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Bank resolution mechanisms revisited: Towards a new era of restructuring[☆]

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A B S T R A C T

Government interventions as a solution to systemic banking crises continue to receive wide criticism. The new regulatory frameworks advocate banks' bail-ins and resolutions that do not require governments' involvement. However, as the recent events with Credit Suisse and Silicon Valley Bank show, the government still plays an active role in rescuing and resolving the bank's problems. We use the financial stability model of Goodhart et al.'s (2005, 2006a) to analyze the effects of various bank policy interventions on banks' performance during the crisis rescue phase. We then explore whether those interventions work effectively in facilitating bank recovery and whether they reduce systemic risk in the long run. We use a unique granular bank-level dataset from 22 advanced economies covering the 1992–2017 period. We find that bank recapitalization without debt resolution measures does not resolve bank distress. The empirical results document that "bad-bank" resolution is positively correlated with a bank's recovery as well as lower systemic risk. Those findings contribute to the ongoing debate on the optimal bank resolution architecture during systemic events.

1. Introduction

Governments accelerated the application of bank rescue packages since the 2007–08 crisis to such an extent that they became highly unpopular with the public because of the fiscal burden that they impose on taxpayers. Bank bailouts can lead to moral hazard and undermine market discipline as they can create rents for bankers (e.g., Avgouleas and Goodhart, 2019; Gropp and Vesala, 2004; Dam and Koetter, 2012). These concerns fueled the regulatory changes in the banking sector, which then led to the introduction of a new bank resolution framework. The European Parliament and Council has enacted the Bank Recovery and Resolution Directive (BRRD) in 2014 which defines the policy interventions for the distressed banks within the EU banking sector. The recent implementation of those resolution frameworks in practice occurred, for instance, in Slovenia in the case of Sberbank, Idea and Getin Noble Bank in Poland or SAREB bank in Spain. Similarly, the introduction of the Dodd-Frank Act defined the policy interventions for banks in the United States. The authorities in G-20 countries require their systemically important financial institutions (SIFIs) to make contingency plans for times of distress, called "Living Wills".[1] They also requested SIFIs to prepare a first-ever 'targeted' resolution plan during the Covid-19 pandemic. The most recent events with Credit Suisse and Silicon Valley Bank brought attention back to the new resolution frameworks by showing that government still plays an active role in rescuing and resolving the bank's problems.

The new resolution frameworks uniformly aim to facilitate an orderly restructuring of distressed banks to reduce the potential contagion effect during the crisis. The costs associated with such interventions are imposed on bank creditors and shareholders. One option under the new resolution frameworks consists of a sale of the business or shares of the distressed institution. Another option involves a restructuring process of the distressed bank's portfolio by setting up a 'bad bank' (Asset Management Company, AMC) where the underperforming assets are separated from the distressed bank. The new regulatory frameworks no longer allow a bailout of distressed banks.

Although the theoretical channels behind the new regulatory frameworks are sound, there is no real evidence of the effectiveness of those frameworks in the context of the systemic banking crisis. At the

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[1] Such bank resolution plans should incorporate scenarios under which certain (less important) parts of a bank could be sold or put into liquidation to limit their systemic effect during a stress event.

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same time, some scholars argue that rapid government intervention is extremely important for limiting both the contagious effects of a crisis and its subsequent repercussions (e.g., Berger et al., 2020). This stands in opposition to the latest regulatory calls to limit bailouts. Also, governments can play an important role in stimulating bank lending as well as NPL restructuring during the crisis (e.g., Berger and Roman, 2017; Homar, 2016). Thus, policymakers and regulators need to carefully assess whether redirecting bank resolution to bank managers and other creditors through bail-ins would indeed be more effective than the use of bailouts and, if so, under what circumstances.

We assess the effectiveness of the new regulations as defined through resolution policies such as (i) a sale of bank assets through a merger and (ii) a "bad-bank" mechanism for bank rescue and recovery. We test those policy interventions under different stress scenarios and contrast them with a bailout mechanism, i.e., the nationalization of a distressed bank. We analyze the effectiveness of those mechanisms in resolving banks' distress by looking at their *ex-post* bank capital, reserves/NPLs as well as lending activities. We then assess how they impact the systemic risk in the banking sector.

Relevant literature mainly tests the impact of recapitalizations on bank behaviour rather than that of crisis resolution policies. A large part of this literature is related to bank bailouts by the government and, thus, the role of capital injections into distressed banks. For instance, Hakenes and Schnabel (2010) find that government actions can have a positive impact through increased banks' profitability caused by access to more favourable funding. Similarly, other scholars find that capital injections can improve banks' capital positions (e.g., Berger and Bouwman, 2013; Giannetti and Simonov, 2013; Duchin and Sosyura, 2014; Mehran and Thakor, 2011; Rose and Wieladek, 2012). Ding et al. (2012) provide evidence from emerging countries in Asia that government interventions can improve the solvency, credit risk and profitability of troubled banks. Other scholars find some positive impacts of government interventions on bank lending activities. For example, Puddu and Waelchli (2015) find that the Troubled Asset Relief Program (TARP) can have a positive effect on small business loans issued by TARP banks as compared to non-TARP banks. However, Acharya et al. (2021) find that fiscally constrained governments "kicked the can down the road" by providing banks with guarantees instead of full-fledged recapitalizations. They explain that forbearance caused undercapitalized banks to shift their assets from loans to risky sovereign debt and to engage in zombie lending, resulting in weaker credit supply, elevated risk in the banking sector, and, eventually, greater reliance on liquidity support from the European Central Bank (ECB). To the best of our knowledge, the only paper that looks at the role of resolution mechanisms in crisis management is by Brei et al. (2020). The authors analyze 135 cross-country banks to test the effect of the "bad-bank" solution on bank recovery in terms of lending activity and reduction in NPLs. They find that the "bad bank" approach seems to be effective in resolving banks' distress when combined with recapitalization.

A new stream of literature analyzes the new regulatory policy, bank bail-ins, as opposed to bank bailouts, and assesses its effect on banking sector recovery. This literature assumes that bank recapitalizations occur as a result of redirecting the losses to bank shareholders and other stakeholders, thus reducing the public cost of the crises. For instance, Beck et al. (2021), analyze the effect of the bail-in of a major Portuguese bank on the credit supply and find some evidence of a contraction in distressed bank lending, though no effect on the aggregated credit supply in the banking sector. However, De Souza et al. (2019) simulate stress scenarios for the Brazilian banking sector in the context of bank bail-ins in comparison to their liquidation. They find that bail-ins cause lower credit contraction to the economy than bank liquidations. Moreover, Beck et al. (2021), Klimek et al. (2015) and Benczur et al. (2017) claim that bank bail-ins – as opposed to bailouts – render lower crisis costs, reduce public spending and, under certain scenarios, might restore economic activity. Fiordalisi et al. (2020) show that investors perceive the new bail-in regime as a credible tool to decrease government interventions, reduce the too-big-to-fail problem, and increase market discipline in the European banking industry. Finally, a few other papers analyze the impact of bank bail-in on bank behaviour claiming that the bail-ins reduce moral hazard behaviour (e.g., Ignatowski and Korte, 2014; Martynova and Perotti, 2018). However, none of those papers specifically refer to the assessment of the resolution policies on banking sector recovery.

There is also limited research on the role of government interventions on the systemic effects. Some recent academic papers consider the effect of bail-ins and their contagion effect, for example, in the paper by Hüser et al. (2017). Galliani and Zedda (2015) test the effectiveness of the bail-in during different banking distress events proving that the mechanism seems to be effective only in limited crises, however in more severe crises external intervention is needed to resolve the crisis. There is a lack of literature evidence on how systemic risk in the banking sector reacts to different resolution procedures that are necessary to be undertaken during severe distress events.

Our paper aims to address those literature gaps, and as opposed to other studies, does not concentrate solely on bank bailouts or bail-ins. It rather examines the effect of different policy interventions in crisis management. It also evaluates how those mechanisms work in the context of systemic risk. Thus, our research approach treats the topic of policy interventions more coherently by analyzing the role of policy interventions from both micro-and macro-perspective in different time dimensions of a crisis.

We begin with the novel application of the Goodhart et al., (2005, 2006a) model of financial stability to analyze the channels through which the policy interventions can affect the recovery of the banking sector, and, thus, reduce the systemic risk. The model of Goodhart et al., (2005, 2006a) has been widely used by policymakers and central

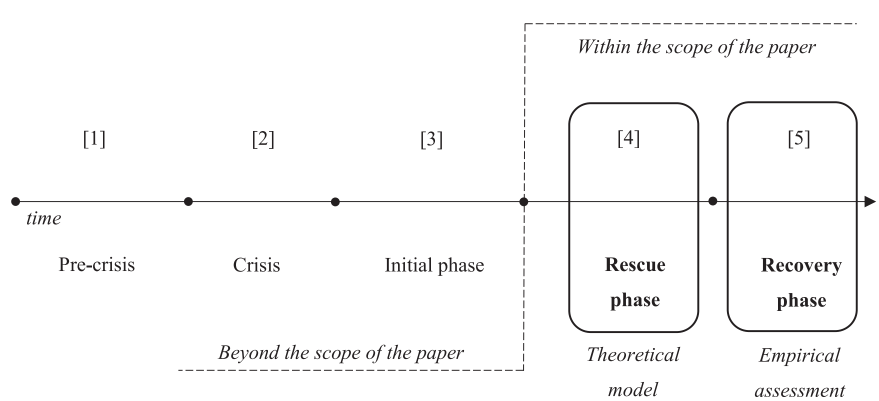

Fig. 1. A simplified timeline of the systemic banking crisis for the illustration of the paper's scope.
Source: Authors (2023).

bankers to study the trade-offs between bank performance and financial stability. An important advantage of the model is its ability to analyze the interactions between different players in the context of the whole banking system. We use the model to incorporate different bank policy interventions and test their impact on multiple parameters such as banks' performance, repayment rates, credit activity, as well as the interbank market. Those are assessed in the rescue phase of the crisis. We incorporate two policy mechanisms into the model, namely (i) the sale of a distressed bank (merger) and (ii) a "bad bank" approach. We contrast them with (iii) a bank bailout (nationalization). The model allows us to test the role of those policy interventions on bank recovery in a comprehensive fashion.

In the second part of the paper, we empirically assess the power of those policy interventions in bank recovery as well as test their effectiveness in the long run. For that, we use a novel bank-level database, originated by Hryckiewicz (2014). While Hryckiewicz (2014) analyzed the effect of different resolutions on banks' risk-taking using a set of 25 countries (mostly emerging economies), we extend the sample and include a large sample of advanced economies. Also, in contrast to Hryckiewicz (2014), we assess the effectiveness of policy interventions on banks' recovery using multiple parameters such as banks' lending, capital levels as well as reserves/NPL positions. We cover 22 advanced countries across the period 1992–2017. Also, given the results on the impact of resolution methods on bank recovery, we analyze how those resolutions relate to systemic risk. More specifically, we are interested in whether and which policy measures can decrease the systemic risk in the crisis. Following Huang et al. (2009) and Segoviano and Goodhart (2009), we use credit default swaps (CDSs) as a systemic risk proxy. We thus argue that the risk premium is expected to decrease following the successful implementation of the resolution strategies due to increasing confidence, resulting from banks' lower losses and potential recovery.

Fig. 1 outlines the focus of our paper along the simplified stages of the systemic banking crisis. Both parts of the paper focus on the post-intervention phase of the systemic crisis where the determinants of crisis are taken as given. Before the crisis [1], the increased fragility occurs with negative shocks within the economy. The initial phase of the crisis [3] refers to the immediate reactions during the containment phase of the crisis. During that phase, the focus is on restoring confidence in the financial markets and minimizing the contagion effects of the crisis. We focus on the last two phases, namely the rescue phase [4] where we apply the theoretical model of Goodhart et al., (2005, 2006a) to test the channels of policy interventions and the recovery phase [5] where we empirically assess the impact of policy interventions on bank recovery.

We find that the success of policy interventions depends on the scale and severity of bank problems as well as on the nature of the crisis. Our results show that the lack of any interventions deepens the distress in the banking sector and spreads the contagion effect of the crisis. This provides some support to the new regulatory efforts. However, our findings also document that not all policy interventions can guarantee success in the same way. Specifically, the success of the policy interventions in crisis management is determined by the use of appropriate restructuring procedures. Bank recapitalization on its own is not effective in restoring bank health and more profound resolution measures are needed to heal the bank's balance sheet. In other words, the "bad bank" mechanism can enable banks' recovery through their post-crisis activity. Effective restructuring can decrease future losses and increases banks' credit activity. In addition, we find that the profound restructuring process with limited involvement of the government can reduce the systemic effect of the crisis. Government-assisted mergers can work well in the initial stage of the crisis, however, they must be assisted by government intervention in the form of recapitalization. There is no evidence of a positive effect of mergers on systemic risk mitigation. The most negative effects are rendered by bailouts.

Our findings contribute to the debate on the reasoning behind the persistent weak performance of the European banking sector after the global financial crisis of 2008–10 (GFC) despite the record level of government financial support. The average profitability of the European banking sector stood at 6.5% after the GFC in comparison to 10–12% before GFC. We argue that despite significant financial support injected into the sector during the crisis, there was a lack of deep bank restructuring that should have been aimed at resolving the problem with NPLs. This issue has been also documented in the study by Acharya et al. (2021). Our findings provide support to policymakers in undertaking more comprehensive resolution actions to aid banks in the next event of distress as the shift of the crisis management policy away from bailouts toward bail-ins does not seem to be sufficient. We call for more regulatory actions and tools to tackle the restructuring of distress at banks.

The paper is organized as follows. Section 2 includes the literature review behind the policy interventions under the new bank resolution framework. Section 3 presents the applied model of financial stability. In Section 4, we carry out the empirical analysis and present the combined results. Section 5 concludes the paper.

2. Background on the policy interventions under the new bank resolution framework

Due to the widespread dislike of bank bailouts used during the GFC, many country authorities and international agencies shifted their focus to new regulatory policies that advocate the use of bail-ins in the event of a next crisis. In Europe, the EU's BRRD and the Single Resolution Mechanism (SRM), one of the pillars of the EU's banking union, came into force between 2014 and 2015. An important element of their frameworks is a new bank resolution mechanism, i.e., bail-in, which envisages that bank resolution takes place without the use of public funds. This removes implicit bailout protection for banks that are "too-big-to-fail", which in the past provided incentives to bankers to engage in excessive risk-taking through, for instance, over-investing in highly risky assets (see Demirgüç-Kunt and Kane, 2002; Demirgüç-Kunt et al., 2008). G-20 leaders have called for the development of resolution plans for SIFIs. SIFIs are now required to develop scenarios in which they consider the restructuring process of a defaulted bank along with rescuing the systemic parts of a bank (see Huertas, 2010). The Financial Stability Board (FSB) issued a set of key attributes that refer to the scope of the resolution, the powers of the resolution authorities, and recovery and resolution planning (FSB, 2011), which are regularly monitored and evaluated (FSB, 2021). Several national documents modified those regulations to give more power to supervisory institutions. For instance, separate national bank resolution frameworks have been established in the UK (the Banking Act, 2009) and Germany (the Bank Restructuring Act, or the German Act on the Recovery and Resolution of Credit Institutions, 2015).

The new bank regulatory frameworks outline policy interventions that can be applied at a distressed bank before any further bankruptcy procedures are undertaken. One policy option is to separate the bank's non-performing loans (NPLs) from healthy assets and sell them to healthy bank(s). This mechanism could involve the withdrawal or cancellation of the troubled bank's license. Here, the liabilities of the troubled bank are taken over proportionally (Klimek et al., 2015). This merger-like policy option differs from a bank liquidation, in which creditors are repaid over time or under specific circumstances not repaid at all. Here, the assets and liabilities of the distressed bank are transferred to other healthy institution(s). Thus, the risk of a potential contagion coming from a bank's distress or liquidation is eliminated. Sheng (1996) argues that this form of merger resolution can be effective if the markets have sufficient funds to absorb the new institution.

Another policy intervention included under the new bank resolution framework is called the "bad-bank" mechanism, or an Asset Management Company (AMC). It involves a transfer of NPLs from the distressed bank's balance sheet into a separate fund. The role of the fund is to clean up the bank's balance sheet to restore its profitability. The fund then aims to maximize the bank's loan recovery through active restructuring.

