture risk, then

SMA capital is comparable. If not, the SMA would fall short from being comparable relative to risk despite its standardization.

Stability – Multiple SMA design features are aimed to ensure stability. The use of a ten year window in the calculation of average annual losses may reduce risk sensitivity in cases where loss profiles change meaningfully over shorter periods, but does guarantee a degree of stability. More importantly, the approach used to bring losses into the calculation guarantees that meaningful changes in average losses have limited impacts on SMA capital. The Loss Component affects SMA capital through a logarithmic function (the ILM), which meaningfully blunts the impact of a change in the Loss Component on capital requirements.

Peters et al. (2016) criticized the SMA for producing unreasonably variable results for banks with the same underlying exposure. In particular, using a lognormal severity distribution with a parametrization they see as representative and assuming that the BI Component is equivalent to $VAR_{0.999}$ of the hypothetical bank, they find that over a 1000 year window capital could reach 80% higher than average capital. The authors interpret these results as implying that the SMA is undesirably volatile. An 80% swing in capital due to luck of the draw is certainly not irrelevant. But the AMA models of most US banks, with their focus on the largest internal loss events, would surely produce much larger swings if this experiment was reproduced using their modeling approach.

Simplicity – The SMA is a simple framework to implement. No estimation is required, and calculations can be implemented in spreadsheet software by a non-expert. The main challenge concerning implementation of the SMA is the requirement of appropriate loss collection, but this challenge is already present under the AMA.

Usefulness to risk management and advancement of quantification – Multiple industry experts expressed concern regarding the uselessness of the SMA to banks' risk management (Peters et al. 2016). The SMA takes a top-of-the-house approach to capital calculation and so, even assuming the SMA methodology is risk sensitive, the framework has limited usefulness to discuss risk at a more granular level. In addition, the SMA produces no incentives for advancement of operational risk quantification. Capital requirements are set by a fixed formula and, thus, the requirements that banks produce internal models for operational risk are eliminated from the Basel Pilar I framework.

5 – Forward-looking and incentive-compatible operational risk capital framework

An ideal risk-based capital framework should exhibit multiple properties: appropriate conservatism, robustness to gaming, risk sensitivity, comparability, stability, simplicity, and usefulness to risk management and advancement of quantification. A revised US operational risk capital framework should improve upon the AMA and the SMA on many of these properties and not rate meaningfully worse than them on any of them. The crucial feature that would allow such positive outcome is the adoption of an incentive-compatible capital calculation mechanism.

In the context of risk-based regulatory capital, incentive-compatibility means that banks have the incentive to disclose their best estimate of future exposure. The AMA requires banks to estimate exposure at the 99.9th percentile over the next year; however, banks do not have the incentive to accurately estimate this exposure. Rather, to maximize return on equity, banks have an incentive to minimize this estimate as much as regulators allow. The situation is similar for the internal ratings-based approach to credit risk capital. In contrast, the internal models market risk framework incentivizes banks to accurately estimate exposure through the back-testing requirements. Banks who record an abnormally high number of loss exceedances over their internal model estimates of the 99th percentile see their regulatory multiplier increase (BCBS 2006). This mechanism, on its own, does not guarantee incentive-compatibility – as banks would still have an incentive to minimize estimates despite the increase in multiplier absent other regulatory consequences, such as withdrawal of model approval – but does provide some automatic incentive toward accurate estimation.

The literature has discussed the incentive-compatibility (or lack thereof) of bank capital frameworks and the desirability of making these frameworks more incentive-compatible. Calomiris (1999) argues that requiring a minimal proportion of subordinated debt and restricting the ability of governments to bail out banks would discourage banks from taking excessive risks. Cuoco and Liu (2006) demonstrate that back-testing requirements associated with the market risk rule help curb portfolio risk and induce revelation of risk. Multiple papers show that banks use securitizations to increase risk while avoiding increases in capital requirements (Rajan et al. 2010, Acharya et al. 2013, Rajan et al. 2015). Mariathasan and Merrouche (2014) show that weakly capitalized banks in countries with weak supervision see large declines in credit risk RWA after model approval, consistent with RWA manipulation. Plosser and Santos (2014) show that low-capital banks underestimate probabilities of default relative to well capitalized firms. Colliard (2015) develops a framework to study the incentive-compatibility of capital requirements and highlights the challenges in achieving incentive-compatibility when tail risk is significant. Finally, Behn et al. (2016) show that internal credit risk models systematically underestimate default rates.

Adoption of an incentive-compatible capital framework would allow meaningful improvement of the risk sensitivity of the capital framework and, at the same time, simplification of its modeling requirements. With aligned incentives, banks' best interest will be to produce accurate exposure projections; thus, within such framework, banks should be provided with freedom to pursue the best modeling methodologies. Regulators would no longer have to be suspicious of scenario analysis, BEICFs, or any other qualitative methods used to forecast exposure. Also, regulators no longer have to challenge the specific statistical details of modeling frameworks. Supervisory burden and banks' compliance burden would be reduced.

However, despite the potential advantages of adopting a capital framework that uses banks' best estimates of future exposure to estimate regulatory capital, I believe prudence requires that a portion of the operational risk capital requirement be based on historical experience. Underestimation of exposure, intentional or not, could lead to undercapitalization and, thus, the operational risk capital framework should be anchored to an estimate of tail exposure based on historical experience and standardized across banks. Also, to comply with Basel requirements, a US operational risk capital framework has to be floored by a Basel approach in effect. This would be the SMA if it ever becomes agreed upon, or one of the Basel II frameworks – for example the Basic Indicator Approach (BIA) – if not.

To reflect the critical features of such a capital framework, I will label it the "Forward-looking and Incentive-compatible approach" and use the acronym FIA to refer to it. The next sub-section provides an example for the design of the FIA.

5.1 – Framework Example

The FIA would include four components: a regulatory formula based on historical experience; a forward-looking component; a function that adjusts capital requirements to guarantee incentive compatibility; and a floor associated to a standardized Basel approach.

Under the example FIA, 50% of the capital requirement would be set according to a regulatory formula similar to the SMA, but calibrated to US experience. This formula would use past losses and a metric of firm size, which could be similar to the BI used in the SMA or different if other metrics (e.g., total assets) prove more correlated with operational loss exposure for US banks. The formula could be calibrated to be capital neutral on an industry basis relative to the AMA on adoption, or it could be calibrated more or less conservatively depending on regulatory goals. The main goal of this article is not to discuss this feature, so I will assume a very simple formula for this portion of the capital requirement (note that this example may be far from capital neutral if implemented):

$$BLC_t(ATL_{t-1}) = 14 \cdot ATL_{t-1}$$

$$ATL_{t-1} = \frac{\sum_{i=t-10}^{t-1} RTL_i}{10}$$

Where BLC_t is the backward-looking component of the FIA for year t, ATL_{t-1} are average total losses experienced by a bank on the ten years prior to t (i.e., year t-10 to t-1), and RTL_i are the realized total losses in year i.

The other 50% of the capital requirement would be set according to a forward-looking component. This component would result from applying a regulatory-prescribed multiplier to banks' loss projections for the next year. When banks project losses close to their median experience, the multiplier should be sufficiently high to cover unexpected tail losses. But in cases where projected losses are large in comparison to historical experience and thus likely tail losses themselves, the marginal increment to capital as losses grow should be moderate so as to not result in unreasonably high capital requirements. An example formula is presented below:

$$FLC_t(PTL_t, BLC_t) = \begin{cases} 10 \cdot PTL_t, if\ 10 \cdot PTL_t \leq BLC_t \\ BLC_t + 2 \cdot \left(PTL_t - \dfrac{BLC_t}{10}\right), otherwise \end{cases}$$

Where FLC_t is the forward-looking component and PTL_t are the projected total losses for year t.

