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Abstract

We study the response of banks to the introduction of a new capital requirement relating to operational risk. To isolate the effect of this new regulation on realized operational risk losses, we take advantage of the partial US implementation relative to full European adoption. Operational risk losses are reduced in treated banks. The extent of loss reduction depends upon the measurement approach used to calibrate operational risk capital requirements. Banks with low institutional ownership and those without binding regulatory capital constraints also present significant loss reduction. We link these findings to incentives for improved risk management and governance post treatment.

JEL Classification: G21, G32

Keywords: Bank Regulation, Basel II, Measurement Approach, Monitoring, Operational Risk

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Operational Risk Capital

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Abstract

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1. Introduction

Bank regulation has been at the forefront of the policymakers agenda since the turn of the new millennium. First, Basel II and, then, the significant upheaval following the financial crisis of 2008 have resulted in a much reformed regulatory capital landscape. How banks have responded to the introduction of new capital regulations and whether these regulations make banks safer remains unclear. We therefore study the introduction of operational risk capital, introduced for the first time under the Basel II accord. To identify the impact of operational risk capital upon realized operational risk losses, we exploit the partial US application relative to the full European implementation. Many issues make it challenging to forecast the reaction of banks to this additional capital regulation for operational risk. In contrast to more conventional credit or market risks, there is no explicit risk-reward tradeoff associated with operational risk.[1] Furthermore, it is not clear that any changes in behavior might stem from heightened market discipline, as some banks already allocated economic capital for operational risk internally and its introduction was not intended to change the aggregate level of regulatory capital held.[2] How banks manage their operational risk exposures in response to this

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[1]Instead an implicit link between operational risk and profitability may exist. Management may neglect to invest in improved processes, systems, risk management or compliance, resulting in greater short-term cash flows but leaving them exposed to longer term operational risks.

[2]As described by the Basel Committee on Banking Supervision (2001), the *intention* of the Basel II Accord was to "leave the total capital requirement for an average portfolio broadly unchanged". The quantitative impact assessment carried out in 2005 highlighted that the *expected* level of aggregate capital would, in fact, drop by between 7.7% and 15.4% for European banks (Basel Committee on Banking Supervision, 2006b).

new capital requirement is thus an important empirical question to understand the implications of capital regulations and the channels through which they propagate.

Many of the largest and most newsworthy losses reported by banks fall under the umbrella of operational risk.[3] Operational risk is formally defined by Basel II as the risk of loss from inadequate or failed internal processes, people, and systems, or from external events (Basel Committee on Banking Supervision, 2006a). Highlighting the economic significance, 95 European banks together held operational risk capital amounting to €123 billion in 2016. In this context, an analysis of the implications of operational risk capital is timely. In 2016 the Bank for International Settlements proposed an extensive overhaul to operational risk requirements (Basel Committee on Banking Supervision, 2016), with particular focus upon calibration of appropriate operational risk capital levels. The effects of the initial introduction of operational risk capital on banks' behavior are, however, still unclear.

Determining banks' response to new capital requirements is challenging, as adjustments are often incremental, making it difficult to disentangle the impact of changes from previous prescriptions, and simultaneous across jurisdictions, resulting in limited cross-sectional variation. Our novel identification strategy is based upon variations in the application of the operational risk capital framework in Europe and the US. Specifically, operational risk capital was introduced only for a small number of systemically important banks in the US, while all Euro-

[3]Examples of large operational losses through unauthorized trading are probably best known, including losses of $1.3 billion in Barings Bank in 1995, $691 billion in Allied Irish Banks in 2002 and of $7.2 billion in Societe Generale in 2008. Operational risk losses are not limited to unauthorized trading, however, but cover a wide spectrum of event types. For example, in recent times, many banks have had to pay large fines to regulators due to various irregularities, also under the umbrella of operational risk.

pean banks were under the umbrella of Basel II and had to set aside capital for operational risks from 2007. This allows us to identify whether or not the introduction of operational risk capital resulted in a change in realized operational risk losses for treated (European) banks. In addition to overcoming the simultaneity problem, we consider the introduction of a new capital requirement, rather than adjustments to extant policies. The benefit is that we do not have to disentangle the incremental effect relative to previous operational risk capital regulations, as would be the case for credit risk capital, for example.[4]

Our primary finding is that banks subject to operational risk capital requirements present lower realized operational risk losses relative to a matched sample of US banks which were not required to hold operational risk capital. These results hold regardless of whether we study all banks in our sample, including those where there are no reported operational risk losses, or whether we condition upon banks with reported losses. The magnitude of the effect is substantial, with a reduction in losses of up to 90% found for treated banks relative to an entropy matched sample of control banks with similar characteristics. These findings suggest that, even in the absence of an explicit requirement to raise further capital as a backstop for operational risk, the introduction of capital regulations relating to operational risk resulted in a reduction in bank operational risk losses.

We investigate three non-mutually exclusive channels underpinning our find-

[4]In addition to introducing operational risk capital, the Basel II Accord also altered the way in which credit risk exposures of banks are calculated through changes in the approach to risk-weighted assets. These changes predominantly impact the quantities of capital held for credit risk. The focus of interest in this paper, however, is the impact upon realized operational risk losses. While there may be potential for misreporting of operational risk losses as credit risk losses or vice versa, there is no clear indication as to any underlying direction and we take the available operational risk loss data at face value.

ings. First, banks may select between various approaches to calibrate the level of operational risk capital to be held, similar to setting appropriate risk-based capital for credit risk exposures (Mariathasan and Merrouche, 2014). Using hand-collected data relating to the measurement approach adopted by banks, we isolate the channel of influence as emanating from banks adopting either the standardized approach or advanced measurement approach to set operational risk capital levels. In contrast, no treatment effect is observed for banks using the basic indicator approach. Common to the standardized and advanced measurement approach is a requirement to demonstrate the presence of strong risk management and governance with respect to operational risk. This highlights the importance of governance and risk management criteria, in addition to granularity of operational risk categorization in influencing realized operational risk losses. These findings are significant in light of the impending withdrawal of the advanced measurement approach, replacing instead with a new standardized approach applicable across all banks.[5]

Second, we investigate the impact of binding capital requirements on banks' response to this new capital charge. The reduction in operational risk losses is only found for banks unconstrained by capital requirements prior to treatment, while no reduction is observed for constrained banks. We attribute this finding to underinvestment by constrained banks culminating in long-run operational risk losses. For example, a bank may delay updating of core systems, resulting in long-

[5]The new Standardized Measurement Approach reflects a hybrid approach to calculating operational risk capital. While it does not adopt an explicit model-based approach to calculating expected operational risk losses, a loss multiplier will be calculated which is a non-linear function of historical losses over the previous 10 years. This is to be combined with information relating to income across different business lines in determining capital requirements.

run outages and associated operational risk costs. This relates to the notion of regulatory arbitrage, in the sense that banks could, either implicitly or explicitly, take risks leading to operational losses without having to hold requisite capital pre-treatment. In contrast, banks holding greater capital buffers are concerned about preserving their franchise value (Boyson et al., 2016) and are willing to invest in systems, risk management and processes, resulting in decreased losses post treatment.

Finally, we examine the relevance of effective monitoring on banks' response to the introduction of operational risk capital. We show that banks with low institutional ownership experienced a reduction in losses post treatment, but find no evidence of a change in operational risk losses for banks with high institutional ownership. Greater monitoring by investors in the pre-treatment period leads to an intensive focus on risk management and governance in banks with high institutional ownership. For banks with low institutional ownership, the evidence for decreased losses post-treatment may relate to a new internal focus on risk management and processes, stemming from the introduction of the operational risk capital requirements.

Our findings are shown to be robust. The identifying assumptions underpinning the difference-in-differences analysis are confirmed to be met, in particular that of a parallel trend over the pre-treatment window. Furthermore, our findings are consistent for entropy balancing on higher-order moments and to the use of a propensity score matching technique. Results are also in agreement for shorter time windows surrounding the regulatory change, demonstrating that our inference is not influenced by delays in loss reporting. While operational risk capital is shown to be linked with a reduction in losses for both banking and non-

banking events, no link is indicated for external operational risk losses, providing further support for the influence of strong internal governance and risk management processes. We show that the reduction in operational risk losses holds when we control for merger activities and bank-specific media coverage. Findings also hold for various alternative loss measures, to the removal of outliers and to the exclusion of losses emanating from the global financial crisis, including legal costs. Finally, the causal impact of the introduction of operational risk under Basel II is further validated using a series of placebo tests.

Our paper builds upon and expands the current literature in a number of interrelated areas of research. First, our paper pertains to the literature considering outcomes resulting from changes in bank regulatory capital requirements (Fraisse et al., 2020; Gropp et al., 2019; Jiménez et al., 2017) and that examining impacts from cross-country differences in banking regulation (Frame et al., 2020; Karolyi and Taboada, 2015). Second, our paper is connected with the literature examining the internal response of banks to regulatory adjustments, especially those addressing issues surrounding the use of model driven approaches for risk-weighting of bank assets (Acharya et al., 2014; Mariathasan and Merrouche, 2014; Vallascas and Hagendorff, 2013). Our paper also links to the literature specific to operational risk, including those focused upon modeling distributional characteristics associated with operational losses (Mitra et al., 2015; Chavez-Demoulin et al., 2006; De Fontnouvelle et al., 2006; Rosenberg and Schuermann, 2006). Of particular relevance to this work is the literature demonstrating that operational risk losses are associated with weak internal risk management and corporate governance (Chernobai et al., 2020; Barakat et al., 2014; Chernobai et al., 2011).

We contribute to the literature in a variety of ways. First, while the majority

of papers focus upon the transmission of higher capital requirements to the real economy, we take advantage of the non-concurrent introduction of operational risk capital to identify the bank-level risk reduction effects of a new capital requirement. Second, we focus on the introduction of a regulatory capital charge which was not intended by policymakers to result in an increase in aggregate bank regulatory capital. Our analysis thus sheds new light on the channels through which capital regulation can influence bank risk and the interaction with banking incentives. This contribution also relates to the proposed regulatory changes to the measurement approach. Finally, we study the implications of operational risk regulation, rather than the accuracy of inputs into operational risk models. This is significant for regulators and policymakers, seeking to understand the success of the extant regulatory regime.

The remainder of this paper is organized as follows: In Section 2, we describe the research design, data and sample. We report our main empirical findings in Section 3, and robustness test results in Section 4. Section 5 concludes.

2. Hypotheses

Seeking to better reflect the increasing complexity of banks and to "promote safety and soundness in the financial system", the Basel II accord introduced a requirement for banks to hold capital for operational risks for the first time (Basel Committee on Banking Supervision, 2006a). Published in June 2006, the capital accord established an explicit capital charge for the purposes of operational risk, calibrating the level of capital required using one of three methods of increasing complexity. With the introduction of the operational risk capital charge, the intention was not to necessarily increase or lower the aggregate regulatory capital

held, but rather to allocate a proportion of total capital to operational risk (Basel Committee on Banking Supervision, 2001). Furthermore, in quantifying the expected changes to capital under the Basel II Accord, the Basel Committee on Banking Supervision (2006b) indicate an anticipated decrease in the total levels of capital held.[6] The implication is that any incentive changes in the recognition, quantification and prevention of operational risk by banks were not directly a consequence of the market disciplining role associated with holding greater aggregate quantities of regulatory capital (Bliss and Flannery, 2002).

The original Basel I accord was established with only an explicit capital charge for credit risk, but the minimum ratio of 8% was set to implicitly account for other risk types. In 2001, the BIS reported that many banks allocate 20% or more of their internal economic capital to operational risk (Basel Committee on Banking Supervision, 2001). Moreover, they recognize that a range of differing approaches were employed by banks to allocate capital internally for operational risk prior to the introduction of explicit regulatory guidelines.[7] Against this backdrop of some banks already holding a proportion of their economic capital for operational risk, the introduction of the Basel operational risk capital charge may be expected to have limited effect on realized risk, especially for the most sophisticated internationally active banks.[8]

[6]This decrease is largely attributed to a reduction in requirements for capital related to credit risk under Basel II. The Basel Committee on Banking Supervision (2006b) indicates an expected operational risk allocation of between 6.1% and 7.5% for G10 banks and between 5.5% and 7.7% for European banks. The addition of this new capital notwithstanding, total capital was expected to drop by between 4.4% and 14.1% for G10 banks and between 7.5% and 18% for European banks.

[7]Methods described include cost volatility, earnings-at-risk, business line valuation techniques, non-quantitative self assessment and loss events links to business volumes (Basel Committee on Banking Supervision, 1999).