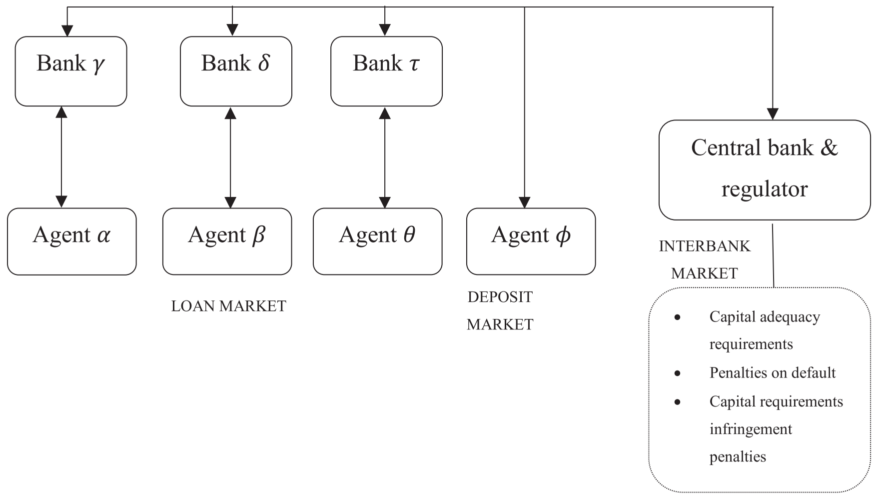

Fig. 2. The model structure – channels of agents and market interactions.
Source: Modified from Lewis (2010).

An important advantage of this policy option is that it removes the uncertainty associated with a bank's asset valuation and, thus, improves bank asset quality. Also, the separating of the bad and good assets of the distressed bank can improve bank solvency and profitability ratios and provide incentives to the good bank to lend in the real sector. It allows for handling larger banks (those deemed "too-big-to-fail"), when market transactions are not possible and, at the same time, limits bail-in costs. However, the "bad-bank" policy option requires market discipline mechanisms to work effectively (see Dell'Ariccia and Ratnovski, 2012).

Although recent banking regulation is committed to avoiding bailouts, it cannot be ruled out that in extreme cases governments would have to step in to save distressed banks using public funds. The EU's SRM regulation envisages the use of national funds to bail out distressed banks if their losses, not less than eight per cent of total liabilities including own funds, have already been absorbed by the creditors of the failing bank through a bail-in mechanism (European Commission, 2014). Some researchers found that in extreme cases, the fund money might be not sufficient to restore the distressed banks and, thus, government intervention would be necessary (see Avgouleas and Goodhart, 2019). In our analysis, we compare the effect of new bank policy resolution mechanisms with bailouts. Studying cross-country experiences with different depths of systemic crises allows us to assess under which crisis scenarios bailouts could be more effective in bank recovery than the new bank policy resolution options.

3. The application of the financial stability model in the context of the new bank resolution framework

3.1. Model description

We begin by exploring the channels of various policy interventions on bank rescue with the help of a variant of the financial stability model of Goodhart et al., (2005, 2006a). It is the first application of this model in such a context despite its popularity among policymakers and central bankers. The model is well-suited to the task. First, the structure of this partially micro-founded general equilibrium (GE) model allows us to set up bank resolution mechanisms in the systemic context. In other words, the model allows us to analyze how the policy interventions implemented at a distressed bank impact the systemic risk in the whole banking sector. Fig. 2 presents the model's structure. The model incorporates three heterogeneous banks, $b \in B = \{\gamma, \delta, \tau\}$, four private sector agents $h \in H = \{\alpha, \beta, \theta, \phi\}$, a Central Bank and a regulator. They all operate in incomplete markets with money and default and within the loan, deposit, and interbank markets. The default rate is defined as the

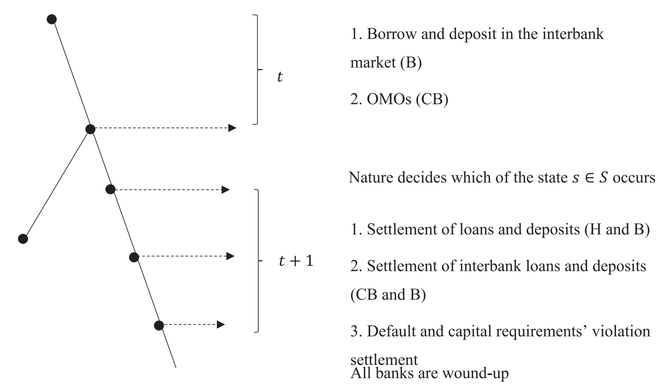

Fig. 3. The time structure of the Goodhart et al. (2005) model.
Source: Goodhart et al. (2005).

probability of the bank shutting down. It is assumed that, if banks are not able to repay their loans when they are due, and in case of the absence of any intervention, they are forced to shut down. The default rates for deposits and the interbank market for each bank are assumed to be the same.[2] Hence, banks cannot choose to pay their depositors and decide not to pay their fellow banks and/or the Central Bank.

Second, the model has two periods, $t \in T = \{1, 2\}$, and two possible states in the second period, $s \in S = \{i, ii\}$, which can be applied in the context of a systemic banking crisis. More specifically, it assumes that all uncertainty is resolved in the second period.[3] At time $t = 1$, markets open, and banks decide on how much to lend or borrow in each market depending on the state of nature, i.e., the good/normal state or the bad/extreme state (i.e., a systemic event during which the resolution mechanism is introduced as bank rescue solution). The level of risk taken by each bank is also different, and as such, it translates into different banks' returns. The good state is represented by i with a probability of p. The bad state is indicated by ii with a probability of

[2] If the default rates vary between deposit and interbank markets, then the individual bank's default rates depend on the respective exposure of each bank on a given market.

[3] The central bank conducts open market operations (OMOs) in the interbank market. The capital adequacy requirements on banks are set by the regulator. At $t + 1$, depending on the state of nature, all financial contracts are settled, subject to any defaults and/or capital requirements violations which are then penalized.

occurrence of $1-p$. These probabilities are constant over time and are known by the private sector agents. The expected value is taken over all possible states. At the end of the second period, all banks are wound up. The such two-period framework allows us to model in different resolution mechanism scenarios and, thus, to study the impact of each mechanism introduction on different agents and markets in the model. Fig. 3 summarizes the time structure of the model.

As in Goodhart et al. (2006a), the model assumes that private sector agents are assigned during the two periods, by history based on their previous banking behaviour or by informational constraint, to borrow from a single bank (i.e., a limited participation assumption).[4] Thus, the agents α, β, and θ borrow from banks γ, δ, and τ, respectively. The remaining agent, Mr. φ, represents the pool of depositors in this economy, which supplies funds to every bank. This implies that there are multiple active markets for deposits (by each separate bank) and loans (by each borrower and her/his assigned bank).

Importantly, the model assumes that banks operate under a perfectly competitive environment, hence the interest rates are taken as given when banks maximize their profits. The business environment is assumed to be highly competitive and so each bank chooses its interest rate when making portfolio decisions to maximize its profits. This is suitable for our model application, in which we need to ensure no monopolistic or oligopolistic banking behaviour is present to avoid biasing the outcome of the calibration exercise.[5]

3.2. Model extension with policy interventions

In the case where a crisis occurs, there is a policy intervention to rescue the distressed bank(s), which is (are) at risk of default. We thus introduce government-assisted mergers and a "bad-bank" mechanism into the model's framework as examples of resolution mechanisms aimed at the restructuring of distressed banks. The model allows us to test the channels through which these mechanisms might affect the banking sector risk. In the further part of the paper, we empirically test the statistical significance of those bank policy mechanisms on banks' recovery.

The decisions of private agents and banks are endogenous under this model, while the Central Bank and the regulator, or a government in general, have predefined strategies that are optimal. Bank resolutions are, thus, taken as given, which removes the issue of selection bias. Specifically, we assume that a government is an agent whose objective is to resolve NPLs to maximize the total output generated by the banking sector, net of any costs associated with the resolution mechanism. These resolutions are assumed to be rationally anticipated by the banks and depositors and the government's choice of a bank for intervention as well as the type of policy mechanism are both assumed to be rational. The model assumes the absence of moral hazard and adverse selection. For example, we assume that banks do not undertake any irrational actions at an ex-ante stage in terms of, for instance, their capital structure or quality of loans in anticipation of the introduction of a specific policy intervention.

The possibility of financial contagion plays a crucial role in motivating policy interventions in the banking sector. Namely, owing to the risk of contagion, failure in one bank can generate failures in other banks. But, at the same time, more capital in the distressed bank γ can also help to protect depositors in the bank δ. In other words, at least in theory, the resolution mechanism could help the distressed bank γ to repair its balance sheet and, at the same time, it could also have a positive impact on the bank δ. Thus, the risk of contagion is assumed to be the core reason justifying the need for policy interventions.

The banks' profit maximization horizon assumption holds under the model. Managers choose to maximize their banks' profit over a finite horizon, because they could depart from these banks for a better alternative contract, or they could change jobs. As explained in Goodhart et al. (2006b), the manager has a particular opportunity cost for working in the bank. He has the option of leaving the bank and seeking alternative employment when he has attained a certain level of profitability,

Table 1
Setup for the application exercise.

Resolution scenario	Banks set up	Setup of the resolution mechanism in the applied model
1. No resolution (baseline scenario)	Bank γ: high NPLsBank δ: moderate NPLs Bank τ: no NPLs	n/a
2. Bailout (nationalization of Bank γ)	Bank γ: high NPLs – intervened Bank δ: moderate NPLs Bank τ: no NPLs	- the government increases household tax to finance the bank resolution in the form of a capital injection into Bank γ- this, in effect, decreases household loan demand and deposit supply functions: $a_{\alpha,\beta,\theta}$: ↓15%$z_{b,1}$: ↓15% - the resolution involves recapitalization of Bank γ through capital injection: e_t^{γ} : ↑15%
3. Bank sale (merger between Bank γ and Bank τ)	Bank γ: high NPLs – intervened Bank δ: moderate NPLs Bank τ: no NPLs – intervened	- the government assists in a merger of Bank γ with Bank τ - all of Bank γ's balance sheet is combined with the balance sheet of Bank τ, and reported under Bank τ - there are two possible options for the government to complete the bank sale resolution: (i). to assist in the merger without any capital injection (Merger 1); (ii). to assist in the merger with an instant capital injection (Merger 2) - if the latter option is chosen, the government increases household tax to finance the recapitalization of Bank τ through: e_t^{τ} : ↑15%- this, in effect, decreases household loan demand and deposit supply functions: $a_{\alpha,\beta,\theta}$: ↓15%$z_{b,1}$: ↓15%
4. "Bad-bank" (Bank γ)	Bank γ: high NPLs – intervened Bank δ: moderate NPLs Bank τ: no NPLs – intervened	- the government assists in restructuring the balance sheet of the "bad" bank (i.e., Bank γ) by shifting all of its healthy assets to Bank τ ("good bank") excluding the capital of Bank γ- the government gradually (Bad bank 1) or instantly (Bad bank 2) injects capital to Bankγ: e_t^{γ} : ↑15% - this capital injection is financed by taxpayer money which, in effect, gradually (Bad bank 1) or instantly (Bad bank 2) decreases household loan demand and deposit supply functions: $a_{\alpha,\beta,\theta}$: ↓15%$z_{b,1}$: ↓15%

Source: Authors' calculations (2023).

[4] Bhattacharya et al. (2003) showed that restricted participation in the loan market can also arise as an equilibrium outcome given that the objective functions of banks also include a relative performance criterion, i.e., a preference to outperform their competitors.

[5] The banks in the model endogenize their decisions in the loan, deposit and interbank markets. This means that they take interest rates as exogenously given when making their optimal portfolio decisions.

thus contributing to the manager's shorter-term incentives. Although the same logic is unlikely to be fully applicable to all forms of bank behaviour, it can still be argued that these are likely to be maximized over a finite period.

Table 1 shows the setup of the application exercise.

Banks are endowed with some capital in the initial period. In the next period, the systemic banking crisis occurs resulting in distress in the banking sector. Since some banks are more affected by the crisis than others, our model assumes the heterogeneity between the level of NPLs among banks, i.e., high, medium, and low levels of NPLs. We assume that the distressed banks need to be rescued through recapitalization because otherwise, they would default. Widespread bank default caused by high NPLs eventually impairs markets. A systemic crisis in the context of this model can be interpreted as a case of equilibrium non-existence, in which default emerges naturally as an equilibrium phenomenon. However, the presence of default in the economy, also compatible with the orderly function of the markets, justifies the role of policy intervention. We define this economic conjuncture as financial fragility. Policy interventions are, thus, assumed to resolve financial fragility and improve economic welfare. Our equilibrium is consistent with the defining properties of competitive equilibrium with rational expectations, agent optimization, and market clearing.[6]

We assume that government injects additional capital (i.e., $e_t^{\gamma}\uparrow 15\%$) that is financed through household taxation, while at the same time, one of the policy interventions is applied. The fixed equity rate of 15% is used under each intervention for the sake of consistency.

More importantly, the model captures the different scales of banks' recapitalization by the government. For example, in the "bad-bank" approach, Bank γ can be recapitalized by the government either gradually ("Bad Bank 1″) or instantly ("Bad Bank 2″). Under the merger resolution, Bank τ instantly receives the capital injection ("Merger 2″). We also consider a case of the merger without capital injection ("Merger 1″). The model assumes that the government bailouts the distressed bank (s) without any specific resolution action (Nationalization).

We adopt the model to allow for the policy intervention to be funded by general tax revenues coming from household agents. Agents α, β, and θ borrow from banks γ, δ and τ, respectively, based on their demand for consumer loans. Each household borrower, $h^b = \{\alpha^{\gamma}, \beta^{\delta}, \theta^{\tau}\}$, demands consumer loans from his nature selected bank and chooses whether to default on his loans in state s ∈ S. The remaining agent, ϕ, supplies his deposits to each bank b.

Because of the limited participation assumption in every consumer loan market, each household's demand for loans is a negative function of the lending rate offered by his nature selected bank. His demand for loans also depends positively on the expected GDP in the subsequent period. Thus, we implicitly assume that household borrowers rationally anticipate GDP in both states of the next period, which then determines their expected future income, and adjust their loan demand in the initial period accordingly to smooth their consumption over time. The money demand function manifests the standard Hicksian elements whereby it responds positively to current and expected income and negatively to interest rates. As in Goodhart et al. (2005), we introduce a linear time trend in each household borrower's loan demand function to improve the empirical fit (i.e., *trend*). Lastly, we add the amount of taxation into the equation to represent an increase in tax caused by the policy intervention to rescue banks (i.e. *TAX*). This is assumed to decrease households' demand for loans. In particular, household h^b's loan demand from his nature selected bank b which under government intervention, $\forall h^b \in H^b$, and b ∈ B is as follows:

$$\ln\left(\mu^{h^b}\right) = a_{h^b,1} + a_{h^b,2}trend - a_{h^b,3}TAX + a_{h^b,4}\ln\left[p\left(GDP_{t+1,i}\right) + (1-p)GDP_{t+1,ii}\right] + a_{h^b,5r^b} \tag{1}$$

where,

$\mu^{h^b} \equiv$ amount of money that agent $h^b \in H^b$ chooses to owe in the loan market of bank b ∈ B in period t,

$GDP_{t+1,s} \equiv$ Gross Domestic Product in period t + 1 if state s ∈ S occurs.

Unlike the loan markets, we do not assume limited participation in the deposit markets. This implies that ϕ can choose to diversify his deposits with every bank. Thus, ϕ's deposit supply with bank b depends not only on the deposit rate offered by b but also on the rates offered by the other banks. Moreover, since banks can default on their deposit obligations, the expected rate of return on deposit investment of ϕ with each bank must be adjusted appropriately for each bank's corresponding expected default rate. Next, ϕ's deposit supply is a positive function of the expected GDP. Finally, the agent ϕ's deposit supply function is reduced by the amount of tax paid to the government to finance the intervention in the banking sector. In symbols, ϕ's deposit supply function with bank b is as follows:

$$\ln\left(d_b^{\phi}\right) = z_{b,1} + b_{b,2}\ln\left[p(GDP_i) + (1-p)GDP_{ii}\right] + z_{b,3}\left[r_d^b\left(pv_i^b\right)\right] + z_{b,4}\sum_{\dot{b}\neq b\in B}\left[r_d^{\dot{b}}\left(pv_i^{\dot{b}} + (1-p)v_{ii}^{\dot{b}}\right]\right] + z_{b,5}TAX \tag{2}$$

where,

$d_b^{\phi} \equiv$ the amount of money that agent ϕ chooses to deposit with bank $b \in B$..

Finally, the model treats the bank capital as an exogenous variable at the ex-ante stage and as endogenous in the subsequent period, i.e., in the period $t+1$. This allows us to test fully the impact of the undertaken resolution mechanisms on banks' distress during the systemic event. However, the model does not consider the lag between the timing of the resolution and the timing at which the impact of such a resolution can be objectively measured. Thus, the model is of best use as a framework to analyse the effect of resolution and bank recapitalizations (here carried out by the government) on banks' recovery and systemic risk and only provides some limited insights into the potential long-term impact of policy interventions on banking sector recovery.

