A test of the inherent predictiveness of the RU, a new metric to express all forms of operational risk in banks

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Abstract In 2016 Allan D. Grody and Peter J. Hughes proposed a method and system termed 'Risk Accounting', an integrated financial and risk accounting framework. Risk Accounting incorporates a novel operational risk exposure quantification technique based on the Risk Unit (RU), a new common additive metric designed to express all forms of operational risk in banks. In this paper, we report on initial tests of the inherent predictiveness of the RU. The test focused on the period leading up to the global financial crisis of 2007-8 and involved the restatement into RUs of publicly available accounting data in the United States relative to a subset of large US banks. We contend that the RU's inherent predictiveness could be concluded if it is demonstrated that an accelerated increase in trended operational risk RUs and subsequent material unexpected losses are positively correlated. We further describe how a monetary value can be stochastically derived and assigned to the RU over time. The inclusion of valued RUs in accounting systems will potentially enable the systematic adjustment of financial performance and condition relative to accepted nonfinancial risks to complement the accounting treatment already applied to financial (credit and market) risks. The resulting harmonisation of the accounting treatment applied to both financial and nonfinancial risks based on stochastic modelling will enable risk-adjusted economic profit to be adopted as the primary business performance metric and economic capital as the primary method of determining both operating and regulatory capital requirements. The real-time or near-real-time production of portfolio views of operational risk exposures based on the RU adds analytical rigour to their management and causes risk mitigation to become both a risk reduction and a profit optimisation initiative. The

more effective management, oversight and governance of exposures to operational risks is the anticipated outcome.

Keywords: *operational risk, risk accounting, risk quantification, expected loss, unexpected loss*

INTRODUCTION

Banks have become operationally dependent on globally interconnected data and information networks in a globalised marketplace that offers customers, counterparties and intermediaries increasingly sophisticated financial products via electronic banking and trading platforms. The result is exponential growth in concentrations of both financial and operational risks in the global banking system. The financial crisis of 2007–8 demonstrated how unquantified and unreported exposures to such risks are capable of escalating to catastrophic proportions before they mutate into losses when triggered by unexpected changes in macroeconomic or other market conditions and/or internal operating failures.

Any measurement system must have a common, standardised unit of measurement that is uniquely associated with the quantifiable properties of the measurement object. Accordingly, operational risk exposures can only be directly and explicitly measured using a nonfinancial unit of measurement, hence the creation and definition of the Risk Unit (RU) to express, in both quantitative and qualitative terms, all forms of exposure to operational risks, including processing, cyber, model, conduct and environmental risks.[1,2]

The universally adopted method of managing exposures to operational risks in financial institutions is risk and control self-assessment (RCSA). Whereas RCSA is effective in identifying operational risk exposures, the use of colour-coding, typically RAG (red/amber/green), to gauge their likely financial impact disenables risk exposure aggregation. This means that real-time or near-real-time analysis of accumulating operational risk exposures through typical portfolio management techniques such as trending, ranking, benchmarking and monitoring of actual exposures against risk budgets and operating limits are not available, thereby inhibiting effective risk oversight and governance.

The introduction of a common additive operational risk metric potentially resolves these limitations. Operational risk quantification using the RU offers a novel dimension to risk analytics through calculations of inherent and residual risks in RUs at the granular transaction level that can be horizontally and vertically aggregated through multiple hierarchies, including group-wide, business line, organisational component (cost centre), product, and customer. Operational risk analytics in RUs are generated through algorithms that use risk-weighted factors from the outputs of risk assessments and associated operating and accounting data. The algorithms enable the production of comprehensive analytics in RUs encompassing both granular and aggregated operational risk exposures.

Recent changes to accounting standards may have far-reaching implications for the ongoing debate on operational risk quantification. A fundamental accounting principle is the 'accrual concept' that requires revenues and expenses to be accounted for when they are earned or incurred, not when they are settled through receipt or payment of cash. That being the case, the question arises whether probable future losses associated with accepted risks should be accounted for in the form of expected loss provisions. If a bank creates a risk in its pursuit of increased shareholder value, it also creates a probability of loss. If that probability of loss can be reasonably estimated, sound accounting practice would be to account for the expected loss upon the creation of the associated risk.[3] Andrew W. Lo observed that risk is not part of the accountant's lexicon, arguing that there is no natural way to capture risk from the current GAAP (Generally Accepted Accounting Principles) accounting perspective, which causes audited financial statements to be essentially backward-looking, thereby limiting their value.[4]

The Financial Accounting Standards Board (FASB) and International Accounting Standards

Board (IASB) have begun to address this gap in GAAP through their overhauling of the accounting treatment applied to asset impairment. The IASB's IFRS 9[5] (International Financial Reporting Standard 9) and the FASB's CECL[6] (current expected credit loss) require banks to include, in credit loss provisions, the estimated cash shortfalls that are likely to occur over the expected life of credit risk assets (loans, lease receivables etc). This change in accounting standards results in banks, for the first time, incorporating estimates of probable future credit losses in audited financial statements. Recognising expected losses in this way complements the incurred losses associated with past economic events that affect obligors' creditworthiness, such as past-due loan repayments and court filings for creditor protection. The aim of the accounting change is to risk-adjust audited financial statements through more timely recognition of expected future losses, thereby making them more forward-looking and, hence, more useful.

In this paper, we contemplate this change in accounting direction that, for the first time, calls for the recognition of probable future losses in audited financial statements, and we consider the implications for exposures to operational risks. We also report on tests of the inherent predictiveness of the RU and conclude whether it has the potential on which to extend expected loss accounting treatment to operational risks.

OPERATIONAL RISKS AND EXPECTED LOSSES

The extreme credit and market risks accepted by banks were not the only causes of the global financial crisis of 2007-8; the failure of critical internal operational risk-mitigating processes and activities were also a contributing factor.[7] Further examples of extreme losses suffered by banks, caused partially or wholly by internal operating failures, include the misguided or fraudulent activities of rogue traders,[8] the payment protection insurance (PPI) mis-selling scandal in the United Kingdom,[9] and the JPMorgan London Whale.[10] In these and similar cases, accumulations of nonfinancial risks hit a tipping point that triggers unexpected losses concentrated in one or more risk types: credit, market, operational or interest rate risk in the banking book (IRRBB). Such unexpected losses are incremental to expected losses associated with accepted financial risks intentionally created within risk appetite boundaries for a projected return.

In principle, expected losses are stochastically determined accounting estimates of projected financial outcomes where the total amount of exposure to risk, at the time of expected loss estimation, is both known and within approved operating limits linked to risk appetite. In contrast, unexpected losses are financial outcomes associated with the failure to accurately identify, quantify, aggregate and report accumulating exposures to risks, and consequently, it is unknown whether such exposures are within approved risk limits. Whereas exposures to financial risks can be quantified in monetary value and systematically reported in accounting systems, a generally accepted method of explicitly quantifying granular operational risk exposures within a common measurement framework and aggregating them in parallel with financial risks has not been widely adopted by banks.

The new impairment accounting included in IFRS 9 and CECL relates specifically to credit risk. Given that the causes of extreme losses in the banking sector in the recent past include unquantified and unreported exposures to operational risks, the impairment accounting treatment prescribed under IFRS 9 and CECL will not address all of the expected losses to which banks are exposed. Consequently, banks' boards of directors, investors, customers, regulatory supervisors and other stakeholders do not have certainty that reported profits present a true and fair view of a bank's financial performance and condition. In cases of excessive risk-taking, a bank may report profits when, in fact, it would have been lossmaking if expected loss provisions had been accounted for. The medium- and longer-term consequences of this condition can be serious if the negative impact on liquidity and capital attributable to probable future losses is not recognised in accounting, which is further compounded through dividends, discretionary bonuses and income taxes paid from overstated profits. If uncorrected, an

organisation will become exposed to the risk of insolvency.

A further consequence of the non-accounting for expected operational risk-related losses is the absence of a profit incentive to improve risk mitigation. If accumulating exposures to operational risks were to be explicitly and dynamically quantified, culminating in a charge to profit and loss, investment in risk mitigation will be viewed by banks' boards and management as both a risk reduction and a profit optimisation initiative, resulting in greater accountability and visibility of operational risk management.

THE CALL FOR 'RISK ACCOUNTING'

Extending the new impairment accounting treatment to operational risk-related expected losses introduces challenges, the most significant being how to resolve the absence of a generally accepted method of explicitly quantifying banks' operational risk exposures and the difficulties inherent in achieving a formulation that ensures an appropriate degree of risk-sensitivity, transparency and comparability. The Bank of England (p. 8) acknowledges these difficulties through its observation: 'Sizing capital for operational risk is a significant challenge. The loss distribution is unusually fat tailed, with infrequent but very large losses, and there is a paucity of data. This problem applies to all operational risks but is especially acute for conduct risk.'[11] This observation highlights the difficulties of deploying stochastic techniques to estimate probable future losses in the absence of a generally accepted approach to the explicit and dynamic quantification of accumulating exposures to operational risks.