[8]No specific reporting requirement for operational risk existed before the introduction of the

A large theoretical literature focuses upon the consequences of bank capital regulation for banks' asset risk, often with conflicting implications. For example, while Koehn and Santomero (1980) describe how risk-seeking banks will respond to increased capital requirements by selecting a riskier mix of assets, Furlong and Keeley (1989) posit that incentives for increased risk decline for banks increasing their capital. Such models provide limited guidance in regards to the introduction of operational risk capital, however, as they are founded upon an expected risk-return relationship.[9] Related empirical studies have demonstrated that banks react to new capital requirements by reducing their risk weighted assets, with resultant changes in lending to the real economy (De Jonghe et al., 2020; Gropp et al., 2019; Imbierowicz et al., 2018). The distinction with the introduction of operational risk capital is that aggregate capital was intended to remain unchanged, providing a lesser incentive to focus upon risk reduction. Given the lack of support for a clear outcome resulting from the introduction of operational risk capital, we propose the following competing hypotheses:

Hypothesis 1a: *The introduction of operational risk capital resulted in no change in realized operational risk losses for treated banks in the post treatment period.*

Hypothesis 1b: *The introduction of operational risk capital resulted in a change in realized operational risk losses for treated banks in the post treatment period.*

We next focus upon the channels through which operational risk capital might impact upon realized losses. Under the Basel II framework, a set of three stan-

operational risk capital requirements. For this reason, it is not possible ex-post to assemble a definitive record of which banks held economic capital for operational risk before the treatment.

[9]While Chapelle et al. (2008) and Jarrow (2008) highlight the possibility of a tradeoff between operational risks and revenues resulting from undertaking such risks, they do not provide any guidance as to how banks might quantify the associated expected operational risk returns.

dardized capital calibration methods were introduced. While banks are encouraged to move towards more sophisticated approaches, they can only do so upon meeting specific requirements in relation to governance and risk management. As previously shown, a focus upon risk management and governance may influence banking risk (Anginer et al., 2018; Ellul and Yerramilli, 2013).

For banks using either the basic indicator approach or the standardized approach, capital is set as a function of revenues. For the basic indicator approach capital is set as a function of 3-year average aggregate bank revenue. Operational risk is calibrated using weights applied to 3-year average revenue across different business lines for the standardized approach, with the intention to provide greater risk sensitivity. As capital is prescribed relative to historical revenues, rather than as a function of expected future operational risk losses, a simple focus upon improved internal processes, including risk management, may not be sufficient to reduce the quantity of operational risk capital required. As part of the process of obtaining regulatory approval to employ the standardized approach, however, banks must demonstrate that strong and appropriate governance and risk management structures are in place ex-ante.[10] No specific governance or risk management criteria for the use of the basic indicator approach are set out in the Basel framework.

The enticement to use the advanced measurement approach is through the use of internal risk modeling frameworks to calculate capital accounting for the

[10]Specifically, to qualify for the standardized approach or advanced measurement approach, banks must satisfy their supervisor that i) their board of directors and senior management, as appropriate, are actively involved in the oversight of the operational risk management framework ii) it has an operational risk management system that is conceptually sound and is implemented with integrity, and iii) it has sufficient resources in the use of the approach in the major business lines as well as the control and audit areas (Basel Committee on Banking Supervision, 2006a).

likelihood and severity of expected future losses. In this case, management may be motivated to focus upon reducing future losses, through risk management, improved processes or otherwise, in order to decrease the quantity of capital required. On the other hand, analogous to findings documented for Basel II internal risk based models (Mariathasan and Merrouche, 2014) and for information used for internal credit scoring (Berg et al., 2020), management may manipulate the modeling process to ensure reductions in the frequency and severity of forecast losses, thus moderating the amount of capital required as a backstop against operational losses. Common with the standardized approach, banks employing the advanced measurement approach must also demonstrate appropriate risk management and governance are in place before implementation. Focusing upon this influence of risk management and governance requirements and links with operational losses previously documented (Chernobai et al., 2011), we propose the following hypothesis:

Hypothesis 2: *Banks using the advanced measurement approach or the standardized approach to calibrate operational risk capital have reduced realized operational risk losses in the post treatment period.*

Regulatory capital requirements may result in banks holding capital which deviates from their optimal level. Such capital constrained banks may use regulatory arbitrage to increase their risk taking without requiring more capital (Boyson et al., 2016). Operational risk may provide a further avenue to increase risk taking for capital constrained banks. For example, a bank may decide not to invest in updating core systems but experiences future operational losses due to system failures. Similarly, a bank may take a less-focused approach to risk manage-

ment due to costs involved, but receive regulatory fines in the long-run. Such approaches allow capital constrained banks to increase short-run profits but with the implication of long-run operational losses. In the face of the introduction of operational risk capital, capital constrained banks are less likely to undertake the necessary investment in risk management and processes given the resultant influence upon profitability. In contrast, banks who are not capital constrained are more concerned with preserving their franchise value (Boyson et al., 2016) and willing to invest in improved systems and processes. This provides motivation for the following hypothesis:

Hypothesis 3: *Banks who are not capital constrained have reduced operational risk losses in the post treatment period.*

Monitoring by large owners is considered as an important governance solution to agency problems (Shleifer and Vishny, 1997). Large owners are more likely to assume monitoring costs than free-riding small investors, particularly when the benefits of monitoring outweigh the costs, and allow large owners to recoup their investments (Gillian and Starks, 2000; Shleifer and Vishny, 1986). Greater monitoring of banks with high institutional ownership leads to a sharper focus upon risk management and governance in such firms pre-treatment. In contrast, banks with low institutional ownership are more likely to require investment in new risk management procedures and better governance in response to the introduction of operational risk capital. As previously detailed, better risk management and governance is associated with fewer operational risk losses (Chernobai et al., 2011), which should lead to a reduction in operational risk losses post treatment in banks with low institutional ownership. This leads us to propose the following

hypothesis:

Hypothesis 4: *Banks with low institutional ownership pre-treatment have reduced operational risk losses in the post treatment period.*

3. Empirical Design

To identify the effects of operational risk capital on realized operational risk losses, we take advantage of the partial US implementation of Basel II relative to full European ratification. Specifically, only a small number of internationally active core US banks were required to apply Basel II and use the advanced measurement approach to set operational risk capital.[11] In Europe all banks were required to hold operational risk capital, calibrated using one of the three measurement approaches previously detailed.

3.1. Difference-in-Differences

To examine the impact of the introduction of operational risk capital under Basel II on operational loss, we use a difference-in-differences setup, which compares the change in bank operational risk losses in European banks with changes in such losses within a similar group of US banks that did not implement Basel II. We estimate model specifications that are variants of the following form:

$$\begin{aligned} ln(OpLoss)_{i,t} = \alpha_0 \quad &+ \quad \alpha_1 Treated_i + \alpha_2 Post_t + \alpha_3 Treated_i \times Post_t \\ &+ \quad \alpha_4 \text{Controls}_{i,t-1} + \text{FE} + \epsilon \end{aligned} \tag{1}$$

[11] The federal banking agencies chose not to apply Basel II to all US banks. The US rule only applies to the very largest, internationally active "core" US banks with at least USD 250 billion of consolidated total assets or at least USD 10 billion of on-balance-sheet risk associated with foreign asset holdings. Such institutions were required to use the most advanced Basel II approaches to calculate credit risk exposures. Basel II initially applied to 19 US banks.

where $ln(OpLoss)_{i,t}$ is the operational risk loss of bank i at time t, measured as the natural logarithm of operational losses. $Treated$ is a treatment group indicator that equals 1 for European banks, and 0 for US banks that did not implement Basel II. $Post$ is a dummy indicator that equals to 1 after the Basel II implementation (from 2007) and 0 before this period. $Controls$ refer to a set of bank-level control variables that are seen as important determinants for bank operational losses. Bank and year fixed effects (FE) are included to account for omitted effects at the bank and time level. The coefficient of interest is α_3, which measures the difference-in-changes in operational losses for countries which implemented Basel II relative to countries that did not. If α_3 is statistically significant, then the introduction of operational risk capital under Basel II has an impact on bank operational losses. The difference-in-differences approach ensures that model estimation is not influenced by permanent and unobserved differences between the treated and the control group or by common trends. We also include a set of time-varying bank-level characteristics associated with operational risk losses to rule out the possibility that the estimates are influenced by a contemporaneous shock to these characteristics. Detailed variable definitions are reported in Appendix A.

3.2. Description of Operational Risk Loss Data and Sample

SAS OpRisk Global Data is the source for the operational loss data employed in this study. SAS OpRisk Global Data is the world's largest, most comprehensive and most accurate repository of information on publicly reported cross-country operational risk losses greater than USD 100,000.[12] The vendor gathers informa-

[12]SAS OpRisk Global Data contains more than 35,000 operational loss events, of which 45% relate to financial services.

tion on operational risk losses from public sources such as news reports, court filings, and SEC filings. We take data from the 2018 reporting cycle of the SAS OpRisk Global Database, which includes losses recognized between 2000 and 2015. All reported loss values are denoted in US dollars and CPI-adjusted to 2018, which allows for comparison across currencies and across time.

We select banks in Europe and US that have data available between 2000 and 2015 on all variables used in the empirical analysis. After matching with accounting data based upon the accounting date of the loss,[13] excluding the "core" US banks, excluding banks that did not survive through the global financial crisis (i.e., 2007–2009), and ensuring we have data available on all variables for the empirical tests, the final sample consists of 710 bank-year observations for 136 banks: 69 banks are in the treatment group (361 bank-year observations) and 67 banks are in the control group (349 bank-year observations).[14] In further analysis, we also include banks where no losses were reported in particular years, setting the loss severity to zero.

Table 1 details the breakdown of losses by country. Over 50% of bank-year losses are from the US, providing a sufficient control sample. Italy, Switzerland and the UK account for the largest proportion of losses outside the US. In Table 2 we detail statistics surrounding losses on an annual basis.

[Table 1 about here.]

[Table 2 about here.]

[13]The accounting date is the date at which the loss is booked in the income statement.

[14]Operational risk losses are aggregated by bank each year to match with the yearly accounting data and to fit with the premise that capital levels are set as a backstop for aggregate losses.

Figure 1 provides some context for our analysis. This details the aggregate quantities of capital reported by European banks and is broken out into credit, market and operational risk capital. Focusing on the latter, in the post treatment period (2007) we observe a sharp increase in the capital held to USD 33 billion. A further large increase is observed in 2008, corresponding to the full European implementation of the advanced methods to calculate capital requirements. Capital continues to increase up to 2011, with a small decrease observed after this point. The total operational risk capital held is economically meaningful, with 95 European banks found to hold EUR 123 billion in 2016.

[Figure 1 about here.]

Figure 1 also shows aggregate credit and market risk capital. While operational risk capital is increasing over time, we find no evidence of an increase in either credit or market risk capital over the period examined. Furthermore, aggregate bank capital is not found to increase in the post-treatment period.

3.3. Matching

As the SAS OpRisk Global Data is left-truncated at a reporting threshold value of USD 100,000, we estimate a Tobit regression model in the 2000–2006 period to identify bank characteristics associated with operational loss severity. Our identification of matching covariates are informed by prior literature on determinants of operational risk, which shows that firms that suffer from operational risk losses tend to be younger, more complex, and with greater ex-ante risk of financial distress (Chernobai et al., 2020, 2011). We also control for credit risk (net chargeoffs and loan growth) and market risk (noninterest income). The model

employed to assess the relevance of such characteristics to our data is as follows:

$$\begin{aligned} ln(OpLoss)_{i,t} = \beta_0 &+ \beta_1 SIZE_{i,t-1} + \beta_2 DPO_{i,t-1} + \beta_3 LIQUID_{i,t-1} \\ &+ \beta_4 \Delta LOAN_{i,t-1} + \beta_5 NCO_{i,t-1} + \beta_6 NII_{i,t-1} \\ &+ \beta_7 ROE_{i,t-1} + \beta_8 GDP_{i,t-1} + \beta_9 \Delta GDP_{i,t-1} + \text{FE} + \epsilon \end{aligned} \tag{2}$$

where $ln(OpLoss)_{i,t}$ is as previously defined. We include bank size (SIZE), dividend payout (DPO), liquid assets (LIQUID), loan growth (ΔLOAN), net charge-offs (NCO), noninterest income (NII), return on equity (ROE), natural logarithm of annual GDP per capital (GDP), annual growth of GDP per capital (ΔGDP), and year and country fixed effects (FE). All variables are measured at (financial) year-end. All continuous variables are winsorized at the 1^{st} and 99^{th} percentiles of their empirical distribution. Detailed variable definitions are reported in Appendix A. Table 3 reports results from the estimation of Equation (2). We identify three bank characteristics that are associated with future operational losses: bank size, return on equity, and noninterest income ratio. Any significant distributional disparity between these variables for treated and control banks can potentially weaken inference from our difference-in-differences framework.

[Table 3 about here.]

We employ entropy balancing (Hainmueller, 2012) to address this problem. Entropy balancing is a generalization of the well-known propensity score matching (PSM) approach that results in enhanced covariate balance relative to PSM (Hainmueller, 2012). Compared with other preprocessing methods, entropy balancing appropriately reweights units to obtain balance, while keeping the weights as close as possible to the base weights. It thus retains valuable information in the processed data and improves efficiency for the subsequent analysis (Hainmueller,

2012). Compared with PSM, entropy balancing does not drop observations or generate random matches, and thus increases test power (King and Nielsen, 2019). For the purposes of entropy balancing, we employ these three significant bank characteristics emerging from the Tobit model regression as matching covariates. The match is done on the first and second moments of matching covariate distributions with a tolerance level of 0.015 (Hainmueller and Xu, 2013).[15] We match in the year before implementation of Basel II, (i.e., 2006)[16] and use the same entropy balance weights in all years in the subsequent difference-in-differences analysis. Table 4 reports descriptive statistics on matching covariates for both unbalanced and entropy balanced samples as of 2006. Panel B shows that the mean and variance of the treatment and weighted control groups are identical after entropy balancing. Statistics are similar for other years, but are not reported for brevity.

