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Regulatory capital and bank risk-resilience amid the Covid-19 pandemic: How are the Basel reforms faring?

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ABSTRACT

In this paper, we address a long-standing policy question of whether higher levels of regulatory capital, ex-ante, makes banks risk-resilient in times of severe economic downturns. Using the Covid-19 crisis as an exogenous shock to the banking system in a difference-in-difference setting, the results indicate that banks with robust pre-crisis regulatory capital ratios are less risky (have a lower insolvency risk) relative to less-capitalized banks amid the crisis period. Further analyses provides evidence consistent with the presence of a potential credit supply channel. Overall, the results suggests that the post 2007-09 Basel reforms have succeeded, to some extent, in strengthening the risk-resilience of banks during the Covid-19 economic fallout.

1. Introduction

In preparation for an unexpected economic crisis such as the one triggered by the ongoing Covid-19 pandemic, the Basel Committee on Banking Supervision (BCBS) rolled out a new risk-based capital framework (under the Basel III reforms), following the 2007-09 financial crisis, in which banks are required to hold higher risk-weighted capital ratios and buffers. This framework aims to ensure that banks have "adequate" and "quality" capital on hand to absorb losses in times of turmoil without becoming insolvent or curtailing credit supply (BCBS, 2021). Yet, governments still had to intervene to absorb the losses of failing banks during the 2007-09 financial crisis, even though these banks fully complied with the Basel framework of "adequate" capital (Flannery and Giacomini, 2015). Herring (2010) shows that banks that required government assistance during the crisis had far more capital than banks that required no state aid. Moreover, Moreira (2022) finds that "changes in capital or even the amount of capital itself is not significantly related to concurrent changes in banks' probability of default" and concludes that "the regulatory framework is likely based on an illusion given that making banks hold more capital does not necessarily make them more resilient (less risky)."

Nevertheless, Altunbas et al. (2021) show that a higher level of tier 1 capital ratio is associated with a lower probability of bank failure during the 2007-09 crisis period, consistent with the results of Berger and Bouwman (2013), who find that capital increases the probability of bank survival during the crisis. Similarly, Demirguc-Kunt et al. (2013) and Beltratti and Stulz (2009) document that well-capitalised banks experience only a marginal decline in their equity values during the crisis relative to less-capitalised banks. Thus, whether a high regulatory capital is a key aspect in ensuring bank stability (lowering insolvency risk) in times of severe economic

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crisis remains an open question relevant to macroprudential policy.

Following its implementation of the Basel III capital framework in July 2013, the Federal Reserve (Fed) conducts annual capital stress tests to assess whether the risk-based capital (regulatory capital) of U.S. banks is sufficient to absorb losses and risk in periods of severe economic downturns without being insolvent, shrinking their balance sheets (reducing lending), or requiring substantial government intervention.[1] These stress tests simulate a hypothetical recession scenario in which there is a significant rise in the rate of unemployment, a sharp decline in real GDP and aggregate demand for goods and services, a fall in equity prices, etc., to evaluate the risk-absorbing quality of banks' capital. Despite their significant role in macroprudential regulation, such simulations may fall short of the nuances of real-world stress scenarios.[2]

The Covid-19 pandemic presents a unique setting for such real-world scenarios to evaluate the role of banks' risk-based capital in absorbing risk (Abboud et al., 2021; BCBS, 2021). In the wake of the pandemic, the unemployment rate in the U.S. reached a record high of 13 percent in the second quarter of 2020;[3] real GDP declined by 8.9 percent in the same period,[4] accompanied by unprecedented losses in the stock market (Pham et al., 2021; Xu, 2021). In the banking sector, difficulties experienced by borrowers amid the pandemic translated into high levels of non-performing loans for most U.S. banks, exposing banks to heightened credit risk (Beck and Keil, 2022). A surge in the levels of loan loss provisions and the resulting decline in net interest and non-interest income, following the drastic decline in consumer and industrial loan demand (Abboud et al., 2021; Li et al., 2021) and banking services in general, led to subsequent deteriorations in bank profitability (Cao and Chou, 2022).