The Risk Accounting method proposed by Grody and Hughes[1,2] offers a solution in the form of an integrated financial and risk accounting framework. In principle, the method they propose incorporates a risk quantification technique that assigns risk values to transactions to complement existing financial accounting values. The pairing of risk and accounting values at the transaction level enables the systematic calculation of granular risk/return metrics that can be aggregated using the data aggregation paths already established in financial and management accounting systems. The result is the alignment of risk-adjusted reporting of financial performance and condition, including the calculation of expected operational risk-related expected losses, and the production of comprehensive operational risk management information and analytics within a common and integrated financial and risk accounting framework.

The interaction of operational with financial and systemic risks

Operational risk mitigation is subject to the four core functions of management, being planning, organising, leading and controlling.[12] An exposure to operational risk invariably exists where the application of these four functions is suboptimal. In contrast, financial risks (credit and market) exist where a bank intentionally creates external financial exposures with customers, intermediaries and counterparties for a projected return. Thus, financial risks are substantially beyond the direct influence of banks' management and, consequently, are not entirely subject to the aforementioned four core functions of management.

It follows that if excessive exposures to operational risks exist, the unbridled creation of external financial risks will be the probable outcome. For example, if a bank's internal lending practices are defective, an operational risk exists, leading to poor quality borrowers being treated as high quality and, conversely, high quality borrowers as poor quality. The result is a loan portfolio with elevated expected credit losses, which is caused by the failure to effectively plan, organise, lead and control the operational risk. This same financial/operational risk dynamic applies to all the operational risk categories set out in Table 1.

The emergence of systemic risk as a primary concern of global regulators is broadly attributable to escalating operational risks, a consequence of the global banking system's dependency on interconnected electronic banking and trading networks, and the functioning of interbank and money markets characterised by a nexus of complex and opaque bilateral obligations. The resulting susceptibility of the global banking system

Table 1: Operational risk categories and EUF assignment criteria

Operational risk categories	Risk management objective	EUF assignment criteria
Processing	Transactions accepted for processing are properly approved, and processing is complete, accurate and timely	Number of operational touchpoints along the product's end-to-end processing cycle
Lending	In the event of an assumed default, a liquidation price for underlying collateral can be realised in a reasonable timeframe and without incurring exceptional losses	The relative time and effort required to liquidate collateral in the event of a credit default with reference to the value retention properties and price stability of underlying collateral
Trading	In the event of an assumed unwinding of a trading risk position, a liquidation price can be realised in a reasonable timeframe and without incurring exceptional losses	The relative time and effort required to unwind a trading position with reference to the availability and reliability of market prices and rates, and the manner in which the product is traded (eg electronic, floor, OTC)
Treasury	**Funding** Stable sources of funding are available to fund immediate and foreseeable operating needs **Interest rate management** In the event of unpredicted interest rate movements, interest rate sensitive assets and liabilities can be extinguished, replaced, extended or renewed in a reasonable timeframe and without incurring exceptional losses	The relative time and effort required to fund a product and manage associated liquidity and interest rate risk with reference to: **Banking book:** interest rate type (fixed or floating) and maturity **Derivatives:** relative degree of complexity **Transactional and trading book:** assume marginal treasury involvement
Selling	Positive customer outcomes are achieved, and customers are treated fairly	Whether the product is . . . An investment product involving the holding of customer monies Directly linked to a sales incentive scheme Bundled with other products (eg a loan with an interest rate swap) . . . and the relative degree of complexity
Environmental	Manufactured outputs do not threaten the wellbeing of infrastructure, the environment and public at large	The product's relative degree of toxicity, combustibility and biodiversity

Notes: EUF, exposure uncertainty factor; OTC, over the counter.
Source: Risk Accounting Standards Board.

to systemic contagion and risk is compounded by the too-big-to-fail syndrome and the emergence of cyber risk as a major regulatory concern.[13]

It is also worthy of note that the introduction of a capital surcharge by the Basel Committee to mitigate the potential threat to the global banking system posed by global systemically important banks (G-SIBs) is calculated based on indicators and weightings that relate to both financial and operational risks.[14] These are:

i. **Size:** total exposures
ii. **Interconnectedness:** intra-financial system assets, liabilities and securities outstanding
iii. **Substitutability/financial institution infrastructure:** payment activity, assets under custody, and underwritten transactions in debt and equity markets
iv. **Complexity:** notional amount of over-the-counter (OTC) derivatives, trading and available for sale securities and highly illiquid assets

v. **Cross-jurisdictional activity:** cross-jurisdictional claims and liabilities

The foregoing is evidence that accumulating exposures to both financial and operational risks are capable of escalating to systemic proportions. Consequently, the extension of international accounting standards to encompass the expected losses associated with both financial and operational risks should be considered if audited financial statements are to present a true and fair view of the financial condition of banks. Such accounting treatment is only feasible if the amount of enterprise-wide exposure to operational and financial risks is the output of a transparent and noncomplex method of identifying, quantifying and aggregating granular exposures to risks and is available within an acceptable timeframe. Whereas granular and aggregated exposures to financial risks are a natural output of accounting systems, there is no direct means of obtaining equivalent information on operational risk exposures.

An accounting conundrum

The calculation of expected credit losses can be complex but is nevertheless facilitated by banks' ready access to credit exposure information in general ledger and subledger systems and quantitative models, historic credit datasets and universally adopted risk reporting conventions, namely, probability of default (PD), exposure at default (EAD) and loss given default (LGD), that have evolved over time to support credit risk pricing decisions and the determination of regulatory capital requirements.

The challenges of extending impairment accounting, as framed in IFRS 9 and CECL, to operational risks are significant, as there is no readily accessible exposure information in accounting systems and no generally accepted method of quantifying exposures to operational risks. Indeed, the current mindset of banks and banking supervisors is that an operational risk is inherently unobservable and, consequently, nonquantifiable. For example, when contemplating the contribution of systemic risk to the destabilisation of financial markets, Luci Ellis, Andy Haldane and Fariborz Moshirian[15] (p. 175) questioned the feasibility of operationalising a policy to limit systemic risk given that 'a risk is inherently unobservable — only outcomes are observable'.

We question this characterisation of risk and argue that banks' exposures to risks are a financial abstraction in the same way that profit and equity are financial abstractions. Making financial abstractions observable so that businesses can measure financial performance and make informed and safe decisions is a function of accounting.[16] For example, in a manufacturing concern, cost accountants use accounting techniques to determine a firm's cost of production in order to calculate product profitability. Information on variable costs, fixed costs and overheads is gathered from across the enterprise, and expert functions provide measurement-based criteria to determine how fixed costs and overheads should be allocated to production units. Each step in a product's manufacturing process is then analysed to determine how the manufacture of products consumes direct and indirect costs. This provides vital information on the composition of product profit margins that is used to manage operating costs and production efficiency.

The fully loaded cost of manufacturing a single product, referred to as the 'unit cost', is a financial abstraction but one that is accepted and relied upon across all industries. It is a composite of cost allocations, estimates, valuations, prepayments, accruals, provisions, depreciation and amortisation. Cost accountants use their skills and techniques to make something that, at first, is essentially unobservable — the fully loaded cost of manufacturing a product — observable. Once institutionalised, it is unthinkable that a manufacturing concern would contemplate operating its business without cost accounting. Whereas the primary concern of a manufacturing enterprise is the cost and efficiency of its production, the primary concern of a bank is the management and mitigation of risk. Arguably, operating a bank without effective risk accounting should be equally unthinkable.

This presents accountants and auditors with a conundrum that reveals a reactive approach to risk and risk management. The absence of proactivity can be attributed to the unavailability of expertly

determined, measurement-based analyses of operational risks and uncertainties. If it is assumed that a bank and its stakeholders require audited financial statements to be risk-adjusted relative to the expected losses associated with operational risks, for it is an undeniable certainty that such probable future losses exist, there is no method in use by banks that will provide accountants with assurance that such exposures are identified, quantified, aggregated and reported with reasonable precision and in a risk-sensitive, transparent, comparable and auditable way. It is not unreasonable for accountants to expect such exposure information to be provided by risk management given that other expert functions routinely provide measurement-based criteria on which costs are allocated in management accounting systems.

Assessment versus measurement

In 2004 the Basel Committee published its second capital accord, Basel II, which included, for the first time, the requirement for banks to set aside protective capital for operational risks. In paragraph 665, it states, 'A bank's internal measurement system (Advanced Measurement Approach — AMA) must reasonably estimate unexpected losses based on the combined use of internal and relevant external loss data, scenario analysis and bank-specific business environment and internal control factors (BEICFs)' (p. 150).[17] Noteworthy is the lack of reference to a bank's explicitly quantified operational risk exposures as an input to the internal measurement system; instead, banks are directed to use a proxy in the form of assessment data derived from scenario analyses and BEICFs.