[Table 4 about here.]

4. Results

4.1. Baseline Results

We use the entropy-balanced sample to examine the difference in operational losses between treated and control banks. Table 5 reports results for the difference-in-differences analysis that compares the change in operational losses of treated banks with those of a control group of matched US banks. As shown in Equation

[15]The tolerance level refers to the maximum deviation from the moment conditions across all the variables included in the set of covariates.

[16]Results remain qualitatively the same when other years in the pre-treatment period is used for the entropy balancing.

(1), *Loss* is regressed on a treatment group dummy *Treated* (1 for European banks; 0 for US banks), a post treatment dummy *Post* (1 for after 2007; 0 before 2007) and an interaction term between the treatment group dummy and the post treatment dummy $Treated \times Post$. A set of bank-specific control variables are included to ensure that our results are not driven by a contemporaneous shock to these time-varying determinants of bank operational losses. We include controls for bank size (natural logarithm of total assets), business complexity (noninterest income over total operating income), deposit ratio (total deposits over total assets ratio), risk-taking (total fair value of derivatives over total assets ratio), yearly GDP per capita and its growth rate.

Baseline results are reported in Table 5. The variable of interest is the interaction term, which captures the impact of the introduction of operational risk capital under Basel II on bank operational losses. Columns 1 to 3 of Table 5 report the baseline results in a setup using Tobit model estimates for a sample where banks with no reported losses are represented with a zero loss value. In column 1, only bank fixed effects are included. In columns 2 and 3, both bank and year fixed effects are included to further control for unobservable bank-specific characteristics that have a potential influence on bank operational losses, with standard errors clustered at the bank and country levels, respectively. Across all specifications, the coefficient on $Treated \times Post$ is found to be significant and negative. This means that banks subject to the Basel II introduction of operational risk capital experienced lower operational risk losses in the post treatment period.

[Table 5 about here.]

In columns 4 through 6, we examine a reduced dataset only containing banks

with reported operational risk losses, using a truncated regression to account for the fact that only losses greater than USD 100,000 are included in the sample. The interaction variable of interest, Treated×Post, is again found to be significant at a 1% level. In other words, treated banks experienced lower operational risk losses post treatment relative to US banks. The economic magnitude of the findings is considerable. Compared to the entropy matched synthetic control sample, the loss magnitude in treated banks is reduced by 90%. Similar findings are evident when bank and year fixed effects are included and for standard errors clustered at the bank and country level. These findings indicate that the introduction of operational risk capital for European banks was associated with a reduction in realized operational risk losses. In subsequent analysis, we examine the channels of influence, considering only banks with reported operational risk losses.

4.2. Measurement Approach

We next examine the channels of influence upon this relationship. First, we focus upon the impact of measurement approach on the relationship between operational risk capital and realized losses. In Table 6, we interact the measurement approach employed by treated banks with the *Post* dummies. Our earlier findings of a reduction in operational risk losses post treatment is borne out for banks employing either the advanced measurement or standardized approaches to set operational risk capital, but not for the basic indicator approach. In other words, banks using the advanced measurement or standardized approaches experienced lower operational risk losses in the post treatment period.

[Table 6 about here.]

While the advanced measurement approach provides flexibility to management in the modeling approach adopted in setting capital, the standardized approach is based upon revenues across a series of business lines, rather than on expected future losses. This means that there are limited incentives to focus on reducing future operational risk losses. In contrast, under the advanced measurement approach, management are motivated to reduced expected future losses in order to curtail the quantities of capital to be held. While the methodology used to calibrate capital differs, common to both approaches is a regulatory requirement for evidence of strong governance and risk management in order to be permitted to adopt these sophisticated approaches. Such requirements are not associated with the basic indicator approach, supporting the notion that the prerequisite of strong governance and risk management contributed to the success of operational risk capital in reducing realized losses. This inference resonates with the findings of Chernobai et al. (2011), where strong governance and risk management were found to be associated with a reduced frequency of operational losses.

4.3. Capital Constraints

Much evidence exists for distinct incentives in the case of capital constrained banks, especially in the context of regulatory arbitrage. Operational risk which, up to 2007, was not associated with an explicit capital change, may be looked upon differently by banks with binding capital requirements, where an incentive to increase risk without holding extra capital exists. Next, we determine whether this results in a differential treatment effect for banks with binding capital constraints.

A set of dummy variables is used to proxy for capital constraints: CAP_{Weak} is set equal to one if a bank's Tier 1 ratio is below or equal the sample median in the

pre-treatment period (2004–2007); CAP_{Well} takes value one if a bank's tier 1 ratio is above the sample median in the same period. The level of tier 1 capital acts as a direct proxy for regulatory capital constraints (Boyson et al., 2016). $OBSL_{Rise}$ equals one if a bank experienced an increase in off-balance sheet leverage for 3 consecutive years between 2004 and 2007; and $OBSL_{Drop}$ equals one if a bank did not experience an increase in off-balance sheet leverage for 3 consecutive years from 2004 to 2007. The focus on off-balance sheet leverage relates to its use in cosmetically transferring risk off-balance sheet, to reduce capital requirements for constrained banks (Acharya et al., 2013).

Results are detailed in Table 7. Coefficients on interaction terms capturing constrained banks (Treated×Post×CAP_{Weak}; Treated×Post×$OBSL_{Rise}$) are not statistically significant while coefficients on interaction terms for unconstrained banks (Treated×Post×CAP_{Well}; Treated×Post×$OBSL_{Drop}$) are significant, which indicates that constrained banks did not experience any reduction in operational losses post treatment relative to the control.

[Table 7 about here.]

While constrained banks may employ strategies which result in operational risks, this results in short-run profitability. Investing in better risk management systems and processes may impede this profitability. Prior to the introduction of operational risk capital, banks did not have to set aside capital for operational risk losses, or capture information regarding the potential for and magnitude of such losses. Unconstrained banks are additionally concerned about preserving their franchise value (Boyson et al., 2016). To this end they are willing to invest in improved risk management systems and processes. It is this focus on risk

management to which we attribute the observed reduction in realized operational risk in treated banks.

4.4. Institutional Ownership

To test the link between institutional ownership and the treatment effect, we employ ownership data obtained from Factset. We create four dummy variables: IO_{Low} takes value one if a bank's ratio of institutional ownership is below or equal the sample median during 2000–2006, and zero otherwise; IO_{High} takes value one if a bank's ratio of institutional ownership is above the sample median for the same period, and zero otherwise; $INDI_{Low}$ takes value one if a bank's ratio of independent institutional ownership is below or equal to the sample median during 2000–2006, and zero otherwise; and $INDI_{High}$ equals one if a bank's ratio of independent institutional ownership is above the sample median for the same period, and zero otherwise.[17]

Table 8 reports results for these tests. Coefficients on interaction terms capturing banks with low monitoring prior to the treatment (Treated×Post×IO_{Low}; Treated×Post×$INDI_{Low}$) are statistically significant while the coefficients on interaction terms capturing banks with high monitoring prior to the treatment (Treated×Post×IO_{High}; Treated×Post×$INDI_{High}$) are not found to be significant. These results suggest that banks with low monitoring exerted by institutional ownership experienced a reduction in the severity of their losses post treatment. We interpret this finding as indicating that the introduction of operational risk capital resulted in greater monitoring of institutions with poor governance,

[17]Following Chen et al. (2007), Almazan et al. (2005), and Brickley et al. (1988), we define independent institutions as those not having potential business ties to the focal firm. Prominent examples of independent institutions include mutual fund managers and investment advisers.

forcing banks to put in place improved risk management and processes to limit future operational risk losses.

[Table 8 about here.]

5. Robustness Tests

5.1. Identifying Assumptions

In order to obtain reliable difference-in-differences estimates, several underlying assumptions must be satisfied. The first assumption to be met is that the treatment group is subject to the adoption of Basel II, but the control group is not. Defining our treatment/control groups as European versus US and by excluding US "core" banks that are subject to adopt Basel II in 2007 ensures that this assumption is valid. Second, the pre and post periods should be balanced in terms of having the same banks in both periods (Atanasov and Black, 2018). Our sample selection criterion of retaining only banks that survived through the 2007–2009 financial crisis period satisfies this condition. Third, the treatment should have a significant effect on the treatment group, as observed in Table 5. Finally, the outcome variable for treatment and control groups should exhibit parallel trends over the pre-treatment period (Atanasov and Black, 2018; Lennox, 2016). That is, in the absence of treatment, the average change in the outcome variable would have been the same for both the treatment and control groups. Because such counterfactual trends are not empirically observable, we perform a counterfactual analysis to compare operational losses of the treatment group with those of the control group. We estimate the counterfactual treatment effect by

estimating Equation (3) below:

$$ln(OpLoss)_{i,t} = \gamma_0 + \sum_{j=1}^{7} \gamma_j Treated_i \times Pre_j + \sum_{k=1}^{9} \gamma_k Treated_i \times Post_k + \text{Controls}_{i,t-1} + \text{FE} + \epsilon \quad (3)$$

We replace the interaction term $Treated \times Post$ in Equation (1) with separate interactions between Treated and year dummies (except for year 2007, which is used as the benchmark). *Pre1–Pre7* refer to 1–7 years before the introduction of Basel II operational risk capital (2000–2006), and *Post1–Post9* refer to 1–9 years after the treatment (2007–2015). The same set of bank-level control variables used in the baseline regression are included. FE refer to year and bank fixed effects here. Our findings, reported in Table 9 and plotted in Figure 2, suggest that the counterfactual treatment effects do not build up in the pre Basel II period, which satisfies the parallel trends assumption and further supports our results in earlier difference-in-differences analysis. Moreover, we note that the treatment interaction coefficient is strongly negative and significant for the majority of years post treatment.

[Figure 2 about here.]

[Table 9 about here.]

In Table 10, we limit the sample to shorter time windows of three, two and one year surrounding the regulatory change. The use of a shorter window mitigates the concern that the effect that we find may be due to other changes taking place during the sample period. In addition, using a shorter window around the regulatory change also alleviates the concern that overall changes in market struc-

ture may be driving our results. Our coefficient of interest remains negative and statistically significant across all specifications in these shorter windows, which provides reassurance that the decrease in operational loss is attributable to the regulatory change imposed by Basel II.

[Table 10 about here.]

5.2. Types of Operational Losses

5.2.1. Banking vs. Nonbanking Losses

Following the BIS business line classification, we define an operational loss as a banking event if it originated from one of the following business lines: Agency Services, Commercial Banking, Payment and Settlement, or Retail Banking. We define a loss as a nonbanking event if it originated from one: Asset Management, Corporate Finance, Insurance, Retail Brokerage, or Trading and Sales. Around 45% of the operational loss events in our sample are classified as nonbanking events. Results, shown in Table 11, panel A, indicate no significant differences between banking and non-banking losses, with operational risk capital associated with reduced losses for both business types. This indicates that our findings are not influenced by whether the bank is undertaking non-banking related business or not.

5.2.2. Internal vs. External Losses

Next, we separate internal events from external events according to Basel II operational risk event categories. We define a loss as an internal event if it originated from one of business disruption and system failures, clients, products, and

business practices, employment practices and workplace safety, execution, delivery, and process management, or internal fraud. Losses arising from damage to physical assets or external fraud are defined as external events. Detailed definitions for these risk event categories are reported in Appendix B. Results, detailed in Panel B of Table 11, suggest that the introduction of Basel II operational risk capital leads to loss reduction only for internal events, reinforcing the notion that the introduction of operational risk capital functions through an improvement in internal risk control and governance in keeping with the earlier results detailed and previous work on the drivers of operational risk losses (Chernobai et al., 2011).

[Table 11 about here.]

5.3. Alternative Loss Measures

We check the robustness of our baseline results to the choice of the operational loss measure by examining the following alternatives: (1) the natural logarithm of operational risk losses scaled by gross income (columns 1 and 2); (2) the natural logarithm of operational risk losses scaled by total assets (columns 3 and 4); (3) the natural logarithm of annual average loss per event (columns 5 and 6); and (4) the natural logarithm of annual average loss per employee (columns 7 and 8).[18] All model specifications using alternative loss measures are estimated using OLS to account for the scaled logarithmic-linear dependent variables. Results, reported in Table 12, indicate that treated banks have lower losses in the post treatment period for all alternative loss measures, confirming our earlier findings.

[18]This is to account for the possibility that loss severity drops but frequency increases as a result of the Basel II regulation.

[Table 12 about here.]

5.4. Removing Outliers

To ensure that our findings are not driven by outliers, we remove the largest 5% of the loss distribution in our sample. Table 13 reports results for these tests: (1) removing the specified outliers in the full sample (columns 1 and 2); (2) removing the outliers in each year (columns 3 and 4); (3) removing the outliers in the treatment and the control groups (columns 5 and 6); and (4) excluding banks with total assets less than USD 10 billion (columns 7 and 8). Results across all specifications examined are consistent and support our finding of a reduction in realized operational losses for treated banks post treatment.