3.3. Model Application

We apply the model using data from the annual accounts of UK banks as used by Goodhart . et al. (2006b)[7] In this comparative static exercise, we categorize the levels of banks' NPLs in the initial period to study the contagious effects between banks and the subsequent impact of the policy interventions on banks' recovery. We, thus, assign Bank γ as a distressed bank with high NPLs, Bank δ as a bank with a moderate stock of NPLs and Bank τ as an example of a healthy bank. Since the 2007–08 financial crisis, NPLs are in the spotlight for both regulators and banks as they have been linked to bank failures and are often the harbingers of a banking crisis (Ghosh, 2015). The deterioration of banks' asset quality by high NPLs is not only financially destabilizing for the banking system, but may also reduce economic efficiency, impair social welfare and decrease economic activity (see Barseghyan, 2010; Gonzales-Hermosillo, 1999; Zeng, 2012; Homar and van Wijnbergen, 2017).

[6] General existence arguments are provided in Goodhart et al. (2006a) and Tsomocos (2003).

[7] In Goodhart et al. (2006b), the seven largest UK banks are assumed to represent the British banking sector. They are measured in terms of their total assets as at the end of 2003 (Abbey National, Barclays, HBOS, HSBC, Lloyds, Royal Bank of Scotland, and Standard Chartered) and other major banks which have either been merged with or acquired by these seven banks over the sample period (NatWest, Bank of Scotland, and Halifax). Their real balance sheet data is used in the application exercise.

Table 2
Summary of the directional changes in the main endogenous variables in the applied model under each resolution scenario.

Endogenous variable	Bank γ (high NPL)	Bank δ (moderate NPL)	Bank τ (no NPL)
Repayment rate in state $i(v_i^b)$	No resolution: -Nationalization: + ~Merger 1: n/aMerger 2: n/aBad bank 1: +Bad bank 2: -~	No resolution: -~Nationalization: -Merger 1: -~Merger 2: -~Bad bank 1: -Bad bank 2: 0	No resolution: -~Nationalization: + ~Merger 1: + ~Merger 2: -~Bad bank 1: -~Bad bank 2: + ~
Repayment rate in state $ii(v_{ii}^b)$	No resolution: -~Nationalization: -~Merger 1: n/aMerger 2: n/aBad bank 1: +Bad bank 2: -~	No resolution: -~Nationalization: -Merger 1: -~Merger 2: +Bad bank 1: +Bad bank 2: 0	No resolution: -~Nationalization: -Merger 1: -~Merger 2: +Bad bank 1: +Bad bank 2: -~
Credit in the loan market $(\overline{m}_t^b)$	No resolution: -~Nationalization: -~ Merger 1: n/aMerger 2: n/aBad bank 1: +Bad bank 2: -~	No resolution: -~Nationalization: + ~Merger 1: -~Merger 2: +Bad bank 1: +Bad bank 2: 0	No resolution: -~Nationalization: + ~Merger 1: -~Merger 2: +Bad bank 1: +Bad bank 2: -~
Capital in state $i(e_i^b)$	No resolution: + ~Nationalization: + ~Merger 1: n/aMerger 2: n/aBad bank 1: +Bad bank 2: + ~	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: -~Bad bank 1: -Bad bank 2: 0	No resolution: + ~Nationalization: -~Merger 1: 0Merger 2: +Bad bank 1: -Bad bank 2: 0
Capital in state $ii(e_{ii}^b)$	No resolution: + ~Nationalization: + ~Merger 1: n/aMerger 2: n/aBad bank 1: +Bad bank 2: + ~	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: -~Bad bank 1: -Bad bank 2: 0	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: +Bad bank 1: -Bad bank 2: 0
Profit in state $i(p_i^b)$	No resolution: -~Nationalization: -~Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: + ~	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: -~Bad bank 1: -Bad bank 2: 0	No resolution: -~Nationalization: -~Merger 1: + ~Merger 2: -~Bad bank 1: -Bad bank 2: 0
Profit in state $ii(p_{ii}^b)$	No resolution: -~Nationalization: -~Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: + ~	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: -~Bad bank 1: -Bad bank 2: 0	No resolution: + ~Nationalization: -~Merger 1: -~Merger 2: -~Bad bank 1: -Bad bank 2: 0
Debt in interbank market $(\mu_{d,t}^b)$	No resolution: + ~Nationalization: -~Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: 0	No resolution: +Nationalization: -Merger 1: + ~Merger 2: -Bad bank 1: -Bad bank 2: 0	No resolution: -~Nationalization: -Merger 1: -~Merger 2: -Bad bank 1: -Bad bank 2: 0
CAR in state i(k_i^b)	No resolution: + ~Nationalization: + ~Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: + ~	No resolution: +Nationalization: -~Merger 1: + ~Merger 2: -Bad bank 1: -Bad bank 2: 0	No resolution: + ~Nationalization: -~Merger 1: + ~Merger 2: -Bad bank 1: -Bad bank 2: -~
CAR in state ii(k_{ii}^b)	No resolution: + ~Nationalization: + ~Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: + ~	No resolution: +Nationalization: -Merger 1: + ~Merger 2: -Bad bank 1: -Bad bank 2: 0	No resolution: + ~Nationalization: -Merger 1: + ~Merger 2: -Bad bank 1: -Bad bank 2: -~
Lending rate (r^b)	No resolution: + ~Nationalization: + ~ Merger 1: n/aMerger 2: n/aBad bank 1: -Bad bank 2: 0	No resolution: -Nationalization: -~Merger 1: +Merger 2: -Bad bank 1: -Bad bank 2: -~	No resolution: + ~Nationalization: -~Merger 1: +Merger 2: -Bad bank 1: -Bad bank 2: 0
Deposit rate (r_d^b)	No resolution: 0Nationalization: 0Merger 1: n/aMerger 2: n/aBad bank 1: 0Bad bank 2: 0	No resolution: -Nationalization: -~Merger 1: +Merger 2: -Bad bank 1: + ~Bad bank 2: + ~	No resolution: 0Nationalization: 0Merger 1: 0Merger 2: 0Bad bank 1: 0Bad bank 2: 0

Note: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change
Source: Authors' calculations (2023).

Our application procedure follows the following steps. In each period t, excluding the Lagrange multipliers, we have a system of 56 equations in 143 unknown variables, of which 87 are exogenous. This implies that there are 87 variables whose values must be chosen to obtain the numerical solution to the model. We select initial outputs that are not too far from the observed values in a reality. Moreover, we ensure that the equilibrium values of all the repayment rates are consistent with real data. Also, the interbank interest rate is lower than both the interest rates charged by both banks since interbank loans are assumed to be default free and thus do not include a default premium. Finally, the deposit rate of the bank γ is higher than that of the bank δ and the private agent φ chooses bank γ to deposit. These initial equilibrium values and exogenous parameter values, as well as the small size of perturbations of the initial equilibrium, ensure the stability of the overall model solution and preserve its solvability. In addition, we can perform our comparative statics policy exercises around the initial equilibrium. Technical Annex 2 includes the values of the exogenous variables and the resulting initial equilibrium under the baseline scenario.

We use these results to derive directional responses of the endogenous variables of our interest to simulate shocks to the economy triggered by the policy interventions. Technical Annex 3 includes the details on the directional changes in those endogenous variables. A comparative analysis is carried out by adjusting the exogenous variables to fully capture the policy intervention dynamics. We then assess how the equilibrium is impacted by these series of changes. The results shed some light on the channels through which different resolution mechanisms influence bank rescue in the event of a systemic crisis.

3.4. Model results

Table 2 reports the summary of the results of the calibration exercise.

Firstly, the "*no policy intervention*" scenario appears to be the worst possible option under which the systemic effect is still at play. This option delivers negative results for almost all endogenous variables in both states of nature. This is particularly evident through the repayment rates, which are decreasing in all subsequent periods, but also in the lending rates, which, consequently rise. Both banks' profitability and credit activity are negatively affected. Those results apply to both healthy (i.e., Bank τ – no NPL) and unhealthy banks (i.e., Banksγ, δ – high, moderate NPLs), which demonstrates that the "*no policy intervention*" scenario spreads the contagion effect from distressed into healthy banks and, thus, worsen the systemic effect of a crisis. We only notice a slightly positive effect of time on the capital ratio, which could be a result of a potential shareholder intervention. Those findings call for a need for a profound restructuring process to rescue distressed banks and unlock the banking sector recovery. This echoes other academic studies, which also called for the necessity of different resolution actions to limit the contagion effect of the crisis and restore banks' health (Homar and van Wijnbergen, 2017).

Secondly, the analysis of the effect of different forms of bank policy interventions shows that there is significant heterogeneity in their impact on the banks' health. Bailouts (nationalization) deliver the least favourable results. Despite capital improvement, banks experience decreasing repayment rates under nationalization. This is noticeable for all groups of banks (i.e., with different levels of NPLs). Such results indicate that in the event of a systemic banking crisis, pure recapitalization is not sufficient to rescue distressed banks. The negative profitability and limited credit activity are also observable at the most distressed banks (i.e., with the highest NPLs), however, a decreasing trend in banks' capital level is observable at two healthier groups of banks with lower levels of NPLs. Thus, nationalization may induce zombie lending, in line with the current literature. It thus calls for deep restructuring measures that are necessary to restore banks' financial health and to reduce risky lending behaviour (e.g., see Landier and Ueda, 2009; Acharya et al., 2021).

Moreover, the bailout result on banks with the highest level of NPLs indicates that a lack of deep restructuring procedures prevents them from any credit activity, thus depressing their financial health even further (i.e., low profitability, and lower repayment rates). Overall, although bailouts could help to limit the systemic effect at less distressed banks, they are not effective in the context of the most distressed banks. This is indicated by the decreasing lending rate in the former group; however, an opposite trend is observable in the latter.

The results of the "bad banks" intervention are more promising. A

Table 3
Descriptive statistics at the country level following IMF economy grouping for advanced economies.

Country	Year of the systemic crisis	Currency crisis (Yes =1, No = 0)	Number of non-intervened banks	Number of intervened banks	Number of bailouts (nationalization)	Number of mergers	Number of "bad-bank" cases
Austria	2008	0	19	8	2	0	2
Belgium	2008	0	11	4	3	1	0
Czech Rep.	1996	0	14	1	0	1	0
Denmark	2008	0	17	6	2	6	2
Estonia	1992	1	4	4	0	4	4
Finland	1991	0	1	1	1	0	1
France	2008	0	60	6	5	0	0
Germany	2008	0	40	14	3	0	5
Greece	2008	0	5	4	4	0	0
Iceland	2008	1	2	2	2	0	1
Ireland	2008	0	5	4	4	0	2
Japan	1997	0	6	11	2	8	9
Lithuania	1995	0	6	4	2	1	2
Netherlands	2008	0	9	4	4	0	0
Norway	1991	0	10	5	2	0	4
S Korea	1997	1	7	6	2	4	2
Slovenia	2008	0	1	5	0	0	3
Spain	2008	0	14	12	3	10	8
Sweden	1991	1	6	2	1	2	2
Switzerland	2008	0	36	2	2	0	0
UK	2007	0	22	14	9	3	3
USA	2007	0	267	6	6	0	4
Total	**-**	**4**	**562**	**149**	**55**	**40**	**54**

Notes: Data on the dates of systemic banking crises come from Laeven and Valencia (2018). The data on intervened banks in individual countries and their type of government resolution mechanism come from the extended database of Hryckiewicz (2014). It is constructed based on the information from central banks' reports and surveys conducted among the central banks.
Source: Authors' calculations (2023).

significant improvement of banks' health at the most distressed banks is observed, i.e., banks with the highest level of NPLs reflected in higher capital levels in both states of nature as well as in the increasing repayment rates in the state *i*. Also, a significant improvement in banks' profitability and capital ratios in the "Bad Bank 2″ occurs (i.e., banks with constant capital injections). Moreover, bad bank resolution can also contribute to higher credit activity. "Bad bank 1″ positively affects the volume of granted loans, and, at the same time, increases repayment rates in the second period (although under the first period, the effect is negative).

The scale of bad bank policy intervention can impact credit market activity. If the "bad bank" is associated with constant capital injections, repayment rates decline in the second period, which could result in the moral hazard behaviour of banks. Despite the better performance of those banks, they engage less in the credit market activity than under the "Bad bank 1″ scenario with instant capital injection. This might be because of some inefficiencies associated with the policy intervention. Lastly, a positive effect of the bad-bank intervention on declining lending rates might be an indication of a decreasing systemic effect associated with the restructuring of the bank's distress.

Finally, the effect of merger resolution also provides interesting insight into the channels of a bank rescue. A positive effect of "Merger 2″ (instant capital injection) on the loan market and repayment rates in state ii (despite negative rates in state i) is observed, which proves the success of this mechanism on bank health. We do not, however, notice the same effect with "Merger 1″ (no government capital injection). Despite higher capital indicators of the affected banks, these institutions appear to suffer from significant recapitalization, which might deepen their distressed position. Those banks appear to suffer from weak credit activity and/or potentially engage in zombie lending. This is shown in the low repayment rates in both states of nature. As a result, we find that banks after "Merger 2″ experience declining lending rates, while banks under "Merger 1″ experience the opposite. This could indicate that government can play an important role in the successful implementation of the merger by cleaning up banks' distress, for example, by guaranteeing the potential future losses and bringing the healthy bank back on the market.

In sum, the model calibration exercise points toward the channels through which the bank policy intervention mechanisms may affect the recovery of the distressed banking sector, and thus reduce the systemic effect during the crisis. In general, we find that the lack of any policy intervention during the systemic banking crisis can deepen banking sector distress, which then leads to the spread of the systemic effect between banks. Moreover, our results also document that bailouts are also not successful to counteract the most severe financial crises. "Bad bank" can deliver the most effective channels in a bank rescue. Due to a profound restructuring of the distressed bank's portfolio, the bank's health improves, and so the systemic effect of a crisis diminishes. This mechanism is also positively associated with the bank's recovery in the credit market at least in the initial period. These channeling effects, however, work only when the government does not significantly intervene in this mechanism, for example, through the provision of a constant bank recapitalization. In such cases, the effectiveness of these mechanisms depreciates. In turn, mergers seem to positively react to government support. This is because the government's role is limited to the guarantees and often to the takeover of a distressed bank portfolio. Such a successful restructuring positively affects the bank rescue as well as the overall health of the banking sector.

4. Empirical Analysis

In this section, we empirically assess the impact of different policy interventions on the recovery of distressed banks as well as a wider systemic risk by looking at a granular bank-level dataset from 22 advanced economies over the period of 1992–2017. The data allows us to assess the effectiveness of the policy interventions on a large sample of banks and countries using the difference-in-difference methodology.

4.1. Data

To test the effectiveness of the policy interventions on bank recovery, we use a sample of banks from 22 countries, which experienced episodes of the systemic banking crisis between 1992 and 2017. We rely on Laeven and Valencia's (2018) mapping of the systemic banking crises.

We combine the country-level data with an extended version of the bank-level database of Hryckiewicz (2014). Hryckiewicz (2014) derived the bank names and their associated policy interventions from national banks' reports and a survey conducted among central banks. This included 42 nationalized banks, 46 merged banks, and 62 banks that were subject to "bad-bank". Those came from 25 countries, of which only 9 were advanced economies.[8] In our paper, we expand the database to cover a wider range of advanced economies. We increase the bank policy intervention coverage in advanced countries to 55 nationalized banks (from 14), 40 merged banks (from 22) and 54 banks (from 25) that were subject to "bad-bank" (see Table 3). Similarly to Hryckiewicz (2014), we exclude data from countries in which financial crises occurred before 1992 due to the unavailability of bank-level data.

Our initial sample consisted of 149 intervened and 4881 non-intervened banks. Since the intervention decision is determined by multiple factors some of which relate to the bank's market position and bank characteristics, comparing the intervened to non-intervened banks might deliver biased results. Thus, we restrict our control sample of non-intervened banks to banks with the same specializations and similar asset sizes as the banks in intervened group. It follows an approach of matching the intervened banks with their non-intervened peers used by Hryckiewicz (2014).[9] The outcome of the peer matching process delivers 633 non-intervened banks. We reduce the time series of our sample in regressions to cover the six years before and after the year in which the given resolution mechanism was introduced. However, in the robustness check, we also test our model using the four-year period. Our dataset results in a final sample of 562 peer banks in our unbalanced panel dataset. Table 3 presents the overview of our sample.

The most common policy intervention in our sample is a bailout (nationalization), closely followed by a "bad bank" approach. This is largely an outcome of the global financial crisis of 2008 that caused a peak in bailouts, particularly in the UK and USA.

Bailout banks were in the vast majority exposed to a range of other interventions such as the use of asset guarantees, introduction of a guarantee on liabilities, liquidity injections, recapitalization, asset relief as well as the policy interventions of mergers and bad banks. Only two banks in the sample were subject only to the bailout mechanism (located in Belgium and Netherlands, respectively). Similarly, "bad-bank" policy intervention was associated with other interventions in all cases. We control for those bank-related institutional settings in the regressions. We do that by introducing a dummy that indicates if the bank was subject to other interventions and interacting it with the key variables of interest to see if the results change.