The application of proxies in place of explicit and dynamic quantification of exposures to operational risks imposes limitations on the usefulness of outputs from the advanced approaches as described by Carolyn V. Currie (p. 19):[18] 'In operational risk modelling the portfolio of risks is not available with any reasonable degree of certainty by any direct means. . . . [This] explains the weakness in proposed approaches to measuring operational risk that rely mainly on loss experience to infer a loss distribution. In essence, these quantification approaches effectively try to imply the "portfolio" of possible operational risk loss events from historic loss events. Imagine taking this approach to credit risk modelling, that is, "deducing" the loan portfolio from historic defaults.'

The Basel Committee on Banking Supervision (BCBS) (p. 7)[19] publicly voiced its own concerns regarding the limitations of the AMA through its observation that the 'range of practice continues to be broad, with a diversity of modelling approaches being adopted by AMA banks. . . . [This] clearly affects the AMA methodology of individual banks and, ultimately, the amount of capital resulting from the application of the AMA. . . . While flexibility allows modelling to reflect individual bank risk profiles, it also raises the possibility that banks with similar risk profiles could hold different levels of capital under the AMA if they rely on substantially different modelling approaches and assumptions'. Imad Moosa[20] highlighted the issues associated with the AMA, in particular, the lack of consensus on what constitutes the approach and its difficult implementation. Banks' return on investment in developing an AMA model is doubtful, as there is no certainty that it produces a lower capital charge than the less sophisticated standardised approaches, notwithstanding whether such investment in sophisticated internal operational risk models can be justified if their predominant purpose is the calculation of regulatory capital.

The Basel Committee advised that the withdrawal of the AMA as an accepted method of calculating regulatory capital is warranted.[21] The Basel Committee argued that the inherent complexity of the AMA and the lack of comparability arising from a wide range of internal modelling practices exacerbated variability in risk-weighted asset calculations that eroded confidence in risk-weighted capital ratios. In December 2017, the Basel Committee released the final rules on operational risk capital in the form of a single nonmodel-based standardised approach (SA) to replace the existing approaches, including the AMA.

Marco Migueis[22] commented that the SA has been the object of criticism from industry practitioners due, primarily, to its lack of risk sensitivity. The application of historic income statement items as proxies for operational risks and

historic operational loss items causes it to be an essentially backward-looking formulation. Whereas the SA may offer a capital calculation method that satisfies regulatory capital adequacy requirements, it does not constitute an acceptable foundation on which to estimate expected losses to risk-adjust audited financial statements. This would require, at a minimum, the ability to quantify operational risk exposures explicitly and dynamically with an equivalent degree of risk sensitivity, transparency and comparability presently available in the quantification of financial risks.

The challenges associated with the measurement of exposures to operational risks are evident in the earliest authoritative papers on the topic of operational risk. The first paper issued by the Basel Committee that addressed sound practices for the management and supervision of operational risk (p. 3)[23] stated, 'Reflecting the different nature of operational risk, for the purposes of this paper, management of operational risk is taken to mean the "identification, assessment, monitoring and control/mitigation" of risk. This definition contrasts with the one used by the Committee in previous risk management papers of the "identification, measurement, monitoring and control" of risk'. Note the reference to operational risk as 'different' and the transformation of the word 'measurement' into 'assessment'. This appears to acknowledge the difficulty associated with measuring such risks, the inference being that an exposure to operational risk can be assessed but not measured.

This position remained substantially unchanged in a subsequent update to the paper (p. 6),[24] which, under Principle 6 'Risk Management Environment — Identification and Assessment' states, 'Senior management should ensure the identification and assessment of the operational risk inherent in all material products, activities, processes and systems to make sure the inherent risks and incentives are well understood'. The paper presents examples of tools that may be used for identifying and assessing operational risk. Under the subheading 'Measurement', it states (p. 12), 'Larger banks may find it useful to quantify their exposure to operational risk by using the output of the risk assessment tools as inputs into a model that estimates operational risk exposure'. The language used can hardly be viewed as an endorsement of this technique. As discussed earlier, the Basel Committee withdrew the application of internal models as an accepted method of calculating regulatory capital, citing their inherent complexity and lack of comparability.

This position from the Basel Committee effectively removes the obligation from banks to seek explicit and dynamic methods of quantifying operational risk exposures, which may explain the lack of engagement of accountants in this area. Indeed, the integration of operational risks in cost and management accounting systems, the production of structured management information reports on operational risks, and the systematic risk-adjustment of audited financial statements are not currently viewed as accounting functions.[4]

In the absence of a generally accepted method of explicitly quantifying exposures to operational risks, banks have universally defaulted to assessment-based risk management techniques, such as key risk indicators (KRIs) and RCSAs. There are numerous methods of reporting the existence and likely impact of operational risks, the most common being a traffic-light system of reporting. It is an axiom that colours are not useful to accountants as a basis for the allocation of the cost of operational risk capital in cost and management accounting systems. Whereas assessment-based metrics provide a vital source of risk intelligence at the granular operating level, their application is inherently subjective and are not aggregatable or comparable along the vertical and horizontal dimensions of a bank.

An overview of the risk quantification (RU) method

This section provides an overview of the proposed risk quantification method using the common operational risk metric, the RU. Detailed descriptions are available in papers published by Grody and Hughes.[1,2]

Prototype software has been developed to support ongoing research and testing of the method. Exposures to operational risks are analysed and reported by the software using the three core risk metrics shown in Table 2. These risk values are permanently assigned to transactions to complement

Table 2: Three core metrics

Inherent Risk	The amount of operational risk in RUs before considering the effects of internal risk mitigation activities and processes (represents maximum exposure to risk)
Risk Mitigation Index (RMI)	A measure of the effectiveness of internal risk mitigating activities and processes on a scale of 0–100
Residual Risk	The amount of operational risk in RUs that remains after reducing inherent risk by the RMI (represents actual exposure to risk)

Note: RU, risk unit.
Source: Risk Accounting Standards Board.

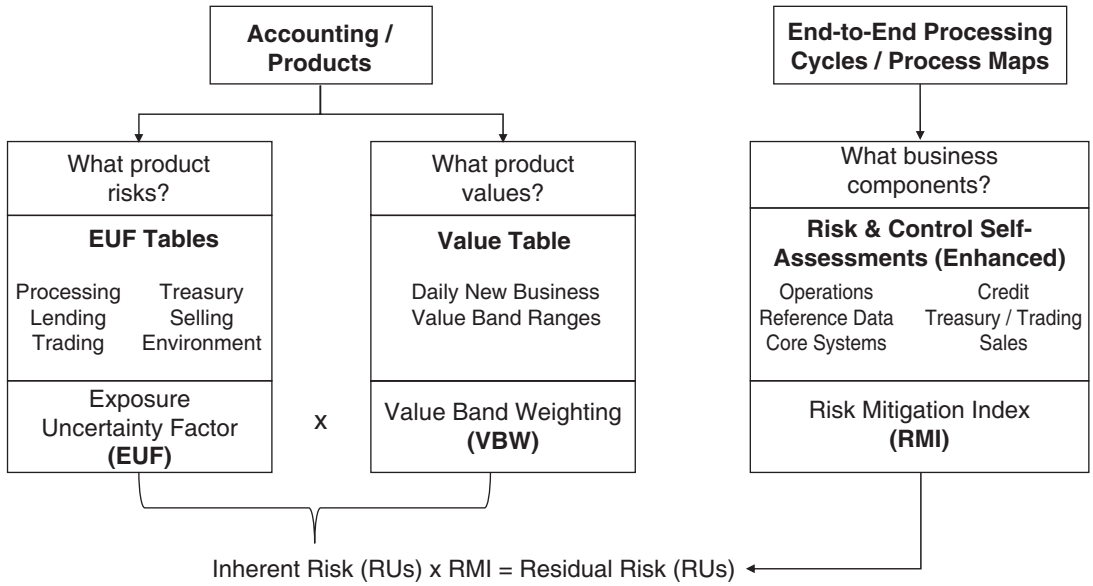

Figure 1: An overview of the risk accounting method
Note: RU, risk unit.
Source: Risk Accounting Standards Board.

the financial accounting values (historic cost, fair value, amortised cost etc) already assigned.

An overview of the risk quantification method and software is shown in Figure 1.