[Table 13 about here.]

5.5. Possible Confounding Events

We check the robustness of our results to a number of possible confounding events that took place in our sample period. First, we perform a number of additional tests addressing the potential impact of the Global Financial Crisis, which struck shortly after the introduction of Basel II. To ensure that our findings are not materially impacted by losses emanating from the crisis, we examine the following specifications with results reported in Table 14: (1) excluding losses originating in the 2007–2009 crisis period from our sample (columns 1 and 2); (2) excluding losses realized in the 2007–2009 crisis period from our sample (columns 3 and 4); (3) deducting associated legal liabilities from the operational loss amount to remove the impact of different litigation propensities across jurisdictions especially

the severe US legal ramifications in the aftermath of the financial crisis (columns 5 and 6); and (4) further controlling for banks' exposure to mortgage loans (MORT; columns 7 and 8). Results, detailed in Table 14, are again supportive of our hypothesis. Legal losses and losses related to problems emerging from the financial crisis are not behind our baseline finding.

Another possible source for operational risk losses might be heightened merger and acquisition (M&A) activities. For instance, the US Gramm-Leach-Bliley Act of 1999 contributed to increased banking sector M&A deals in the years following its passage. To counter the potential impact of M&A activities, we include two additional control variables capturing M&A activities at both the bank- and country-level. First, we follow Ellul and Yerramilli (2013), defining banks experiencing a large-scale M&A as those whose year-on-year growth rate in book value of assets exceeds 20%. We then include an M&A trend variable summing up the number of M&A deals for each country-year. Results, reported in columns 9 and 10 of Table 14, indicate a reduction in operational losses for treated banks and provide reassurance that our results are not driven by M&A activities.

The potential effect of the interaction between media attention, operational risk event disclosure, and the size of the institution may help in explaining our findings (Chernobai et al., 2020). Given that operational risk events are often public events and large financial institutions are naturally the focus of public scrutiny and thus attract more media coverage, we include a media-attention control variable to account for any potential media bias. Employing the Financial Times Historical Archive, we compute the number of news articles that include a headline or paragraphs mentioning the names of our sample banks in a given year. We then include the news count as an additional control variable (*Media attention*)

in our models for a formal robustness test. The results are reported in columns 11 and 12 of Table 14. The coefficients for *Media attention* are statistically significant but economically small. Nevertheless, the economic and statistical significance of the treatment relating to operational risk capital remains robust, indicating reduced operational risk losses for European banks post treatment.

[Table 14 about here.]

5.6. Placebo Tests

We further confirm the causal impact of the introduction of Basel II operational risk capital on bank operational risk losses by performing two placebo (falsification) tests based on the differences-in-differences model described in Equation (1). In the first test, we select both pre- and post-periods before the introduction of operational risk capital (2000–2003 as the pre period; 2004–2006 as the post period), and assume 2004 is the treatment year (i.e., introduction of Basel II operational risk capital). In the second test, we define both pre- and post-periods after Basel II operational risk capital is introduced (2008–2011 as the pre period; 2012–2015 as the post period), and assume 2012 is the treatment year. Similarly, entropy balance weighting is performed in the year before the assumed treatment year. Results for these two tests are reported in Panel A and Panel B of Table 15, respectively. For both specifications, we do not find a significant and negative coefficient on the interaction term ($Treated \times Post$), providing further support for the causal impact of Basel II operational risk capital on associated realized operational risk losses.

[Table 15 about here.]

5.7. Alternative Matching Choices

5.7.1. Entropy Balancing on Higher Order Moments

Entropy balancing works through obtaining convergence in matching based on a trade-off between the number of matching covariates, number of moments of the distribution of matching covariates (i.e., matching up to mean, variance or skewness), and the tolerance level. Our baseline results are based on a entropy-balanced sample matching upon three covariates (i.e., SIZE, NII and ROE) up to the second moment at the tolerance level of 0.015. To test the sensitivity of our findings to the matching criteria employed, we implement the entropy balancing based on the following combinations of parameters: (1) matching upon the three matching covariates up to the third moment of their distribution, with a tolerance level of 0.1; and (2) matching only upon bank size up to the third distributional moment at a tolerance level of 0.001. Balancing properties of matching covariates under these two specifications are reported in Appendix C1. Related difference-in-differences results, reported in Appendix C2, support our primary finding that operational risk losses are reduced for treated banks in the post treatment period.

5.7.2. Propensity Score Matching

We next employ propensity score matching (PSM) as an alternative matching technique to create a matched sample. The matching is performed based on data from 2006 using the same set of covariates. We first implement nearest neighbor matching (Rosenbaum and Rubin, 1983) by selecting a control bank (without replacement) for each treatment bank that has the closest propensity score. We then perform radius matching that considers all non-treated observations within a specified radius (0.1) around a treated bank's propensity as control units. Ra-

dius matching allows for higher precision than nearest neighbor matching (Huber et al., 2013). Matching is performed with replacement, which means that each non-treated bank can be used as a neighbor for multiple treated banks. Appendix D1 reports the balancing properties of the matching covariates under these two PSM specifications. No statistically significant differences are found between the two samples, providing support for balance between treatment and control samples. Subsequent results, reported in Appendix D2, are strongly supportive of the baseline results, albeit there is an indication of reduced sample size and/or lower test efficiency using PSM due to the information loss in the preprocessing stage.

5.7.3. No Matching

In order to demonstrate our results are independent of the matching procedures selected, we examine a specification where no matching is performed to identify the group of control banks. Results reported in Appendix E are consistent with our baseline results.

5.8. Other Robustness

We conduct a number of further robustness tests in this section and provide details in Appendix F. First, we exclude the year 2007 from our sample to account for any difference in the speed of initial implementation of Basel II across countries in the treatment group. We also utilize a balanced sample of pre (2000–2006) versus post period (2008–2014). Results in columns 1 and 2 indicate that our baseline results are not driven by the unbalanced pre- and post-sample periods.

Second, as there may be a lag before losses are updated in the dataset, we look at a further specification removing the last three years in the sample period, where we can be reasonably confident that all relevant losses have been reported.

Again, we find a consistent treatment effect for the treated banks (columns 3 and 4). Last, to address the potential for the standard error of the estimators being underestimated by difference-in-differences standard errors (Bertrand et al., 2004), we average all variables in the pre- and post-treatment periods to perform entropy balancing and the subsequent regression. Results, reported in columns 5 and 6, remain qualitatively the same. These findings also support our earlier results that the introduction of operational risk capital led to a reduction in operational losses.

6. Conclusions

Forming a significant element of the ongoing overhaul to the regulatory capital framework, operational risk capital has received increased attention from both academic researchers and policymakers. While much of the focus in the literature has been on modeling the distributional characteristics associated with and correlations between operational risk losses, this paper provides the first assessment of the response of banks to the introduction of operational risk capital. We find that treated banks, those who were obliged to hold capital for operational risk from 2007, experienced a reduction in operational risk losses post treatment.

Considering the channels underpinning this finding, we demonstrate that banks using either the standardized approach or advanced measurement approach witness a subsequent reduction in operational risk losses. Given the very different calibration approaches involved in these measurement approaches, the interpretation we place on this finding is that it is the associated requirement for strong governance and risk management imposed which leads to the reduction in risk demonstrated.

The reduction in operational risk losses post treatment is also found to only

hold for banks which are not capital constrained, with no observed reduction for unconstrained banks. This finding is attributed to underinvestment in core systems and processes in constrained banks, giving rise to operational risk losses. Unconstrained banks are more concerned about preserving their franchise value, investing in systems and risk management, which in turn results in decreased operational risk losses. We also isolate a further channel, whereby banks with low institutional monitoring experience experience reduced operational risk losses. This indicates that the introduction of operational risk capital resulted in increased monitoring for banks with poor governance.

Overall, the findings in this paper contribute both to the literature considering banks' responses to capital regulation and that relating to bank operational risk. The findings suggests that the introduction of bank operational risk capital provides banks with incentives to manage operational risk more actively. While our findings shed light on the impact of operational risk capital on banking risk, they are relevant to policy makers implementing the new framework surrounding the calibration of operational risk capital.

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Figure 1: Risk Capital Held by Sample European Banks

This figure shows the evolution of risk capital held by 45 European banks with detailed data by risk category available throughout 2007–2015. CR, MR and OR refer to Credit Risk, Market Risk and Operational Risk, respectively. Risk capital data is hand-collected from annual reports and Pillar 3 disclosure.

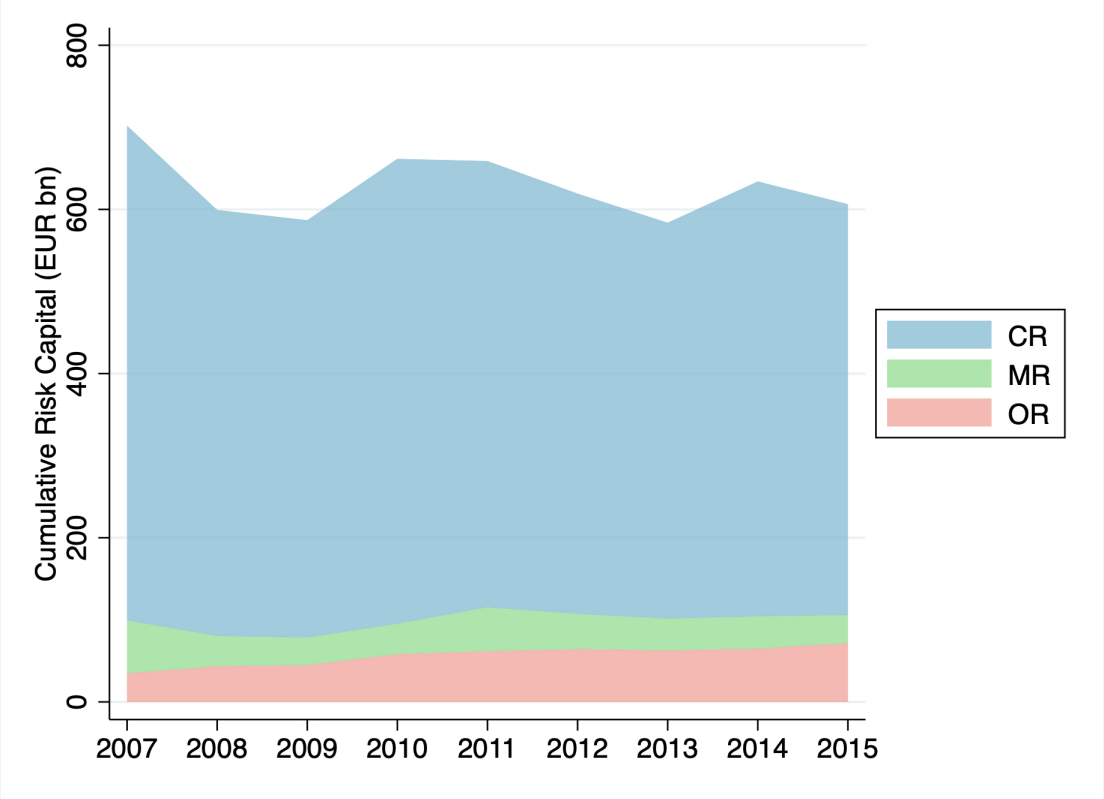

Figure 2: Counterfactual Treatment Effects

This figure depicts the counterfactual treatment effects. The treatment year (2007) is used as the benchmark (i.e., coefficient constrained to equal zero). The counterfactual treatment effects do not build up before the treatment, which satisfies the parallel trends assumption for reliable difference-in-differences estimates.