To this end, whether banks with higher regulatory capital, *ex-ante,* have a lower risk of insolvency during the ongoing pandemic register as the most immediate natural question. We conjecture that if risk-based capital ratios are effective in absorbing banks' losses (and risk), then we expect that when a large unexpected negative shock to bank risk occurs – including unprecedented levels of credit risk, increases in the cost of liquidity, and declining profitability – as is the case with the ongoing pandemic, well-capitalised banks will be in a better position to withstand the shock and hence their degree of insolvency risk will not increase as much as less-capitalised banks. Robust ex-ante levels of regulatory capital can affect banks' risk resilience through a credit-supply channel. The rationale is that continuous credit supply, especially to distressed clients, sustains business and household activity in times of economic downturns (Gambacorta and Marques-Ibanez, 2011), thus alleviating further loan defaults by such clients (Kryzanowski et al., 2022). This will potentially reduce banks' credit risk and consequently their degree of insolvency risk. It could be directly inferred that better capitalised banks will be better positioned to absorb (by writing off against capital) unprecedented increases in loan losses (e.g., rising levels of non-performing loans) in the wake of the pandemic while sustaining economic activity (Flannery and Giacomini, 2015; Gambacorta and Marques-Ibanez, 2011), thus making insolvency remote.[5]

The most recent literature mainly focuses on how banks' regulatory capital and buffers affect their resilience in terms of their ability to lend amid the pandemic (Abboud et al., 2021; BCBS, 2021; Cao and Chou, 2022). However, little is known about the impact of the former on banks' insolvency risk during the pandemic.[6] An examination of this relationship is particularly relevant for two main reasons. First, in the absence of government support, capital and risk represent two interrelated factors that affect banks' asset allocation and credit supply simultaneously (Kanga et al., 2020). In this regard, less risky banks tend to enjoy a lower funding cost relative to riskier banks, which enables them to lend more resiliently in times of crisis (Sclip et al., 2021). Analysing the capital-risk relationship is therefore equally pivotal in understanding banks' ability to refinance lending activities.

Second, even though the lack of failure (and low credit risk) of large, internationally active banks during the early stages of the ongoing Covid-19 crisis has been credited to the robust capital levels bolstered by the Basel framework (BCBS, 2021), such a relationship might be far from causal (and also limited by data availability). This may be, at least partly, due to the extensive government support measures rolled out by authorities, such as the Federal Reserve Board, to mitigate the economic impact of the pandemic on banks.[7] Further and current analysis is therefore needed to disentangle the true effect of the Basel framework, on bank stability, from that of government interventions, as well as validate earlier results with recent data since the full effect of the pandemic on banking is still unfolding and hence unknown.[8]

Moreover, the relationship between bank's capital and risk may be confounded by unobserved bank-specific factors which are correlated with both capital and risk. For instance, Moreira (2022) argues that it is possible banks with more capital are the ones with adept managers who also have a low risk-appetite, thus making insolvency remote. In this case, causality runs from managerial risk aversion and/or skill to bank stability rather than from banks' capital. Employing the appropriate methodological techniques to identify the true impact (unravel causality) of the Basel framework on bank stability, amid the ongoing pandemic, thus lends a valuable

[1] Federal Reserve Stress Tests: (https://www.federalreserve.gov/supervisionreg/stress-tests-capital-planning.htm)

[2] Common pitfalls in stress testing: (https://www.moodysanalytics.com/-/media/article/2012/2012-10-12-Common-Pitfalls-and-Challenges-in-Stress-Testing-of-Banks.pdf)

[3] U.S. Bureau of Labour Statistics (https://www.bls.gov/opub/mlr/2021/article/unemployment-rises-in-2020-as-the-country-battles-the-covid-19-pandemic.htm)

[4] The U.S. Economy and the Global Pandemic:(https://www.whitehouse.gov/wp-content/uploads/2022/04/Chapter-3-new.pdf)

[5] We document supporting empirical evidence for the credit supply channel. We identify treated banks that are most likely to extend credit in the wake of the pandemic and find that the results are particularly pronounced for these set of banks, suggesting the presence of a potential credit supply mechanism of banks' regulatory capital. We present details in the Internet Appendix B and Table A.4.

[6] BCBS (2021) and Abboud et al. (2021) are two related exceptions.