We select a wide range of bank-level variables to empirically assess the impact of resolutions on banks' performance, activity, and more importantly systemic risk. We control for the set of different factors that

Table 4
Variables – definitions and sources.

Variable	Definition	Source
Bank-level variables:		
Loan ratio (Loans/ Total Assets)	The ratio of net loans to total assets refers to loans and finance leases, net of loan-loss reserves, as a percent of total assets. Total assets includes all assets (current and long-term) as of the date indicated, as carried on the balance sheet.	S&P Global Market Intelligence, BankFocus/ BankScope
Loan growth	The ratio of loan growth refers to a simple growth in gross loans over one year. Gross loans values advanced to a borrower, to be repaid at a later date, usually with interest. The loans are usually classified as property loans, residential and commercial, home improvement loans, construction loans.	S&P Global Market Intelligence, BankFocus/ BankScope
Reserves / NPLs	Loan loss reserves as a percent of problem loans. Loan loss reserves includes reserves, both general and specific, for losses on loans and finance leases only, they do not include reserves for operating leases, real estate owned or other investments. Problem loans refer to nonperforming loans as reported by the company or, where not available, calculated as the sum of loans classified as substandard, doubtful and loss. For U.S. companies, nonperforming loans is the sum of non-accruing and renegotiated loans.	S&P Global Market Intelligence, BankFocus/ BankScope
Bank profitability (ROAE)	Return on average equity is a measure of the return on shareholder funds (%). It refers to the performance of a company over a financial year. This ratio is an adjusted version of the return of equity that measures the profitability of a company.	S&P Global Market Intelligence, BankFocus/ BankScope
Bank liquidity (Liquid Assets / Total Deposits & Borrowings)	The ratio of the value of liquid assets (easily converted to cash) to total deposits and borrowings. Liquid assets is the sum of cash and cash equivalents, including bank loans, securities held for trading, securities held at fair value and securities available for sale. Total deposits include all domestic and foreign deposits from customers, interest bearing as well as non-interest bearing, in a bank.	S&P Global Market Intelligence, BankFocus/ BankScope
Bank size (Total Assets)	Total assets (in mln USD) expressed in logarithmic form. It includes all assets (current and long-term) as of the date indicated, as carried on the balance sheet.	S&P Global Market Intelligence, BankFocus/ BankScope
Total Capital Ratio	Total capital ratio as defined by the latest regulatory and supervisory guidelines. For U.S. institutions, this will be transitional when applicable, and the lesser of the standardized and advanced	S&P Global Market Intelligence, BankFocus/ BankScope

(*continued on next page*)

[8] This includes Croatia, Czech Republic, Estonia, Finland, Japan, South Korea, Lithuania, Norway, Sweden.

[9] We begin with the bank selection based on the overlap of the lending activities, i.e., loan-to-total asset ratio of the non-intervened banks falling within the range of loan-to-total asset ratio of the intervened banks as at the year in which the given resolution mechanism was introduced. This stage of selection delivers 677 peer banks. Next, we replicate the process, but this time based on the total asset figures, which results in the selection of 749 peer banks. Following the approach frequently used in micro banking studies, we apply several screens to exclude implausible and unreliable observations. This involves a clean-up process of both selected and non-selected peer banks in order to ensure that the final peer selection is well matched with the characteristics of the intervened banks. For instance, we look only for the banks that are deposit takers which characterizes our intervened banks. We exclude bank observations with (i) negative or missing values for total assets, (ii) negative total loans, (iii) loan-to-asset ratio larger than one, or (iv) capital-to-asset ratio larger than one. The final outcome delivers 633 peer banks. We also repeat the matching process using alternative techniques under robustness checks such as propensity score matching techniques, which delivered similar results.

Table 4 (*continued*)

Variable	Definition	Source
	approaches. For non-U.S. institutions, this may be transitional or fully loaded, depending on availability.	
Total equity / Total Assets	The ratio measures the amount of protection afforded by the bank by the equity they invested in. Total equity is defined as under the indicated accounting principles. Includes par value, paid in capital, retained earnings, and other adjustments to equity. Total assets include all assets (current and long-term) as of the date indicated, as carried on the balance sheet	S&P Global Market Intelligence, BankFocus/ BankScope
Loan Loss Reserves / Gross Loans	Loan loss reserves as a percent of gross loans. Loan loss reserves includes reserves, both general and specific, for losses on loans and finance leases only, they do not include reserves for operating leases, real estate owned or other investments. Gross loans values advanced to a borrower, to be repaid at a later date, usually with interest. The loans are usually classified as property loans, residential and commercial, home improvement loans, construction loans.	S&P Global Market Intelligence, BankFocus/ BankScope
Net Interest Margin	The difference between the interest income generated by banks and the amount of interest paid out to their lenders, relative to the amount of their assets (%).	S&P Global Market Intelligence, BankFocus/ BankScope
Credit Default Swaps (CDSs)	A financial derivative or contract that allows an investor to "swap" or offset his or her credit risk with that of another investor. Defined as at closing mid-price for senior debt at 3-year tenor. Collected at par spread as at the end of the period.	S&P Global Market Intelligence
Intervention dummy	Dummy equals to 1 if a bank has received any of the following government interventions: bailout (nationalisation), sale of a bank (merger), 'bad' bank. Dummy equals to 0 for all the other banks.	National central banks
Bailout dummy	Dummy equals to 1 if a bank was nationalised, i.e. subject to a public financial support in exchange for ownership. Dummy equals to 0 for all the other banks.	National central banks
Government-assisted merger dummy	Dummy equals to 1 if a bank has been taken over by another bank with help of a government. Dummy equals to 0 for all the other banks.	National central banks
'Bad-bank' dummy	Dummy equals to 1 if a bank was subject to a restructuring process in the form of a separate entity to transfer to its toxic assets. Dummy equals to 0 for all the other banks.	National central banks
Industry-level variables:		
Concentration ratio	The assets of three largest banks as a share of assets of all banks in the economy (%)	World Bank Financial Structure Database (July 2018)
Bank deposits to GDP	Demand, time and saving deposits in deposit money banks as a share of GDP (%)	World Bank Financial Structure Database (July 2018)
Country-level variables:		
GDP growth rate	Annual percentage growth of rate of GDP at market prices based on constant local currency (annual)	World Bank Development Indicators (2022)
Inflation	Annual percentage change in consumer price index (annual), in logarithms	IMF (2022)
Current account balance	The sum of net exports of goods and services, net primary income, and net secondary income expressed as a ratio of GDP (%)	IMF (2022)
Debt to GDP ratio	The ratio between a country's government debt and its gross domestic product.	IMF (2022)
Currency crisis	Dummy = 1 indicating the currency crisis occurring in the same year as systemic banking crisis	Laeven and Valencia (2018)
Business extent of disclosure index	Disclosure index measures the extent to which investors are protected through disclosure of ownership and financial information. The index ranges from 0 to 10, with higher values indicating more disclosure.	World Bank, Doing Business project (2019)
Legal origin	Classification of legal origin following La Porta et al. (1999): French, German, Scandinavian, British, Socialist	La Porta et al. (1999)

Source: Authors (2023).

may influence the results. Table 4 lists the variables used in our analysis. Specifically, we control for the bank's profitability (return on average equity, ROAE), liquidity (ratio of liquid assets to total deposits and borrowings, LATDB), and bank size (total asset, TA). We expect that the effect of policy interventions may vary among those variables. Scholars find that a bank's size and strength can impact a bank's activity and distress (e.g., see Berger and Roman, 2020).

We explore four main dependent variables to assess the impact of the intervention channels on bank recovery. We use loan ratio and loan growth as proxies for bank lending. We proxy the level of the restructuring process by using the ratio of loan loss reserves/NPLs (reserves/ NPLs). To control for any non-linear effects in our regressions and to reduce any bias from outliers, we transform the ratio to its logarithmic form and truncate it at the 1st and 99th percentiles. Although this paper is looking into bank performance during periods of financial instability, and, thus, keeping those outliers could have been desirable, the view that some of them may be caused by one-off events or data errors is applied.[10] Finally, we also test the effect of different policy interventions on the total capital ratio. We then test alternatives, namely total equity to total assets ratio under the robustness checks. We expect the effect of policy interventions on bank recovery through the level of restructuring, bank's performance and activity to differ among various policy mechanisms.

We also test the effect of bank policy interventions on the level of systemic risk. The empirical literature comes with distinct measures of

[10] We investigate the results with all observations under the loan loss reserves/NPLs under the robustness checks and find no significant difference in our reported results.

Table 5
Descriptive statistics of bank characteristics.

	Non-intervened banks (1)		Intervened banks (2)		Intervened – non-intervened banks (3)	
	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
(1) Before the introduction of the resolution mechanism (six years)						
Reserves/NPLs	210.189	200.005	72.250	89.848	-137.939 * **	7.257
Total capital ratio	17.327	16.661	11.344	6.156	-5.983 * **	0.497
Loan ratio	57.847	14.971	59.478	16.677	1.631 * *	0.936
Loan growth	1.737	15.161	1.690	11.827	-0.047 *	0.779
Bank profitability (ROAE)	10.047	23.838	8.334	80.813	-1.714 *	3.675
TA (ln)	7.4135	2.377	10.0318	2.634	2.618 * **	0.121
Liquidity	37.520	23.119	35.069	24.046	-2.450 * *	1.285
(2) After the introduction of the resolution mechanism (six years)						
Reserves/NPLs	95.852	111.541	75.158	63.099	-20.694 * **	3.079
Total capital ratio	16.618	10.286	11.313	18.976	-5.305 * **	0.808
Loan ratio	59.819	15.858	55.222	18.161	-4.597 * **	0.796
Loan growth	0.820	11.927	33.306	563.672	32.485 * *	23.842
Bank profitability (ROAE)	5.721	39.464	-2.374	114.354	-8.095 * *	3.872
TA (ln)	8.106	2.442	10.175	2.780	2.068 * **	0.099
Liquidity	35.965	24.635	33.440	27.461	-2.524 * *	1.070
(3) Difference between "after" and "before" introduction of resolution mechanisms						
Reserves/NPLs	-114.336 * **	5.435	2.909 * **	5.710	117.246 * **	4.790
Total capital	-0.709 * **	0.405	-0.031 * **	0.858	0.678 * **	0.375
Loan ratio	1.972 * **	0.442	-4.257 * **	1.146	-6.229 * **	0.415
Loan growth	-0.917 * **	0.423	31.616 * **	23.850	32.533 * **	3.787
Bank profitability (ROAE)	-4.327 * **	0.818	-10.708 * **	5.275	-6.381 * **	1.191
TA (ln)	0.693 * **	0.062	0.143 * **	0.143	-0.550 * **	0.061
Liquidity	-1.556 * **	0.666	-1.629 * **	1.534	-0.074 * **	0.612
No. of banks	562		149			
Total no. of obs.	4831		1567		-	-

Notes: this table shows the mean and standard deviation of bank characteristics used in our analysis. Each statistic is differentiated by the period before and after the implementation of the resolution mechanism for a given bank (dimension 1) and whether the bank was intervened (dimension 2). Differences are calculated across both dimensions. Differences-in-differences based on t-tests are shown in the bottom right corner.
* Standard deviations are shown in the respective column, with significance at 10%
* * Standard deviations are shown in the respective column, with significance at 5%
* ** Standard deviations are shown in the respective column, with significance at 1%.
Source: Authors' calculations (2023).

systemic risk. For example, Beck et al. (2021) use the conditional value at risk (ΔCoVaR) developed and described by Adrian and Brunnermeier (2016). It assesses the contribution of a bank *i* to the overall distress of the financial system. It is calculated as a difference between the value at risk (VaR) of the financial system conditional on a particular institution experiencing extreme losses and the value at risk of the financial system conditional on the same institution's asset returns being at their median level. Brownlees and Engle (2017) develop the SRISK measure, which has also been widely used in the academic literature. Its value represents the capital shortfall of a bank *i* conditional on a severe market decline which might occur during a typical financial crisis. Huang et al. (2009) and Segoviano and Goodhart (2009), on the other hand, all use credit default swaps (CDSs) to look at how individual institutions contribute to the potential distress of the system within a multivariate setting. Similarly, Bellia et al. (2021) use CDS data from European banks to study the impact of regulatory and resolution reforms announcements and actions on limiting the value of implicit bank debt guarantees. Consequently, given our sample properties, we decided to follow the approach of the latter researchers.

In our paper, we decided to use bank credit default swaps (CDS) as a proxy for systemic risk. In contrary to many other studies, we are not interested in any capital shortfall caused by the distressing event. In turn, we are interested in the overall distress of the banking sector which can be captured by the CDSs. Since the banks operate in a network of interdependent organizations, the distress of one institution has an immediate effect on other banks (Elliott et al., 2017). Consequently, we are interested in how the policy interventions affect bank CDSs, and thus the systemic risk in the banking sector. Our data is available for 102 banks from six advanced economies (USA, UK, Switzerland, Netherlands, France, and Germany), in which 37 banks were subject to intervention. We look at the period from 2010 to 2017 in those regressions.

Table 5 presents descriptive statistics for key bank-level variables. The statistics are divided by intervened and non-intervened banks as well as by the period before and after the introduction of the specific bank policy intervention. We report the difference between intervened and non-intervened banks (under the final two columns) as well as the difference between the periods before and after the intervention (under the third sub-section).

The intervened banks are, on average, less capitalized than their non-intervened counterparts before the introduction of the policy measure. Interestingly though, the intervened banks have lower loan growth than non-intervened banks before the intervention, however, they increase their loan growth significantly after the intervention. This might suggest that overall policy interventions are effective in recovering banks' activity in the real economy. The data also suggest that non-intervened banks have a higher reserves/NPLs ratio than intervened banks both before and after the intervention, which calls for further analysis.

Finally, we also include several industry- and country-level controls in our regressions, e.g. banking industry concentration ratio, proxies for countries' macroeconomic conditions (GDP growth, inflation), and corporate governance proxies such as the business extent of disclosure index. Those are important to control due to the unobservable external forces that could influence the implementation as well as the effectiveness of resolution mechanisms. For instance, the quality of rule of law, legal frameworks, as well as the level of development of corporate governance in each country, can constrain the effectiveness of bank policy interventions. We also apply country-level fixed effects in our regressions. In addition, we also test the interaction of country and bank interaction with time-fixed effects as well as country and time-fixed effects under robustness checks confirming our main conclusions.

4.2. Empirical methodology

The key question is whether and which bank policy intervention can successfully contribute to the bank recovery, and, thus, could be effective in the reduction of the systemic effect of the crisis. To this extent, we apply the difference-in-difference (DID) methodology to evaluate the effect of various policy interventions on bank recovery. The conventional DID estimator requires that in the absence of the treatment, the average outcomes for the treatment and control groups would have followed parallel paths over time. This is a strong assumption that is likely to be implausible in our case, i.e., the pre-intervention bank characteristics that are thought to be associated with the dynamics of the chosen bank performance variables are likely to be unbalanced between treated and non-treated banks. The bank selection into treatment can also depend on covariates, which determine also the treatment (i.e., intervention) outcome. In these circumstances, conditional exogeneity is not plausible. Thus, we use a semiparametric DID estimator as introduced by Abadie (2005) that uses milder assumptions and thus provides more realistic counterfactual outcomes.

Specifically, Abadie (2005) proposed a two-stage semiparametric estimator with the so-called parallel trend assumption. In this framework, a propensity score is estimated in the first stage to explicitly account for any observed confounders that may affect both the treatment take-up by banks as well as the outcome trend. The Abadie estimator allows for the differences in the observed characteristics to create non-parallel paths between the treated and control group of banks. The model adopts a two-step strategy to estimate the average effect of the treatment (ATE) (i.e., policy intervention mechanism) for the treated (i.e., intervened banks). It delivers more credible estimates through control for any cases where the selection for treatment might be correlated with characteristics that affect the outcome variables, i.e., bank performance.