A core principle of Risk Accounting is that significant exposure to operational risk and the potential to incur material unexpected losses are created upon the transfer of financial products and instruments to external parties, as it is sales and trades that trigger banks' supply chains and operating infrastructures into action. Inherent operational risk is calculated by combining two product-related risk factors in an algorithm. The first are exposure uncertainty factors (EUFs) summarised in Table 1, which relate to the relative operating complexity and consequent process burden each product imposes on the organisation. EUF tables have been developed relative to six operational risk categories: transaction processing, lending, trading, treasury (funding and interest rate management), selling and environmental impact. EUFs are scaled to a value between 0 and 20. A sample lending EUF table adapted for the test of the RU's predictiveness is shown in Table 3.

The second are value band weightings (VBWs) that are extracted from the value table shown in Table 4. The value table comprises ascending bands of the amounts of daily production throughput with a VBW assigned to each band. The value bands plotted against the VBWs produce a logarithmic curve that depicts how the rate of change in risk

Table 3: Sample lending EUF table

Form of security/type of instrument	EUF
Casual overdraft	2
Credit card	2
Unsecured	2
Cash	4
Cashlike instruments (cash, liquid AAA collateral)	5
Sovereign guarantee	5
Exchange traded derivatives	5
Over–the-counter (OTC) derivatives	14
Repurchase agreements (repos)	5
Trade receivables	8
Instruments subject to mark-to-market	8
Autos	8
Inventory	12
Equipment	12
Other secured	8
Investments subject to mark to model	12
Agricultural production	14
Personal guarantee	14
Agricultural production	14
Project financing	16
Residential property: First lien	16
Residential property: Junior lien	20
Residential property: Owner occupied	16
Residential property: 1–4 family property	16
Residential property: >5 family property	16
Farmland	16
Commercial real estate	18
Farmland	18
Collateralised debt obligations/asset-backed securities	18
Personal guarantee	14
Foreign exposure: Increment the above EUFs by:	6

Note: EUF, exposure uncertainty factor.
Source: Risk Accounting Standards Board.

decelerates as operational throughput accelerates due to the enhanced processing sophistication and automation that naturally occurs as production volumes and values increase.

Residual operational risk is the result of applying the risk mitigation index (RMI) against the inherent RUs. The RMI is calculated from RCSAs that set out the industry consensus best-practice risk and control activities and processes that, when effectively designed and operating as intended, positively impact on risk mitigation. For the purposes of residual operational risk quantification in RUs, the traffic-light RAG assessments typically used in RCSAs are replaced by numeric risk mitigation factors preassigned by subject matter experts denoting each risk and control activity's and process's relative risk mitigation impact. For example, in business continuity planning, a full disaster simulation has greater risk mitigation impact than key staff maintaining a copy of the plan at an offsite location.

There are two types of input to the RCSA software:

i. Binary: 'yes/no' indicating the presence or absence of compliance with an industry consensus best practice
ii. Nonbinary: the degree of compliance with industry consensus best practice by reference to a set of predetermined benchmarks

The software generates an algorithm based on these inputs that calculates the respective RMIs. A sample enhanced RCSA is shown in Table 5. Banks' existing RCSAs will require upgrading to 'enhanced' status to accommodate the assignment of numeric risk mitigation factors.

Two variable inputs are input to the software's calculation engine to produce risk analytics:

i. The amount of daily operational throughput being new business booked relative to each product, which can be captured either manually or via automated interfaces with accounting systems
ii. Risk factors gathered from across the bank that are input via structured, simple-to-follow enhanced RCSAs captured at preselected organisational levels (eg process, production team,

Table 4: The value table

Band		$ Ranges		Value band weighting (VBW)
1	0	to	62,500	**2.0**
2	62,500	to	125,000	**2.6**
3	125,000	to	250,000	**3.4**
4	250,000	to	500,000	**4.3**
5	500,000	to	1,000,000	**5.5**
6	1,000,000	to	2,000,000	**7.1**
7	2,000,000	to	4,000,000	**8.9**
8	4,000,000	to	8,000,000	**11.3**
9	8,000,000	to	16,000,000	**14.1**
10	16,000,000	to	32,000,000	**17.6**
11	32,000,000	to	64,000,000	**21.9**
12	64,000,000	to	128,000,000	**27.0**
13	128,000,000	to	256,000,000	**33.1**
14	256,000,000	to	512,000,000	**40.4**
15	512,000,000	to	1,024,000,000	**49.1**
16	1,024,000,000	to	2,048,000,000	**59.3**
17	2,048,000,000	to	4,096,000,000	**71.2**
18	4,096,000,000	to	8,192,000,000	**85.0**
19	8,192,000,000	to	16,384,000,000	**101.0**
20	16,384,000,000	to	32,768,000,000	**119.3**
21	32,768,000,000	to	65,536,000,000	**140.1**
22	65,536,000,000	to	131,072,000,000	**163.6**

Source: Risk Accounting Standards Board.

department, division) and in accordance with a predetermined timetable that can be in real time, daily, weekly, monthly, upon occurrence of an event etc

An important feature of Risk Accounting is that inputs and, consequently, outputs are auditable. EUFs are set and approved during the initial product approval process and are updated when changes to the product's structure, its method of distribution or operational handling occur. Auditors can independently verify that EUFs have been appropriately documented and approved by management and consistently applied. Operational throughput and mapping to the value table can be independently verified against accounting systems. Enhanced RCSAs are adapted such that inputs fall into two categories: (i) whether a risk and control attribute is complied with or not or (ii) the selection of the degree of deviation from a best-practice benchmark from a dropdown box. In either case, an auditor can independently verify whether a respondent has provided appropriate RCSA inputs.

Risk quantification software generates algorithms that convert these inputs into risk metrics in RUs to produce a portfolio view of operational risks. The portfolio management

Table 5: Sample enhanced RCSA: Business continuity planning (extract)

Risk and control activities and processes		Risk mitigation factor
01	Your unit's activities can be recovered and reactivated at an alternative site in an acceptable timeframe	100
02	Your unit has a fully documented business continuity plan	100
03	The recovery of your unit's activities at an alternative site has been fully tested through a live simulation of a disaster scenario, under the direction of a business continuity specialist, within the past 12 months	75
04	Your unit's business continuity plan has been reviewed and signed off by a business continuity specialist within the last 12 months	30
05	All key personnel assigned to your unit have been fully briefed by the business continuity specialist on the procedures to be followed and their respective roles and responsibilities if the business continuity plan were to be invoked	15
06	Your unit's business continuity plan has been reviewed and signed off by your unit's manager	10
07	Contact information (names, functions and contact details) relative to all personnel affected by the plan, if invoked, is current and readily accessible by key personnel (supervisors and managers) from an offsite location	5
08	A notification (callout) test coordinated by the business continuity specialist has been performed within the last 12 months	5
09	All key personnel (supervisors and managers) have been issued a copy of an up-to-date business continuity plan with instructions to maintain it readily accessible at an offsite location	5

Source: Risk Accounting Standards Board.

techniques enabled by the risk quantification method and software include:

i. the reporting and analysis of granular and aggregated exposures to operational risks by multiple categories, including group-wide, business line, organisational component (cost centre), product and customer;
ii. direct comparisons of exposures to operational risks within and between organisations and organisational components (assuming the method's tables and templates and associated weightings and risk factors are uniformly applied) and their benchmarking and ranking according to risk criteria;
iii. identification and prioritisation of risk mitigation initiatives with a calculation of the risk reduction impact in RUs of each initiative; and
iv. the setting of operational risk budgets and operating limits in RUs across all vertical and horizontal dimensions of the organisation with the potential for real-time or near-real-time monitoring of accumulating exposures to risks versus approved risk budgets and operating limits.

Calculation of expected losses

The pairing of financial accounting and risk accounting values in RUs in a single source of controlled and audited accounting data at the transaction level enables the production of combined financial and risk reports and analyses. In particular, the potential is created for risk-adjusted profits or 'economic profit' to become the primary business performance metric. For the purposes of this paper, economic profit is deemed to be the accounting profit less a provision for expected losses associated with accumulated financial and nonfinancial risks.