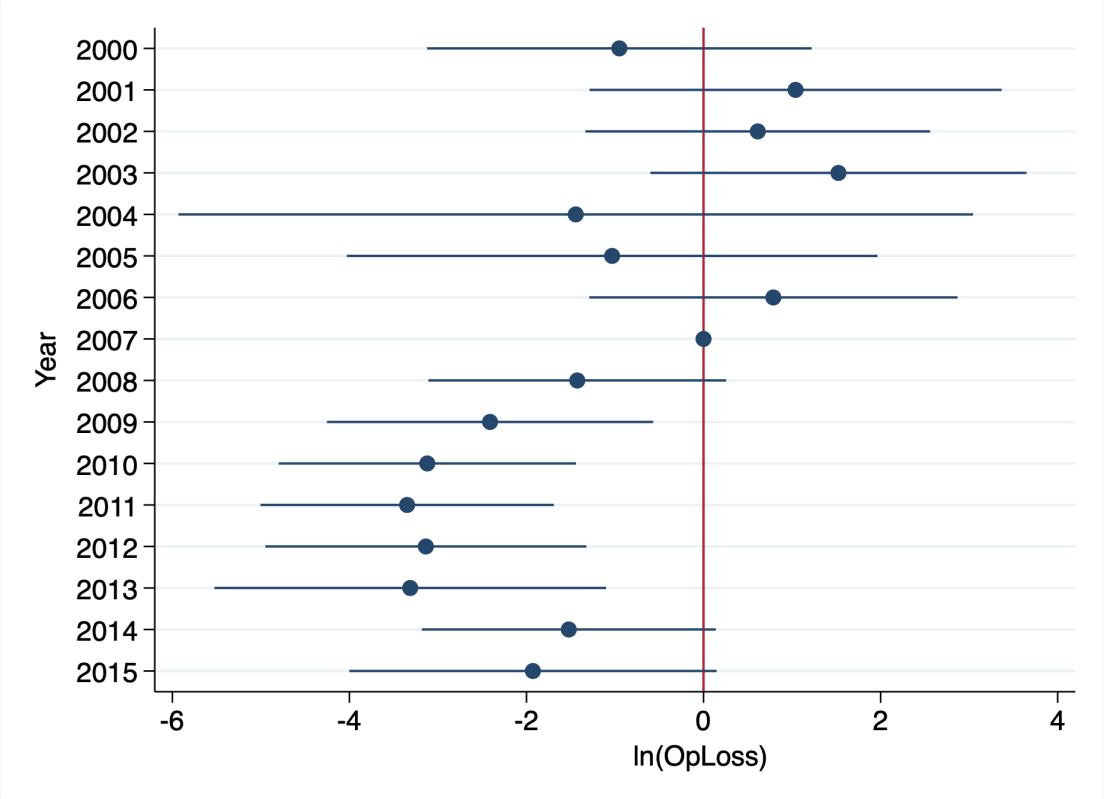

Table 1: Sample Composition by Country

This table outlines the sample of operational losses for each country examined in the paper. Panel A details the number of bank-year observations where all banks are included each year. Where there is no reported loss the loss magnitude is set equal to zero. Panel B details the number of bank-year observations where reported operational risk losses are non-zero.

	Panel A. Zero+Nonzero		*Panel B. Nonzero*	
Country	Frequency	Percent	Frequency	Percent
Austria	541	2.77	11	1.55
Belgium	78	0.40	11	1.55
Cyprus	65	0.33	7	0.99
Denmark	298	1.53	7	0.99
France	528	2.70	37	5.21
Germany	7,739	39.61	25	3.52
Greece	66	0.34	15	2.11
Hungary	30	0.15	6	0.85
Ireland	20	0.10	15	2.11
Italy	482	2.47	50	7.04
Netherlands	79	0.40	15	2.11
Norway	591	3.03	4	0.56
Poland	62	0.32	4	0.56
Portugal	56	0.29	6	0.85
Spain	298	1.53	20	2.82
Sweden	106	0.54	21	2.96
Switzerland	517	2.65	44	6.20
United Kingdom	573	2.93	63	8.87
United States	7,407	37.91	349	49.15
Total	**19,536**	**100.00**	**710**	**100.00**

Table 2: Loss Distribution by Year

This table reports the distribution of reported losses by year. Frequency and percent summarize the number of reported bank-year losses. Mean, median, min and max report the statistical characteristics of the loss magnitude per year. All losses are aggregated by bank-year, in USD million, and CPI-adjusted to 2018.

	Frequency	Percent	Mean	Median	Min	Max
2000	9	1.27	4.91	2.83	1.46	14.17
2001	10	1.41	74.46	7.30	0.18	635.32
2002	14	1.97	19.77	9.56	1.82	68.37
2003	21	2.96	54.89	5.91	0.17	481.63
2004	21	2.96	548.75	1.93	0.19	11313.95
2005	34	4.79	68.51	7.99	0.12	951.64
2006	54	7.61	1119.04	9.66	0.14	29119.26
2007	74	10.42	195.39	16.85	0.14	2760.76
2008	70	9.86	166.66	16.04	0.12	2386.04
2009	67	9.44	103.51	11.16	0.13	1292.92
2010	60	8.45	78.19	9.37	0.12	722.33
2011	68	8.17	104.89	6.89	0.14	2152.48
2012	67	9.44	541.16	5.05	0.11	10204.90
2013	55	7.75	361.88	6.40	0.12	9616.25
2014	53	7.46	275.38	9.85	0.16	3443.77
2015	43	6.06	1015.16	19.34	0.13	21811.00
Full Sample	**710**	**100.00**	**330.62**	**8.68**	**0.11**	**29119.26**

Table 3: Characterizing Operational Losses

This table identifies bank characteristics associated with operational loss severity. A Tobit model with year and country fixed effects is estimated, where the dependent variable is the natural logarithm of aggregated bank-year operational losses. Standard errors are clustered at the bank level and robust t-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Coefficient	t-statistic
Dependent variable: $ln(OpLoss)$		
ln(Total assets)	2.709***	[14.906]
Dividend payout	0.011	[0.996]
Liquid assets	4.685	[1.605]
ΔLoan	-0.010	[-0.605]
Net chargeoffs	-60.135	[-0.575]
Noninterest income	4.041**	[2.008]
Return on equity	-7.707**	[-1.990]
ln(GDP per capita)	-40.710	[-1.624]
ΔGDP per capita	387.118	[1.453]
Constant	369.140	[1.385]
Year FE	Yes	
Country FE	Yes	
Cluster level	Bank	
Observations	7,096	
R-squared	0.087	
Sample	Zero+Nonzero	
Model	Tobit	

Table 4: Descriptive Statistics of Unbalanced and Entropy Balanced Samples

This table reports descriptive statistics of unbalanced and entropy balanced samples. The balancing is based on year 2006, uses the first two moments of the distribution of matching covariates, and a tolerance level of 0.015.

	Treated		Control	
Unbalanced	Mean	Variance	Mean	Variance
ln(Total assets)	14.470	3.817	13.200	2.486
Noninterest income	0.358	0.043	0.194	0.024
Return on equity	0.112	0.009	0.150	0.034

	Treated		Control	
Entropy balanced	Mean	Variance	Mean	Variance
ln(Total assets)	14.470	3.817	14.470	3.817
Noninterest income	0.358	0.043	0.358	0.043
Return on equity	0.112	0.009	0.112	0.009

Table 5: Baseline Results

This table presents estimates of the treatment effect from the introduction of operational risk capital using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Treated×Post is an interaction term between the treatment group dummy and post-treatment dummy. Specifications (1)-(3) employ a Tobit model for a sample containing all bank-year observations. Specifications (4)-(6) use a truncated regression to estimate the treatment effect for a sample of banks with reported operational risk losses. Robust t-statistics and z-statistics are reported in brackets for tobit model and truncated model, respectively. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$	(5) $ln(OpLoss)$	(6) $ln(OpLoss)$
Treated×Post	-2.025***	-2.358***	-2.358***	-2.281***	-2.401***	-2.401***
	[-3.113]	[-3.713]	[-3.711]	[-3.049]	[-3.186]	[-4.853]
Post	1.091**			1.596**		
	[2.312]			[2.103]		
ln(Total assets)	1.154***	1.173***	1.173***	0.733	0.895*	0.895***
	[3.760]	[3.470]	[6.270]	[1.413]	[1.825]	[6.850]
Noninterest income	0.092	-0.039	-0.039	-0.071*	-0.067**	-0.067**
	[0.110]	[-0.042]	[-0.066]	[-1.778]	[-2.552]	[-2.445]
Deposit ratio	-4.935***	-4.837***	-4.837***	-2.437	-2.744	-2.744***
	[-3.636]	[-3.264]	[-4.375]	[-1.440]	[-1.534]	[-5.964]
Derivatives use	-4.491	2.215	2.215	-1.045	-1.641	-1.641
	[-0.623]	[0.299]	[0.343]	[-0.658]	[-0.752]	[-0.884]
ln(GDP per capita)	9.644**	4.783	4.783	-5.051	1.887	1.887
	[2.076]	[0.573]	[0.527]	[-1.082]	[0.377]	[0.364]
ΔGDP per capita	-0.015	0.498***	0.498***	0.013	0.074	0.074
	[-0.251]	[3.056]	[2.587]	[0.180]	[0.684]	[0.676]
Constant	-142.504	-93.317	-93.317	58.303	-18.811	-18.811
	[-1.048]	[-0.623]	[-0.576]	[1.228]	[-0.354]	[-0.343]
Year FE	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Bank	Country	Bank	Bank	Country
Observations	19,536	19,536	19,536	710	710	710
R-squared	0.171	0.169	0.169	0.505	0.512	0.512
Sample	Zero+Nonzero	Zero+Nonzero	Zero+Nonzero	Nonzero	Nonzero	Nonzero
Model	Tobit	Tobit	Tobit	Truncated	Truncated	Truncated

Table 6: Measurement Approach

This table examines the role of the measurement approach used to calibrate operational risk capital using a difference-in-differences model. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Dummy variables for the measurement approach, Basic Indicator Approach, The Standardized Approach and Advanced Measurement Approach, are interacted with the Post dummy variable. Specifications (1)-(2) employ a Tobit model for a sample containing all bank-year observations. Specifications (3)-(4) use a truncated regression to estimate the treatment effect for a sample of banks with reported operational risk losses. Robust t-statistics and z-statistics are reported in brackets for tobit model and truncated model, respectively. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$
Basic Indicator Approach×Post	1.682	1.682	-0.861	-0.861
	[1.409]	[1.062]	[-0.880]	[-0.754]
The Standardized Approach×Post	-3.276***	-3.276***	-2.077***	-2.077***
	[-4.073]	[-3.612]	[-3.043]	[-2.863]
Advanced Measurement Approach×Post	-3.206***	-3.206***	-2.009***	-2.009***
	[-3.383]	[-3.515]	[-2.634]	[-3.025]
ln(Total assets)	1.146***	1.146***	0.872*	0.872***
	[3.240]	[5.479]	[1.651]	[5.137]
Noninterest income	-0.322	-0.322	-0.067**	-0.067**
	[-0.343]	[-0.611]	[-2.529]	[-2.401]
Deposit ratio	-5.142***	-5.142***	-2.574	-2.574***
	[-3.477]	[-5.373]	[-1.325]	[-4.234]
Derivatives use	3.610	3.610	-1.048	-1.048
	[0.445]	[0.517]	[-0.403]	[-0.480]
ln(GDP per capita)	18.507**	18.507***	3.488	3.488
	[2.157]	[2.764]	[0.634]	[0.660]
ΔGDP per capita	0.322*	0.322*	0.010	0.010
	[1.830]	[1.750]	[0.095]	[0.095]
Constant	-204.307**	-204.307***	-35.994	-35.994
	[-2.236]	[-2.824]	[-0.611]	[-0.645]
Year FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country
Observations	8,290	8,290	660	660
R-squared	0.160	0.160	0.510	0.510
Sample	Zero+Nonzero	Zero+Nonzero	Nonzero	Nonzero
Model	Tobit	Tobit	Truncated	Truncated

Table 7: Capital Constraints

This table examines the role of capital constraints on the introduction of operational risk capital using a difference-in-differences model. The dependent variable is the natural logarithm of aggregated bank-year operational losses. In specifications (1)-(2), CAP_{Weak} (CAP_{Well}) is a dummy value set equal to one if a bank's Tier 1 ratio is below or equal (above) the sample median in the pre-treatment period (2004-2007). In specifications (3)-(4) $OBSL_{Rise}$ ($OBSL_{Drop}$) is a dummy variable set equal to one if a bank experienced an increase (no increase) in off-balance sheet leverage for 3 consecutive years between 2004 and 2007. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

Panel A. Regulatory Capital			*Panel B. Off-Balance Sheet Leverage*		
	(A1) $ln(OpLoss)$	(A2) $ln(OpLoss)$		(B1) $ln(OpLoss)$	(B2) $ln(OpLoss)$
Treated×Post×CAP_{Weak}	-0.870	-0.870	Treated×Post×$OBSI_{Rise}$	-1.108	-1.108
	[-1.071]	[-1.482]		[-0.941]	[-0.952]
Treated×Post×CAP_{Well}	-1.999***	-1.999***	Treated×Post×$OBSI_{Drop}$	-2.805***	-2.805***
	[-2.761]	[-2.925]		[-3.644]	[-5.321]
ln(Total assets)	0.871*	0.871***	ln(Total assets)	0.897*	0.897***
	[1.740]	[5.727]		[1.833]	[6.974]
Noninterest income	-0.067**	-0.067**	Noninterest income	-0.067**	-0.067**
	[-2.502]	[-2.408]		[-2.559]	[-2.446]
Deposit ratio	-2.719	-2.719***	Deposit ratio	-2.727	-2.727***
	[-1.508]	[-5.618]		[-1.524]	[-5.859]
Derivatives use	-2.630	-2.630*	Derivatives use	-1.361	-1.361
	[-1.223]	[-1.711]		[-0.614]	[-0.725]
ln(GDP per capita)	2.036	2.036	ln(GDP per capita)	1.967	1.967
	[0.409]	[0.386]		[0.401]	[0.379]
ΔGDP per capita	0.046	0.046	ΔGDP per capita	0.082	0.082
	[0.442]	[0.438]		[0.743]	[0.734]
Constant	-20.193	-20.193	Constant	-19.424	-19.424
	[-0.379]	[-0.361]		[-0.372]	[-0.354]
Treated×Post×Weak+Treated×Post×Well	-2.869***	-2.869***	Treated×Post×Rise+Treated×Post×Drop	-3.913**	-3.913***
	[-2.860]	[-3.910]		[-2.380]	[-2.960]
Year FE	Yes	Yes	Year FE	Yes	Yes
Bank FE	Yes	Yes	Bank FE	Yes	Yes
Cluster Level	Bank	Country	Cluster Level	Bank	Country
Observations	710	710	Observations	710	710
R-squared	0.507	0.507	R-squared	0.515	0.515
Sample	Nonzero	Nonzero	Sample	Nonzero	Nonzero
Model	Truncated	Truncated	Model	Truncated	Truncated