More formally, the model aims to estimate the causal effect of the policy mechanism on our four bank-level dependent variables (y) at time t, namely reserves/NPL ratio, total capital ratio, loan ratio, and loan growth. Each bank in the sample has two potential outcomes: (y_{1t}, y_{0t}). y_{1t} is the value of y if the bank is under a policy mechanism at time t. y_{0t} is the value of y had the bank not received the policy intervention at time t. d_t is equal to 1 when a bank is intervened by time t and 0 otherwise. At baseline b no bank is treated (i.e., intervened). x_b is a vector of covariates that is measured at the baseline. Thus, the model attempts to estimate the average treatment effect on the treated (ATET) (i.e., intervened) banks as follows:

$$ATET \equiv \mathbb{E}(y_{1t} - y_{0t} | d_t = 1) \tag{3}$$

However, because y_{0t} is unobserved for the treated banks, the ATET cannot be directly estimated. Thus, the model assumes y_{0b} is the value y at time $t = 0$ (i.e., baseline). x_b is a set of pre-treatment characteristics. Finally, $(y_t - y_b)$ is the change of y between time t and the baseline b, and $\pi(x_b) \equiv \mathbb{P}(d = 1 | x_b)$ is the conditional probability of being in the treatment group (i.e., propensity score). The propensity score is estimated using a linear polynomial function of order four, which delivers the best fit. Abadie (2005) shows that the sample analogue of

$$\mathbb{E}\left(\frac{y_t - y_b}{\mathrm{P}(d_t = 1)} * \frac{d - \pi(x_b)}{1 - \pi(x_b)}\right) \tag{4}$$

given an unbiased estimate of the ATET if the below Eqs. (3) and (4) hold.

$$\mathbb{E}(y_{0t} - y_{0b} | d_t = 1, x_b) = \mathbb{E}(y_{0t} - y_{0b} | d_t = 0, x_b) \tag{5}$$

$$\mathbb{P}(d_t = 1) > 0 and \quad \pi(x_b) < 1 \tag{6}$$

The estimator is a weighted average of the difference of trend - $(y_t - y_b)$ - across treatment groups. It proceeds by reweighing the trend for the untreated banks based on their propensity score $\pi(x_b)$. Because $\{\pi(x_b)\}/\{1 - \pi(x_b)\}$ is an increasing function of $\pi(x_b)$, untreated banks

Table 6
Effects of resolution mechanisms on the ex-post bank performance (ATET) –full sample of 22 advanced economies.

	Reserves/ NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit. (ROAE)	-0.0008	0.00949	-0.0106 * *	0.0142	0.00864	-0.0339 *	-0.0291	0.0908	-0.0991 *	0.0008	-0.073	0.00631
	(0.00384)	(0.0251)	(0.00427)	(0.0178)	(0.0486)	(0.0204)	(0.0361)	(0.301)	(0.0516)	(0.0281)	(0.154)	(0.0157)
Bank size (TA)	1.343 * **	0.588	0.600 * **	5.348 * **	3.943 * *	1.894 * **	11.67 * **	11.46	3.983 * *	0.0909	2.263	-0.681
	(0.122)	(0.458)	(0.129)	(0.594)	(1.639)	(0.589)	(1.753)	(7.452)	(1.653)	(0.549)	(2.007)	(0.702)
Bank liquidity (LATDB)	-0.00661	-0.13 * *	-0.0200	-0.0448 * *	-0.48 * **	-0.106 *	0.226 * **	-1.577 * *	0.0782	0.0119	0.442	0.0478
	(0.005)	(0.06)	(0.0130)	(0.0203)	(0.169)	(0.0611)	(0.0655)	(0.702)	(0.118)	(0.038)	(0.362)	(0.0581)
Constant	-16.5 * **	-2.723	-6.656 * **	-64.58 * **	-33.31	-20.07 * **	-165.0 * **	-87.74	-62.51 * **	-1.528	-43.72	2.115
	(1.507)	(7.046)	(1.577)	(7.333)	(20.55)	(6.905)	(20.55)	(101.5)	(19.43)	(6.199)	(36.62)	(6.752)
No. of banks	789	650	677	791	647	670	791	670	698	762	659	668
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023).

Table 7
Effects of resolution mechanisms on the ex-post bank performance (ATET) – sub-sample of 21 advanced economies (excl. USA).

	Reserves/ NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit. (ROAE)	-0.0011	0.00953	-0.00418	0.0130	0.00879	-0.00783	-0.0382	0.0947	-0.00651	0.0031	-0.073	0.0101
	(0.00456)	(0.0246)	(0.00482)	(0.0215)	(0.0470)	(0.0235)	(0.0405)	(0.317)	(0.0836)	(0.03)	(0.15)	(0.020)
Bank size (TA)	1.023 * **	0.431	-0.791 * **	4.356 * **	3.677 * *	-4.41 * **	8.736 * **	11.43	-13.90 * *	0.174	3.590	-1.166
	(0.149)	(0.619)	(0.286)	(0.802)	(1.762)	(1.252)	(2.305)	(9.160)	(6.211)	(0.687)	(3.35)	(1.417)
Bank liquidity (LATDB)	0.0035	-0.138 * *	-0.0590 * **	-0.000281	-0.50 * **	-0.26 * **	0.296 * **	-1.614 * *	-0.457 * *	0.0118	0.415	0.0335
	(0.00418)	(0.0539)	(0.0147)	(0.0187)	(0.160)	(0.0707)	(0.0651)	(0.646)	(0.182)	(0.04)	(0.33)	(0.062)
Constant	-13.4 * **	-0.679	9.724 * **	-56.23 * **	-29.39	52.27 * **	-137.0 * **	-85.92	151.8 * *	-2.266	-58.89	8.397
	(1.940)	(9.147)	(2.888)	(10.40)	(23.89)	(12.51)	(28.59)	(126.5)	(63.25)	(7.958)	(52.2)	(14.80)
No. of banks	550	461	480	552	464	475	548	448	481	552	456	459
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023).

Table 8
Effects of resolution mechanisms on the ex-post bank performance (ATET) – high NPL sub-sample (all 22 advanced economies).

	Reserves/NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	-0.001	0.008	-0.005	0.013	0.006	-0.009	-0.035	0.086	-0.034	0.003	-0.064	0.011
	-0.005	-0.021	-0.005	-0.021	-0.042	-0.026	-0.042	-0.302	-0.079	-0.028	-0.129	-0.021
Bank size (TA)	1.070 * **	0.422	-0.740 * **	4.621 * **	3.652 * *	-4.318 * **	9.394 * **	11.340	-12.3 * *	0.258	3.444	-1.142
	-0.152	-0.552	-0.274	-0.843	-1.656	-1.176	-2.475	-8.720	-5.671	-0.693	-2.973	-1.435
Bank liquidity (LATDB)	0.002	-0.13 * **	-0.0543 * **	-0.007	-0.48 * **	-0.253 * **	0.286 * **	-1.57 * *	-0.32 * *	0.012	0.398	0.044
	-0.004	-0.048	-0.015	-0.019	-0.152	-0.076	-0.066	-0.640	-0.146	-0.041	-0.293	-0.066
Constant	-13.85 * **	-0.792	8.846 * **	-59.2 * **	-29.670	51.06 * **	-144.* **	-87.040	125.0 * *	-3.478	-56.39	7.364
	-1.979	-8.104	-2.813	-10.920	-22.120	-12.220	-30.860	-120.70	-57.150	-8.129	-45.98	-15.54
No. of banks	559	463	479	553	466	473	550	449	484	555	459	458
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index, currency crisis dummy), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023)

Table 9
Effects of resolution mechanisms on the ex-post bank performance (ATET) – high NPL sub-sample (21 advanced economies excl. USA).

	Reserves/NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	-0.001	0.008	-0.005	0.013	0.006	-0.009	-0.035	0.086	-0.033	0.002	-0.064	0.011
	-0.005	-0.021	-0.005	-0.022	-0.042	-0.026	-0.042	-0.301	-0.079	-0.029	-0.129	-0.021
Bank size (TA)	1.032***	0.416	-0.742***	4.413***	3.665**	-4.32***	8.92***	11.38	-12.6**	0.206	3.451	-1.092
	-0.151	-0.556	-0.269	-0.830	-1.653	-1.159	-2.435	-8.83	-5.746	-0.696	-3.011	-1.428
Bank liquidity (LATDB)	0.003	-0.13***	-0.0543***	0.000	-0.49***	-0.25***	0.297***	-1.57**	-0.32**	0.013	0.398	0.044
	-0.004	-0.048	-0.015	-0.019	-0.151	-0.076	-0.066	-0.634	-0.145	-0.041	-0.293	-0.066
Constant	-13.46***	-0.724	8.878***	-57.1***	-29.810	51.11***	-139.0***	-87.43	127.7**	-2.775	-56.48	6.878
	-1.967	-8.140	-2.775	-10.760	-22.170	-12.080	-30.35	-122.0	-57.860	-8.163	-46.37	-15.47
No. of banks	547	459	473	549	461	467	542	442	476	547	454	450
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index, currency crisis dummy), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.
Source: Authors' calculations (2023).

with a higher propensity score are given a higher weight.

The semiparametric DID regression model under which the Abadie estimator is calculated distinguishes the estimation procedure between the whole sample (i.e., banks subject to intervention; and banks not subject to intervention) and the treatment group (i.e., banks subject to intervention). The Abadie estimator allows to capture the heterogeneities in the estimations for the treatment group using a set of indicators that can modify the treatment effect of the intervention, i.e., bank size (total assets), profitability (ROAE), liquidity (liquid assets-to-total deposits and borrowings, LATDB).

The Abadie estimator allows to capture two periods, before ($d_t = 0$) and after the intervention ($d_t = 1$). Our data covers up to six years before and after the intervention (and up to 4 years under robustness checks). Thus, we include time fixed effects in our regressions to control for any time-invariant unobserved individual bank characteristics.

The following set of control bank-level variables are used in the regression models: bank profitability (ROAE), bank size (total assets), liquidity (liquid assets-to-total deposits and borrowings, LATDB), capital ratio (except when used as a dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable).

We also include country controls (i.e., GDP growth, inflation, business disclosure country index) and country-fixed effects to control for any unobservable country characteristics. We test additional interaction terms such as those between country and bank interactions with time fixed effects as well as country and time fixed effects. We report no significant change in our reported results.

Most of the banks in our sample come from a limited number of countries, which gives the US-based banks a total share of 38%. Since Abadie's (2005) model does not allow the use of sampling weights, we run our regressions for the sub-samples of non-US banks separately to see whether the results stay consistent.

We also check the distribution of the (placebo) effects estimated for all bank units in the control group. The null hypothesis that the effect of the intervention is equal to zero was rejected as the effect estimated for the ('true') treated unit was abnormal relative to the distribution of placebo estimates.

5. Results

5.1. The Impact of Policy Intervention on Bank Recovery

Tables 6–9 present the semiparametric DID regression results. In addition to the assessment of the constant terms, which show the impact of the given policy intervention on the dependent variables in terms of ATE, we explore how the effect of a given resolution is modified through key bank characteristics, namely, bank size (i.e., Total Assets, TA), its profitability (i.e., ROAE) as well as liquidity (i.e., liquid assets-to-total deposits and borrowings, LATDB). We analyze both the full sample of all advanced economies as well as a sub-sample, where we exclude the US banks to reduce any bias caused by the dominance of the US banks in our sample.

Additionally, in line with our theoretical model, we also divide our sample into two sub-groups depending on the level of NPLs.[11] This approach helps to see whether the effect of policy intervention could depend on the severity of the systemic crisis and to be consistent with our model settings. Tables 8–9 report those results.

The results deliver interesting evidence that complements the theoretical findings of this paper on the channels of policy intervention in the bank recovery process. Bailouts are not effective in restoring bank health

[11] The banks are stratified into three sub-samples based on their NPL ratio: high (NPL ratio $\geq$ 63.8), moderate (10 $\geq$ NPL ratio $<$ 63.8) and low (NPL ratio $<$ 10). Due to low number of observations, the sample is divided into two groups: high NPLs (NPL ratio $\geq$ 63.8) and otherwise.

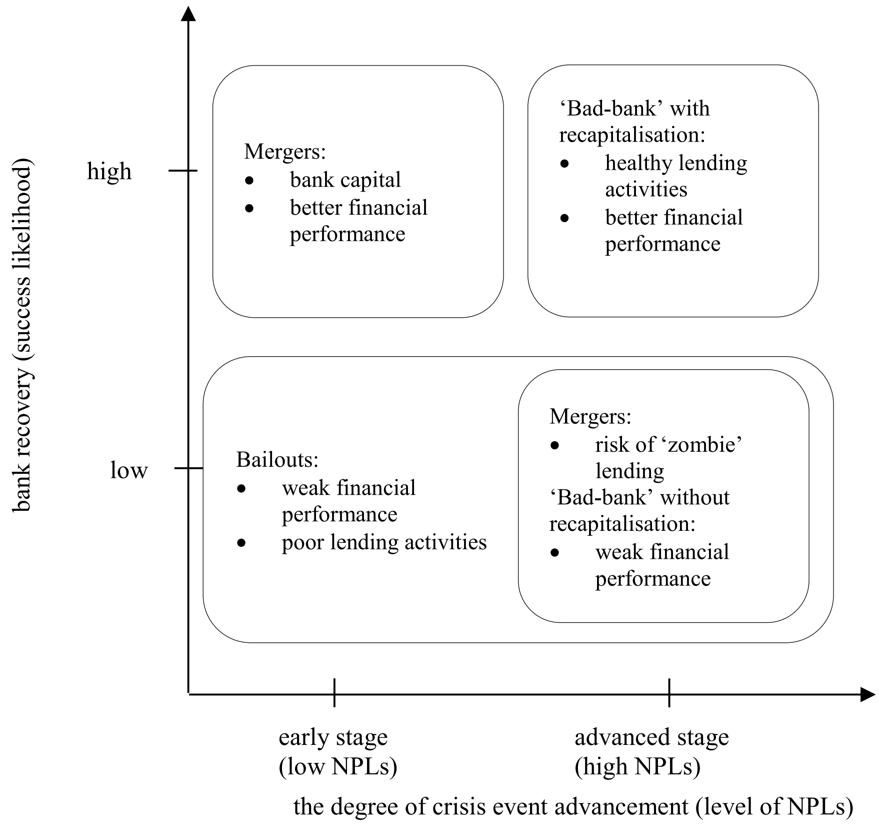

Fig. 4. The trade-offs between the success of bank policy intervention in bank recovery and the severity of the crisis.
Source: Authors (2023).

and, consequently, bank credit activity. The coefficients of constant terms are statistically significant and negative in most regressions. This applies to all dependent variables except loan growth. We argue that pure capital injection could leave banks in distress if relevant restructuring is not undertaken. Banks still struggle with low capitalization (as suggested by the negative impact of bank bailout on capital ratio) within six years after the introduction of the policy intervention. A negative coefficient of capital ratio might also be a result of zombie lending as indicated by declining ex-post repayment rates found under our theoretical model. We find that low performance translates into banks' limited credit activity, as compared to their peers. Our findings are consistent with Acharya et al. (2021) and Brei et al. (2020) who claim that capital injections should be associated with bank restructuring. They claim that banks can only then restore their health and engage in credit expansion. Our results indicate that pure recapitalizations could have concentrated on fulfilling banks' capital requirements, which could not be sufficient to restore credit activity.

More interestingly, the negative impact of nationalization is particularly strong in the sub-sample of banks with high NPLs (both in the US and non-US sub-samples). This provides additional evidence to the theoretical finding that calls in favour of restructuring procedures of distressed banks.

Importantly, we find that the policy resolutions are more successful in unlocking bank recovery. This is in line with the theoretical findings. Though the results are less promising on the whole sample of countries (Table 6), which might be an effect of different scales of recapitalizations of banks among different advanced economies (Acharya et al., 2021), they are more profound in the non-US sample of countries (Table 7). There is a positive effect of a bad bank on capital ratios and reserve ratios (resulting from the lowering number of NPLs as suggested by the theoretical model). Also, a bad bank is the most effective during systemic crises when bank distress is driven by a high level of NPLs. The separation of the bad portfolio from the distressed banks allows those institutions to improve their financial health, which then translates into a higher credit activity (loan ratios coefficients in Tables 8 and 9).

Our results indicate that restructuring mechanisms are the main drivers of banks' recovery, which can limit moral hazard and zombie lending. This is particularly the case when the scale of policy intervention is limited, as indicated in the theoretical model. A bad bank is an effective tool in unlocking bank recovery, particularly in the event of a more severe crisis (Tables 8–9).

Lastly, there is no evidence to consistently support mergers as a good tool to tackle bank recovery. As indicated under the theoretical model, mergers can only be effective at the initial stages of a crisis or in the event of a less severe crisis, when the banking sector is not deeply concerned with the problem of bad loans. Moreover, the effectiveness of the merger depends on the scale of government participation. The bigger scale of guarantees and portfolio restructuring induced by the government, the greater effect of the merger on bank recovery. Consequently, our regression results show a mixed impact of the merger on bank recovery. This can be explained by the country's institutional context in which the mergers are applied. For instance, mergers were found to be more effective in countries where the market discipline work adequately (see, for example, Sheng, 1996).

Fig. 4 summarizes those results on the spectrum of the success likelihood (i.e., measurers of bank financial performance) of the studied bank policy interventions (y-axis) against the severity of the crisis during which those interventions occurred (x-axis). The definitions of those two degrees of crisis advancement correspond to our theoretical and empirical models. Specifically, the "advanced stage" refers to the event where the NPLs are high (i.e., (NPL ratio $\geq$ 63.8) whereas the "early stage" refers to the event of low or moderate NPLs (i.e., NPL ratio $<$ 63.8). High NPLs ultimately predict bank failures (Gonzales-Hermosillo et al., 1997). Elevated levels of NPLs) are a common feature of many

Table 10
Effects of resolution mechanisms on the ex-post bank performance (ATET): bank credit default swaps (CDSs).