IFRS 9 and CECL set out the procedures for calculating and accounting for expected losses associated with credit risks. There are two possible approaches to calculating and accounting for

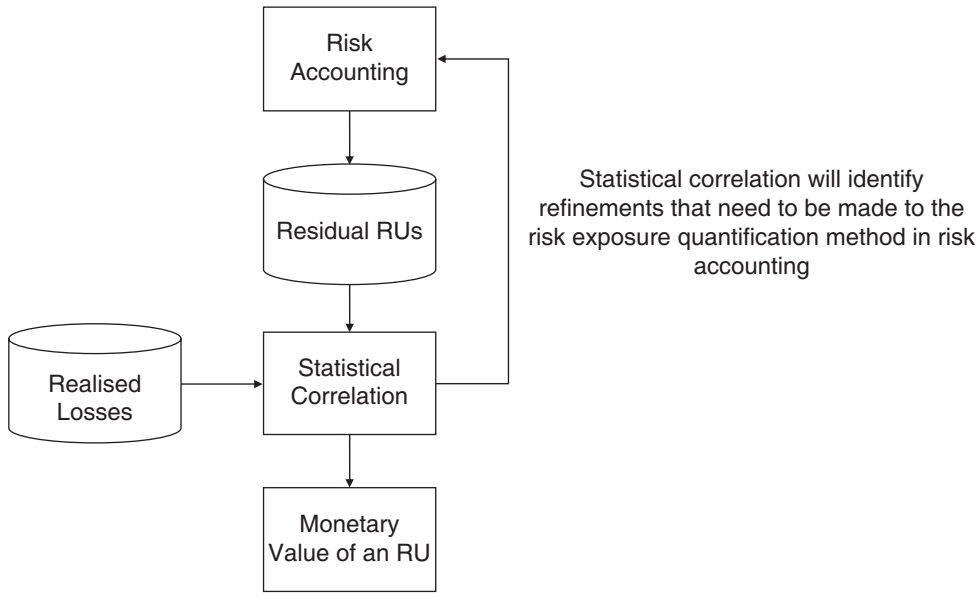

Figure 2: Deriving the monetary value of an RU
Note: RU, risk unit.

expected losses associated with operational risks using the risk quantification method described in the overview earlier.

The first is a cost accounting solution that involves allocating the cost of operational risk capital to products in proportion to residual RUs aggregated for each business line. The cost of capital is determined according to the bank's required rate of return on capital, typically referred to as the 'hurdle rate'. This effectively creates the potential for the performance of business lines to be reported on the basis of economic profit being the natural output of accounting systems that adopt Risk Accounting. A comprehensive enterprise risk management (ERM) system will be the outcome, as business line managers will be incentivised to minimise residual RUs due to rewarding risk mitigation initiatives through a lower capital charge. Given that the residual RU calculations will be available by product, the capital charge can be readily integrated into accounting systems, which are also product based, and become an integral part of product pricing.

The second is a financial accounting solution. As with any risk measurement system, the calculation of RUs in Risk Accounting will initially rely on subjective, albeit expert, inputs, but these will become progressively more objective and, consequently, more precise over time. Given the RU is an additive metric, the statistical correlation of past operational risk losses with associated residual RUs is enabled, as shown in Figure 2. The statistical correlation of RUs with realised losses will allow, over time, a monetary value of an RU to be derived. Once valued, residual RUs will theoretically represent probable future losses to be applied in operational risk expected loss provisions included in audited financial statements.

The integrity of the RU valuation is dependent on the degree of universality of the method of its calculation and the operating losses and associated residual RUs included in its calculation. BCBS[25] sets out the Basel Committee's aspiration for an effective balancing of risk sensitivity, simplicity and comparability in the global regulatory framework. If Risk Accounting is deemed to have the potential to meet such aspiration, the valuation of the RU will need to be underpinned by universally adopted risk quantification and auditing standards. Regulated banks could then be required to upload details of realised operating losses and associated residual RUs to a central server where the RU valuation is modelled.

If banks' residual RUs by product can become available in real time or near real time to the supervisory bodies responsible for exercising regulatory oversight, it will constitute a major step towards more effective monitoring of accumulating systemic risks in the global financial system. The posting of residual RUs to a distributed ledger will facilitate the exercising of oversight and governance of both regulators and the posting banks. Such an operating model will be consistent with Lo's suggestion that 'a new branch of accounting — "risk accounting" — must be developed and widely implemented before systemic risk can be truly measured and managed on a global scale' (p. 2).[4]

Expected operational risk losses: Regulatory considerations

US regulators have considered the incorporation of expected operational risk-related losses in regulatory capital calculations. Migueis[22] describes seven properties that an ideal regulatory capital framework should meet, including appropriate conservatism, robustness to gaming, risk sensitivity, comparability, stability, simplicity, and usefulness to risk management and advancement of risk quantification. Migueis evaluates Basel's advanced (AMA) and standardised (SA) operational risk capital calculations relative to these properties, concluding that both are deemed to have significant flaws: the AMA is vulnerable to gaming, lacks comparability and is complex; the SA lacks risk sensitivity, particularly due to its lack of a forward-looking perspective, and possibly lacks appropriate conservativeness.

To counter these flaws, Migueis proposes an alternative framework termed '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 incorporation of operational risk-related loss projections in the FIA proposed by Migueis, in principle, equates to the concept of accounting for expected losses set forth in IFRS 9 and CECL relative to credit risks. In other words, accounting for expected operational risk losses using the Risk Accounting method proposed by Grody and Hughes has the potential to meet the seven desired regulatory capital framework properties put forward by Migueis for operational risk through an accounting solution.

Risk accounting implementation issues

The basic framework in support of the Risk Accounting operating model described earlier already exists. GAAP represent a core pillar of accounting and auditing practices that are applied in the preparation of audited financial statements. Their extension to embrace Risk Accounting would be typical of the work undertaken by global accounting standard-setting bodies that are constantly updating and refining accounting standards.

Julian Williams[26] described the risk quantification method proposed by Grody and Hughes as a relatively simple-to-implement approach. Roger Chen[26] further described it as both novel in addressing the limitations of existing risk measurement frameworks and practical in adapting the control and reporting frameworks that already exist in accounting and general ledger systems.

In many jurisdictions, bank regulatory supervisors require the submission of comprehensive GAAP data to enable their proactive monitoring of the global financial system. For example, the US Federal Reserve in its FR-Y14Q reports requires regulated banks to submit comprehensive GAAP reports including 'a complete history of operational losses'.[27] Regulatory bodies routinely publish guidance on risk management best practices, for example, guidance on model risk management.[28] For risk quantification using the Risk Accounting method, these would require restatement in a consistent RCSA format with weightings assigned denoting the relative degree of importance of each risk and control attribute and benchmark in mitigating exposure to risk.

Notwithstanding the foregoing, a debate will need to be had on the challenges banks may face should they be required to adopt Risk Accounting as a matter of policy. This will include examinations of:

i. the extent to which Risk Accounting could potentially displace the existing operational risk regulatory capital adequacy framework with a more risk sensitive risk quantification method;
ii. the operating efficiencies that can be potentially gained by positioning capital planning and management as a function of accounting rather than quantitative modelling; and
iii. the extent regulatory capital requirements can be moderated if tried and tested accounting controls were to be extended to risk information expressed in RUs.

TESTS OF THE INHERENT PREDICTIVENESS OF THE RU

Introduction

A principal aim of the test was to determine whether the RU possesses predictive properties. This would potentially be the case if it could be demonstrated that an accelerated increase in trended operational risk RUs and subsequent material unexpected losses were positively correlated.

The test involved the restatement in operational risk RUs of banks' quarterly financial data[29] made publicly available by the Federal Reserve Bank of Chicago.[30] Trended operational risk exposures in RUs and profits and losses (net income before taxes [NIBT])[31] in the period leading up to the global financial crisis of 2007–8 were compared to facilitate an examination of the extent to which accumulating operational risk RUs and NIBT were correlated. The exceptional downturn in banks' NIBT, primarily in 2008, was used as a proxy for unexpected losses.

The accounting values reported in quarterly financial data are in conformity with US GAAP, which means that for the purposes of the test, they are directly comparable between banks and across reporting periods. Similar to banks' financial, management and cost accounting systems, Risk Accounting is structured according to product categories, for example, loans and lease financing receivables, investments (securities), trading assets and liabilities, deposits, and derivatives and their respective subcategories. Consequently, the structure of quarterly financial data broadly supports the application of Risk Accounting.

Table 6: US banks included in test sample

Sample of US banks included in test		
Bank of America	Huntington Bancshares	PNC Financial Services
BB&T Corporation	JPMorgan Chase	Regions Financial
Capital One	Keycorp	State Street
Citigroup	M&T Bank	Suntrust
Fifth Third Bancorp	Northern Trust	Wells Fargo

For the purposes of the test, it is assumed that the main source of material unexpected losses is financial risk assets and derivatives. Consequently, non-risk assets (eg fixed assets, cash balances) and all liabilities were excluded from the test.

The test was applied to a sample of 15 of the largest US banks shown in Table 6.

Banks that underwent significant re-organisations (mergers, acquisitions etc) during the test period were not included in the sample to ensure the comparability of trended RU and NIBT outputs along the time series.

The test was applied to publicly available financial data, as it was not practical to engage directly with a sufficiently representative number of banks at this initial stage of the research. Consequently, liberal use of proxies and assumptions were made that are summarised in Table 7. A sample lending EUF table adapted for the product categorisations used in the quarterly financial data is shown in Table 3.

Test results

The chart shown in Figure 3, and summarised in tabulated form in Table 8, plots two progressions relative to total risk assets (securities, loans and lease financing receivables, and trading assets) and total derivatives for the sample banks shown in Table 6: (1) inherent risk (IR), ie exposure to inherent operational risks in RUs, and (2) NIBT.