[7] What did the Fed do in response to the Covid-19 crisis? (https://www.brookings.edu/research/fed-response-to-covid19)

[8] Lessons from Covid-19 on Basel reforms and next steps: (https://www.bis.org/speeches/sp220511.htm)

contribution to policy (Berger and Bouwman, 2013; Moreira, 2022).

We exploit the Covid-19 shock as a quasi-natural experiment by employing a dynamic and static difference-in-difference design, where we compare the insolvency risk of well-capitalised banks (treatment) and less-capitalised banks (control) before and during the Covid-19 crisis. Based on a matched sample of US commercial banks over the period 2017q1 to 2022q2, our results suggest that banks with higher levels of ex-ante regulatory capital ratios (*Tier 1 ratio* and *Total capital ratio*) have a lower degree of insolvency risk amid the pandemic. Further analyses indicate that the documented effect is more pronounced for treated banks who are most likely to extend further credit in the wake of the pandemic, consistent with our conjecture of a *credit supply channel* in times of crisis. The results remain robust when we control for additional bank-specific factors potentially correlated with both capital and insolvency risk as well as when we employ an alternative matching technique.

Our paper contributes to the literature by providing empirical evidence that highlights the effectiveness of a regulatory cushion in times of stress (Allen et al., 2011; Berger and Bouwman, 2013; Berger and Demirgüç-Kunt, 2021). This differs from most existing studies that mainly focus on how banks' capital affects their risk in normal periods (non-crisis periods) and hence do not, per se, reveal much information about the potential role of the former in ensuring bank stability in times of severe economic downturns (Bostandzic et al., 2022; Moreira, 2022). Moreover, prior studies examine the relation between bank capital and insolvency risk during other economic crisis and find mixed results (e.g., Altunbas et al., 2012; Beltratti and Stulz, 2009; Berger and Bouwman, 2013; Bostandzic et al., 2022; Demirguc-Kunt et al., 2013; Estrella et al., 2000; Flannery and Giacomini, 2015; Herring, 2010; Wheelock and Wilson, 2000). Our analyses differ from these studies in three ways. First, the Covid-19 crisis, unlike other economic crisis triggered by financial market malpractices and macro-economic factors, is a health-induced shock and hence the findings we document captures dynamics which may be different from the above studies (Beck and Keil, 2022; Berger and Demirgüç-Kunt, 2021; Duan et al., 2021; Kryzanowski et al., 2022).

Second, we provide robust and consistent empirical evidence that reflects the first global real-world stress test following the global financial crisis (GFC), thus contributing to current discussions on the role of the post 2007-09 Basel reforms in avoiding another systemic banking crisis (Abboud et al., 2021; BCBS, 2021; Berger and Demirgüç-Kunt, 2021; Duan et al., 2021). Third, unlike the existing studies, we attempt to disentangle the impact of banks' capital from that of government interventions in the wake of the pandemic. This is necessary in that the swift and wide range of Federal support extended (directly or indirectly) to banks during the current crisis (relative to past crisis) equally have the potential effect of stabilizing banks and hence could confound the true impact of banks' capital on their degree of insolvency risk (Abboud et al., 2021; Berger and Demirgüç-Kunt, 2021). No such attempts, as far as we know, have been made in the literature to address such concerns.

Furthermore, we employ an event study approach rather than the conventional association study approach that is commonly used in the literature (e.g., Abboud et al., 2021; Altunbas et al., 2007, 2012; Berger and Bouwman, 2013; Kanga et al., 2020). The latter approach is relatively less effective in addressing endogeneity concerns related to correlated omitted variables and feedback effect running from bank risk to capital (Bostandzic et al., 2022; Januzzi and Moreira, 2022; Kanga et al., 2020), thus casting doubts on whether the results documented in this regard could be interpreted as causal (Bostandzic et al., 2022; Moreira, 2022). Our study thus adds depth to the existing literature by exploiting the unique setting of the Covid-19 pandemic as a quasi-natural experiment, which better alleviates the potential endogeneity between banks' capital and insolvency risk (Moreira, 2022). While we make no claims of methodological innovations to the literature, as far as we are aware, only few studies have employed a similar approach (e.g., Bostandzic et al., 2022; Gropp et al., 2019).