To ensure that the FIA is incentive compatible and, thus, that banks use their best operational loss projection, a capital add-on is needed to penalize underestimation. When banks under-project losses in year t, the capital requirement of year t+1 would be increased by the capital underestimation of year t times a scalar, which would be set high enough so that banks do not opt to systematically postpone holding capital. An example formula is presented below:

$$UA_{t+1}(RTL_t, PTL_t) = \begin{cases} 0, if\ PTL_t \geq RTL_t \\ 2 \cdot \big(FLC_t(RTL_t, :) - FLC_t(PTL_t, :)\big), otherwise \end{cases}$$
$$= Max\big\{2 \cdot \big(FLC_t(RTL_t, :) - FLC_t(PTL_t, :)\big), 0\big\}$$

Where UA_{t+1} is the underestimation adjustment for year t+1.

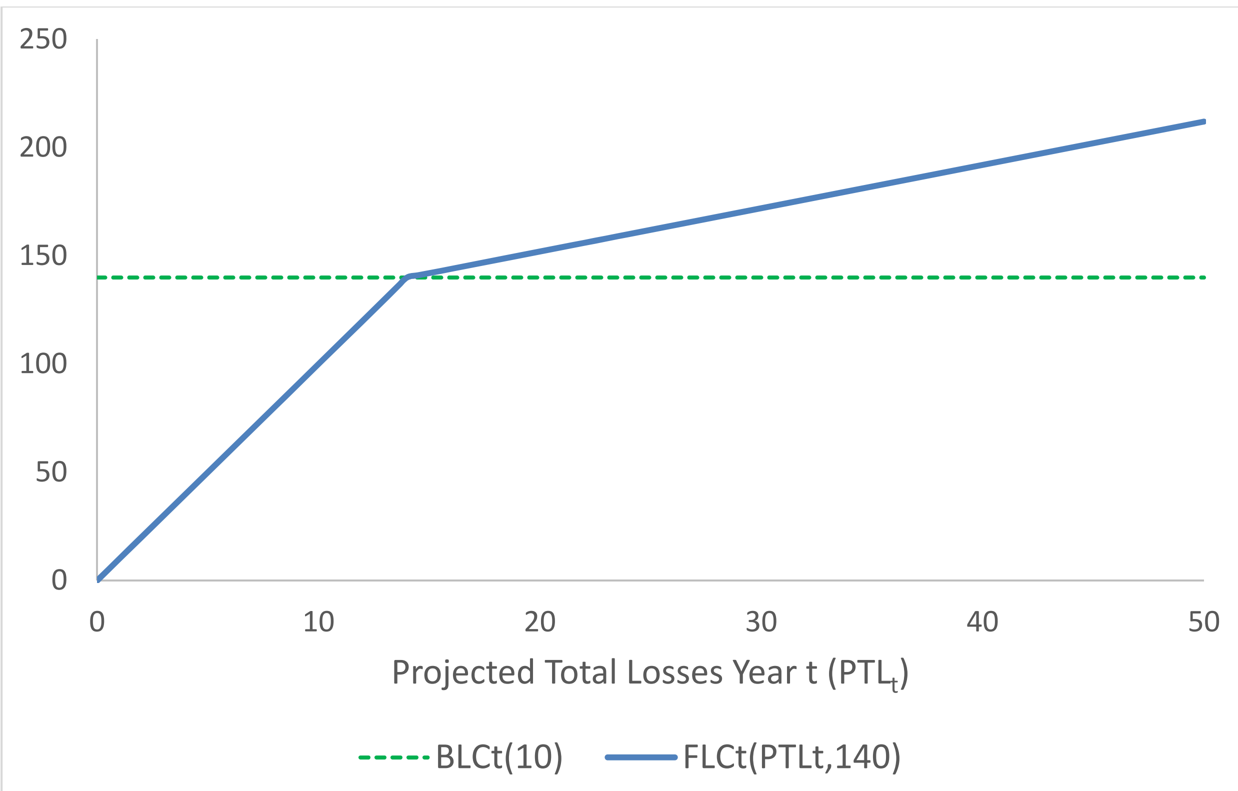
Finally, to comply with the Basel accords, the US operational risk capital framework needs to be floored by a Basel framework. If the SMA is agreed upon to replace all other operational risk frameworks, the SMA would be this floor. While if the SMA is not agreed upon, the BIA could be set as a floor to capital requirements. Capital requirements are summarized by the formula below:

$$FIA\ Capital_t = Max\{0.5 \cdot BLC_t + 0.5 \cdot (FLC_t + UA_t), SMA_t\ or\ BIA_t\}$$

Realized losses are introduced in the calculation when they produce an accounting impact, both in the backward-looking component and in the underestimation adjustment function. The use of accounting dates is necessary in the backward-looking component to ensure that all losses impact capital calculations for the prescribed number of years (e.g., 10). While in the underestimation adjustment, the use of the accounting view is needed so that apples-to-apples comparisons of projected losses to realized losses can be done. This accounting date treatment of operational losses includes legal events. When legal reserves increase, these increases should be counted as operational losses in the year they are first registered in the income statement. Similarly, reserve releases (except the reserve releases directly resulting from settlement payments) would count as loss recoveries, which would offset other operational losses in a year.

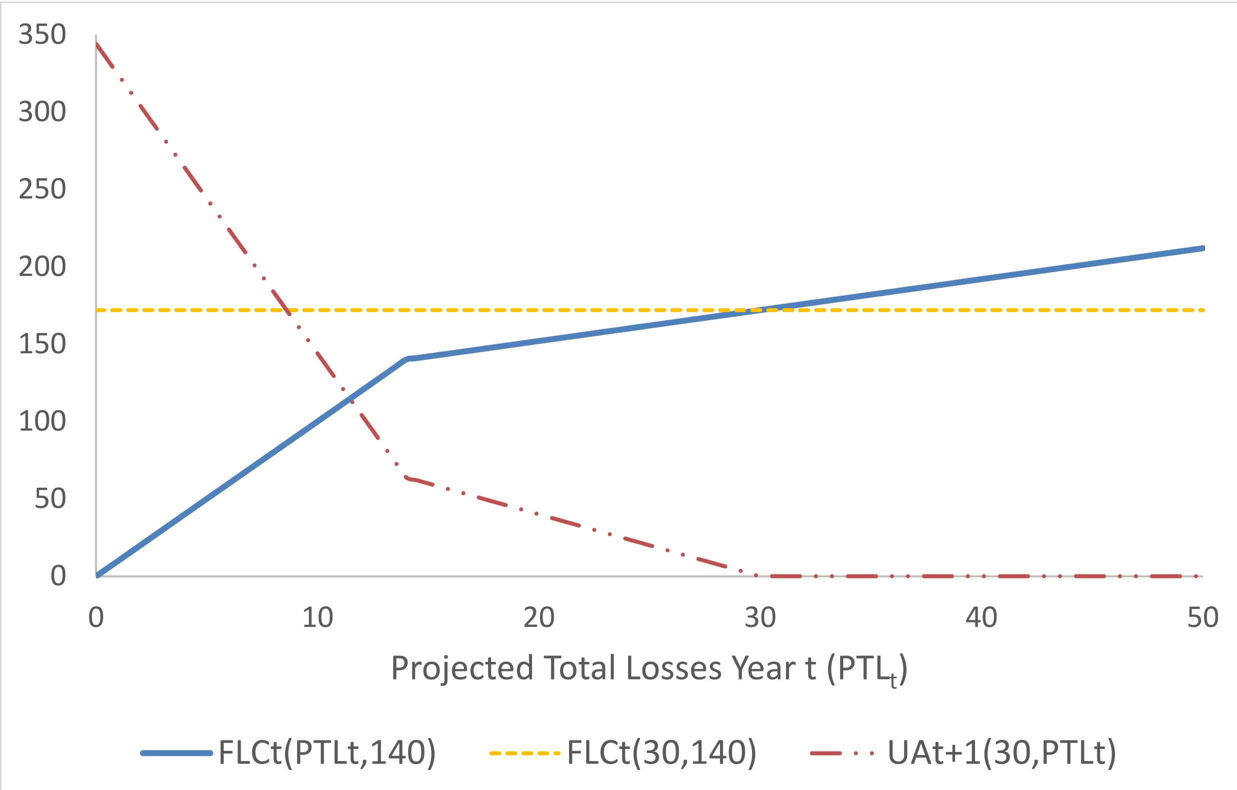
The figures below illustrate how the backward-looking component, the forward-looking loss component, and the underestimation adjustment operate in conjunction. Figure 1 plots the forward-looking loss component as a function of projected losses in comparison to the backward-looking component of a bank that experienced 10 in average losses in the previous ten years and, thus, has a backward-looking component of 140.