	Original full sample (up to t6)			Extended full sample (up to t8)		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	0.720	2.067 * **	2.419 * **	2.512 * **	2.115 * **	2.543 * **
	(32.51)	(0.576)	(0.253)	(0.388)	(0.222)	(0.334)
Bank size (TA)	221.2	-80.24	37.27 * *	59.34 * *	-52.31	55.91 * **
	(2545)	(182.2)	(15.50)	(24.77)	(59.89)	(11.11)
Bank liquidity (LATDB)	-5.939	4.935	0.526	0.244	3.470	0.0443
	(101.0)	(3.366)	(0.373)	(0.829)	(2.135)	(0.272)
Constant	-2683	824.9	-591.4 * **	-838.9 * **	527.5	-818.2 * **
	(28,838)	(2248)	(204.1)	(303.0)	(710.1)	(147.9)
No. of banks	132	84	89	192	130	132
Country Dummy	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions for both (i). the original full sample used in the paper, i.e. up to six years prior/after the intervention and (ii). the extended sample covering up to eight years prior/after the intervention. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable, i.e., credit default swaps. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. The numbers are significantly lowered due to the data availability on CDS available in the S&P Global Market Intelligence. These are available in few advanced economies (USA, UK, Switzerland, Netherlands, France, Germany) and cover the period from 2010 onwards. Longer lags up to eight years prior/post intervention are used as an alternative proxy for the severity of the crisis due to poor coverage of high NPLs in the studied sub-sample of banks. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index, debt to GDP ratio, interest rate swaps), bank controls (ROAE, bank size, liquidity, capital ratio, loan ratio, reserves to NPL ratio, time and country dummies. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.
Source: Authors' calculations (2023).

banking crises. The literature acknowledges that high NPLs impair bank balance sheets, depress credit growth, and delay output recovery (Aiyar et al., 2015; Kalemli-Ozcan, Laeven, and Moreno, 2015, IMF 2016).

5.2. The Impact of Policy Interventions on Systemic Risk

Our regressions till now mainly tested the impact of resolution mechanisms on the recovery of distressed banks without checking how they affect the systemic risk. The positive impact of policies on bank recovery might contribute to the reduction of the systemic effect of the crisis. To verify such eventuality, we assess the impact of policy interventions on systemic risk. We use bank CDSs as a proxy of systemic risk following other scholars (e.g., Huang et al., 2009). Our model specifications remain consistent with the previous regressions except for the dependent variable, which is now a systemic risk proxy. Similar to the previous models, we analyze the effect six years before and after the policy intervention. In addition, we also test extended time lags (i.e., up to 8 years after the intervention). Table 10 presents those results.

Our results document that the systemic risk measures are negatively correlated with bad bank intervention. The coefficients are highly significant. The results provide some evidence that the policy interventions can have the power to effectively restore a bank's long-term health, which then translates into lower systemic effects. The clean-off banks' bad debt leads to a higher loan repayment rate as indicated in the theoretical model. This, in turn, lowers the probability of default of individual banks and thus increases the confidence in the whole banking sector. Interestingly, we do not find any evidence of the success of other mechanisms, despite their partial positive effect on some banks' characteristics, as proven in the theoretical model and earlier empirical results. One occurrence is recorded with a negative effect of a bailout on CDSs under an eight-year lag. This could be because the government's guarantees may retain confidence in the market in the longer term. However, the theoretical model also indicated that this also leads to higher chances of moral hazard and zombie lending. We, thus, advocate for deeper bank restructuring to be used in the case of more advanced stress events of a systemic character.

5.3. Robustness Checks

We carry out some standard checks on our main regression results and sample matching techniques. First, we reduce the time series spread of our dataset by two years from six to four years before/after the introduction of each of the resolutions. We drop certain controls as well as replace the variables used in the regressions with alternative proxies (e.g., ROAE with net interest margin; LATDB with reserves/gross loans). We recorded no significant change in our findings.

We also run regression without country and time fixed effects as well as add additional interaction terms such as those between country and bank interactions with time fixed effects as well as country and time fixed effects. Tables 11,12 and 13 present the regression results on our baseline specifications.

We also repeated the sample matching process with some alternative techniques using multiple propensity score matching (PSM) options. The PSM matching estimator is most suited in cases where the covariate distributions differ substantially between the treated (i.e., intervened) and control (i.e., non-intervened) groups (Imbens, 2014). We tested multiple PSM options with kernel match such as those combined with the multivariate distance matching via kmatch command as well as with a common psmatch2 command. We matched the loan-to-total asset ratio as well as the total asset figures to remain consistent with the matching variables used under the main results. We repeated the matching process for all four dependent variables.

Due to brevity reasons, we do not show the results for all of those robustness checks. They are available upon request. Table 14 summarises their outcomes.

Overall, we can see that the results remain broadly in line with our original estimates. Consequently, we can confirm that our results are robust toward various sampling and estimation specifications techniques.

Table 11
Effects of resolution mechanisms on the ex-post bank performance (ATET) –robustness checks regressions on the sub-sample of 21 advanced economies (excl. USA) with additional interactions between country and bank fixed effects.

	Reserves/NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	0.00039	0.00669	-0.00144	0.0161	0.00014	-0.00299	-0.0199	0.0482	0.0154	0.0111	-0.0632	-0.0116
	(0.0049)	(0.019)	(0.00410)	(0.0201)	(0.0373)	(0.0210)	(0.0483)	(0.22)	(0.065)	(0.021)	(0.11)	(0.0193)
Bank size (TA)	1.073 * **	0.316	-0.899 * **	3.928 * **	3.074 *	-3.83 * **	7.64 * **	9.235	-12.60 * **	-0.257	3.158	0.130
	(0.191)	(0.586)	(0.117)	(0.981)	(1.611)	(0.77)	(2.787)	(8.50)	(3.579)	(0.863)	(3.14)	(0.778)
Bank liquidity (LATDB)	-0.0049	-0.102 * *	-0.039 * **	-0.0353	-0.35 * *	-0.21 * **	0.28 * **	-1.054 *	-0.295	-0.0216	0.375	-0.0393
	(0.0051)	(0.049)	(0.0109)	(0.0271)	(0.168)	(0.0462)	(0.0801)	(0.62)	(0.195)	(0.045)	(0.25)	(0.0519)
Constant	-13.09 * **	-1.064	10.26 * **	-46.6 * **	-28.96	45.41 * **	-116.9 * *	-87.16	133.6 * **	5.489	-51.88	-2.560
	(2.414)	(8.103)	(1.592)	(12.07)	(20.80)	(10.06)	(34.00)	(106.1)	(45.75)	(9.687)	(45.6)	(7.913)
Observations	599	475	502	585	489	503	597	487	482	591	489	497
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country*Bank	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Bank*Time	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Those robustness checks regressions remove country controls (GDP growth, inflation, business disclosure country index) as interaction terms between country and bank fixed effects are introduced. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023).

Table 12
Effects of resolution mechanisms on the ex-post bank performance (ATET) – robustness checks regressions on the sub-sample of 21 advanced economies (excl. USA) with additional interactions between time and bank fixed effects.

	Reserves/NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	-0.00079	0.00922	-0.00471	0.0176	0.00774	-0.0100	-0.0409	0.0885	-0.0106	0.00265	-0.0715	0.0117
	(0.00457)	(0.0242)	(0.00474)	(0.0223)	(0.0460)	(0.0231)	(0.0338)	(0.309)	(0.0824)	(0.0273)	(0.146)	(0.0191)
Bank size (TA)	1.267 * **	0.394	-0.745 * **	5.174 * **	3.666 * *	-4.066 * **	11.56 * **	11.15	-12.69 * *	0.463	3.771	-0.969
	(0.176)	(0.641)	(0.257)	(0.897)	(1.792)	(1.036)	(2.422)	(9.181)	(5.707)	(0.904)	(3.304)	(1.341)
Bank liquidity (LATDB)	-0.00492	-0.13 * **	-0.0551 * **	-0.0447 *	-0.478 * **	-0.237 * **	0.232 * **	-1.511 * **	-0.413 * *	-0.00121	0.385	0.0365
	(0.00431)	(0.0495)	(0.0140)	(0.0231)	(0.144)	(0.0657)	(0.0708)	(0.572)	(0.176)	(0.0582)	(0.301)	(0.0627)
Constant	-15.92 * **	-0.492	9.009 * **	-63.41 * **	-30.24	47.60 * **	-168.1 * **	-87.67	137.4 * *	-5.029	-59.89	6.612
	(2.244)	(9.307)	(2.633)	(11.33)	(23.86)	(10.50)	(29.80)	(125.9)	(59.29)	(9.482)	(50.97)	(14.05)
Observations	529	474	459	530	472	455	526	459	469	529	469	430
Country Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country*Bank	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bank*Time	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable), time and country dummies. Those robustness checks regressions also include interactions between time and bank fixed effects. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023).

Table 13
Effects of resolution mechanisms on the ex-post bank performance (ATET) – robustness checks regressions on the sub-sample of 21 advanced economies (excl. USA) without any fixed effects.

	Reserves/NPLs			Total capital ratio			Loan ratio			Loan growth		
	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank	Bailout	Merger	Bad-bank
Bank profit (ROAE)	0.000731	0.00628	-0.0061 * *	0.0249	0.00299	-0.0202	-0.00776	0.0376	-0.093 * **	0.00213	-0.0488	-0.0165
	(0.00600)	(0.0105)	(0.00251)	(0.0315)	(0.0204)	(0.0180)	(0.0606)	(0.119)	(0.0314)	(0.029)	(0.066)	(0.0126)
Bank size (TA)	0.973 * **	0.623	-1.652 * **	3.717 * **	3.646 * **	-8.202 * **	2.884	14.51 * *	-21.86 * **	-0.105	2.339	2.614
	(0.225)	(0.394)	(0.443)	(1.129)	(1.318)	(1.413)	(2.603)	(6.415)	(4.277)	(0.764)	(1.669)	(2.477)
Bank liquidity (LATDB)	0.00164	-0.148 * **	-0.00824	-0.0198	-0.493 * *	-0.0633	0.33 * **	-1.606 * *	0.404 * *	0.0119	0.489	-0.0264
	(0.00410)	(0.0508)	(0.0108)	(0.0149)	(0.170)	(0.0734)	(0.0479)	(0.627)	(0.161)	(0.037)	(0.346)	(0.0764)
Constant	-12.61 * **	-2.344	15.96 * **	-46.70 * **	-28.45	82.48 * **	-61.84 *	-124.0	187.5 * **	1.414	-46.05	-29.32
	(2.954)	(5.765)	(4.134)	(14.84)	(17.80)	(13.44)	(33.10)	(79.78)	(39.19)	(9.105)	(29.69)	(22.54)
Observations	607	629	585	610	631	584	616	654	577	608	620	576
Country Dummy	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Time Dummy	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Country*Bank	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Bank*Time	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Notes: this table reports estimates of the average effect of resolution mechanisms for intervened banks derived from semi-parametric DID regressions. It shows how the effect of each resolution mechanism varies with a bank's profitability, size, and liquidity level. The constant shows the impact of the resolution mechanism on the dependent variable. The reported average treatment effect on the treated (ATET) are estimated using a linear polynomial function to approximate the propensity score. The "number of banks" indicates the number of individual banks used for the estimations that satisfy the condition that their respective estimated propensity score is bigger than 0 and smaller than 1. All regressions include the following control variables: industry control (banking sector concentration ratio), country controls (GDP growth, inflation, business disclosure country index), bank controls (ROAE, bank size, liquidity, capital ratio (except when used as dependent variable), loan ratio (except when used as dependent variable), reserves to NPL ratio (except when used as dependent variable). Those robustness checks regressions include no fixed effects. Standards errors are in parentheses and clustered at bank-level. Significance levels are denoted as follows: * $p < 0.10$, * * $p < 0.05$, and * ** $p < 0.01$.
Source: Authors' calculations (2023).

Table 14
Summary of the other robustness checks techniques and their outcomes.

Robustness check	Results summary
Regressions with shorter time series (from six to four years before/after treatment)	Consistent sign of the constant in all regressions. Broadly similar size of the significant coefficients in all regressions.
Regressions with higher order approximation (order of 5)	Consistent sign of the constant in all regressions. Broadly similar size of the significant coefficients in all regressions.
Regressions with net interest margin instead of ROAE & reserves to gross loans instead of LATDB	Consistent sign of the constant in all regressions except loan growth regression with merger case. Broadly similar size of the significant coefficients in all regressions. The constant coefficients under merger cases in all regressions except loan growth gained significance in comparison to original results.
Sample matching with PSM options on loan-to-assets ratio	Broadly similar results of matching on loan-to-total asset ratio under all dependent variables except loan growth.
Sample matching with PSM options on total assets	Broadly similar results of matching on total assets under all dependent variables except loan growth.

Source: Authors (2023).

6. Conclusion

For many years governments have been rescuing failing banks through bailouts. Those actions have not always been successful and often led to the emergence of moral hazard in the economy. Thus, regulators across the globe changed their attitude toward bank distress by redefining the new regulatory policy framework for the events of the next distress. It is broadly believed that the new resolution approach should limit losses to the banking sector as well as further negative contagious effects of the crisis. The new regulatory reforms assume that potential losses should be initially covered by the bank's stakeholders (i.e., bail-ins) and that bailouts should only be applied in extreme cases when all other resolution methods fail.

These new reforms raise questions on how successful each policy intervention could be in bank distress resolution. Moreover, it has not been tested comprehensively how these mechanisms perform during systemic episodes of stress events. We tackle these questions in our paper.

First, we apply the theoretical model of financial stability by Goodhart et al., (2005, 2006a) to explore the impact of three policy interventions out of them two are resolution mechanisms: a bank sale via merger, a "bad bank" approach and bank recapitalizations on bank recovery. Second, we assess these resolutions using the semi-parametric DID methodology on a novel bank-level database consisting of 149 banks from 22 advanced economies, which were subject to these regulatory mechanisms during the 1992–2017 periods of systemic banking crises. The key question is whether banks that underwent different policy interventions recover their financial health to a level where they could continue their credit activity in the real sector. We also look at how different policy interventions interrelate with other banks' performance and, thus, whether they can mitigate the contagious effect during a stress event.

We find that restructuring a distressed bank is necessary to restore financial health and, consequently, to restore its credit activity. Our results consistently show that a "bad-bank" intervention with sufficient recapitalization is an effective mechanism to restructure a bank's portfolio problem and to restore its capital to a level that enables further lending to the real sector. In contrast, pure capital injection in the form of a bailout does not deliver the desired results. We find that it is negatively related to the capital ratio even several years after the intervention took place. We argue that a lack of appropriate restructuring of a bank's high NPLs is likely to "bite" bank capital. In contrast, the "bad-bank" intervention allows banks to restore their capital position, which then translates into higher credit extension. Our findings support the so-far studies indicating that BRRD might be more effective in managing bank distress during the crisis than bailout interventions. However, our findings additionally prove that it will be only the case when bank bail-ins will be additionally combined with profound resolution measures.

We also find some evidence that in the cases when the systemic shock is not widely spread, a merger with the distressed bank supports bank rescue and recovery. Finally, we find that the "bad-bank" mechanism not only effectively restores banks' health but also helps in reducing systemic risk. We call in favour of deeper bank restructuring in a stress event with the presence of systemic risk.

Our paper provides contributions to some important policy dilemmas in the banking sector. First, it contributes to the discussion on the reasons behind the weak performance of European banks after the GFC of 2008–10 despite the significant scale of bailouts carried out during that period. Second, our findings confirm that the recent regulatory reform, such as the BRRD, the Dodd-Frank Act or Living Will, that shift the focus from bank bailouts into new resolution mechanisms is indeed the right approach, which could help to ensure better management of the financial crisis through restoring banks' activities in the credit market. Finally, our findings shed some light on the possible ways that bankers as well as banking sector regulators and authorities could apply during such systemic events of distress. Our paper calls, however, for more work into carefully tuning bank policy frameworks towards mitigating systemic risk.

Appendices

See Appendix.

Technical Appendices

Technical Annex 1: Goodhart, Sunirand and Tsomocos (2004, 2005) – model equations

The model has three heterogeneous banks, b ∈ B= {γ, δ, τ}, four private sector agents, a ∈ A= {α, β, θ, φ}, a Central Bank and a regulator. The time horizon extends over two periods, t ∈ T = {1, 2}and two possible states in the second period, s ∈ S= {i, ii}. State i is a normal/good state and occurs with probability p, while state ii represents an extreme/crisis event. Individual bank borrowers are assigned during the two periods, by history or by informational constraint, to borrow from a single bank: agents α, β, and θ borrow from banks γ, δ, and τ, respectively. The remaining agent, φ, represents the pool of depositors in this economy who supply funds to every bank. This limited participation assumption implies multiple active markets for deposits (by separate bank) and for loans (by borrower and bank). In addition, we assume a single, undifferentiated, interbank market where deficit banks borrow from surplus banks, and wherein the Central Bank conducts OMOs.