Finally, our findings contribute to the literature on the potential mechanisms that explain the relation between banks' capital and insolvency risk. Prior studies advance arguments in line with monitoring (Allen et al., 2011; Baron, 2020; Mehran and Thakor, 2011), asset-substitution moral hazard (Acharya et al., 2016), and market capitalization (Bostandzic et al., 2022; Sarin and Summers, 2016). We add to this literature by documenting robust empirical evidence in support of a credit supply channel in reducing banks' insolvency risk in times of crisis (see Internet Appendix B). By so doing, we generate an interesting (consistent) link with the current literature on the Covid-19 crisis which enhances understanding of the role of banks' regulatory capital during the ongoing pandemic (e.g., Abboud

Table 1
Summary statistics.

	Full Sample			Matched Sample (Tier 1 ratio)			Matched Sample (Total capital ratio)		
Variables	#Obs.	Mean	Std.D	#Obs.	Mean	Std.D	#Obs.	Mean	Std.D
Z -score	8,720	6.024	1.367	5,635	6.045	1.378	5,622	6.058	1.389
Tier 1 ratio	7,963	13.044	2.853	4,951	13.262	3.276	4,978	13.304	3.201
Total capital ratio	8,135	14.710	2.763	5,065	15.029	3.091	5,102	14.938	3.119
Size	9,329	8.109	1.569	5,992	8.068	1.582	5,965	8.118	1.610
Cash-to-assets ratio	9,031	0.064	0.057	5,764	0.066	0.059	5,768	0.066	0.059
Loan loss provision ratio	7,584	0.001	0.002	4,722	0.001	0.002	4,765	0.001	0.002
Cost-to-income ratio	9,304	3.965	5.455	5,949	3.949	5.263	5,932	3.802	5.117
Deposits-to-assets ratio	9,304	0.819	0.058	5,974	0.818	0.058	5,961	0.818	0.057
ROE	9,257	0.025	0.022	5,930	0.025	0.023	5,917	0.025	0.021
Loan growth	8,575	0.025	0.070	5,543	0.026	0.074	5,553	0.025	0.072

Notes: To control for outliers in the data, all variables are winsorized at the 1st and 99th percentiles of their distribution. Our panel is unbalanced typically because there are not always observations for each bank and every quarter. This is the case for the number of observations for variables such as the *Z-score*, which is computed over a rolling window, and difference variables such as loan growth. Another source of the unbalance stems from observations which do not always have values for all variables in a specific quarter. We provide detailed summary statistics in the online appendix C.

et al., 2021; BCBS, 2021; Cao and Chou, 2022; Duan et al., 2021; Kryzanowski et al., 2022). In this regard, our findings suggest that banks with higher levels of ex-ante regulatory capital are relatively more risk-resilient during the pandemic plausibly due to their ability to lend resiliently to households and businesses (Abboud et al., 2021; BCBS, 2021; Cao and Chou, 2022). Lending resilience reduces further loan defaults by clients (Gambacorta and Marques-Ibanez, 2011; Kryzanowski et al., 2022), which in turn mitigates banks' credit risk (Beck and Keil, 2022), their degree of insolvency risk, and hence their contribution to systemic risk during the pandemic (Duan et al., 2021).

2. Data and methodology

Our original sample includes an unbalanced panel of 450 U.S. commercial banks spanning 22 quarters from 2017q1 to 2022q2. The data are retrieved from the Compustat Bank Fundamentals Quarterly database and includes both active and inactive banks. We employ the *Z-score* as our proxy for banks' insolvency risk and use two regulatory capital ratios - Tier 1 ratio and Total capital ratio. Tier 1 ratio is banks' tier 1 capital as a fraction of their risk-weighted assets. Total capital ratio is banks' total capital (Tier 1 plus Tier 2 capital) normalised by their risk-weighted assets. Table 1 reports the descriptive statistics for the full and matched samples used in our main analysis.

To identify the causal effect of banks' regulatory capital on their degree of insolvency risk amid the ongoing Covid-19 pandemic, this study employs Covid-19 as an exogenous shock to banking in a difference-in-difference (DID) estimation technique that investigate the differences in insolvency risk between better-capitalised and less-capitalised banks before and after (during) the Covid-19 crisis. We code the treatment group (well-capitalised banks) as banks with an average Tier 1 ratio (2019 average) in the top tercile of the Tier 1 ratio distribution in 2019 (before the Covid-19 shock) and those in the bottom tercile as the control group (e.g. see Cao and Chou, 2022; Sclip et al., 2021).