Figure 1



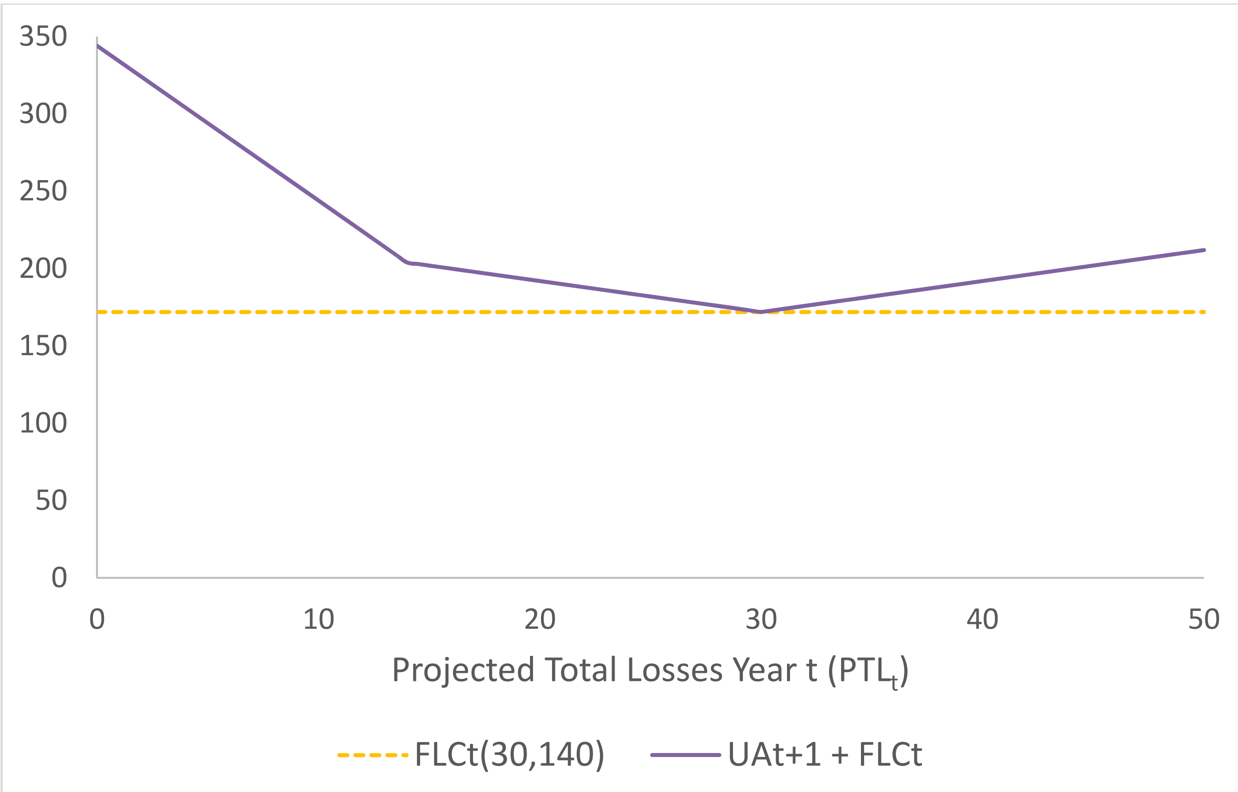
Continuing the example, Figure 2 shows how the underestimation adjustment in year t+1 relates to the project total losses in year t when the realized losses in year t are 30.

Figure 2



Finally, Figure 3 shows that the sum of the forward-looking loss component of year t and the underestimation adjustment of year t+ 1 is minimized when the bank accurately estimated realized losses.

Figure 3



5.2 – Incentive Compatibility

The example FIA does not offer incentive-compatibility under all circumstances. Assume that a bank is willing to trade off an increase of up to δ units of expected capital requirements tomorrow for each unit of capital requirements today. Then, the bank's optimization problem can be written as

$$\min_{PTL_t} FLC_t + \delta \cdot E(UA_{t+1})$$

And if the bank has certainty over the losses that will occur, the problem simplifies to

$$\min_{PTL_t} FLC_t + \delta \cdot UA_{t+1} \Leftrightarrow \min_{PTL_t} FLC_t(PTL_t, :) + 2 \cdot \delta \cdot Max[FLC_t(RTL_t, :) - FLC_t(PTL_t, :), 0]$$

This optimization is solved by $PTL_t = RTL_t$, as long as $2 > 1/\delta$. This condition is likely to hold in practice because banks' cost of capital are generally not so high as to make banks prefer to hold two dollars of capital in year t+1 for each dollar of capital "saved" in year t. So the FIA would likely be fully incentive-compatible under the unrealistic scenario of banks having full certainty over future losses.

Uncertainty complicates achieving incentive compatibility. Ignoring time discounting and retaining the risk-neutrality assumption, the example FIA is incentive-compatible if 1) the mean of the distribution of RTL_t corresponds to the median and 2) the lower bound of the distribution of RTL_t is such that $10RTL_{lowerbound} > BLC$ (see proof in appendix) or the upper bound of distribution of RTL_t is such that $10RTL_{upperbound} < BLC$ (proof is analogous). Intuitively, incentive compatibility is obtained under these assumptions because moving the projection away from the mean is equally penalized in both directions – the underestimation adjustment multiplier of two is set to guarantee this outcome.

The assumptions used in the previous paragraph to achieve incentive-compatibility under uncertainty are quite restrictive. Moving away from these assumptions affects incentive-compatibility in different ways:

Domain of RTL_t – If the domain of RTL_t includes a portion for which $10RTL_t < BLC_t$ and a portion for which $10RTL_t > BLC_t$, then the proposed formula would result in banks having an incentive to overestimate total losses because the penalty introduced by UA in the lower portion of the domain is larger than the capital increment resulting from overestimation.

Risk preferences – If banks are risk averse regarding capital requirements, then they will tend to overestimate losses to make the capital requirement less volatile. While if banks are risk loving regarding capital requirements, they will tend to underestimate losses to make the capital requirement more volatile.

Time discounting – Time discounting should lead banks to underestimate losses under the proposed formula. In theory, this effect could be exactly counterbalanced by multiplying the penalty factor in the underestimation adjustment by the inverse of the time discount factor. In practice, this would only restore perfect incentive-compatibility if the same discount factor applied to all banks (which is unlikely) or if different multipliers were applied to different banks (which is unpractical).

Mean and median equality – If the distribution of possible total losses is positively skewed (mean bigger than median), as is likely the case for all banks, then banks will have an incentive to under-project losses relative to expected losses.[6] While if the distribution is negatively skewed (mean smaller than median), then banks would have an incentive to over-project.

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[6] Under the example shown in the appendix, banks will chose PTL_t = Median[RTL_t].