Table 7: Significant proxies and assumptions used in the test

Risk accounting method	Proxies and assumptions
Inherent operational risk RUs are calculated based on daily new business by product category accessible in banks' accounting systems (general ledgers and sub-ledgers) either manually or via automated interfaces.	Inherent operational risk RUs are calculated by product category based on the quarterly financial data reported in FR Y-9C submissions as proxies for the volume of business conducted; amounts applied in the RU calculations are the average quarter-end balances in each year for each selected bank.
Inherent RU calculations are based on expertly validated exposure uncertainty factors (EUFs) calibrated for each product category and approved in banks' product review and approval process.	Researchers assigned EUFs to products according to reasoned assumptions. Reasoned EUF assignments could not be made where products' attributes are determined according to the idiosyncrasies of individual organisations. For example, the selling EUF table (conduct risk) enquires as to sales incentive schemes. In these cases, EUF assignments were excluded from the calculation.
Expected losses are calculated based on residual operational risk RUs.	Expected losses are calculated based on inherent operational risk RUs: the calculation of residual RUs requires the calculation of individual banks' risk mitigation indexes (RMIs) that were not available.
Unexpected losses are the actual amounts reported by banks and registered in loss event databases.	Unexpected losses use a proxy being material downturns in NIBT reported in the quarterly financial data.
Accounting values are converted into value band weightings via the value table that are input to the calculation of inherent operational risk RUs.	Whereas the maximum possible loss associated with on-balance sheet risk assets is the principal outstanding, the same is not necessarily true of the notional values of outstanding off-balance sheet derivative contracts. Whereas this requires further analysis, the method of calculating inherent operational risk RUs did not differentiate between principal and notional values.

Notes: NIBT, net income before taxes; RU, risk unit.

The test revealed an increase of 58.1 per cent in exposures to operational risks over the eight-year period. In other words, the incremental process burden on the operating infrastructures of these banks comprising operations, information technology (IT), data management, accounting, risk management and audit increased by 58.1 per cent, which is attributable to extreme increases in operational throughput (higher VBWs) that were concentrated in complex products (higher EUFs).

A primary contributor to the increase in operational risk RUs in this period was the creation of the subprime mortgage market that relied on interlinked securities and derivatives, all related to asset-backed securities and subprime mortgages.[32] This is substantiated by the charts shown in Figures 4, 5 and 6 that show increases of 66.3 percent in operational risk RUs during the period 2001–8 (loans secured by residential mortgages), 61.1 per cent (trading assets: mortgage-backed securities), and 67 per cent (derivatives), respectively.

The losses attributed to the subprime fiasco were catastrophic. For example, the Bank of England projected ultimate credit losses associated with subprime asset-backed securities of between US$150 and US$200bn (Chart 6, p. 8).[33] This is also substantiated in the test outputs shown in Table 8 that show annualised profits (positive NIBT) of the sample 15 banks of US$117.7bn in 2006 that collapsed to losses (negative NIBT) of US$42.9bn in 2008.

CONCLUSION

Williams et al.[26] provide commentary on the implications emanating from the absence of comprehensive measurement-based approaches to

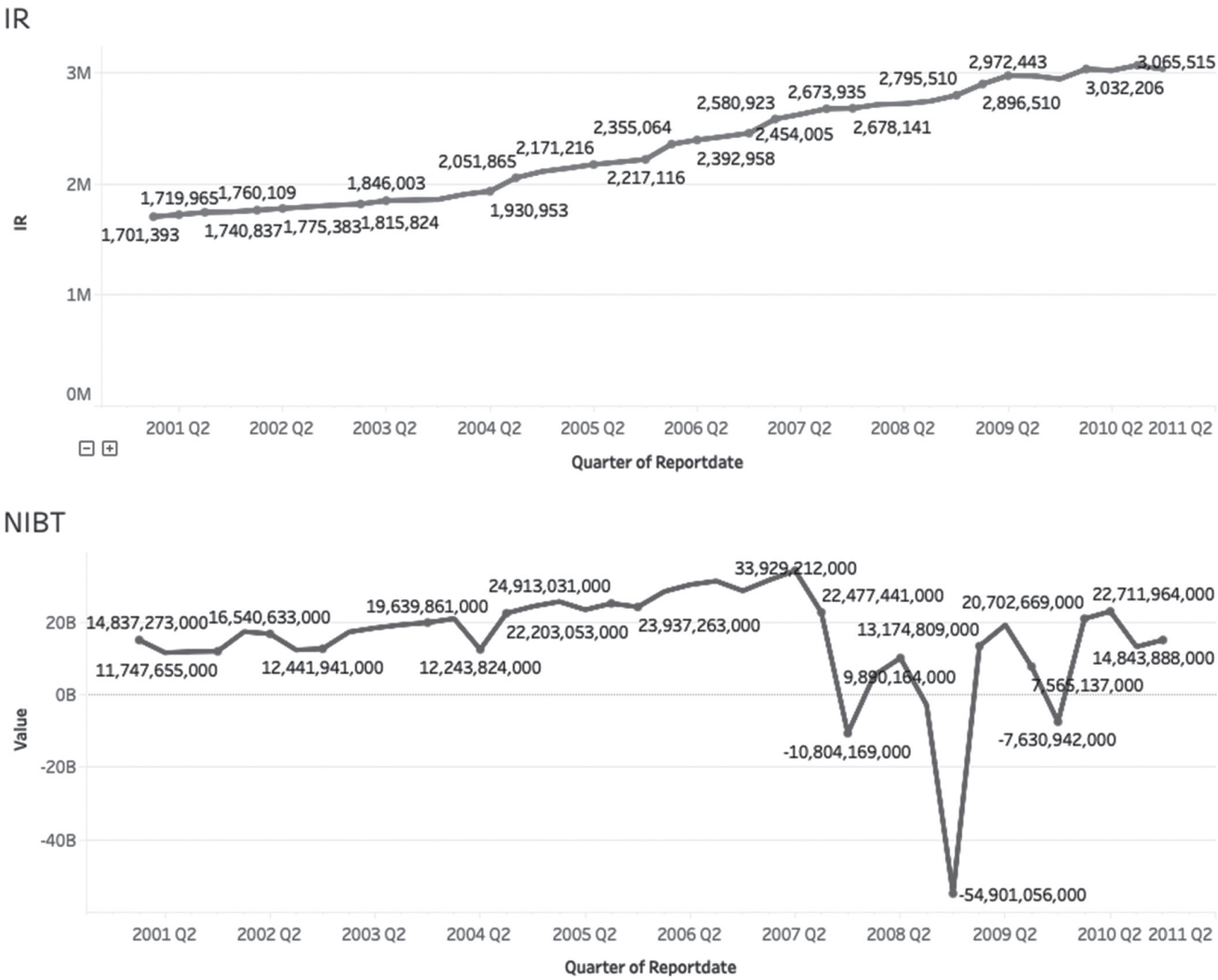

Figure 3: Total risk assets and derivatives
Notes: IR, inherent risk; NIBT, net income before taxes.

operational risk management and the associated lack of integrated accounting and risk management systems. Suboptimal risk governance and regulatory oversight are the outcomes. The RU is a proposed operational risk metric aimed at resolving the absent integration of accounting and risk within a common risk quantification and reporting framework. The RU's potential to resolve such absence is illustrated through Williams' study of the London Whale trading loss suffered by JPMorgan (p. 416), where he describes the lapses that caused the trading positions to spiral out of control and observes, 'Here, the RU would bloom'.

The empirical evidence of a positive correlation between accumulating operational risk RUs and losses begs the question whether banks' boards of directors, management and their supervisory regulators would have responded differently had RU-based operational risk analytics been available at the time. The toxic combination of exceptionally high volumes of subprime mortgages and their complex chains of interlinked securities and derivatives resulted in risks that were unknown to anyone at the time (p. 45).[34] A 58.1 per cent increase in exposures to operational risks over an eight-year period, revealed by the test of the predictiveness

Table 8: Trended increases in inherent RUs and NIBT

Year	Qtr	Operational risk exposures (RU thousands)			Net income before taxes ($ millions)		
		Quarter	Yearly average	Yearly increase (%)	Quarter	Year	Yearly increase (%)
2001	1	1,701			14,837		
	2	1,720			11,356		
	3	1,741			11,643		
	4	1,775	1,734		11,748	49,584	
2002	1	1,760			17,135		
	2	1,775			16,541		
	3	1,791			12,114		
	4	1,805	1,783	2.8	12,442	58,232	17.4
2003	1	1,816			17,060		
	2	1,846			18,160		
	3	1,851			19,031		
	4	1,857	1,843	3.4	19,640	73,891	26.9
2004	1	1,903			20,722		
	2	1,931			12,244		
	3	2,052			22,203		
	4	2,108	1,999	8.5	24,105	79,274	7.3
2005	1	2,139			25,405		
	2	2,171			23,171		
	3	2,194			24,913		
	4	2,217	2,180	9.1	23,937	97,426	22.9
2006	1	2,355			28,182		
	2	2,393			30,083		
	3	2,422			31,054		
	4	2,454	2,406	10.4	28,371	117,690	20.8
2007	1	2,581			31,345		
	2	2,625			33,929		
	3	2,674			22,477		
	4	2,678	2,640	9.7	(10,804)	76,947	(34.6)
2008	1	2,713			5,147		
	2	2,719			9,890		
	3	2,742			(2,990)		
	4	2,796	2,743	3.9	(54,901)	(42,854)	(155.7)
Increase 2001 to 2008			1,008	58.1			

Notes: NIBT, net income before taxes; RU, risk unit.