To reduce treatment assignment bias, we employ the propensity score matching (PSM) technique, based on observed bank-specific covariates (average *size*, average *cost-to-income ratio*, and average *Z-score*), to identify a comparable control group for treated banks. Using the PSM-matched sample, we develop an event study set-up to test for the condition of having no pre-trends.[9] This provides preliminary evidence of the dynamics of the treatment effect over the observation window (2017q1 to 2022q2). We specify the following dynamic model:

$$Z-\text{score}_{i,s,t} = \beta_1 + \beta_2 \text{Treat}_i + \beta_{-5}\text{Treat}_i \times I\{Q_t \le -5\} + \sum_{q=-4}^{4} \beta_Q \text{Treat}_i \times I\{Q_t = q\} + \beta_{5+}\text{Treat}_i \times I\{Q_t \ge 5\} + \sum_{k=1}^{K} \beta_k X_{ki,s,t-1} + \theta_i + \theta_{st} + \varepsilon_{i,s,t} \quad (1)$$

where: $Z-score_{i,s,t}$ is the proxy for insolvency risk of bank i in state s at quarter t;[10] $Treat_i$ is the treatment group dummy which is equal to 1 if bank i has an average Tier 1 ratio (in 2019) in the top tercile of the distribution, and 0 if its average Tier 1 ratio belongs to the bottom tercile of the distribution; Q_t is the relative quarters from the Covid-19 shock (2020q1), $Q_t = (t - 2020q1)$; β_{-5} is the single co-efficient that captures far leads and β_{5+} is the single co-efficient for far lags (the most current effects); The observation window runs from 2017q1 to 2022q2. To better capture the exogenous component of a variation in regulatory capital, we restrict the event window to the interval [-5; +5] from the quarter of the Covid-19 shock (2020q1); Following standard practise in the literature, we assign a value of 1 to dummies at the extremes of the event window where $-5 \ge Q_t \ge 5$ and normalise the quarter before the Covid-19 shock (2019q4) to zero; $X_{ki,s,t-1}$ is a matrix of lagged bank-specific covariates that includes bank *size, cost-to-income ratio, cash-to-assets ratio*, and *loan loss provision ratio;* θ_i are bank-specific fixed effects and θ_{st} are state-quarter fixed effects; $\varepsilon_{i,s,t}$ is the error term.[11]

Next, we specify a static difference-in-difference design to examine the average causal effect of bank capital on risk. The specification is as follows:

[9] In robustness tests, we match by actual pre-crisis levels, rather than averages, and obtain qualitatively similar results (See Internet Appendix A and Table A.2 and Table A.3 for a detailed description).

[10] $Z-\text{score}_{i,s,t} = \ln\left(\frac{ROA_{i,s,t} + EQUI_{i,s,t}}{SD\_ROA_{i,s,t}}\right)$. ROA is the return on assets; EQUI is the equity ratio; and SD_ROA is the standard deviation of return on assets calculated over a 3-year rolling window. Higher values of Z-score indicate a lower degree of bank insolvency risk and lower levels imply a higher degree of insolvency risk.

[11] Our choice of control variables has been extensively employed in the existing literature to explain banks' insolvency risk (or related concepts) (e.g. see Altunbas et al., 2007; Bitar et al., 2018; Demirguc-Kunt et al., 2013; Kanga et al., 2020; Moreira, 2022). In further tests, we add additional controls for banks' profitability (Return on equity (ROE)) and funding structure (Deposits-to-assets ratio) as potential covariates which are likely correlated with both capital and insolvency risk (Altunbas et al., 2007; Flannery & Giacomini, 2015; Shleifer & Vishny, 2010). We continue to obtain significant results (See Internet Appendix A for details and Table A.1 for the results)

$$Z-score_{i,s,t} = \beta_1 + \beta_2 Treat_i + \beta_3 Covid_t + \beta_4 Treat_i \times Covid_t + \sum_{k=1}^{K} \beta_k X_{ki,s,t-1} + \theta_i + \theta_t + \theta_{st} + \varepsilon_{i,s,t} \quad (2)$$

where: $Covid_t$ is the post Covid-19 shock indicator equal to 1 from 2020q1 onwards, and 0 otherwise; The DID co-efficient of interest is β_4, which captures the difference in insolvency risk between banks with relatively high regulatory capital, ex-ante, and those with relatively less capital after the Covid-19 shock; θ_i,$\theta_t$andθ_{st}denote bank, quarter, and state-quarter fixed effects respectively. Different combinations of these fixed effects are included in the regressions.