The likely real-life deviations from the example used to show incentive-compatibility under uncertainty pull incentives in different directions. The domain of RTL and preference for stable capital likely pull toward overestimation, while time discounting and losses' positive skew pull toward underestimation. Which of these forces should dominate in general is unclear, but assuming that underestimation incentives dominate, supervisors should not worry too much. As shown before, when there is certainty regarding loss amounts, banks will have incentive to use their true loss projections in the capital formula. And while certain types of large loss events are likely unpredictable one year out (e.g., rogue traders, natural disasters), the largest source of operational losses in the US – litigation – is different. Large legal loss events typically evolve over multiple years, accruing reserves along the way. Accounting standards around whether losses are "probable" and "estimable" inform whether banks should add to (or subtract from) their reserves for a legal loss event. But banks frequently know in advance that losses are going to be deemed "probable" and "estimable" and thus reserved for, if for no other reason because banks' legal and accounting departments ultimately make this subjective decision. So, the most significant portion of the operational losses of US banks can likely be predicted with some accuracy one year out. Under the FIA, banks will have material incentives to use these estimates in capital calculations.

In summary, the proposed framework pulls banks towards their best estimates of future losses, particularly when losses can be predicted with a good degree of accuracy. When uncertainty is large, banks may have incentive to under-project losses relative to their expectation because loss distributions typically are positively skewed; but banks will have incentive to use their projections for large reserve and settlement amounts over which they have a good degree of confidence.

5.3 – Possible Modifications

The FIA example described so far highlights the main features of an operational risk framework aiming to improve upon the AMA and the SMA. In this sub-section, a few possible modifications to this baseline FIA designed to address certain weaknesses of the framework are discussed.

Lowering the penalty – The underestimation adjustment function proposed in the previous sub-section was designed to achieve incentive-compatibility under uncertainty for some loss distributions. The multiplier of two used in its formula is needed to achieve this incentive-compatibility. However, when banks have reasonably accurate forecasts of certain losses (as I argued in previous sub-section is often the case for legal losses), a much smaller penalty is needed to induce banks to use these losses in the forward-looking component. In such cases, all that is needed is that the multiplier is large enough to cover banks' intertemporal discount factor. Given that legal events are by far the largest source of operational losses in the US, the underestimation adjustment function multiplier could likely be meaningfully smaller than two and still nudge banks towards using their best estimates for their most relevant exposures. For example, the underestimation adjustment function could be as follows:

$$UA_{t+1}(RTL_t, PTL_t) = \begin{cases} 0, if\ PTL_t \geq RTL_t \\ 1.25 \cdot \left(FLC_t(RTL_t, :) - FLC_t(PTL_t, :)\right), otherwise \end{cases}$$

Banks would no doubt prefer such lower multiplier, as it would lead to lower capital requirements and less capital variation in response to underestimation. Supervisors may prefer the higher multiplier, but, in my view, the framework should be the least punitive possible to achieve the goals of risk sensitivity and appropriate conservatism. Given the other strengths of the proposed framework, I believe some relaxation of the underestimation adjustment, even as it moves the framework away from full incentive compatibility, is appropriate to improve capital stability.

Multiple years of projections – The proposed FIA only requires banks to project losses one year out. But the FIA could be adjusted to require banks to project two or even three years of losses. The formula of the forward-looking component and the underestimation adjustment would only need slight modifications. For example, if two years of projections were used, instead of plugging projected total losses in year t, PTL_t, in these formulas, banks would plug instead average projected losses in year t and year t+1, $(PTL_t + PTL_{t+1})/2$. Similar to projected losses, realized losses would be introduced as the average of two years of losses. The underestimation adjustment function would only kick-in on t+2 because only after year t and year t+1 are completed can the accuracy of the average projection be assessed. Example formulas are provided below:

$$FLC_t(PTL_t^{t-1}, PTL_{t+1}^{t-1}, BLC_t) = \begin{cases} 10 \cdot \dfrac{PTL_t^{t-1} + PTL_{t+1}^{t-1}}{2}, if\ 10 \cdot \dfrac{PTL_t^{t-1} + PTL_{t+1}^{t-1}}{2} \leq BLC_t \\ BLC_t + 2 \cdot \left(\dfrac{PTL_t^{t-1} + PTL_{t+1}^{t-1}}{2} - \dfrac{BLC_t}{10}\right), otherwise \end{cases}$$

$$= \begin{cases} 5PTL_t^{t-1} + 5PTL_{t+1}^{t-1}, if\ 5PTL_t^{t-1} + 5PTL_{t+1}^{t-1} \leq BLC_t \\ 0.8BLC_t + PTL_t^{t-1} + PTL_{t+1}^{t-1}, otherwise \end{cases}$$

$$UA_{t+2}(RTL_t, RTL_{t+1}, PTL_t^{t-1}, PTL_{t+1}^{t-1})$$

$$= \begin{cases} 0, if\ PTL_t^{t-1} + PTL_{t+1}^{t-1} \geq RTL_t + RTL_{t+1} \\ 2 \cdot \left(FLC_t(RTL_t, RTL_{t+1}, :) - FLC_t(PTL_t^{t-1}, PTL_{t+1}^{t-1}, :)\right), otherwise \end{cases}$$

The superscript "t-1" is added to PTL to denote these are projections made at the end of year t-1 (as was the case in previous formulas). The projections made at the end of t-1 for losses in years t and t+1 affect FLC_t and UA_{t+2}. Then, at the end of year t, a new set of projections is made for year t+1 and t+2, which affect FLC_{t+1} and UA_{t+3}. So, all years are projected twice, once two years prior and once the year prior, but projections made at the end of a year (e.g., t-1) are only used to inform the forward-looking component of the upcoming year (e.g., t).

The main advantage of such change is that deviations from expected losses tend to average out over time and, thus, if banks accurately project expected loses, the underestimation adjustment function would be less used. As a downside, loss projections beyond one year are less accurate, particularly when moving further out. Projections three or more years away are unlikely to have much accuracy. Also, using the average in cases where loss totals are projected to be very different in the two years may not be sensible. For example, if losses are projected to be very high in year t, but very low in year t+1, lowering year t's capital requirements on behalf of low projected losses in t+1 is not prudent.

Underestimation adjustment split through time – For simplicity, in the example I discussed up to this point, the adjustment relative to underestimation in year t fully accrues in year t+1. However, splitting the underestimation adjustment over multiple years would increase capital stability and, thus, may be preferable. To compensate for additional time discounting and maintain incentive-compatibility, the multiplier in the underestimation adjustment split through multiple years would need to be higher than the multiplier applied in an underestimation adjustment that fully accrues in the year after the underestimation. The formula below exemplifies how this modification could work if the underestimation adjustment is split over two years:

$$\begin{aligned} UA_{t+2}(RTL_t, RTL_{t+1}, PTL_t, PTL_{t+1}) \\ &= Max\{1.1 \cdot (FLC_t(RTL_t, :) - FLC_t(PTL_t, :), 0)\} \\ &+ Max\{1.1 \cdot (FLC_t(RTL_{t+1}, :) - FLC_t(PTL_{t+1}, :), 0)\} \end{aligned}$$

The underestimation adjustment for year t+2 would have components related to underestimation in years t and t+1. To account for additional time discounting and starting from the multiplier of 2 used in the baseline example, the multiplier would increase to, for example, 2.2. Then, because the adjustment for underestimation in year t would be split into years t+1 and t+2, the portion allocated to t+2 would have a multiplier equal to 2.2/2 = 1.1.

The downside of splitting the underestimation adjustment through multiple years is that the penalty for underestimation would live longer in the calculation and, thus, the weight of older loss events would increase. Nevertheless, on balance, increasing capital stability by having the underestimation adjustment accrue over multiple years (e.g., three or four) is likely sensible.