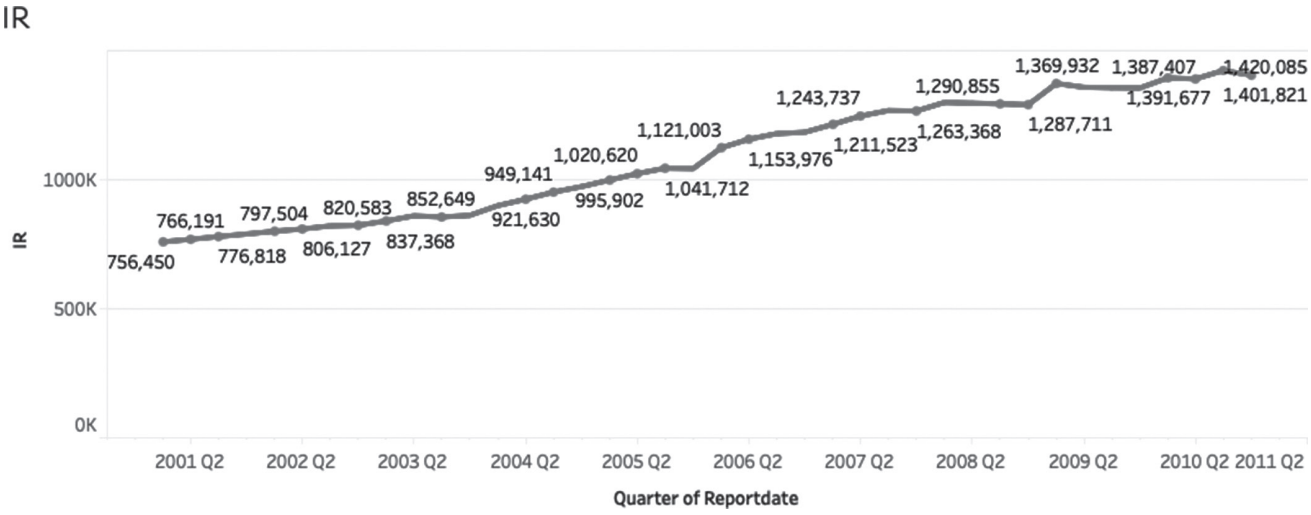

Figure 4: Total derivatives
Note: IR, inherent risk.

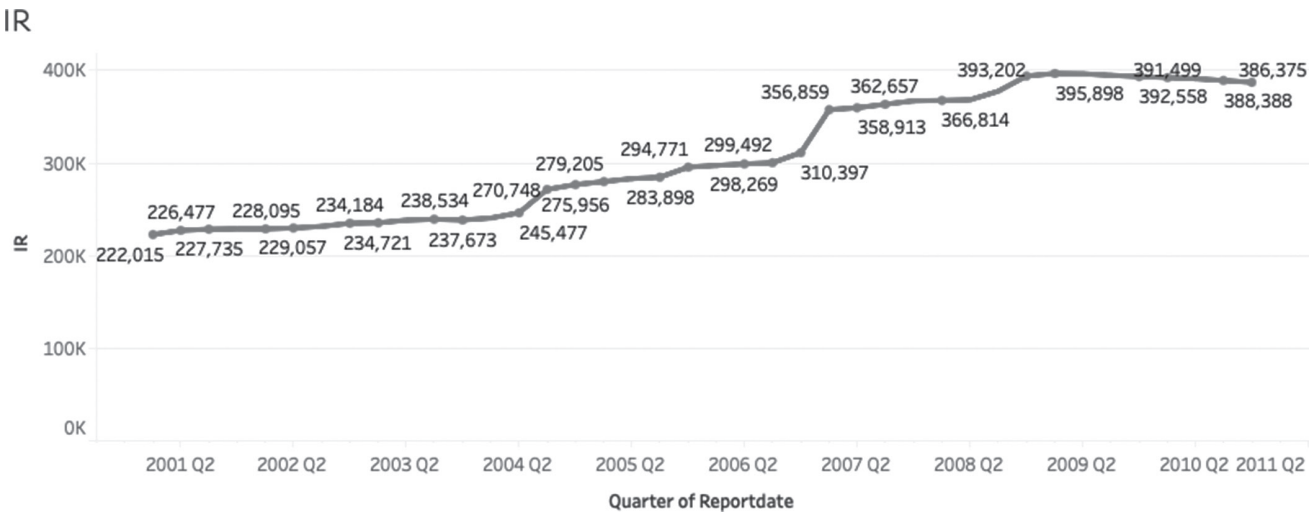

Figure 5: Loans secured by residential properties
Note: IR, inherent risk.

of the RU, however, has a clarity that, in all probability, would have demanded a response.

The weakness of banks' risk data aggregation capabilities and risk reporting practices and the severe consequences that resulted for the banks and the stability of the financial system as a whole were highlighted by the Basel Committee in its analysis of the causes of the financial crisis (p. 1).[35] The conclusion is that banks' operating infrastructures encompassing operations, IT, data management, accounting, risk management and audit were wholly unprepared to process, account for, risk manage and audit subprime mortgages.

The results of the test provide an initial indication of the inherent predictiveness of the RU. Such results, however, cannot be considered conclusive given the limited scope of the test and the liberal use of the proxies and assumptions set out in Table 7. Conclusiveness can only be achieved through simulations of the risk accounting method

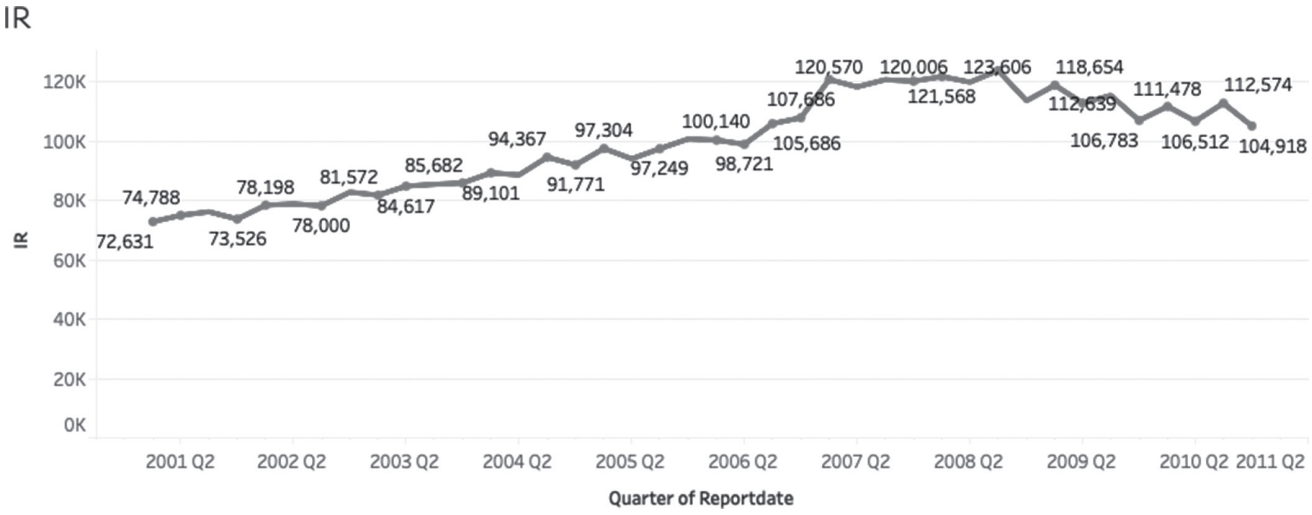

Figure 6: Trading assets: Mortgage-backed securities
Note: IR, inherent risk.

conducted in the operating environments of a representative sample of banks. In this regard, it is expected that the aforementioned proxies and assumptions will be replaced by direct inputs from banks as the research progresses to its subsequent phases to include such simulations.