Table 8: Institutional Ownership

This table examines the role of institutional ownership on the introduction of operational risk capital using a difference-in-differences model. The dependent variable is the natural logarithm of aggregated bank-year operational losses. In specifications (1)-(2), IO_{Low} (IO_{High}) is a dummy value set equal to one if a bank's ratio of institutional ownership is below (above) the sample median during 2000-2006. Similarly, $INDI_{Low}$ ($INDI_{High}$) is a dummy value set equal to one if a bank's ratio of independent institutional ownership is below (above) the sample median during 2000-2006. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

Panel A. Institutional Ownership

	(A1) $ln(OpLoss)$	(A2) $ln(OpLoss)$
Treated×Post×IO_{Low}	-2.380***	-2.380***
	[-3.065]	[-4.920]
Treated×Post×IO_{High}	-1.993	-1.993
	[-1.211]	[-1.170]
ln(Total assets)	1.040**	1.040***
	[2.141]	[4.614]
Noninterest income	-0.069***	-0.069**
	[-2.629]	[-2.426]
Deposit ratio	-3.981*	-3.981***
	[-1.879]	[-5.293]
Derivatives use	0.246	0.246
	[0.148]	[0.280]
ln(GDP per capita)	-1.907	-1.907
	[-0.351]	[-0.311]
ΔGDP per capita	0.044	0.044
	[0.350]	[0.358]
Constant	19.506	19.506
	[0.334]	[0.301]
Treated×Post×IO_{Low} +Treated×Post×IO_{High}	-4.372**	-4.372**
	[-2.170]	[-2.430]
Year FE	Yes	Yes
Bank FE	Yes	Yes
Cluster Level	Bank	Country
Observations	526	526
R-squared	0.563	0.563
Sample	Nonzero	Nonzero
Model	Truncated	Truncated

Panel B. Independent Institutional Ownership

	(B1) $ln(OpLoss)$	(B2) $ln(OpLoss)$
Treated×Post×IND_{Low}	-2.427***	-2.427***
	[-3.076]	[-5.037]
Treated×Post×IND_{High}	-1.895	-1.895
	[-1.289]	[-1.261]
ln(Total assets)	1.035**	1.035***
	[2.121]	[4.458]
Noninterest income	-0.069***	-0.069**
	[-2.623]	[-2.421]
Deposit ratio	-3.975*	-3.975***
	[-1.874]	[-5.235]
Derivatives use	0.267	0.267
	[0.160]	[0.301]
ln(GDP per capita)	-1.868	-1.868
	[-0.347]	[-0.308]
ΔGDP per capita	0.046	0.046
	[0.365]	[0.372]
Constant	19.089	19.089
	[0.330]	[0.297]
Treated×Post×IND_{Low} +Treated×Post×IND_{High}	-4.322**	-4.322***
	[-2.310]	[-2.680]
Year FE	Yes	Yes
Bank FE	Yes	Yes
Cluster Level	Bank	Country
Observations	526	526
R-squared	0.563	0.563
Sample	Nonzero	Nonzero
Model	Truncated	Truncated

Table 9: Test of Identifying Assumptions

Counterfactual treatment effects are estimated in this table using the model detailed in Equation 3. Treated dummy is interacted with individual years. The treatment year (2007) is used as the benchmark (i.e., coefficient constrained to equal zero). Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Coefficient	z-statistic
Dependent variable: $ln(OpLoss)$		
Treated×Year_2000	-0.950	[-0.858]
Treated×Year_2001	1.040	[0.876]
Treated×Year_2002	0.613	[0.617]
Treated×Year_2003	1.524	[1.406]
Treated×Year_2004	-1.443	[-0.630]
Treated×Year_2005	-1.033	[-0.675]
Treated×Year_2006	0.789	[0.743]
Treated×Year_2007	0.000	
Treated×Year_2008	-1.426*	[-1.662]
Treated×Year_2009	-2.412**	[-2.566]
Treated×Year_2010	-3.121***	[-3.642]
Treated×Year_2011	-3.349***	[-3.962]
Treated×Year_2012	-3.136***	[-3.391]
Treated×Year_2013	-3.313***	[-2.936]
Treated×Year_2014	-1.522*	[-1.797]
Treated×Year_2015	-1.927*	[-1.821]
ln(Total assets)	1.020**	[2.127]
Noninterest income	-0.065**	[-2.246]
Deposit ratio	-2.866	[-1.577]
Derivatives use	1.381	[0.688]
ln(GDP per capita)	8.008	[1.471]
ΔGDP per capita	-0.185**	[-2.318]
Constant	-85.077	[-1.461]
Year FE	Yes	
Bank FE	Yes	
Cluster level	Bank	
Observations	710	
R-squared	0.544	
Sample	Nonzero	
Model	Truncated	

Table 10: Shorter Event Windows

This table examines the effect of limiting the event window to a period one (specifications 1-2), two (specifications 3-4) and three (specifications 5-6) years pre- and post-treatment. The treatment effect from the introduction of operational risk capital is estimated using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Treated×Post is an interaction term between the post-treatment dummy and treatment group dummy. Specifications (1)-(3) employ a Tobit model for a sample containing all bank-year observations. Specifications (4)-(6) use a truncated regression to estimate the treatment effect for a sample of banks with reported operational risk losses. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$	(5) $ln(OpLoss)$	(6) $ln(OpLoss)$
Treated×Post	-2.340***	-2.340***	-1.938**	-1.938***	-1.729*	-1.729***
	[-2.918]	[-4.710]	[-2.276]	[-3.188]	[-1.745]	[-2.607]
ln(Total assets)	2.376*	2.376***	3.474*	3.474***	1.245	1.245**
	[1.871]	[4.567]	[1.845]	[5.585]	[0.777]	[2.145]
Noninterest income	-0.113	-0.113***	-0.130*	-0.130***	-0.187***	-0.187***
	[-1.639]	[-6.271]	[-1.827]	[-7.654]	[-2.948]	[-5.580]
Deposit ratio	-5.268	-5.268***	0.733	0.733	-13.053	-13.053***
	[-1.612]	[-10.476]	[0.160]	[0.401]	[-1.508]	[-4.351]
Derivatives use	-3.724*	-3.724***	-3.209	-3.209**	-5.063	-5.063
	[-1.889]	[-3.438]	[-1.279]	[-2.114]	[-0.674]	[-0.891]
ln(GDP per capita)	-5.888	-5.888	-4.912	-4.912	14.062	14.062
	[-0.660]	[-0.711]	[-0.449]	[-0.492]	[0.577]	[0.829]
ΔGDP per capita	0.259*	0.259*	0.063	0.063	-0.383	-0.383
	[1.851]	[1.886]	[0.345]	[0.283]	[-1.398]	[-1.351]
Constant	40.540	40.540	5.171	5.171	-145.262	-145.262
	[0.422]	[0.463]	[0.045]	[0.049]	[-0.573]	[-0.811]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country
Observations	380	380	299	299	198	198
R-squared	0.540	0.540	0.603	0.603	0.719	0.719
Sample	[–3, +3]	[–3, +3]	[–2, +2]	[–2, +2]	[–1, +1]	[–1, +1]
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Table 11: Types of Operational Losses

This table examines the treatment effect for different types of operational risk losses. Panel A considers banking and non-banking losses, while Panel B details results for Internal and External operational losses. The treatment effect from the introduction of operational risk capital is estimated using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Panel A. Banking vs. Nonbanking Events				*Panel B. Internal vs. External Events*			
	(A1) $ln(OpLoss)$	(A2) $ln(OpLoss)$	(A3) $ln(OpLoss)$	(A4) $ln(OpLoss)$	(B1) $ln(OpLoss)$	(B2) $ln(OpLoss)$	(B3) $ln(OpLoss)$	(B4) $ln(OpLoss)$
Treated×Post	-1.868**	-1.868***	-2.426*	-2.426***	-3.583***	-3.583***	-0.727	-0.727
	[-2.446]	[-3.109]	[-1.858]	[-3.972]	[-3.467]	[-7.878]	[-0.843]	[-0.977]
ln(Total assets)	-0.147	-0.147	1.875**	1.875***	0.273	0.273**	1.919	1.919***
	[-0.221]	[-1.160]	[2.278]	[2.690]	[0.360]	[2.438]	[1.365]	[4.789]
Noninterest income	-0.195	-0.195	-0.299***	-0.299***	-0.080	-0.080	1.720	1.720
	[-0.090]	[-0.218]	[-3.718]	[-14.685]	[-1.641]	[-1.594]	[1.051]	[1.597]
Deposit ratio	-3.260	-3.260***	-3.113	-3.113*	-2.284	-2.284***	-1.406	-1.406
	[-1.138]	[-6.111]	[-1.183]	[-1.675]	[-1.140]	[-4.724]	[-0.360]	[-1.473]
Derivatives use	-1.697	-1.697	-0.391	-0.391	-0.279	-0.279	-3.104	-3.104*
	[-0.708]	[-0.682]	[-0.107]	[-0.172]	[-0.118]	[-0.144]	[-1.421]	[-1.890]
ln(GDP per capita)	8.159*	8.159	-5.490	-5.490	2.316	2.316	2.160	2.160
	[1.734]	[1.533]	[-0.413]	[-0.349]	[0.400]	[0.454]	[0.170]	[0.141]
ΔGDP per capita	-0.055	-0.055	0.103	0.103	-0.055	-0.055	0.272	0.272
	[-0.499]	[-0.649]	[0.350]	[0.477]	[-0.396]	[-0.441]	[1.065]	[1.205]
Constant	-66.418	-66.418	46.953	46.953	-11.372	-11.372	-42.877	-42.877
	[-1.338]	[-1.180]	[0.328]	[0.281]	[-0.184]	[-0.210]	[-0.301]	[-0.263]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country	Bank	Country
Observations	599	599	268	268	568	568	307	307
R-squared	0.411	0.411	0.483	0.483	0.482	0.482	0.363	0.363
Sample	Banking	Banking	Nonbanking	Nonbanking	Internal	Internal	External	External
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Table 12: Alternative Loss Measures

This table examines the treatment effect for different dependent variables. Specifications (1)-(2) examine the natural logarithm of operational risk losses scaled by gross income, (3)-(4) the natural logarithm of operational risk losses scaled by total assets, (5)-(6) the natural logarithm of annual average loss per event and (7)-(8) the natural logaritm of annual average loss per employee. The treatment effect from the introduction of operational risk capital is estimated using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Robust t-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(\frac{OpLoss}{Gross\ income})$	(2) $ln(\frac{OpLoss}{Gross\ income})$	(3) $ln(\frac{OpLoss}{Total\ assets})$	(4) $ln(\frac{OpLoss}{Total\ assets})$	(5) $ln(\frac{OpLoss}{Loss\ count})$	(6) $ln(\frac{OpLoss}{Loss\ count})$	(7) $ln(\frac{OpLoss}{Capita})$	(8) $ln(\frac{OpLoss}{Capita})$
Treated×Post	-2.040***	-2.040***	-2.124***	-2.124***	-1.609**	-1.609***	-2.123***	-2.123***
	[-2.623]	[-4.101]	[-2.635]	[-4.157]	[-2.594]	[-3.521]	[-2.710]	[-5.602]
ln(Total assets)	-0.031	-0.031	-0.155	-0.155	0.260	0.260***	-0.176	-0.176**
	[-0.068]	[-0.362]	[-0.338]	[-1.377]	[0.563]	[4.124]	[-0.368]	[-2.211]
Noninterest income	-0.054***	-0.054***	-0.050***	-0.050***	-0.044***	-0.044***	-0.060***	-0.060***
	[-5.157]	[-4.873]	[-4.294]	[-4.035]	[-3.547]	[-3.396]	[-4.895]	[-4.619]
Deposit ratio	-2.669	-2.669***	-2.973	-2.973***	-2.252	-2.252***	-2.769	-2.769***
	[-1.476]	[-7.416]	[-1.638]	[-6.117]	[-1.287]	[-5.739]	[-1.589]	[-8.684]
Derivatives use	-0.756	-0.756	-0.786	-0.786	-1.765	-1.765	-2.009	-2.009
	[-0.323]	[-0.399]	[-0.332]	[-0.408]	[-0.771]	[-0.773]	[-0.842]	[-1.103]
ln(GDP per capita)	-0.109	-0.109	1.276	1.276	1.604	1.604	1.686	1.686
	[-0.023]	[-0.023]	[0.262]	[0.250]	[0.359]	[0.397]	[0.396]	[0.385]
ΔGDP per capita	0.052	0.052	0.055	0.055	-0.007	-0.007	0.014	0.014
	[0.499]	[0.502]	[0.526]	[0.508]	[-0.070]	[-0.071]	[0.148]	[0.153]
Constant	3.572	3.572	-11.648	-11.648	-4.386	-4.386	-7.014	-7.014
	[0.070]	[0.070]	[-0.225]	[-0.217]	[-0.093]	[-0.103]	[-0.154]	[-0.151]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country	Bank	Country
Observations	709	709	710	710	710	710	708	708
R-squared	0.327	0.327	0.404	0.404	0.365	0.365	0.331	0.331
Sample	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