3. Results

The first building block of the empirical analysis in this paper is based on an event study design in Eq. (1) which aims to preclude concerns about the presence of common trends prior to the Covid-19 shock and show the dynamics of the treatment effect. The point estimates (coefficients) from Eq. (1) are presented graphically in Fig. 1

From Fig. 1, no pre-trends can be observed. Point estimates are consistently insignificant and close to zero throughout the pre-Covid period. This implies that, before the Covid-19 shock, there is no statistically significant difference in the *Z-score* (insolvency risk) between treated and control banks. On the other hand, there is a jump at quarter 0 (2020q1) and a gradual increase thereof. The point estimates from the quarter of the shock until three quarters later are statistically significant and positive. Overall, the event study provides preliminary evidence that well-capitalised banks (in terms of Tier 1 capital ratio), ex-ante, tend to have a lower insolvency risk (higher *Z-scores*) during the pandemic than less-capitalised banks of otherwise similar characteristics. Most importantly, the results lend support to any causal interpretation of results in the subsequent static DID regressions in Eq. (2).

The next building block is the canonical (static) regression in Eq. (2) which estimates the average causal effect of banks' pre-crisis capital on their degree of insolvency risk. Here, the condition of having no pre-trends has been tested with the event study in Eq. (1). However, the requirement of a constant treatment effect across quarters and among banks is taken as an assumption. The results are presented in Table 2. The estimated parameter of interest, β_4, is significantly positive in all specifications, consistent with the results in the event study. Particularly in column (1), the coefficient is 0.3060 (significant at the 1 percent level), which implies that the average *Z-score* of banks with a higher Tier 1 capital ratio, ex ante, is 0.3060 log units higher than that of less-capitalised banks amid the ongoing pandemic. In Table 3, we present results for Total capital ratio and obtain qualitatively similar results. The DID term remains significant and positive in all specifications. The results suggest that banks that enter the pandemic with robust capital levels have a lower insolvency risk than their peers during the Covid-19 crisis.

Finally, we attempt to disentangle the effect of regulatory capital on banks' insolvency risk from that of the extensive support facilities provided by the Federal Reserve, in the wake of the Covid-19 pandemic, as the latter could confound the sensitivity of banks' insolvency risk to regulatory capital ratios (Abboud et al., 2021; BCBS, 2021). To the extent that such interventions were primarily aimed at strengthening banks' ability to lend amid the crisis, they could directly affect (reduce) banks' level of credit risk since continuous credit supply to businesses reduces further client loan defaults amid the pandemic (Beck and Keil, 2022; Bruno and Marino, 2018), thus making bank insolvency unlikely. We attempt to partial out these effects by adding an additional control for banks' loan growth in Eq. (2).[12] Table 4 reports the results. Overall, the results are qualitatively the same as those in Table 1. This suggests that holding banks' loan growth constant (which reflects, to some extent, government interventions), banks with robust levels of capital, prior to the Covid-19 crisis, are relatively risk-resilient than less-capitalised banks during the pandemic.