Notwithstanding the foregoing, if it does become widely accepted that the RU possesses predictive properties that are truly representative of all forms of operational risk, the rewards are potentially significant: risk reporting can be tied to a single source of audited accounting data available in accounting and general ledger systems; the reporting of financial condition and performance can be risk-adjusted as a natural output of cost and management accounting systems causing economic profit to become the primary business performance metric; and a greater degree of analytical rigour can be applied to operational and systemic risks based on the explicit quantification of atomic risk exposures and their valid aggregation, potentially in real time or near real time, thereby providing the much sought-after portfolio view of operational risks.

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References

1 Grody, A. D. and Hughes, P. J. (2016) 'Risk accounting — Part 1: The risk data aggregation and risk reporting (BCBS 239) foundation of enterprise risk management (ERM) and risk governance', *Journal of Risk Management in Financial Institutions*, Vol. 9, No. 2, pp. 130–146.

2 Grody, A. D. and Hughes, P. J. (2016) 'Risk accounting — Part 2: The risk data aggregation and risk reporting (BCBS 239) foundation of enterprise risk management (ERM) and risk governance', *Journal of Risk Management in Financial Institutions*, Vol. 9, No. 3, pp. 224–248.

3 Hughes, P. J. (2020) 'Accounting's operational risk missing link', *Global Association of Risk Professionals*, available at: https://www.garp.org/#!/risk-intelligence/culture-governance/compliance/a1Z1W000005UUWDUA4 (accessed 7th December, 2020).
4 Lo, A. W. (2008) 'Hedge funds, systemic risk, and the financial crisis of 2007–2008: *written testimony of Andrew W. Lo Prepared for the U.S. House of Representatives Committee on Oversight and Government Reform, Hearing on Hedge Funds*', available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1301217 (accessed 7th December, 2020).
5 IASB (2014) 'IFRS 9: financial instruments', *London: International Accounting Standards Board*, available at: https://www.ifrs.org/issued-standards/list-of-standards/ifrs-9-financial-instruments/ (accessed 7th December, 2020).
6 FASB (2016) 'Financial instruments — credit losses (topic 326): measurement of credit losses on financial instruments', *Financial Accounting Standards Board*, available at: https://www.fasb.org/jsp/FASB/Document_C/DocumentPage?cid=1176168232528&acceptedDisclaimer=true (accessed 7th December, 2020).
7 Walker, R. (2015) 'The increasing importance of operational risk in enterprise risk management', *Journal of Enterprise Risk Management*, Vol. 1, No. 1.
8 Rick, S. and van den Brink, G. J. (2015) 'Mitigating Rogue-Trading behaviour by means of appropriate, effective operational risk management', *Journal of Operational Risk*, Vol. 10, No. 3, pp. 1–20.
9 McConnell, P. and Blacker, K. (2012) 'Systemic operational risk the UK payment protection insurance scandal', *Journal of Operational Risk*, Vol. 7, No. 1, pp. 1–60.
10 Zeissler, A. G., Ikeda, D. and Metrick, A. (2014) 'JPMorgan chase London Whale A: risky business', *Yale Program on Financial Stability Case Study 2014-2A-V1*, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2577827 (accessed 7th December, 2020).
11 Bank of England (2020) 'The PRA's methodology for setting Pillar 2 capital', *Bank of England — Prudential Regulatory Authority*, available at: https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/statement-of-policy/2020/the-pras-methodologies-for-setting-pillar-2a-capital-update-february-2020.pdf?la=en&hash=4EB02F435F5BF46507222B09F0DE271333A5409E (accessed 7th December, 2020).
12 Schraeder, M., Self, D., Jordan, M. and Portis, R. (2014) 'The functions of management as mechanisms for fostering interpersonal trust', *Advances in Business Research*, Vol. 5, pp. 50–62.
13 Rochet, J.-C. (2010) 'Systemic risk, changing the regulatory perspective', *International Journal of Central Banking*, Vol. 6, No. 4, pp. 259–276.
14 BCBS (2014) 'The G-SIB assessment methodology — score calculation', *Bank for International Settlements*, available at: https://www.bis.org/bcbs/publ/d296.pdf (accessed 7th December, 2020).
15 Ellis, L., Haldane, A. and Moshirian, F. (2014) 'Systemic risk, governance and global financial stability', *Journal of Banking and Finance*, Vol. 45, pp. 175–181.
16 Hughes, P. J. (2019) 'Non-financial risks: developments in accounting', *Global Association of Risk Professionals*, available at: https://www.garp.org/#!/risk-intelligence/culture-governance/erm/a1Z1W000005TzsDUAS (accessed 7th December, 2020).
17 BCBS (2006) 'International convergence of capital measurement and capital standards', *Bank for International Settlements*, available at: http://www.bis.org/publ/bcbs128.pdf (accessed 7th December, 2020).
18 Currie, C. (2005) 'A test of the strategic effect of Basel II operational risk requirements on banks', available at: SSRN: http://ssrn.com/abstract=831304_(accessed 7th December, 2020).
19 BCBS (2011) 'Operational risk — supervisory guidelines for the advanced measurement approaches', *Bank for International Settlements*, available at: https://www.bis.org/publ/bcbs196.pdf (accessed 7th December, 2020).
20 Moosa, I. A. (2008) 'A critique of the advanced measurement approach to regulatory capital against operational risk', *Journal of Banking Regulation*, Vol. 9, No. 3, pp. 151–164.

21 BCBS (2016) 'Consultative document — standardised measurement approach for operational risk', *Bank for International Settlements*, available at: https://www.bis.org/bcbs/publ/d355.pdf (accessed 7th December, 2020).
22 Migueis, M. (2017) 'Forward-looking and incentive-compatible operational risk capital framework. Finance and economics discussion series 2017-087', *Board of Governors of the Federal Reserve System*, available at: https://www.federalreserve.gov/econres/feds/files/2017087r1pap.pdf (accessed 7th December, 2020).
23 BCBS (2003) 'Sound practices for the management and supervision of operational risk', *Bank for International Settlements*, available at: https://www.bis.org/publ/bcbs96.pdf (accessed 7th December, 2020).
24 BCBS (2011) 'Principles for the sound management of operational risk', *Bank for International Settlements*, available at: https://www.bis.org/publ/bcbs195.pdf (accessed 7th December, 2020).
25 BCBS (2013) 'The regulatory framework: balancing risk sensitivity, simplicity, and comparability', *Bank for International Settlements*, available at: http://www.bis.org/publ/bcbs258.pdf (accessed 7th December, 2020).
26 Williams, J., Chen, R., Antoncic, M., Litke, A., Abbott, M. and Mark, R. (2016) 'Comments on risk accounting', *Journal of Risk Management in Financial Institutions*, Vol. 9, No. 4, pp. 413–420.
27 US Federal Reserve (2018) 'Instructions for the capital assessments and stress testing information collection (reporting form FR Y-14Q)', *Board of Governors of the Federal Reserve System*, available at: https://www.federalreserve.gov/reportforms/forms/FR_Y-14Q20181231_i.pdf (accessed 7th December, 2020).
28 US Federal Reserve (2011) 'SR 11-7: guidance on model risk management', *Board of Governors of the Federal Reserve System*, available at: https://www.federalreserve.gov/supervisionreg/srletters/sr1107.htm (accessed 7th December, 2020).
29 'Quarterly consolidated financial statements for holding companies (FR Y-9C) submitted by regulated banks in the USA', available at: https://www.federalreserve.gov/apps/reportforms/reporthistory.aspx?sOoYJ+5BzDal8cbqnRxZRg== (accessed 7th December, 2020).
30 Federal Reserve Bank of Chicago 'Holding company data', available at: https://www.chicagofed.org/banking/financial-institution-reports/bhc-data (accessed 7th December, 2020).
31 Reported in quarterly financial data as 'Income (loss) before applicable income taxes and discontinued operations.'
32 Arestis, P. and Karakitsos, E. (2009) 'Subprime mortgage market and current financial crisis', Working Paper WP08-09, Cambridge Centre for Economic and Public Policy, available at: https://www.landecon.cam.ac.uk/research/real-estate-and-urban-analysis/centres/ccepp/copy_of_ccepp-publications/wp08-09.pdf (accessed 7th December, 2020).
33 Bank of England (2008) 'Financial Stability Report, No. 23', April, *Bank of England*, available at: https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2008/may-2008.pdf (accessed 7th December, 2020).
34 Gorton, G. (2008) 'The panic of 2007', NBER Working Paper Series, No. 14358, National Bureau of Economic Research: Cambridge, MA, available at: https://www.nber.org/system/files/working_papers/w14358/w14358.pdf (accessed 7th December, 2020).
35 BCBS (2013) 'Principles for effective risk data aggregation and risk reporting', *Bank for International Settlements*, available at: http://www.bis.org/publ/bcbs239.pdf (accessed 7th December, 2020).