Weighting of backward-looking and forward-looking component – The proposed FIA would weigh the backward-looking component and the forward-looking component equally. This is an arbitrary assumption, despite my belief it represents a reasonable balance between conservatism and forward-looking perspective. Instead of this assumption, FIA's weights could be made dynamic, in accordance with the principles of credibility theory and optimal model averaging. But any such framework should not require complicated estimation. One possible approach would be to compare, over a five year window, realized losses to projected losses and to average past losses, and make the weights of the backward-looking and the forward-looking component vary inversely to the mean squared error of the corresponding loss estimates.

$$w_t^{BLC} = \frac{MSE_{t-1}^{PTL}}{MSE_{t-1}^{PTL} + MSE_{t-1}^{ATL}}$$

$$w_t^{FLC} = 1 - w_t^{BLC}$$

$$MSE_t^{PTL} = \frac{\sum_{i=0}^{4}(RTL_{t-i} - PTL_{t-i})^2}{5}$$

$$MSE_t^{ATL} = \frac{\sum_{i=0}^{4}(RTL_{t-i} - ATL_{t-1-i})^2}{5}$$

Where w_t^{BLC} is the weight of the backward-looking component in year t, w_t^{FLC} is the weight of the forward-looking component in year t, MSE_t^{PTL} is the mean squared error of banks' loss projections over the previous five years, and MSE_t^{ATL} is the mean squared error of using past average losses to project losses over the previous five years

Such framework would dynamically adjust to projection performance. However, supervisory conservatism should require that even if the accuracy of projections is very good for a period of time, the weight applied to the backward-looking component not go to zero. Even within a dynamic framework of this kind, a weight of the backward-looking component below 30% would likely be imprudent.

5.4 – Evaluation of the FIA

This sub-section evaluates the FIA according to the seven properties of an ideal capital framework and relative to the AMA and the SMA.

Appropriate conservatism – The proposed FIA includes multiple features to guarantee conservatism: the 50% weight on a backward-looking standardized figure, the multiplier that extrapolates from projected losses to tail exposure, the floor associated with a Basel standardized approach, and the underestimation adjustment function. Still, the ultimate degree of conservatism depends on the parametrization of all these components. The FIA cannot be less conservative than the SMA, if the SMA is agreed upon by the BCBS and the US remains compliant with Basel requirements, but can be more, less, or equally conservative relative to the AMA currently implemented in US banks depending on what US supervisory agencies decide is appropriate.

Robustness to gaming – By limiting how low capital can be under the FIA, the backward-looking component and the floor based on a Basel standardized approach directly limit gaming opportunities. The mechanism used to guarantee incentive-compatibility aims to ensure that the forward-looking component is not gamed either. Nevertheless, as previously discussed, this mechanism is likely to work better the more certainty there is about future losses. Banks may retain some incentive to underestimate expected losses under the FIA when there is meaningful uncertainty. But banks would have incentive to include in the FIA losses they are fairly certain will occur. Thus, this framework includes stronger incentives against underestimation than the AMA, wherein such incentives are completely absent. Given its more limited number of inputs, the SMA is likely more robust to gaming than the FIA. But as I discuss in the rest of this section, this robustness comes at a cost.

A possible criticism of this framework is that the mechanism used to provide banks with incentives for accurate estimation only works if banks are fairly certain of their own existence beyond the year ahead. If a bank is in perilous capital situation and under threat of large losses, it may have a short-term incentive to not accurately project losses. This criticism is fair, but the weakness of this framework under this scenario is, to an extent, already present in the AMA and the SMA. If a bank faces in the near future a large operational loss, an order of magnitude (or more) larger than everything it ever experienced before, such exposure may also not be fully captured by the SMA or by US AMA models.[7] Unlike the AMA and the SMA, the proposed framework would at least nudge banks to provide accurate projections of such solvency-threatening losses. Ultimately, no matter how a Pillar I framework is designed, there are extreme situations where supervisors have to exercise judgment. If a bank in a perilous capital situation and with known large legal exposure projects unreasonably low losses for the upcoming year, supervisory review should be triggered and the bank should be required to hold additional capital under Pillar II.

Risk sensitivity – The introduction of the forward-looking component aims to make the FIA risk sensitive. Banks would be able to use estimation methodologies that are best tailored to their specific risks and as much granularity as they find appropriate. Simultaneously, the underestimation adjustment aims to guarantee that banks have incentives to make accurate loss projections rather than loss projections that minimize capital (while passing regulatory muster). So, by improving incentive-compatibility, the underestimation adjustment is a critical mechanism towards ensuring the risk sensitivity of forward-looking estimates.

[7] Large losses of a magnitude similar to other large losses in the past would be captured by the SMA and the AMA. But they would also be partially captured under the proposed framework, even if banks chose to not project them, because 50% of the capital would be set according to a backward-looking, SMA-like formula.

The inclusion of a backward-looking component may lead to a decrease in risk sensitivity relative to an alternative framework that relied solely on an incentive-compatible forward-looking component. However, appropriate conservatism, robustness to gaming, and comparability concerns justify the inclusion of a backward-looking component. Similar backward-looking concerns apply to the underestimation adjustment itself, but in this case the need is even more critical because the underestimation adjustment is necessary to guarantee incentive-compatibility and thus the risk sensitivity of the forward-looking component.

The FIA would require banks to project next year's losses, which can be interpreted as the projection of expected losses.[8] Then, projected losses are multiplied by regulatory determined factors aiming to reflect the ratio of losses on an average year to some notion of tail exposure. Such approach is similar to the loss multipliers in the SMA, but departs from direct estimation of tail exposure under the AMA. Uniform extrapolation from expected losses to tail exposure is unlikely to maximize tail risk sensitivity. But as discussed before, AMA estimates likely lack risk sensitivity because banks are not directly incentivized to accurately estimate tail exposure.

Multiple research papers have argued for a lowering of the estimation percentile associated with the AMA in tandem with the use of regulatory multipliers to restore appropriate conservatism, but these papers envisioned that the requirement would still target a high percentile of the loss distribution rather than expected losses (Mignola and Ugoccioni 2006, Neslehova et al. 2006, Cope et al. 2009, Ames et al. 2015). It is possible, perhaps likely, that extrapolation from a high percentile (e.g., 90th, 95th) to tail exposure (99.9th percentile or thereabouts) is more accurate than extrapolation from expected losses. However, producing appropriate incentives for estimation of a tail percentile could be more complex and result in more capital instability than penalizing realized loss underestimation. If the approach relied on establishing underestimation of a tail percentile, multiple years of observation would be needed before an underestimation adjustment could be assessed. This slower process could meaningfully reduce banks' short and medium term incentives to produce accurate forecasts in the forward-looking component. Moreover, the penalty would likely need to be much larger to guarantee incentive-compatibility, thus increasing capital volatility. If instead the approach relied on a larger penalty when realized losses are above projected losses to ensure that banks target a high percentile of the annual loss distribution (rather than expected or median losses), the triggering of the underestimation adjustment would result in higher capital volatility than the proposed approach.

[8] I do not believe a possible FIA rule would need to point banks to estimate next year's expected losses. Banks may prefer to target expected losses plus or minus some percentage, or target certain loss percentiles, depending on their aversion to capital fluctuations and their intertemporal preferences for capital. Nevertheless, incentives would be in place to discourage underestimation relative to expectation and, particularly, discouraging underestimation when expected losses do not suffer from much uncertainty.

The forward-looking component of the FIA can immediately respond to banks' perceived changes in risk, and thus, after the implementation of improved risk controls or reduction of exposure to certain businesses, banks would be able to immediately realize capital gains. Thus, the forward-looking portion of this framework would produce strong incentives for improved risk controls and de-risking.

By combining a forward-looking component with a backward-looking component calibrated to US exposure, the FIA would likely prove to be more risk sensitive than the SMA. While in theory the AMA could be more risk sensitive than the FIA, in practice the lack of incentives for accurate estimation embedded in the AMA plus the US regulatory focus on covering past losses likely imply that the AMA fails to be risk sensitive and, thus, that the FIA would likely outperform it on this critical dimension.