At t = 1,loan, deposit and interbank markets open. Banks decide how much to lend/borrow in each market, expecting any one of the two possible future scenarios to occur. The Central Bank conducts OMOs in the interbank market. At t = 2 all financial contracts are settled, subject to any defaults and/or capital requirements' violations, which are then penalised. At the end of the second period all banks are wound up.

The interbank net borrowers' (banks γ and τ) optimisation problems

Bank b ∈ {γ, τ} maximises its payoff, which is a quadratic function of expected profits in the second period minus non-pecuniary penalties that it has to incur if it defaults on its deposit and interbank obligations. It also suffers a capital violation penalty proportional to its capital requirement violation. Formally, the optimisation problem of bank b∈{γ, τ}is as follows:

$$\max_{\overline{m}^b, \mu^b, \mu_d^b, \upsilon_s^b, s \in S} \prod b = \sum_{s\in S} p_s \left[\pi_s^b - c_s^b \left(\pi_s^b\right)^2 \right] - \sum_{s\in S} p_s \left[\lambda_{ks}^b \max\left[0, \overline{k}^b - k_s^b\right] + \lambda_s^b \left[\mu^b - \upsilon_s^b \mu^b\right] + \lambda_s^b \left[\mu_d^b - \upsilon_s^b \mu_d^b\right] \right]$$

subject to

$$\overline{m}^b + A^b = \frac{\mu^b}{(1+p)} + \frac{\mu_d^b}{(1+r_d^b)} + e_0^b + Others^b \tag{2}$$

$$\upsilon_s^b \mu^b + \upsilon_s^b \mu_d^b + Others^b + e_0^b \leq \upsilon_{sb}^{h^b} \left(1 + r^b\right) \overline{m}^b + \left(1 + r^A\right) A^b, s \in S \tag{3}$$

where,

$$\pi_s^b = \triangle(3) \tag{4}$$

$$e_s^b = e_0^b + \pi_s^b, s \in S \tag{5}$$

$$k_s^b = \frac{e_s^b}{\overline{\omega} \upsilon_{sb}^{h^b} (1 + r^b) \overline{m}^b + \widetilde{\omega} (1 + r^A) A^b}, s \in S \tag{6}$$

$\Delta(x) \equiv$ the difference between RHS and LHS of inequality (x).
$p_s \equiv$ probability that state s ∈ S will occur,
$c_s^b \equiv$ coefficient of risk aversion in the utility function of bank b ∈ B,
$\lambda_{ks}^b \equiv$ capital requirements' violation penalties imposed on bank b ∈ B in state s ∈ S,
$\overline{k}^b \equiv$ capital adequacy requirement for bank b ∈ B,
$\lambda_s^b \equiv$ default penalties on bank b ∈ B,
$\mu^b \equiv$ amount of money that bank b ∈ {γ, τ} owes in the interbank market,
$\mu_d^b \equiv$ amount of money that bank b ∈ B owes in the deposit market,

$\upsilon_s^b \equiv$ repayment rates of bank b ∈ B to all its creditors in state s ∈ S,
$\overline{m}^b \equiv$ amount of credit that bank b ∈ B extends in the loan market,
$A^b \equiv$ the value of market book held by bank b ∈ B,
$e_s^b \equiv$ amount of capital that bank b ∈ B holds in state s ∈ {0} ∪ S,
$Others^b \equiv$ the 'others' item in the balance sheet of bank b ∈ B,
$r^b \equiv$ lending rate offered by bank b ∈ B,
$r_d^b \equiv$ deposit rate offered by bank b ∈ B,
$\rho \equiv$ interbank rate,
$r^A \equiv$ the rate of return on market book,
$\upsilon_{sb}^{h^b} \equiv$ repayment rates of agent $h^b \in H^b = \{\alpha^\gamma, \beta^\delta, \theta^\tau\}$ to his nature-selected bank b ∈ B in the consumer loan market,
$\overline{\varpi} \equiv$ risk weight on consumer loans, and.
$\widetilde{\omega} \equiv$ risk weight on market book.

Eq. (2) implies that, at t = 1, the assets of bank b ∈ {γ, τ}, which consist of its credit extension and market book investment, must be equal to its liabilities obtained from interbank and deposit borrowing and its initial equity endowment, where $Others^b$ represents the other assets. Eqs. (3) and (4) then show that, dependent on which of the s ∈ S actually occurs, the profit that bank b incurs in the second period is equal to the difference between the amount of money that it receives from its asset investment and the amount that it has to repay on its liabilities, adjusted appropriately for default in each market. As shown in Eq. (5), the profit earned is then added to its initial capital, which in turn becomes its capital in the second period. Finally, Eq. (6) implies that the capital to asset ratio of bank b in state s ∈ S is equal to its capital in state s divided by its risk-weighted assets in the corresponding state.

The interbank net lender's (bank δ) optimisation problem

Bank δ, unlike the other two banks, is a net lender in the interbank market. Thus it suffers only a default penalty in the deposit market. Formally, bank δ's optimisation problem is as follows:

$$\max_{\overline{m}^\delta, d^\delta, \mu_d^\delta, \upsilon_s^\delta, s \in S} \prod\delta = \sum_{s\in S} p_s\left[\pi_s^\delta - c_s^\delta\left(\pi_s^\delta\right)^2\right] - \sum_{s\in S} p_s\left[\lambda_{ks}^\delta \max\left[0, \overline{k}^\delta - k_s^\delta\right] + \lambda_s^\delta\left[\mu_d^\delta - \upsilon_s^\delta \mu_d^\delta\right]\right]$$

subject to

$$A^\delta + d^\delta + \overline{m}^\delta = e_0^\delta + \frac{\mu_d^\delta}{(1 + r_d^\delta)} + Others^\delta \tag{7}$$

$$\upsilon_s^\delta \mu_d^\delta + Others^\delta + e_0^\delta \leq \upsilon_{s\delta}^{\beta^\delta} \overline{m}^\delta (1 + r^\delta) + A^\delta\left(1 + r^A\right) + \widetilde{R}_s d^\delta (1 + \rho) \tag{8}$$

where,

$$\pi_s^\delta = \triangle(8) \tag{9}$$

$$e_s^\delta = e_0^\delta + \pi_s^\delta \tag{10}$$

$$k_s^\delta = \frac{e_s^\delta}{\overline{\varpi}\upsilon_{s\delta}^{\beta^\delta}(1 + r^\delta)\overline{m}^\delta + \widetilde{\omega}\widetilde{R}_s d^\delta(1 + \rho) + \widetilde{\omega}(1 + r^A)A^\delta} \tag{11}$$

$d^\delta \equiv$ bank δ's investment in the interbank market,
$\widetilde{R}_s \equiv$ the rate of repayment that bank δ expects to get from its interbank investment, and.
$\omega \equiv$ risk weight on interbank investment.

The budget set of bank δ is similar to those of the other two banks except that it invests in, instead of borrows from, the interbank market. Moreover, its risk weighted assets in the second period, as shown in Eq. (11), also includes bank δ's expected return on its interbank investment.

Central bank and regulator

The Central Bank conducts monetary policy by engaging in open market operations in the interbank market. It can either set its base money (*M*) as its monetary policy instrument, allowing the interbank rate to be determined endogenously, or it can fix the interbank rate and let its base money adjust endogenously to clear the interbank market.

The regulator sets capital adequacy requirements for all banks ($\overline{k}^b$) and imposes penalties on their failure to meet such requirements (λ_{ks}^b) and on default on their financial obligations in the deposit and interbank markets (λ_s^b). Finally, the regulator sets the risk weights on consumer loan, interbank and market book investment ($\overline{\varpi}, \omega, \widetilde{\omega}$).

Household sector

The government intervention is funded by general tax revenues coming from household agents. Agents α, β, and θ borrow from banks γ, δ and τ, respectively, based on their demand for consumer loans. Goodhart et al. (2005) do not explicitly model the optimisation problems of households, mostly because it is very difficult, if at all possible, to find real disaggregated data for private agent sectors, e.g. monetary and goods endowment for each bank's borrowers and depositors. Thus, instead of explicitly providing microfoundations for households' decisions, they, and we as well, endogenise them by assuming the following reduced-form equations.

Each household borrower, $h^b = \{\alpha^\gamma, \beta^\delta, \theta^\tau\}$, demands consumer loans from his nature selected bank and chooses whether to default on his loans in state s ∈ S. The remaining agent, ϕ, supplies his deposits to each bank b.

Household borrowers' demand for loans

Because of the limited participation assumption in every consumer loan market, each household's demand for loans is a negative function of the lending rate offered by his nature selected bank. His demand for loans also depends positively on the expected GDP in the subsequent period. Thus, we implicitly assume that household borrowers rationally anticipate GDP in both states of the next period, which then determines their expected future income, and adjust their loan demand in the initial period accordingly in order to smooth their consumption over time. The money demand function manifests the standard Hicksian elements whereby it responds positively to current and expected income and negatively to interest rates. As in Goodhart et al. (2005), we introduce a linear time trend in each household borrower's loan demand function to improve the empirical fit (i.e. *trend*). In particular, household h^b's loan demand from his nature-selected bank b which under government intervention, $\forall h^b \in H^b$, and b ∈ B is as follows:

$$\ln\left(\mu^{h^b}\right) = a_{h^b,1} + a_{h^b,2} trend + a_{h^b,3}\ln\left[p(GDP_{t+1,i}) + (1-p)GDP_{t+1,ii}\right] + a_{h^b,4}r^b (1)$$

where,

$\mu^{h^b} \equiv$ amount of money that agent $h^b \in H^b$ chooses to owe in the loan market of bank b ∈ B in period t,

$GDP_{t+1,s} \equiv$ Gross Domestic Product in period t + 1 if state s ∈ S occurs.

Deposit supply

Unlike the loan markets, we do not assume limited participation in the deposit markets. This implies that ϕ can choose to diversify his deposits with every bank. Thus, Mr. ϕ's deposit supply with bank b depends not only on the deposit rate offered by b but also on the rates offered by the other banks. Moreover, since banks can default on their deposit obligations, the expected rate of return on deposit investment of ϕ with each bank has to be adjusted appropriately for each bank's corresponding expected default rate. Next, ϕ's deposit supply is a positive function of the expected GDP. In symbols, ϕ's deposit supply function with bank b is as follows:

$$\ln\left(d_b^\phi\right) = z_{b,1} + b_{b,2}\ln\left[p(GDP_i) + (1-p)GDP_{ii}\right] + z_{b,3}\left[r_d^b(pv_i^b)\right] + z_{b,4}\sum_{\dot{b}\neq b\in B}\left[r_d^{\dot{b}}(pv_i^{\dot{b}} + (1-p)v_{ii}^{\dot{b}}\right]\left(2\right)$$

where,

$d_b^\phi \equiv$ amount of money that agent ϕ chooses to deposit with bank $b \in B$..

Households' loan repayment rates

We assume that each household's repayment rate on his loan obligation to his nature-selected bank in state s ∈ S is a positive function of the corresponding GDP level as well as the aggregate credit supply in the economy. The latter variable captures the effect of 'credit crunch' in the economy whereby a fall in the overall credit supply in the economy aggravates the default probability of every household. Specifically, the functional form of the repayment rate of household h^b, $\forall h^b \in H^b$, to his nature-selected bank b ∈ B, in state s ∈ S is as follows:

$$\ln\left(v_{s^b}^{h^b}\right) = g_{h^b,s,1} + g_{h^b,s,2}\ln(GDP_s) + g_{h^b,s,3}[\ln(\overline{m}^\gamma) + \ln(\overline{m}^\delta) + \ln(\overline{m}^\tau)](14)$$

GDP

We have assumed that households' actions depend on their expected GDP in the second period. So, in this section we endogenise GDP in both states of the second period. We assume that GDP in each state is a positive function of the aggregate credit supply available in the previous period. Since the Modigliani-Miller proposition does not hold in our model, higher credit extension as a result of loosening monetary policy, or any other shocks, generates a positive real balance effect that raises consumption demand and ultimately GDP. In particular, the following functional form for GDP in state s ∈ S of the second period (GDPs) holds.

$$\ln(GDP_s) = u_{s,1} + u_{s,2}[\ln(\overline{m}^\gamma) + \ln(\overline{m}^\delta) + \ln(\overline{m}^\tau)] + u_{s,3}[\ln(e_s^\gamma) + \ln(e_s^\delta) + \ln(e_s^\tau)](15)$$

Market clearing conditions

There are seven active markets in the model (three consumer loan, three deposit and one interbank markets). Each of these markets determines an interest rate that equilibrates demand and supply in equilibrium.

$$1 + r^b = \frac{\mu^{h^b}}{\overline{m}^b}, h^b \in H^b, \forall b \in B (\text{i.e.bank b's loan market clears}) \quad (16)$$

$$1 + r_d^b = \frac{\mu_d^b}{d_b^\phi}, \forall b \in B (\text{i.e.bank b's deposit market clears}) \quad (17)$$

$$1 + \rho = \frac{\mu^\gamma + \mu^\tau}{M + d^\delta} (\text{i.e.interbank market clears}) \quad (18)$$

We note that these interest rates, i.e. r^b, $r_d^b$and ρ, b ∈ B, are the ex-ante nominal interest rates that incorporate default premium since default is permitted in equilibrium. Their effective (ex-post) interest rates have to be suitably adjusted to account for default in their corresponding markets.

Equilibrium

The equilibrium in this economy is characterised by a vector of all choice variables of active agents such that banks maximise their payoff function subject to their budget constraints, all markets clear (i.e. conditions 16, 17, and 18 are satisfied), bank δ is correct in its expectation about the repayment rates that it gets from its interbank investment, and, finally, loan demand, deposit supply, repayments rates, and GDP in both states s satisfy the reduced form equations (12)-(15).

Source: Goodhart et al., (2004, 2005).

Technical Annex 2: Exogenous variables and the resulting initial equilibrium under the baseline scenario

See Annex 2 section here.