Table 13: Removing Outliers

This table examines the treatment effect after removing outliers in the dependent variable and assessing the impact of bank size. Specifications (1)-(2) correspond to a sample where observations corresponding to the largest 5% of operational losses over the full sample are removed, (3)-(4) removes observations corresponding to the largest 5% of losses each year, (5)-(6) removes the top 5% in the treated and control samples, while (7)-(8) examines whether findings hold when banks with total assets less than USD 10 billion are removed. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$	(5) $ln(OpLoss)$	(6) $ln(OpLoss)$	(7) $ln(OpLoss)$	(8) $ln(OpLoss)$
Treated×Post	-1.902**	-1.902***	-2.165***	-2.165***	-1.545**	-1.545***	-2.460***	-2.460***
	[-2.420]	[-3.692]	[-2.926]	[-4.766]	[-2.086]	[-3.220]	[-2.971]	[-4.601]
ln(Total assets)	0.861*	0.861***	0.936*	0.936***	1.151***	1.151***	0.466	0.466**
	[1.792]	[11.752]	[1.908]	[10.605]	[2.930]	[8.342]	[0.582]	[2.511]
Noninterest income	-0.063**	-0.063**	-0.067**	-0.067**	-0.061**	-0.061**	-0.293***	-0.293***
	[-2.262]	[-2.156]	[-2.530]	[-2.417]	[-2.353]	[-2.197]	[-5.221]	[-9.626]
Deposit ratio	-2.251	-2.251***	-2.793	-2.793***	-3.028*	-3.028***	-1.692	-1.692***
	[-1.164]	[-7.270]	[-1.554]	[-6.306]	[-1.818]	[-4.561]	[-0.685]	[-3.443]
Derivatives use	-2.683	-2.683*	-2.750	-2.750*	-1.950	-1.950	-1.242	-1.242
	[-1.312]	[-1.860]	[-1.236]	[-1.654]	[-1.065]	[-1.382]	[-0.554]	[-0.612]
ln(GDP per capita)	-0.482	-0.482	-0.069	-0.069	0.012	0.012	2.047	2.047
	[-0.117]	[-0.113]	[-0.014]	[-0.015]	[0.003]	[0.003]	[0.399]	[0.390]
ΔGDP per capita	0.160	0.160	0.089	0.089	0.124	0.124	0.075	0.075
	[1.416]	[1.410]	[0.783]	[0.799]	[1.062]	[1.059]	[0.671]	[0.668]
Constant	6.109	6.109	1.145	1.145	-3.558	-3.558	-13.958	-13.958
	[0.139]	[0.135]	[0.022]	[0.024]	[-0.071]	[-0.077]	[-0.256]	[-0.250]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country	Bank	Country
Observations	674	674	682	682	675	675	583	583
R-squared	0.448	0.448	0.460	0.460	0.499	0.499	0.460	0.460
Sample	Remove top 5% in full sample	Remove top 5% in full sample	Remove top 5% in each year	Remove top 5% in each year	Remove top 5% in treated/control	Remove top 5% in treated/control	Remove banks TA<10bn	Remove banks TA<10bn
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Table 14: Possible Confounding Events

This table examines the sensitivity of findings to various confounding factors. Specifications (1)-(2) exclude all losses originating during the Global Finance Crisis period 2007-2009, (3)-(4) excludes losses realized during the 2007-2009 period, (5)-(6) deduct any legal liabilities from the operational risk loss amount to remove the impact of different litigation propensities, (7)-(8) incorporates a variable (MORT) to control for banks exposure to mortage loans, (9)-(10) include two variables to control for M&A activities, while (11)-(12) include a control variable for media attention. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$	(5) $ln(OpLoss)$	(6) $ln(OpLoss)$	(7) $ln(OpLoss)$	(8) $ln(OpLoss)$	(9) $ln(OpLoss)$	(10) $ln(OpLoss)$	(11) $ln(OpLoss)$	(12) $ln(OpLoss)$
Treated×Post	-2.110**	-2.110***	-3.141***	-3.141***	-2.377***	-2.377***	-2.341***	-2.341***	-2.858***	-2.858***	-2.302***	-2.302***
	[-2.527]	[-4.330]	[-3.692]	[-5.132]	[-3.056]	[-4.653]	[-3.173]	[-4.730]	[-3.033]	[-4.340]	[-3.123]	[-4.751]
ln(Total assets)	0.440	0.440***	1.237**	1.237***	0.686	0.686***	0.887*	0.887***	1.132**	1.132***	0.968**	0.968***
	[0.625]	[2.788]	[2.170]	[8.320]	[1.385]	[6.135]	[1.840]	[7.668]	[2.164]	[12.040]	[2.017]	[8.231]
Noninterest income	-0.056***	-0.056***	-0.061***	-0.061***	-0.070**	-0.070**	-0.067***	-0.067***	-0.223***	-0.223***	-0.067***	-0.067***
	[-2.659]	[-2.740]	[-8.530]	[-11.002]	[-2.326]	[-2.227]	[-2.998]	[-2.862]	[-3.679]	[-9.629]	[-2.752]	[-2.644]
Deposit ratio	-3.219	-3.219***	-4.228*	-4.228***	-3.203*	-3.203***	-2.425	-2.425***	-2.352	-2.352***	-2.884	-2.884***
	[-1.172]	[-6.707]	[-1.819]	[-6.822]	[-1.842]	[-7.098]	[-1.352]	[-5.930]	[-1.228]	[-8.999]	[-1.629]	[-5.930]
Derivatives use	0.162	0.162	2.494	2.494	-1.737	-1.737	-1.789	-1.789	-0.877	-0.877	-0.442	-0.442
	[0.076]	[0.119]	[0.797]	[1.230]	[-0.791]	[-0.922]	[-0.807]	[-0.925]	[-0.368]	[-0.386]	[-0.180]	[-0.196]
ln(GDP per capita)	6.165	6.165	0.402	0.402	1.713	1.713	2.228	2.228	4.599	4.599	0.657	0.657
	[0.993]	[0.977]	[0.053]	[0.056]	[0.338]	[0.339]	[0.439]	[0.439]	[0.447]	[0.349]	[0.135]	[0.136]
ΔGDP per capita	-0.034	-0.034	-0.100	-0.100	0.070	0.070	0.076	0.076	0.067	0.067	0.088	0.088
	[-0.209]	[-0.232]	[-0.781]	[-1.013]	[0.638]	[0.636]	[0.703]	[0.691]	[0.447]	[0.432]	[0.801]	[0.798]
Mortgage exposure							2.073	2.073***				
							[1.618]	[4.235]				
Large M&A									-0.763**	-0.763***		
									[-2.221]	[-5.642]		
ln(M&A deals)									0.045	0.045		
									[0.103]	[0.104]		
Media attention											-0.002*	-0.002**
											[-1.780]	[-1.990]
Constant	-54.990	-54.990	-7.470	-7.470	-13.423	-13.423	-22.602	-22.602	-51.422	-51.422	-7.021	-7.021
	[-0.836]	[-0.830]	[-0.093]	[-0.098]	[-0.249]	[-0.251]	[-0.420]	[-0.421]	[-0.471]	[-0.367]	[-0.134]	[-0.138]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country	Bank	Country	Bank	Country	Bank	Country
Observations	506	506	499	499	707	707	710	710	654	654	710	710
R-squared	0.425	0.425	0.529	0.529	0.505	0.505	0.515	0.515	0.500	0.500	0.514	0.514
Sample	Exclude losses originated 2007–2009	Exclude losses originated 2007–2009	Exclude losses realized 2007–2009	Exclude losses realized 2007–2009	Losses net of legal liabilities	Losses net of legal liabilities	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Table 15: Placebo Tests

This table presents results from two placebo tests. In Panel A, the treatment year is taken as 2004, while in Panel B the treatment occurs in 2012. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Panel A. Treatment in 2004			*Panel B. Treatment in 2012*		
	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$
Treated×Post	-0.252	1.537	1.537***	0.544	0.648	0.648
	[-0.219]	[1.262]	[4.020]	[1.003]	[1.318]	[1.436]
Post	-1.319			-0.287		
	[-1.366]			[-0.712]		
ln(Total assets)	0.137	0.189	0.189	0.016	0.094	0.094
	[0.079]	[0.098]	[0.118]	[0.016]	[0.094]	[0.586]
Noninterest income	-5.297	-3.104	-3.104**	-0.062***	-0.063***	-0.063***
	[-0.718]	[-0.354]	[-2.055]	[-2.697]	[-3.575]	[-3.053]
Deposit ratio	0.996	0.978	0.978	-5.464**	-4.322*	-4.322***
	[0.185]	[0.156]	[0.286]	[-2.222]	[-1.778]	[-5.217]
Derivatives use	-2.536	2.016	2.016***	-4.770***	-3.916*	-3.916**
	[-0.589]	[0.364]	[2.813]	[-2.720]	[-1.797]	[-1.970]
ln(GDP per capita)	20.119	79.462***	79.462***	3.191	6.596	6.596
	[1.135]	[2.686]	[17.879]	[0.476]	[1.494]	[1.460]
ΔGDP per capita	0.075	0.216	0.216	0.006	0.035	0.035
	[0.285]	[0.332]	[0.493]	[0.068]	[0.325]	[0.429]
Constant	-196.965	-824.856***	-824.856***	-15.214	-54.085	-54.085
	[-1.144]	[-2.791]	[-22.675]	[-0.212]	[-1.050]	[-1.126]
Year FE	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Bank	Country	Bank	Bank	Country
Observations	107	107	107	513	513	513
R-squared	0.580	0.624	0.624	0.584	0.591	0.591
Sample	2000–2006	2000–2006	2000–2006	2008–2015	2008–2015	2008–2015
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Appendix A. Variable Definition

Variable Label	**Definition**	**Source**
Dependent variables		
$OpLoss$	The present value of CPI-adjusted operational losses as of 2018	SAS OpRisk Global
$ln(OpLoss)$	Natural logarithm of $OpLoss$	SAS OpRisk Global
$ln(\frac{OpLoss}{Gross\ income})$	Natural logarithm of $OpLoss$ scaled by gross income	SAS OpRisk Global
$ln(\frac{OpLoss}{Total\ assets})$	Natural logarithm of $OpLoss$ scaled by total assets	SAS OpRisk Global
$ln(\frac{OpLoss}{Loss\ count})$	Natural logarithm of annual average $OpLoss$ per event	SAS OpRisk Global
$ln(\frac{OpLoss}{Capita})$	Natural logarithm of $OpLoss$ scaled by the number of employees	SAS OpRisk Global
Bank characteristics		
$ln(Total\ assets)$	Natural logarithm of a bank's total assets at fiscal year end	Bankscope
$Deposit\ ratio$	Deposits scaled by total assets	Bankscope
$Derivatives\ use$	Total fair value of a bank's derivatives divided by total assets	Bankscope
$Dividend\ payout$	Dividends paid divided by net income	Bankscope
$Large\ M\&A$	Dummy=1 if a bank experienced year-on-year growth rate in book value of assets exceeding 20%	Bankscope
$Liquid\ assets$	Liquid assets divided by total assets	Bankscope
$\Delta Loan$	Annual growth rate of gross loans	Bankscope
$Media\ attention$	The number of news articles for each bank in a given year	Financial Times
$Mortgage\ exposure$	Mortgage loans divided by total assets	Bankscope
$Net\ chargeoffs$	Net loan charge-offs divided by gross loans	Bankscope
$Noninterest\ income$	Noninterest income divided by the sum of net interest income and noninterest income	Bankscope
$Return\ on\ equity$	Pretax income scaled by total assets	Bankscope
$Basic\ Indicator\ Approach$	Dummy=1 if a bank's operational risk capital is calculated using Basic Indicator Approach	Annual Report; Pillar 3

Appendix A. Variable Definition continued

Variable Label	Definition	Source
The Standardized Approach	Dummy=1 if a bank's operational risk capital is calculated using The Standardized Approach	Annual Report; Pillar 3
Advanced Measurement Approach	Dummy=1 if a bank's operational risk capital is calculated using Advanced Measurement Approach	Annual Report; Pillar 3
CAP_{Weak}	Dummy=1 if a bank's Tier 1 ratio is below or equal the sample median from 2004 to 2007	Bankscope
CAP_{Well}	Dummy=1 if a bank's Tier 1 ratio is above the sample median from 2004 to 2007	Bankscope
$OBSL_{Rise}$	Dummy=1 if a bank experiences an increase in off-balance sheet leverage for 3 consecutive years between 2004 and 2007	Bankscope
$OBSL_{Drop}$	Dummy=1 if a bank does not experience an increase in off-balance sheet leverage for 3 consecutive years between 2004 and 2007	Bankscope
IO_{Low}	Dummy=1 if a bank's ratio of institutional ownership is below or equal the sample median during 2000–2006.	Factset
IO_{High}	Dummy=1 if a bank's ratio of institutional ownership is above the sample median during 2000–2006.	Factset
IND_{Low}	Dummy=1 if a bank's ratio of independent institutional ownership is below or equal the sample median during 2000–2006.	Factset
IND_{High}	Dummy=1 if a bank's ratio of independent institutional ownership is above the sample median during 2000–2006.	Factset
Country characteristics		
$ln(GDP\ per\ capita)$	Natural logarithm of annual GDP per capita	WDI database
$\Delta GDP\ per\ capita$	Annual growth rate of GDP per capita	WDI database
$ln(M\&A\ deals)$	Natural logarithm of the total number of M&A deals in each country each year	Bankscope

Appendix B. Basel II Operational Risk Event Categories

Basel II describes seven operational risk event categories:

Business Disruption and System Failures: Losses arising from disruption of business or system failures.