4. Conclusion

This study employs the Covid-19 shock in a difference-in-difference setup to examine the risk-absorbing effectiveness of banks' regulatory capital in times of crisis. By so doing, this paper answers a relevant question as to whether well-capitalised banks, ex-ante, are more risk-resilient in times of severe economic downturn. The results, after an attempt to disentangle the confounding effect of government support, suggests that banks with robust pre-crisis regulatory capital ratios have a lower degree of insolvency risk amid the pandemic than banks with lower regulatory capital ratios. In further analyses, we also find that the results are particularly pronounced for banks who are most likely to extend credit in the wake of the pandemic, consistent with our conjecture of a credit supply channel of banks' regulatory capital in times of crisis (see Internet Appendix B). Overall, these results lend support to the effectiveness of the post 2007-09 Basel reforms in strengthening financial stability. Our study thus has direct implications for bank regulation such that, we provide empirical evidence that sheds light on a core mandate of banks' regulatory capital under an appropriate setting: a stress scenario. This contrasts with most of the existing literature whose findings are largely applicable to banks under normal (non-stress) conditions, and thus have little (relatively) relevance to the concept of risk-absorption under stress (e.g., see Bostandzic et al., 2022;

[12] We acknowledge that this approach is not exactly perfect and might even conflict with the credit supply argument. Thus, we do not claim it completely addresses the foregoing concern. A better way will be to control for actual bank-specific government support over the period. Unfortunately, we do not have access to such data. That notwithstanding, our attempt helps alleviate potential confounding effects of significant government assistance.

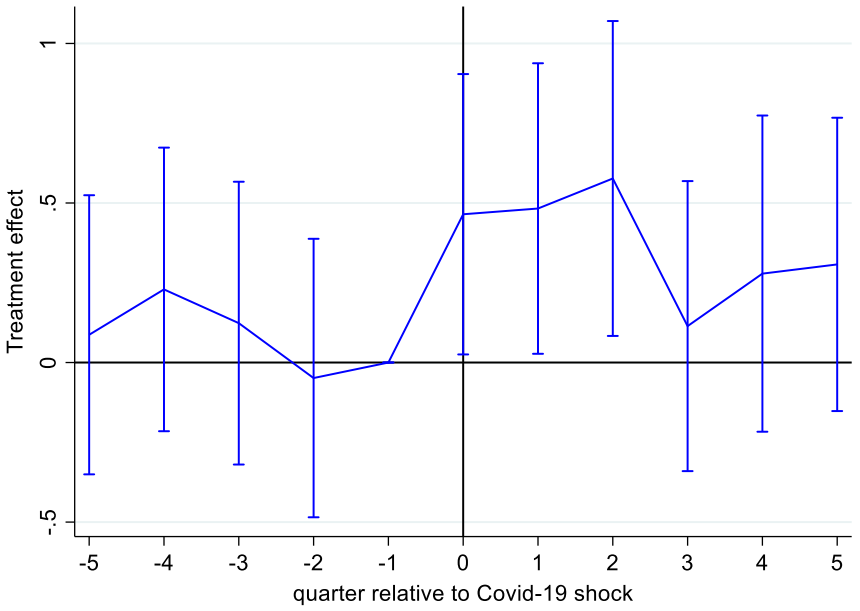

Fig. 1. Event study.
Notes: The observation window is from 2017q1 to 2022q2, and the event window is restricted over the interval [-5; +5], i.e., five quarters around the Covid-19 shock; treatment effects for all periods beyond the event window are accumulated at β_{-5} and β_{5+} accordingly; the x-axis denotes the relative quarters from the Covid-19 shock, with 0 depicting the actual quarter of the shock (2020q1); the year prior to the shock (-1(2019q4)) is coded as the omitted category, whereas the y-axis presents the estimated treatment effect within a 95 percent confidence interval.

Table 2
Difference-in-difference: regulatory capital (Tier 1 capital) ratio and insolvency risk.

Variables	(1) Z-score	(2) Z-score	(3) Z-score	(4) Z-score
Treat* × *Covid	**0.306*** **	**0.239** **	**0.319*** **	**0.271** **
	(0.091)	**(0.100)**	**(0.100)**	**(0.115)**
Size			0.324**	0.298
			(0.155)	(0.182)
Cash-to-assets ratio			-0.645	-0.983
			(0.691)	(0.710)
Cost-to-income ratio			-0.001	-0.003
			(0.004)	(0.005)
Loan loss provision ratio			-104.000***	-96.190***
			(16.940)	(20.940)
Constant	6.517***	6.526***	4.047***	4.294***
	(0.074)	(0.072)	(1.256)	(1.465)
Bank FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	No	Yes	No
State-Quarter FE	No	Yes	No	Yes
Observations	5,635	5,635	4,619	4,619
R-squared	0.138	0.287	0.152	0.324

***Notes*:** In columns (1) and (2) of Table 2, we regress the *Z-score* on the DID interaction term in addition to controlling for bank and quarter fixed effects (column 1) as well as bank and state-quarter fixed effects (column 2). In columns (3) and (4), we include bank-specific covariates respectively. Robust standard errors, clustered by bank, are in parentheses. *. **, and *** represent statistical significance at the 10%, 5%, and 1% levels respectively.