Comparability – Despite also using banks' internal estimates, the FIA would improve capital comparability relative to the AMA. Half of the requirement would be set according to a backward-looking function, which would apply equally to all banks. The projection methodologies for the forward-looking component could vary meaningfully across banks, but if certain banks systematically underestimate exposure, the framework would automatically require them to hold more capital. Also, the factor used to extrapolate from projected losses to tail exposure would apply equally to all banks. Finally, capital requirements would be floored by the SMA or the BIA, which would apply equally to all banks.

Unlike the SMA, capital calculation under the FIA is not fully standardized. Differences in estimation methodologies across banks could lead to differences in capital requirements for banks with similar exposures. But FIA requirements are likely to be better aligned with risk than SMA requirements. Thus, the FIA capital outcomes may be as comparable as or more comparable than SMA capital outcomes relative to risk.

Stability – The FIA is designed to require larger amounts of capital before years where banks predict large losses and smaller amounts before years where banks predict small losses. Thus, the FIA is meant to vary more than a framework that does not move in reaction to changes in foreseen risk. But this variation of the FIA is appropriate, as it correlates with risk variation. Unlike the AMA and the SMA, the forward-looking component of the FIA varies before losses occur rather than after, as should be desirable in a capital framework.

The underestimation adjustment of the FIA introduces capital volatility after unforeseen large losses. This feature is similar to how capital reacts to large losses under the US implementation of the AMA and how it would react under the SMA, but the swings could be larger. Unfortunately, implementing an incentive-compatible capital calculation approach is bound to result in a degree of volatility. As is discussed in the previous sub-section, the volatility originated by the underestimation adjustment could be reduced by spreading this capital add-on through multiple years.

Simplicity – The regulatory formulas used to calculate FIA capital should be similarly simple as the SMA formulas. The methods used by banks to project losses could be as simple or complex as banks prefer. But given the shift of focus from AMA's 99.9th percentile to expected losses, FIA models are likely to be simpler than AMA models and more accessible to non-expert bankers and regulators.

Usefulness to risk management and advancement of quantification – By incentivizing accurate estimation of future losses, the FIA is intended to provide useful information to banks' risk management processes. The shift from estimation of the 99.9th percentile to one-year-out loss projection may also make estimates more useful to risk management activities.

Unlike the SMA, the FIA would keep the incentive for advancement of operational risk quantification. By introducing incentive-compatibility, the FIA would allay regulatory fears around gaming and thus allow banks to pursue methodologies that best project losses, regardless of whether they are based on internal losses, external losses, scenario analysis, risk control self-assessments, or key risk indicators. Such modeling freedom could lead to accomplishment of the initial AMA vision of "letting a thousand flowers bloom" and consequent advancement of our understanding of operational risk. In my view, the advancement of operational risk quantification is also facilitated by the shift from estimation of the 99.9th percentile to expected loss projection, as models can more quickly improved by confronting them with empirical evidence.

6 – Conclusion

This paper makes a case for adoption of the Forward-looking and Incentive-compatible approach (FIA), an operational risk capital framework that balances appropriate conservatism, robustness to gaming, risk sensitivity, comparability, stability, simplicity, and usefulness to risk management and advancement of quantification. The key ingredient to jointly achieve these goals is guaranteeing that the framework is incentive compatible, or at least close to it. The case for such framework is also based on the weaknesses of the alternatives, the AMA and the proposed SMA. The AMA chases an impossible goal, measurement of the 99.9th percentile of the loss distribution, which has led to model complexity and opportunities for gaming. To counter-act this issue, US AMA models have experienced significant regulatory intervention, which tented to restrict their forward-looking nature. The SMA suffers from lack of forward-looking inputs and will likely require meaningful watering down relative to current US AMA capital requirements to achieve international agreement.

For banks, the proposed framework offers a move towards risk sensitivity and away from regulatory involvement in their modeling frameworks. Under the FIA, banks would be freer to invest on the risk quantification processes most appropriate to their situations, thus increasing the potential for synergy between their regulatory compliance efforts and internal risk management goals. By allowing a more forward-looking approach, the FIA would assist economic capital allocation within the bank and capital management through risk controls and decrease of exposure.

A possible criticism of this framework is that even if banks can predict large legal losses somewhat accurately, most will prefer not to do so to protect sensitive reserve information. In defense of the FIA, banks would not need to disclose individual loss events when projecting total losses and the AMA and the SMA already require the use of legal reserves prior to settlement. But despite these caveats, the use of legal losses under the FIA would certainly lead to quicker and more transparent revelation of losses. And so when larger than usual legal losses are on the horizon, they would affect capital requirements sooner, allowing industrious analysts to deduce rough estimates. This is a feature, not a bug of the proposal. Banks that do not share my enthusiasm for disclosure of top-of-the house exposure information to the market may prefer a framework that does not rely on accurately projecting losses over the next year. To account for this possibility, if supervisors ever decide to consult on a framework similar to the FIA, they should provide the industry with the opportunity to comment on having fully backward-looking capital requirements. Nevertheless, the benefits offered by the FIA are multiple and so its calibration should be made appealing to banks in comparison to a fully backward-looking option. In the example calibration, the multiplier of average losses in the backward-looking component is larger than the multiplier applied to forward-looking projections. This feature should remain in the final framework. Over the long-run, capital requirements should be higher for banks that chose a fully backward-looking option than for banks using the FIA. Banks should be given the option to have more disclosure and less capital (on average), or less disclosure and more capital. I believe a large share of banks would opt for the former.

From the perspective of supervisors, the proposed framework also offers many attractive features. Chief among them is that this framework would meaningfully increase risk sensitivity relative to the SMA and the US implementation of the AMA and, in particular, would incentivize banks to raise capital before large predictable losses occur, rather than after. The information provided to supervisors by banks loss projections within this framework would also be invaluable, as supervisors currently lack loss projections for which banks have incentives to achieve accuracy.[9] The overall conservatism of the framework could be set at the level supervisors find appropriate – at, above, or below current AMA requirements. Finally, this framework would decrease supervisory burden relative to the AMA, as supervisors would no longer have to argue with banks over the statistical minutia of estimating the 99.9th percentile of loss distributions; instead, the framework would automatically adjust capital for banks that under-project losses.

The case for the FIA is stronger if the SMA is agreed upon at the BCBS and its final calibration results in an undesirable decrease in the operational risk capital requirements of US banks; or if the SMA is never agreed upon at the BCBS, but US regulators still want to eliminate the AMA due to its multiple shortcomings. If the agreed upon SMA results in capital levels that are seen as desirable by policy-makers, there would be no space to implement a FIA while also complying with Basel agreements.

Besides the concerns of US regulators regarding capitalization and how the US framework relates to the Basel framework, developments on the legislative arena should also be taken into account when reforming the operational risk capital framework. Concerns regarding the backward-looking nature of operational risk capital requirements have resulted in legislators including language related to operational risk in the recently unveiled Financial Choice Act, a bill that aims to reform the US financial regulatory framework. In particular, the bill mentions "An appropriate Federal banking agency may not establish an operational risk capital requirement for banking organizations, unless such requirement—(…) is determined under a forward-looking assessment of potential losses that may arise out of a banking organization's current activities and businesses, which is not solely based on a banking organization's historical losses; (…)." As I write these words, the fate of the Financial Choice Act remains to be seen; nevertheless, I believe the approach presented in this paper is more consistent with the vision for operational risk capital presented in the Financial Choice Act than the AMA (as currently implemented) or the SMA.