	Initial equilibrium			Exogenous variables in the model	
Endogenously solved	$r_t^{\gamma}= 0.154$	$k_{t+1,i}^{\delta}= 0.20$	$e_{t+1,ii}^{\gamma} = 0.83$	$Other_t^{\gamma}= -11.0$	$z_{\gamma,1}= 1.56$
	$r_t^{\delta}= 0.453$	$k_{t+1,ii}^{\delta}= 0.21$	$e_{t+1,i}^{\delta}= 3.90$	$Other_t^{\delta}= -2.69$	$z_{\delta,1}= 2.53$
	$r_t^{\tau}= 0.155$	$k_{t+1,i}^{\tau}= 0.17$	$e_{t+1,ii}^{\delta}= 3.43$	$Other_t^{\tau}= 27.06$	$z_{\tau,1}= 3.3$
	$r_{d,t}^{\gamma}= 0.04$	$k_{t+1,ii}^{\tau}= 0.13$	$e_{t+1,i}^{\tau}= 10.59$	$g_{\alpha^{\gamma},i,1}= -0.75$	$u_{i,1}= 3.61$
	$r_{d,t}^{\delta}= 0.024$	$\pi_{t+1,i}^{\gamma}= 0.26$	$e_{t+1,ii}^{\tau}= 7.31$	$g_{\alpha^{\gamma},ii,1}= -1.04$	$u_{ii,1}= 0.1$
	$r_{d,t}^{\tau}= 0.04$	$\pi_{t+1,ii}^{\gamma}= -0.34$	$\widetilde{R}_{t+1,i}= 1.28$	$g_{\beta^{\delta},i,1}= -0.76$	$c_i^{\gamma}= 0.214$
	$\mu_{d,t}^{\gamma}= 11.47$	$\pi_{t+1,i}^{\delta}= 0.33$	$\widetilde{R}_{t+1,ii}= 0.75$	$g_{\beta^{\delta},ii,1}= -1.04$	$c_{ii}^{\gamma}= 0.129$
	$\mu_{d,t}^{\delta}= 43.71$	$\pi_{t+1,ii}^{\delta}= -0.13$	$\mu_t^{\alpha^{\gamma}}= 10.83$	$g_{\theta^{\tau},i,1}= -0.75$	$c_i^{\delta}= 0.159$
	$\mu_{d,t}^{\tau}= 65.32$	$\pi_{t+1,i}^{\tau}= 2.11$	$\mu_t^{\beta^{\delta}}= 14.59$	$g_{\theta^{\tau},ii,1}= -1.04$	$c_{ii}^{\delta}= 0.351$
	$k_{t+1,i}^{\gamma}= 0.138$	$\pi_{t+1,ii}^{\tau}= -1.17$	$\mu_t^{\theta^{\tau}}= 63.45$	$a_{\alpha^{\gamma},1}= -3.85$	$c_i^{\tau}= 0.024$
	$k_{t+1,ii}^{\gamma}= 0.09$	$e_{t+1,i}^{\gamma}= 1.43$	M= −16.81	$a_{\beta^{\delta},1}= -3.35$	$c_{ii}^{\tau}= 0.042$
				$a_{\theta^{\tau},1}= -2.08$	
Calibrated	$\overline{m}_t^{\gamma}= 9.39$	$d_{\delta,t}^{\phi}= 33.79$	$v_{t+1,i}^{\alpha^{\gamma}}= 0.91$	$a_{h^b,2_{(\forall h\in H^b)}} = 1.41$	$e_t^{\delta}= 3.567$
	$\overline{m}_t^{\delta}= 10.04$	$d_{\tau,t}^{\phi}= 62.81$	$v_{t+1,i}^{\beta^{\delta}}= 0.90$	$a_{h^b,3_{(\forall h\in H^b)}} = 0.68$	$e_t^{\tau}= 8.48$
	$\overline{m}_t^{\tau}= 54.95$	$d_t^{\delta}= 15.96$	$v_{t+1,i}^{\theta^{\tau}}= 0.91$	$A_t^{\gamma}= 2.462$	$\overline{\omega}= 1$
	$d_{\gamma,t}^{\phi}= 11.03$	$\mu_t^{\tau}= 11.96$	$GDP_{t+1,\ i} = 89.83$	$A_t^{\delta}= 8.669$	$\omega(\widetilde{\omega})= 0.2$
				$A_t^{\tau}= 31.903$	$\rho_t= 0.04$
				$e_t^{\gamma}= 1.175$	
Arbitrarily selected	$v_{t+1,ii}^{\alpha^{\gamma}}= 0.80$	$v_{t+1,i}^{\gamma}= 0.975$	$v_{t+1,ii}^{\delta}= 0.963$	$g_{h,i,2_{(\forall h\in H^b)}} = 0.05$	$u_{s,2_{(\forall s\in S)}} = 0.1$
	$v_{t+1,ii}^{\beta^{\delta}}= 0.80$	$v_{t+1,ii}^{\gamma}= 0.952$	$v_{t+1,i}^{\tau}= 0.997$	$g_{h,ii,2_{(\forall h\in H^b)}} = 0.05$	$z_{b,2_{(\forall b\in B)}} = 0.19$
	$v_{t+1,ii}^{\theta^{\tau}}= 0.80$	$v_{t+1,i}^{\delta}= 0.963$	$v_{t+1,ii}^{\tau}= 0.937$	$g_{h,i,3_{(\forall h\in H^b)}} = 0.05$	$z_{b,3_{(\forall b\in B)}} = 0.5$
			$GDP_{t+1,\ ii} = 85.24$	$g_{h,ii,3_{(\forall h\in H^b)}} = 0.1$	$z_{b,4_{(\forall b\in B)}} = 0.1$
				$\overline{k}_{t+1,S(\forall s\in S)}^{\gamma}= 0.11$	$u_{s,2_{(\forall s\in S)}} = 0.1$
				$\overline{k}_{t+1,S(\forall s\in S)}^{\delta}= 0.16$	$r_t^{A}= 0.045$
				$\overline{k}_{t+1,S(\forall s\in S)}^{\tau}= 0.13$	$\rho= 0.95$
				$\lambda_{ks(\forall b\in B,s\in S)}^{b}= 0.1$	$a_{\alpha^{\gamma},2}= 0.025$
				$\lambda_{i(b\in B)}^{b}= 0.9$	$a_{\beta^{\delta},2}= -0.12$
				$\lambda_{ii(b\in B)}^{b}= 1.1$	$a_{\theta^{\tau},2}= 0.04$

Source: Authors (2023).

Legend:

Endogenously-solved variables:

r_t^b: lending rate offered by bank *b* in period *t*

$r_{d,t}^b$: deposit rate offered by bank *b* in period *t*

$\mu_{d,t}^b$: Bank *b*'s debt in the interbank market in period *t*

$k_{t+1,i}^b$: Bank *b*'s capital adequacy ratio (CAR) in period *t* + *1* in state *i*

$k_{t+1,ii}^b$: Bank *b*'s capital adequacy ratio (CAR) in period *t* + *1* in state *ii*

$\pi_{t+1,i}^b$: Bank *b*'s profit in period *t* + *1* in state *i*

$\pi_{t+1,ii}^b$: Bank *b*'s profit in period *t* + *1* in state *ii*

$e_{t+1,i}^b$: Bank *b*'s capital in period *t* + *1* in state *i*

$e_{t+1,ii}^b$: Bank *b*'s capital in period *t* + *1* in state *ii*

$\widetilde{R}_{t+1,i}$: Repayment rate expected by banks from interbank lending at period t + 1 in state i

$\widetilde{R}_{t+1,ii}$: Repayment rate expected by banks from interbank lending at period t + 1 in state ii

$\mu_t^{a^b}$: Amount of money that agent *a* chooses to owe in the loan market of bank *b* at time t

$\overline{B}$: Government bonds

Calibrated variables:

$\overline{m}_t^b$: Amount of credit that bank *b* extends in the loan market in period *t*

$d_{b,t}^{\phi}$: Amount of money that agent ϕ chooses to deposit with bank *b* at time *t*

d_t^b: Bank *b*'s interbank lending in period *t*

μ_t^{τ}: Amount of money that bank τ owes in the interbank market in period t

$v_{t+1,i}^{a^b}$: Repayments rates of agent a^bin the loan market in period t + 1 in state i

$GDP_{t+1,\ i}$: GDP in period t + 1 in state i

Arbitrarily selected:

$v_{t+1,ii}^{a^b}$: Repayments rates of agent a^bin the loan market in period t + 1 in state ii

$v_{t+1,i}^b$: Repayment rate of bank *b* in period *t* + *1* in state *i*

$v_{t+1,ii}^b$: Repayment rate of bank *b* in period *t* + *1* in state *ii*

$GDP_{t+1,\ ii}$: GDP in period t + 1 in state ii

Exogenous variables in the model

$Other_t^b$: The 'other' items in the balance sheet of bank b in period t
$g_{a^b,i,1}$: household's repayment rate functional form for agent a in regards to bank b in state i
$g_{a^b,ii,1}$: household's repayment rate functional form for agent a in regards to bank b in state ii
$a_{a^b,1}$: household's demand for loans functional form for for agent a in regards to bank b
$z_{b,1}$: deposit supply functional form for bank b
$u_{i,1}$: GDP function form in state i
$u_{ii,1}$: GDP function form in state ii
c_i^b: coefficient of risk aversion in the utility function of bank b in state i
c_{ii}^γ: coefficient of risk aversion in the utility function of bank b in state ii
$a_{h^b,3_{(\forall h \in H^b)}}$: household's demand for loans functional form
$a_{h^b,4_{(\forall h \in H^b)}}$: household's demand for loans functional form
A_t^b: Other assets of bank b in period t
e_t^b: Bank b's capital in period t
$\overline{\omega}$: Risk weight on consumer loans
$\omega(\widetilde{\omega})$: Risk weight on investment (risk weight on market book)
ρ_t: Interbank rent in period t
$g_{h,i,2_{(\forall h \in H^b)}}$: elements of the household's repayment rate functional form in state i
$g_{h,ii,2_{(\forall h \in H^b)}}$: elements of the household's repayment rate functional form in state ii
$g_{h,i,3_{(\forall h \in H^b)}}$: elements of the household's repayment rate functional form in state i
$g_{h,ii,3_{(\forall h \in H^b)}}$: elements of the household's repayment rate functional form in state ii
$\overline{k}_{t+1,S(\forall s \in S)}^\gamma$: *Capital adequacy requirements*
$\lambda_{ks(\forall b \in B, s \in S)}^b$: *Non-pecuniary penalty for capital adequacy requirement violation of bank b in state s*
$\lambda_{i(b \in B)}^b$: *Non-pecuniary penalty for capital adequacy requirement violation of bank b in state i*
$\lambda_{ii(b \in B)}^b$: *Non-pecuniary penalty for capital adequacy requirement violation of bank b in state ii*
$u_{s,3_{(\forall s \in S)}}$: elements of the GDP functional form
$z_{b,2_{(\forall b \in B)}}$: elements of the deposit supply form
$z_{b,3_{(\forall b \in B)}}$: elements of the deposit supply form
$z_{b,4_{(\forall b \in B)}}$: elements of the deposit supply form
$u_{s,2_{(\forall s \in S)}}$: elements of the GDP functional form
r_t^A: The rate of return on market book in period t
ρ: Probability that state i will occur in the next period
$a_{a^b,2}$: elements of the household's demand for loans functional form for agent a in relation to bank b
Notes: $b \in B = \{\gamma, \delta, \tau\}$; $a \in A = \{\alpha, \beta, \theta, \phi\}$

Technical Annex 3: Detailed tables with the directional changes in the endogenous variables under the theoretical model

See Annex 3 section here Tables A1–A6 here.

Table A1
Directional changes in the endogenous variables in the model caused by deteriorating NPL ratios of Bank γ ('high NPLs') and Bank δ ('moderate NPLs'): no resolution – baseline scenario.

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	+ ~	-	+ ~
r_d^b(deposit rate)	0	-	0
$\overline{m}_t^b$(credit in the loan market)	-~	-~	-~
π_i^b (profit in state i)	-~	+ ~	-~
π_{ii}^b (profit in state ii)	-~	+ ~	+ ~
e_i^b(capital in state i)	+ ~	+ ~	+ ~
e_{ii}^b (capital in state ii)	+ ~	+ ~	+ ~
$\mu_{d,t}^b$(debt in interbank market)	+ ~	+	-~
k_i^b (CAR in state i)	+ ~	+	+ ~
k_{ii}^b (CAR in state ii)	+ ~	+	+ ~
v_i^b(repay. Rate in state i)	-	-~	-~
v_{ii}^b(repay. Rate in state ii)	-~	-~	-~
GDP_i	-~		
GDP_{ii}	-~		
M	+ ~		

Note: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Source: Authors (2023).

Table A2
Directional changes in the endogenous variables in the model under 'Nationalisation' scenario.

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	+ ~	-~	-~
r_d^b(deposit rate)	0	-~	0
$\overline{m}_t^b$(credit in the loan market)	-~	+ ~	+ ~
π_i^b (profit in state i)	-~	-~	-~
π_{ii}^b (profit in state ii)	-~	-~	-~
e_i^b(capital in state i)	+ ~	-~	-~
e_{ii}^b (capital in state ii)	+ ~	-~	-~
$\mu_{d,t}^b$(debt in interbank market)	-~	-	-
k_i^b (CAR in state i)	+ ~	-~	-~
k_{ii}^b (CAR in state ii)	+ ~	-	-
v_i^b(repay. rate in state i)	+ ~	-	+ ~
v_{ii}^b(repay. rate in state ii)	-~	-	-
GDP_i	+ ~		
GDP_{ii}	+ ~		
M	+ ~		

Note: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Recap of the exercise setup:
- the government increases household tax to finance the bank resolution in the form of a capital injection into Bank γ
- this, in effect, decreases household loan demand and deposit supply functions:
$a_{\alpha,\beta,\theta}$: ↓15%
$z_{b,1}$: ↓15%
- the resolution involves recapitalization of Bank γ through capital injection: e_t^γ : ↑15%
Source: Authors (2023).

Table A3
Directional changes in the endogenous variables in the model under 'Government-assisted merger' scenario without any capital injection (Merger 1).

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	n/a	+	+
r_d^b(deposit rate)	n/a	+	0
$\overline{m}_t^b$(credit in the loan market)	n/a	-~	-~
π_i^b (profit in state i)	n/a	+ ~	+ ~
π_{ii}^b (profit in state ii)	n/a	+ ~	-~
e_i^b(capital in state i)	n/a	+ ~	0
e_{ii}^b (capital in state ii)	n/a	+ ~	+ ~
$\mu_{d,t}^b$(debt in interbank market)	n/a	+ ~	-~
k_i^b (CAR in state i)	n/a	+ ~	+ ~
k_{ii}^b (CAR in state ii)	n/a	+ ~	+ ~
v_i^b(repay. rate in state i)	n/a	-~	+ ~
v_{ii}^b(repay. rate in state ii)	n/a	-~	-~
GDP_i	-~		
GDP_{ii}	-~		
M	+ ~		

Notes: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Recap of the exercise setup:
- the government assists in a merger of Bank γ with Bank τ
- all of Bank γ's balance sheet is combined with the balance sheet of Bank τ, and reported under Bank τ
- the government completes the bank sale resolution: through assisting in the merger without any capital injection (Merger 1).
Source: Authors (2023).

Table A4
Directional changes in the endogenous variables in the model under 'Government-assisted merger' scenario with an instant capital injection (Merger 2).

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	n/a	-	-
r_d^b(deposit rate)	n/a	-	0
$\overline{m}_t^b$(credit in the loan market)	n/a	+	+
π_i^b (profit in state i)	n/a	-~	-~
π_{ii}^b (profit in state ii)	n/a	-~	-~
e_i^b(capital in state i)	n/a	-~	+
e_{ii}^b (capital in state ii)	n/a	-~	+
$\mu_{d,t}^b$(debt in interbank market)	n/a	-	-
k_i^b (CAR in state i)	n/a	-	-
k_{ii}^b (CAR in state ii)	n/a	-	-
v_i^b(repay. rate in state i)	n/a	-~	-~
v_{ii}^b(repay. rate in state ii)	n/a	+	+
GDP_i	+		
GDP_{ii}	+		
M	+		

Notes: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Recap of the exercise setup:
- the government assists in a merger of Bank γ with Bank τ
- all of Bank γ's balance sheet is combined with the balance sheet of Bank τ, and reported under Bank τ
- the government completes the bank sale resolution through assisting in the merger with an instant capital injection (Merger 2)
- thus, the government increases household tax to finance the recapitalization of Bank τ through: e_t^{τ} : ↑15%
- this, in effect, decreases household loan demand and deposit supply functions:
$a_{\alpha,\beta,\theta}$: ↓15%
$z_{b,1}$: ↓15%
Source: Authors (2023).

Table A5
Directional changes in the endogenous variables in the model under 'Bad bank' scenario with a gradual capital injection (Bad bank 1).

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	-	-	-
r_d^b(deposit rate)	0	+ ~	0
$\overline{m}_t^b$(credit in the loan market)	+	+	+
π_i^b (profit in state i)	-	-	-
π_{ii}^b (profit in state ii)	-	-	-
e_i^b(capital in state i)	+	-	-
e_{ii}^b (capital in state ii)	+	-	-
$\mu_{d,t}^b$(debt in interbank market)	-	-	-
k_i^b (CAR in state i)	-	-	-
k_{ii}^b (CAR in state ii)	-	-	-
v_i^b(repay. rate in state i)	+	-	-~
v_{ii}^b(repay. rate in state ii)	+	+	+
GDP_i	+		
GDP_{ii}	+		
M	+		

Notes: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Recap of the exercise setup:
- the government assists in restructuring the balance sheet of the "bad" bank (i.e., Bank γ) by shifting all of its healthy assets to Bank τ ("good bank") excluding the capital of Bank γ
- the government gradually (Bad bank 1) injects capital to Bankγ: e_t^{γ} : ↑15%
- this capital injection is financed by taxpayer money which, in effect, gradually (Bad bank 1) decreases household loan demand and deposit supply functions:
$a_{\alpha,\beta,\theta}$: ↓15%
$z_{b,1}$: ↓15%
Source: Authors (2023).

Table A6
Directional changes in the endogenous variables in the model under 'Bad bank' scenario with an instant capital injection (Bad bank 2).

Endogenous variable	Bank γ	Bank δ	Bank τ
r^b(lending rate)	0	-~	0
r_d^b(deposit rate)	0	+ ~	0
$\overline{m}_t^b$(credit in the loan market)	-~	0	-~
π_i^b (profit in state i)	+ ~	0	0
π_{ii}^b (profit in state ii)	+ ~	0	0
e_i^b(capital in state i)	+ ~	0	0
e_{ii}^b (capital in state ii)	+ ~	0	0
$\mu_{d,t}^b$(debt in interbank market)	0	0	0
k_i^b (CAR in state i)	+ ~	0	-~
k_{ii}^b (CAR in state ii)	+ ~	0	-~
v_i^b(repay. rate in state i)	-~	0	+ ~
v_{ii}^b(repay. rate in state ii)	-~	0	-~
GDP_i	0		
GDP_{ii}	0		
M	0		

Notes: + (-) substantial increase (decrease); + ~(-~) weak increase (decrease); 0 – no change.
Recap of the exercise setup:
- the government assists in restructuring the balance sheet of the "bad" bank (i.e., Bank γ) by shifting all of its healthy assets to Bank τ ("good bank") excluding the capital of Bank γ
- the government instantly (Bad bank 2) injects capital to Bankγ: e_t^{γ} : ↑15%
- this capital injection is financed by taxpayer money which, in effect, instantly (Bad bank 2) decreases household loan demand and deposit supply functions:
$a_{\alpha,\beta,\theta}$: ↓15%
$z_{b,1}$: ↓15%
Source: Authors (2023).

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