Moreira, 2022).

Moreover, findings from prior economic downturns may not be applicable under the current crisis since Covid-19, unlike other financial crisis, is a health-induced shock and thus the dynamics of its impact on banks may be different (Kryzanowski et al., 2022). Furthermore, unlike existing studies that heavily rely on an association study type approach, our study uses an event style approach which better alleviates potential endogeneity concerns (Moreira, 2022). Finally, given the potential confounding effect of the unique nature (relative to other crisis) of Federal interventions in the wake of the pandemic, disentangling such an effect, though empirically challenging, is crucial in identifying the incremental effect of banks' regulatory capital (Abboud et al., 2021). Even though our approach at addressing such a concern is not perfect, to the best of our knowledge, such an attempt has not yet been carried out in the existing literature.

Table 3
Difference-in-difference: regulatory capital (Total capital ratio) and insolvency risk.

Variables	(1) Z-score	(2) Z-score	(3) Z-score	(4) Z-score
Treat* × *Covid	**0.231****	**0.187***	**0.253****	**0.226****
	(0.092)	**(0.100)**	**(0.100)**	**(0.109)**
Size			0.474***	0.413**
			(0.146)	(0.165)
Cash-to-assets ratio			-0.425	-0.750
			(0.679)	(0.723)
Cost-to-income ratio			-0.004	-0.002
			(0.004)	(0.005)
Loan loss provision ratio			-115.800***	-119.300***
			(17.110)	(19.400)
Constant	6.490***	6.493***	2.771**	3.289**
	(0.071)	(0.069)	(1.182)	(1.340)
Bank FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	No	Yes	No
State-Quarter FE	No	Yes	No	Yes
Observations	5,622	5,622	4,668	4,668
R-squared	0.148	0.319	0.168	0.359

***Notes*:** In columns (1) and (2) of Table 3, we regress the *Z-score* on the DID interaction term in addition to controlling for bank and quarter fixed effects (column 1) as well as bank and state-quarter fixed effects (column 2). In columns (3) and (4), we include bank-specific covariates respectively. Robust standard errors, clustered by bank, are in parentheses. *. **, and *** represent statistical significance at the 10%, 5%, and 1% levels respectively.

Table 4
Difference-in-difference: controlling for loan growth.

Variables	(1) Z-score	(2) Z-score	(3) Z-score	(4) Z-score
	Tier 1 ratio	Total capital ratio	Tier 1 ratio	Total capital ratio
Treat* × *Covid	**0.325*****	**0.256****	**0.259****	**0.217***
	(0.102)	**(0.103)**	**(0.118)**	**(0.111)**
Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	No	No
State-Quarter FE	No	No	Yes	Yes
Observations	4,373	4,421	4,373	4,421
R-squared	0.158	0.174	0.334	0.368

***Notes*:** In this table, we include an additional control for banks' loan growth to partial out the effect of the various lending-driven government support during the Covid-19 crisis. In columns (1) and (2), we regress the *Z-score* on the DID interaction term (for Tier 1 ratio and Total capital ratio respectively) in addition to controlling for bank and quarter fixed effects. In columns (3) and (4), we control for bank and state-quarter fixed effects accordingly. Robust standard errors, clustered by bank, are in parentheses. *. **, and *** represent statistical significance at the 10%, 5%, and 1% levels respectively.

Author statement

We, the undersigned, declare that the manuscript "Regulatory capital and bank risk-resilience amid the Covid-19 pandemic: How are the Basel reforms faring?" is original, has not been published before, and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that all have approved the order of authors listed in the manuscript of us. We understand that the Corresponding Author is the sole contact for the Editorial process. He is responsible for communicating with the other author about progress, submissions of revisions, and final approval of proofs.

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The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2022.103591.

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