Given the current uncertainty regarding the fate of the SMA, US policy-makers preferences around capitalization levels, and possible legislative mandated changes to the operational risk capital framework, I believe the time is right to propose an alternative to improve the operational risk framework. The FIA would increase risk sensitivity versus the alternatives on the table, while retaining conservatism and minimizing gaming. I hope this paper fosters a discussion about these ideas involving regulators, industry practitioners, and academics, and that its underlying concepts can be improved. The operational risk capital framework is at turning point. Regulators and industry should use this opportunity.

[9] Banks are required to project operational losses under baseline and adverse conditions within the CCAR process. However, the CCAR framework does not include a direct incentive for banks to accurately project operational losses.

References

Acharya, Viral, Philipp Schnabl, and Gustavo Suarez (2014). "Securitization without risk transfer." *Journal of Financial Economics* Vol. 107, 515-536.

Admati, Anat (2016). "The Missed Opportunity and Challenge of Capital Regulation." *National Institute Economic Review* Vol. 235, R4-R14.

Admati, Anat, and Martin Hellwig (2014). *The Bankers' New Clothes: What's Wrong with Banking and What to Do about It*. Princeton University Press.

Aikman, David, Mirta Galesic, Gerd Gigerenzer, Sujit Kapadia, Konstantinos Katsikopoulos, Emma Murphy, and Tobian Neumann (2014). "Taking uncertainty seriously: simplicity versus complexity in financial regulation." Financial Stability Paper No. 28. Bank of England.

American Bankers Association (2016). Comment letter on the Standardized Measurement Approach. http://www.aba.com/Advocacy/commentletters/Documents/basel-operational-risk-capital-proposal-6216.pdf. Retrieved on May 8, 2017.

Ames, Mark, Til Schuermann, and Hal Scott (2015). "Bank capital for operational risk: A tale of fragility and instability." *Journal of Risk Management in Financial Institutions* Vol. 8, 227-243.

Basel Committee on Banking Supervision (2006). "International Convergence of Capital Measurement and Capital Standards – A Revised Framework."

Basel Committee on Banking Supervision (2012). "Core Principles on Effective Banking Supervision."

Basel Committee on Banking Supervision (2013). "The regulatory framework: balancing risk sensitivity, simplicity and comparability."

Basel Committee on Banking Supervision (2016). "Standardized Measurement Approach for operational risk."

Behn, Markus, Rainer Haselmann, and Vikrant Vig (2016). "The limits of model-based regulation." Working Paper Series No 1928. European Central Bank.

Blum, Jürg (2008). "Why Basel II may need a leverage ratio restriction." *Journal of Banking & Finance* Vol. 32, 1699-1707.

Board of Governors of the Federal Reserve System (2014). "Supervisory Guidance for Data, Modeling, and Model Risk Management Under the Operational Risk Advanced Measurement Approaches." Basel Coordination Committee Bulletin 14-1.

Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation, Office of the Comptroller of the Currency, and Office of Thrift Supervisions (2011). "Interagency Guidance on the Advanced Measurement Approaches for Operational Risk."

British Bankers' Association (2016). Comment letter on the Standardized Measurement Approach. https://www.bba.org.uk/policy/financial-and-risk-policy/prudential-capital-and-risk/operational-risk/bba-response-to-the-basel-committees-consultation-on-the-standardised-measurement-approach-for-operational-risk/. Retrieved on May 8, 2017.

Calomiris, Charlos (1999). "Building an incentive-compatible safety net." *Journal of Banking & Finance* Vol. 23, 1499-1519.

Chapelle, Ariane, Bertrand Hassani, Gareth Peters, Evan Sekeris, and Pavel Shevchenko (2016). "Discarding the AMA could become a source of op risk. "*Risk.net*. http://www.risk.net/risk-management/operational-risk/2451089/discarding-the-ama-could-become-a-source-of-op-risk. Retrieved on May 8, 2017.

Colliard, Jean-Edouard (2015). "Strategic Selection of Risk Models and Bank Capital Regulation." 15th Society for the Advancement of Economic Theory Conference on Current Trends in Economics. University of Cambridge, UK.

Cope, Eric, Giulio Mignola, Gianluca Antonini, and Roberto Ugoccioni (2009). "Challenges and pitfalls in measuring operational risk from loss data." *Journal of Operational Risk* Vol. 4 (4), 3-27.

Cuoco, Domenico, and Hong Liu (2006). "An analysis of VaR-based capital requirements." *Journal of Financial Intermediation* Vol. 15, 362-394.

Curti, Filippo, Ibrahim Ergen, Minh Le, Marco Migueis, and Roberto Stewart (2016). "Benchmarking Operational Risk Models." Finance and Economics Discussions Series 2016-070. Board of Governors of the Federal Reserve System.

Danielsson, Jon (2002). "The emperor has no clothes: Limits to risk modelling." *Journal of Banking and Finance* Vol. 26, 1273-1296.

Department of the Treasury, Federal Reserve System, and Federal Deposit Insurance Corporation (2007). "Risk-Based Capital Standards: Advanced Capital Adequacy Framework – Basel II."

Diamon, Douglas, and Raghuram Ranjan (2000). "A Theory of Bank Capital." *The Journal of Finance* Vol. 55, 2431-2465.

Dimon, Jamie (2017). Letter to shareholders. JP Morgan Chase. https://www.jpmorganchase.com/corporate/investor-relations/document/ar2016-ceolettershareholders.pdf. Retrieved on May 8, 2017.

Dombrovskis, Valdis (2016). Speech by VP Dombrovskis at the European Banking Federation Conference: Embracing Disruption. https://ec.europa.eu/commission/commissioners/2014-2019/dombrovskis/announcements/speech-vp-dombrovskis-european-banking-federation-conference-embracing-disruption_en. Retrieved on May 8, 2017.

Elliott, Douglas (2013). "Higher Bank Capital Requirements Would Come at a Price." Brookings Institute. https://www.brookings.edu/research/higher-bank-capital-requirements-would-come-at-a-price/. Retrieved on May 8, 2017.

European Banking Authority (2015). "Regulatory Technical Standards on assessment methodologies for use of AMAs for operational risk."

European Banking Federation (2016). Comment letter on the Standardized Measurement Approach. http://www.ebf-fbe.eu/wp-content/uploads/2016/06/EBF_020386-EBF-Final-Response-to-BIS-on-CD-SMA-for-operational-risk_3June2016.pdf. Retrieved on May 8, 2017.

Federal Reserve Bank of Minneapolis (2016). "The Minneapolis plan to end too big to fail."

Firestone, Simon, Amy Lorenc, and Ben Ranish (2017). "An Empirical Economic Assessment of the Costs and Benefits of Bank Capital in the US." Finance and Discussion Series 2017-034. Board of Governors of the Federal Reserve System.

Hegarty, Michael (2016). "Euro banks to bear brunt of €115bn SMA capital hike: study." *Risk.net*. http://www.risk.net/risk-management/2460262/euro-banks-to-bear-brunt-of-eu115bn-sma-capital-hike-study. Retrieved on May 8, 2017.

Heid, Frank (2007). "The cyclical effects of the Basel II capital requirements." *Journal of Banking & Finance* Vol. 31, 3885-3900.

Hinchliffe, Jimi (2016). "The death of one thousand flowers or the AMA reborn?" *Journal of Operational Risk* Vol. 11 (4), 79-91.

Hoenig, Thomas (2013). "Basel III Capital: A Well-Intended Illusion." Remarks to the International Association of Deposit Insurers 2013 Research Conference. https://www.fdic.gov/news/news/speeches/spapr0913.html. Retrieved on May 8, 2017.

Hoenig, Thomas (2015). "Post-Crisis Risks and Bank Equity Capital." Remarks to the 18th Annual International Banking Conference at the Federal Reserve Bank of Chicago. https://www.fdic.gov/news/news/speeches/spnov0515.html. Retrieved on May 8, 2017.

Hoenig, Thomas, and Charles Morris (2013). "Restructuring the Banking System to Improve Safety and Soundness" in *The Social Value of the Financial Sector: Too Big to Fail or Just Too Big.* World Scientific Publishing.