Clients, Products, and Business Practices: Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.

Employment Practices and Workplace Safety: Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity/discrimination events.

Execution, Delivery, and Process Management: Losses from failed transaction processing or process management, from relations with trade counterparties and vendors.

Internal Fraud: Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/ discrimination events, which involves at least one internal party.

Dadvanced measurement approachge to Physical Assets: Losses arising loss or dadvanced measurement approachge to physical assets from natural disaster or other events.

External Fraud: Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party.

Source: Bank for International Settlements (2001)

Appendix C1. Descriptive Statistics of Unbalanced and Entropy Balanced Samples

This table reports descriptive statistics of unbalanced and entropy balanced samples. The balancing is based on year 2006. Panel A reports the balancing property of the first three moments of the distribution of matching covariates, with a tolerance level of 0.1. Panel B presents the balancing based on the first three moments of the distribution of bank size, with a tolerance level of 0.001.

Panel A. 3rd Moment Entropy Balanced on 3 Matching Covariates

	Treated			Control		
Unbalanced	Mean	Variance	Skewness	Mean	Variance	Skewness
ln(Total assets)	14.470	3.817	0.922	13.200	2.486	0.744
Noninterest income	0.358	0.043	0.970	0.194	0.024	1.713
Return on equity	0.112	0.009	2.167	0.150	0.034	9.431

	Treated			Control		
Entropy balanced	Mean	Variance	Skewness	Mean	Variance	Skewness
ln(Total assets)	14.470	3.817	0.922	14.470	3.818	0.921
Noninterest income	0.358	0.043	0.970	0.358	0.043	0.969
Return on equity	0.112	0.009	2.167	0.112	0.009	3.017

Panel B. 3rd Moment Entropy Balanced on Bank Size

	Treated			Control		
Unbalanced	Mean	Variance	Skewness	Mean	Variance	Skewness
ln(Total assets)	14.470	3.809	0.919	13.180	2.551	0.677

	Treated			Control		
Entropy balanced	Mean	Variance	Skewness	Mean	Variance	Skewness
ln(Total assets)	14.470	3.809	0.919	14.470	3.809	0.919

Appendix C2. Difference-in-Differences Results: 3-Moment Entropy Balancing

This table uses a synthetic control sample resulting from 3-moment entropy balancing. Estimates of the treatment effect from the introduction of operational risk capital are presented using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Treated×Post is an interaction term between the treatment group dummy and post-treatment dummy. Specifications (A1)-(A3) employ an entropy-balanced sample created in Panel A of Appendix C1. Specifications (B1)-(B3) use an entropy-balanced sample created in Panel B of Appendix C1. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Panel A. 3rd Moment; 3 Covariates			*Panel B. 3rd Moment; Bank Size*		
	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$
Treated×Post	-2.721***	-2.779***	-2.779***	-2.239***	-2.311***	-2.311***
	[-3.335]	[-3.539]	[-5.704]	[-2.825]	[-2.868]	[-4.604]
Post	2.270**			1.657*		
	[2.265]			[1.663]		
ln(Total assets)	0.584	0.809	0.809***	0.433	0.620	0.620***
	[1.151]	[1.539]	[7.121]	[0.685]	[0.983]	[4.444]
Noninterest income	-0.065**	-0.063***	-0.063***	-0.066**	-0.064***	-0.064***
	[-2.299]	[-3.511]	[-3.471]	[-2.365]	[-3.542]	[-3.203]
Deposit ratio	-1.865	-2.431	-2.431***	-2.541	-2.629	-2.629***
	[-1.049]	[-1.268]	[-5.334]	[-1.559]	[-1.599]	[-5.659]
Derivatives use	-0.678	-0.618	-0.618	-1.064	-0.495	-0.495
	[-0.447]	[-0.312]	[-0.382]	[-0.712]	[-0.291]	[-0.296]
ln(GDP per capita)	-8.585	2.270	2.270	-3.811	1.966	1.966
	[-1.450]	[0.464]	[0.466]	[-0.641]	[0.391]	[0.388]
ΔGDP per capita	0.045	0.074	0.074	0.019	0.035	0.035
	[0.602]	[0.696]	[0.705]	[0.311]	[0.329]	[0.332]
Constant	98.377	-19.338	-19.338	50.510	-12.804	-12.804
	[1.516]	[-0.367]	[-0.376]	[0.786]	[-0.236]	[-0.238]
Year FE	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Bank	Country	Bank	Bank	Country
Observations	712	712	712	714	714	714
R-squared	0.498	0.508	0.508	0.507	0.518	0.518
Sample	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Appendix D1. Balancing Property of the Matching Covariates

This table details the sample balancing properties of the matching covariates. The balancing is based on year 2006. Panel A reports the balancing properties of the matching covariates using nearest neighbor matching. Panel B reports the balancing properties of the matching covariates using radius matching.

Panel A. Nearest Neighbor Matching

	Treated	Control	Difference	t-statistic	p-value
ln(Total assets)	17.012	16.735	0.277	0.62	0.538
Noninterest income	0.435	0.410	0.025	0.34	0.733
Return on equity	0.188	0.192	-0.003	-0.13	0.899

Panel B. Radius Matching

	Treated	Control	Difference	t-statistic	p-value
ln(Total assets)	18.234	17.848	0.386	1.11	0.272
Noninterest income	0.444	0.417	0.028	0.62	0.537
Return on equity	0.189	0.169	0.021	1.27	0.207

Appendix D2. Difference-in-Differences Results: Propensity Score Matching

This table presents estimates using a propensity score matched sample to isolate the treatment effect from the introduction of operational risk capital using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Treated×Post is an interaction term between the treatment group dummy and post-treatment dummy. Specifications (A1)-(A3) employ a control sample generated using nearest neighbor matching as shown in Panel A of Appendix D1. Specifications (B1)-(B3) use a control sample created using radius matching as reported in Panel B of Appendix D1. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	Panel A. Nearest Neighbor Matching			*Panel B. Radius Matching*		
	(A1)	(A2)	(A3)	(B1)	(B2)	(B3)
	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$	$ln(OpLoss)$
Treated×Post	-2.843***	-3.040***	-3.040***	-1.389**	-1.641***	-1.641***
	[-3.230]	[-3.237]	[-3.771]	[-2.347]	[-2.700]	[-3.636]
Post	1.095*			0.453		
	[1.712]			[0.886]		
ln(Total assets)	1.069	1.528*	1.528	0.588	1.055***	1.055***
	[1.260]	[1.776]	[1.619]	[1.487]	[2.707]	[3.764]
Noninterest income	-4.560*	-5.276**	-5.276***	-0.051***	-0.051***	-0.051***
	[-1.881]	[-2.303]	[-2.911]	[-9.309]	[-9.756]	[-9.011]
Deposit ratio	-3.513*	-3.398	-3.398**	-2.066	-1.663	-1.663*
	[-1.858]	[-1.291]	[-2.171]	[-1.613]	[-1.269]	[-1.763]
Derivatives use	-13.571	-17.122	-17.122	-1.500	-0.682	-0.682
	[-1.069]	[-1.227]	[-1.118]	[-0.927]	[-0.408]	[-0.290]
ln(GDP per capita)	1.552	2.298	2.298	2.780	4.082	4.082
	[0.382]	[0.491]	[0.472]	[0.801]	[0.804]	[0.753]
ΔGDP per capita	-0.060	0.068	0.068	0.002	-0.031	-0.031
	[-0.794]	[0.614]	[0.695]	[0.049]	[-0.334]	[-0.265]
Constant	-14.657	-31.046	-31.046	-23.302	-45.544	-45.544
	[-0.391]	[-0.668]	[-0.725]	[-0.655]	[-0.840]	[-0.773]
Year FE	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Bank	Country	Bank	Bank	Country
Observations	239	239	239	712	712	712
R-squared	0.280	0.309	0.309	0.513	0.527	0.527
Sample	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero	Nonzero
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated

Appendix E. Difference-in-Differences Results: No Matching

This tables uses the original unmatched sample to present estimates of the treatment effect from the introduction of operational risk capital using the difference-in-differences model detailed in Equation 1. The dependent variable is the natural logarithm of aggregated bank-year operational losses. Treated×Post is an interaction term between the treatment group dummy and post-treatment dummy. No matching is performed to identify the group of control banks (i.e., All banks in our original sample that are not subject to the treatment are included in the control sample). Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$
Treated×Post	-1.386**	-1.631***	-1.631***
	[-2.356]	[-2.704]	[-3.673]
Post	0.491		
	[0.970]		
ln(Total assets)	0.664*	1.079***	1.079***
	[1.731]	[2.795]	[3.813]
Noninterest income	-0.050***	-0.052***	-0.052***
	[-9.548]	[-10.398]	[-9.585]
Deposit ratio	-2.204*	-1.794	-1.794*
	[-1.758]	[-1.392]	[-1.894]
Derivatives use	-1.931	-0.943	-0.943
	[-1.133]	[-0.547]	[-0.396]
ln(GDP per capita)	1.740	3.943	3.943
	[0.508]	[0.775]	[0.724]
ΔGDP per capita	0.012	-0.031	-0.031
	[0.239]	[-0.346]	[-0.269]
Constant	-13.436	-44.380	-44.380
	[-0.382]	[-0.818]	[-0.748]
Year FE	No	Yes	Yes
Bank FE	Yes	Yes	Yes
Cluster Level	Bank	Bank	Country
Observations	781	781	781
R-squared	0.520	0.532	0.532
Sample	Nonzero	Nonzero	Nonzero
Model	Truncated	Truncated	Truncated

Appendix F. Other Robustness Tests

This table reports additional robustness test results. Specifications (1) and (2) exclude 2007 and employ a balanced pre (2000–2006) versus post period (2008–2014). Specifications (3) and (4) remove the last three years in the sample period. Specifications (5) and (6) average all variables in the pre- and post-treatment periods to perform entropy balancing and the subsequent regressions. Robust z-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All variables are defined in Appendix A.

	(1) $ln(OpLoss)$	(2) $ln(OpLoss)$	(3) $ln(OpLoss)$	(4) $ln(OpLoss)$	(5) $ln(OpLoss)$	(6) $ln(OpLoss)$
Treated×Post	-3.089***	-3.089***	-2.546***	-2.546***	-2.829***	-2.829***
	[-3.888]	[-4.803]	[-3.507]	[-4.712]	[-4.737]	[-5.677]
ln(Total assets)	0.981	0.981***	1.451**	1.451***	2.444**	2.444***
	[1.540]	[10.771]	[2.142]	[9.112]	[2.307]	[13.949]
Noninterest income	-0.188***	-0.188***	-0.166***	-0.166***	1.177*	1.177***
	[-2.942]	[-5.318]	[-2.870]	[-7.865]	[1.655]	[22.946]
Deposit ratio	-3.681**	-3.681***	-3.484**	-3.484***	-6.404*	-6.404***
	[-2.013]	[-15.193]	[-1.961]	[-12.914]	[-1.651]	[-3.576]
Derivatives use	0.998	0.998	-2.352	-2.352	8.908**	8.908**
	[0.486]	[0.771]	[-1.122]	[-1.244]	[2.327]	[2.019]
ln(GDP per capita)	14.133	14.133	3.224	3.224	6.165	6.165
	[1.297]	[1.049]	[0.347]	[0.223]	[1.015]	[1.121]
ΔGDP per capita	0.003	0.003	0.073	0.073	-0.596**	-0.596***
	[0.020]	[0.021]	[0.589]	[0.494]	[-2.081]	[-3.144]
Constant	-149.453	-149.453	-41.957	-41.957	-89.730	-89.730
	[-1.290]	[-1.045]	[-0.434]	[-0.275]	[-1.574]	[-1.568]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster Level	Bank	Country	Bank	Country	Bank	Country
Observations	540	540	559	559	175	175
R-squared	0.482	0.482	0.536	0.536	0.817	0.817
Sample	2000–2006; 2008–2014	2000–2006; 2008–2014	2000–2012	2000–2012	Averaged pre & post	Averaged pre & post
Model	Truncated	Truncated	Truncated	Truncated	Truncated	Truncated