International Monetary Fund (2014). “How Big is the Implicit Subsidy for Banks Considered Too Important to Fail?” in *Global Financial Stability Report April 2014*.

Jones, David (2000). “Emerging problems with the Basel Capital Accord: Regulatory capital arbitrage and related issues.” Journal of Banking & Finance Vol. 24, 35-58.

Lever, Jake, Martin Krzywinski, and Naomi Altman (2016). “Model selection and overfitting.” *Nature Methods* Vol. 13, 703-704.

Mariathasan, Mike, and Ourda Merrouche (2014). “The manipulation of basel risk-weights.” *Journal of Financial Intermediation* vol. 23, 300-321.

Marlin, Steve (2016). “European banks face steep op risk capital hike from SMA.” *Risk.net*. http://www.risk.net/risk-management/operational-risk/2453958/european-banks-face-steep-op-risk-capital-hike-from-sma. Retrieved on May 8, 2017.

McConnell, Patrick (2017). “Standardized measurement approach: is comparability attainable.” *Journal of Operational Risk* Vol. 12 (1), 71-110.

Meek, Jessica (2014). “Scenarios fill the speculative gaps, op risk panel says.” *Risk.net*. https://www.risk.net/risk-management/operational-risk/2350885/scenarios-fill-speculative-gaps-op-risk-panel-says. Retrieved on May 8, 2017.

Mignola, Giulio, and Roberto Ugoccioni (2006). “Sources of uncertainty in modeling operational risk losses.” *Journal of Operational Risk* Vol. 1 (2), 33-50.

Mignola, Giulio, Roberto Ugoccioni, and Eric Cope (2016). “Comments on the Basel Committee on Banking Supervision proposal for a new standardized approach for operational risk.” *Journal of Operational Risk* Vol. 11 (3), 51-69.

Nešlehová, Johanna, Paul Embrechts, and Valérie Chavez-Demoulin (2006). “Infinite mean models and the LDA for operational risk.” *Journal of Operational Risk* Vol. 1 (1), 3-25.

Opdyke, John, and Alexander Cavallo (2012). “Estimating Operational Risk Capital: The Challenges of Truncation, the Hazards of Maximum Likelihood Estimation, and the Promise of Robust Statistics.” *Journal of Operational Risk* Vol. 7 (3), 3-90.

Peters, Gareth, Pavel Shevchenko, Bertrand Hassani, and Ariane Chapelle (2016). “Should the advanced measurement approach be replaced with the standardized measurement approach for operational risk?” *Journal of Operational Risk* Vol. 11 (3), 1-49.

Peura, Samu, and Jussi Keppo (2006). “Optimal Bank Capital with Costly Recapitalization.” *The Journal of Business* Vol. 79, 2163-2201.

Plosser, Matthew, and João Santos (2014). "Banks' Incentives and the Quality of Internal Risk Models." Staff Report No. 704. Federal Reserve Bank of New York.

Rajan, Uday, Amit Seru, Vikrant Vig (2010). "Statistical Default Models and Incentives." *American Economic Review: Papers & Proceedings* Vol. 100, 506-510.

Rajan, Uday, Amit Seru, and Vikrant Vig (2015). "The failure of models that predict failure: Distance, incentives, and defaults." *Journal of Financial Economics* Vol. 115, 237-260.

Repullo, Rafael (2004). "Capital requirements, market power, and risk-taking in banking." *Journal of Financial Intermediation* Vol. 13, 156-182.

Tarullo, Daniel (2008). *Banking on Basel: The Future of International Financial Regulation*. Peterson Institute.

Tarullo, Daniel (2012). "Statement by Governor Daniel K. Tarullo." Federal Reserve Board of Governors. https://www.federalreserve.gov/newsevents/press/bcreg/tarullo20120607a.htm. Retrieved on May 8, 2017.

Tarullo, Daniel (2016). "Financial Regulation Since the Crisis." Federal Reserve Bank of Cleveland and Office of Financial Research 2016 Financial Stability Conference. https://www.federalreserve.gov/newsevents/speech/tarullo20161202a.htm. Retrieved on May 8, 2017.

The Clearing House, The Securities Industry and Financial Markets Association, and Financial Services Roundtable (2016). Comment letter on the Standardized Measurement Approach. https://www.theclearinghouse.org/~/media/Action%20Line/Documents/Volume%20VII/20160603_TCH_Comments_BCBS_Operational_Risk.pdf. Retrieved on May 8, 2017.

The Risk Management Association (2016). "RMA/AMAG Comment Letter on SMA." http://www.rmahq.org/WorkArea/DownloadAsset.aspx?id=18820. Retrieved on May 8, 2017.

Van den Heuvel, Skander (2008). "The welfare cost of bank capital requirements." *Journal of Monetary Economics* Vol. 55, 298-320.

Appendix

Proving Incentive Compatibility

Assumptions:

1) RTL_t is a random variable with domain [d, + ∞)
2) 10d > BLC_t
3) $f(RTL_t)$ is the probability density function of RTL_t and is > 0 in the full domain of RTL_t
4) $E[RTL_t]$ = Median[RTL_t]
5) No time discounting
6) Bank is risk-neutral regarding future capital amounts

Given assumptions 5 and 6, banks want to minimize the expected value of the sum of the FLC_t and UA_{t+1}. Given assumption 1 and that underestimation is penalized, banks will always choose PTL_t > d. So, the sum of FLC_t and UA_{t+1} simplifies to the formula below:

$$FLC_t + UA_{t+1} = BLC_t + 2\left(PTL_t - \frac{BLC_t}{10}\right) + 2 \cdot Max\{2RTL_t - 2PTL_t, 0\}$$
$$= 0.8BLC_t + 2PTL_t + 4Max\{RTL_t - PTL_t, 0\}$$

The expected value of this expression, conditional on PTL_t (which is picked by the bank) and BLC_t (which is known when a bank picks PTL_t) is given by the formula below:

$$E[FLC_t + UA_{t+1}] = 0.8BLC_t + 2PTL_t + 4E[Max\{RTL_t - PTL_t, 0\}]$$
$$= 0.8BLC_t + 2PTL_t + 4\int_{PTL_t}^{+\infty} (RTL_t - PTL_t) f(RTL_t) dRTL_t$$
$$= 0.8BLC_t + 2PTL_t + 4\int_{PTL_t}^{+\infty} RTL_t f(RTL_t) dRTL_t - 4PTL_t \int_{PTL_t}^{+\infty} f(RTL_t) dRTL_t$$

To verify that setting projected losses equal to expected losses is the optimal choice for banks under this set of assumptions (and thus show that the capital framework is incentive compatible), I need to show that $PTL_t = E[RTL_t]$ minimizes $E[FLC_t + UA_{t+1}]$. To do so, I show below that the first-order and second order conditions for a global minimum are met:

$$\frac{\partial E[FLC_t + UA_{t+1}]}{\partial PTL_t} = 2 - 4PTL_t \cdot f(PTL_t) - 4\int_{PTL_t}^{+\infty} f(RTL_t) dRTL_t + 4PTL_t \cdot f(PTL_t)$$
$$= 2 - 4\int_{PTL_t}^{+\infty} f(RTL_t) dRTL_t$$

$$\frac{\partial E[FLC_t + UA_{t+1}]}{\partial PTL_t}(PTL_t = E[RTL_t]) = 2 - 4 \underbrace{\int_{E[RTL_t]}^{+\infty} f(RTL_t)dRTL_t}_{=0.5\ because\ E[RTL_t]=Median[RTL_t]} = 2 - 4 \cdot 0.5$$

$$= 0$$

$$\frac{\partial^2 E[FLC_t + UA_{t+1}]}{\partial {PTL_t}^2} = 4f(PTL_t) > 0$$