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Bank recapitalization and economic recovery after financial crises☆,☆☆

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ABSTRACT

Does support to distressed banks early on during financial crises mitigate the macroeconomic consequences of financial distress, and if so does it matter what form the intervention takes? We analyze the effects of government and central bank interventions in 69 systemic banking crises since 1980, of which 29 are part of the recent global financial crisis. Our estimation approach controls for the correlation between intervention measures and the time-invariant component of unobservable crisis severity. We find that timely bank recapitalizations substantially reduce the duration of recessions, underscoring the distortions caused by zombie banks and the costs of regulatory forbearance.

1. Introduction

As early as 2009, Reinhart and Rogoff (2009a) pointed out that "recessions surrounding financial crises are usually long compared to normal recessions". Their research highlights large declines in output, slow recoveries and large and persistent negative effects on unemployment, public debt and fiscal deficits in the aftermath of banking crises. The subsequent experiences in the United States and particularly in Western Europe lend further support to their findings. So interventions of governments and central banks during financial crises may not only be needed to preserve the key functions of the financial system but also to mitigate the macroeconomic consequences of financial distress. But how effective are intervention measures in this respect, do they reduce duration of recessions? And does it matter how governments intervene? What are the economic costs of regulatory forbearance (inaction by regulators) during a crisis and the subsequent costs zombie banks impose on society? We attempt to answer these questions by empirically investigating durations of recessions after 69 systemic banking crises from the period 1980–2014. We find that bank recapitalizations substantially reduce recession duration. We also look at other intervention mechanisms such as liquidity support and guarantees on bank liabilities but find little or no positive effect of these measures on the expected recession duration.

We build on the empirical literature on financial crises, which documents large output losses and substantial fiscal costs of intervention (Reinhart and Rogoff, 2009; Hoggarth et al., 2002; Honohan and Klingebiel, 2003; Claessens et al., 2005).[1] Several papers (Kroszner et al., 2007; Dell' et al., 2008; Laeven and Valencia, 2013a) point at a transmission channel of bank distress to lower economic growth by showing that sectors more dependent on external finance grow disproportionally slower during and

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[1] Note Howard, Martin, and Wilson (2010) for a somewhat different view. They argue that time to recovery after a financial crisis induced recession is longer not because the recovery process is any different but because the initial recession is much deeper.

after banking crises. Importantly, Laeven and Valencia (2013a) find that recapitalizations of distressed banks and discretionary fiscal policy significantly increase growth of such firms. Furthermore, Chodorow-Reich (2014) provides evidence that weak banks lend less, which results in lower employment. Bank recapitalizations such as the TARP program in the US can mitigate the negative effects of bank distress on employment and reduce bankruptcies according to Berger and Roman (2015). A number of papers find that bank recapitalizations increase loan supply (cf. Li, 2013; Berger et al., 2016 or Poczter, 2016).

The consequences of regulatory forbearance, i.e. failing to address the undercapitalization of banks, can be clearly seen from the Japanese experience. Poorly capitalized banks tend to "evergreen" loans to insolvent firms (Peek and Rosengren, 2005; Watanabe, 2010). Because the inefficient firms then do not exit their industries, more productive firms may delay entry, which can lead to a long stagnation (Caballero et al., 2008). Injecting equity into such banks can help but only if banks are recapitalized sufficiently: in their analysis of Japanese banking distress, Giannetti and Simonov (2013) show that banks that remain weakly capitalized after a recapitalization may use the new funds to increase lending to zombie firms rather than to healthy ones. Acharya et al. (2016) make a similar point on a sample of European banks. In this paper, we assess whether all this micro-evidence translates into effects of macroeconomic significance.

Our work is also part of a recent literature on the desired policy response to long lasting recessions (see Blanchard et al., 2015 or Schularick and Taylor, 2012). Specifically, our paper is related to the burgeoning literature on interactions between sovereign debt and undercapitalized banks, the so called 'Diabolic Loop' (see Gennaioli et al., 2014 or van der Kwaak and van Wijnbergen, 2014). Undercapitalized banks are a key link in the amplification cycles at the core of that literature.

To set the stage for our empirical analysis, we first present a theoretical model that analyzes the effectiveness of bank recapitalization. The key inefficiency in the model is that after a shock has eroded a bank's assets, banks have incentives to shift risk by rolling over loans to borrowers in distress. Since the banks are undercapitalized, a correspondingly larger part of the risk associated with the rollover will then be borne by creditors of the bank or by whoever steps in to rescue the bank when it gets into distress. Recapitalizing such zombie banks mitigates this incentive problem. Other interventions may prevent bank failures but generally do not address the incentive problem and therefore do not improve welfare as much as bank recapitalization. In a simple macroeconomic extension, we show that recapitalizing banks leads to stronger recovery (higher expected future output) than one can expect in a zombie bank environment with distorted rollover incentives.

We test these theoretical predictions by estimating a duration model with crisis-specific fixed effects on a panel dataset, taking into account that intervention may be endogenous to crisis severity: it is plausible that governments are more likely to intervene in severe than in mild crises. If a measure increases the probability of recovery but is more likely to be used in severe crises, which in turn are associated with longer recessions, regressions may spuriously indicate that the measure is not effective. In our sample, crises where banks were recapitalized were on average indeed much more severe than crises where recapitalizations were not used. But our estimation results, that take this endogeneity issue into account, show a highly significant and positive effect of bank recapitalizations on the probability of recovery. As a consequence, severe recessions are predicted to last two years less after recapitalization, down from 14 to 6 quarters. Light recessions are still expected to be shortened by about half a year after recapitalization, down from 5 to 3 quarters. These findings clearly show the costs of zombie banks and regulatory forbearance to society.

The paper is organized as follows. Section 2 presents the theoretical model. The empirical methodology is explained in Section 3 where we also describe the data used. Results on recapitalizations and subsequent recovery are presented and discussed in Section 4. Section 5 concludes.

2. Model

We use a simple theoretical model to show how interventions to counteract the negative consequences of loans turning bad for bank capital can favorably affect recession duration. In contrast to the existing literature on intervention (see for example, Diamond and Rajan, 2011; Philippon and Schnabl, 2013; Philippon and Skreta, 2012; Tirole, 2012), we do not focus on adverse selection problems; nor on the ex ante (collective) moral hazard created by bailout expectations (Farhi and Tirole 2012). Instead we analyze the ex post moral hazard in lending that arises after a negative shock has eroded the value of bank assets and as a consequence bank capital. Our model is perhaps most closely related to a very early contribution to the literature on bank intervention, Berglof and Roland (1995), who investigate why so called soft budget constraints emerge. They argue that banks that have sufficient capital enforce discipline on borrowers and thereby induce effort in firms, while those with little capital refinance inefficient firms in order to benefit from a government bailout (see also Landier and Ueda, 2009).

Core to our model is that the presence of nonperforming loans can give banks ample opportunities for risk shifting. Nonperforming loans can be very high in systemic banking crises. The average peak value of the ratio of NPLs to total banking assets during the 65 crises from the dataset of Laeven and Valencia (2013b) is 20%. The model is set up to demonstrate how bank recapitalization improves incentives of a zombie bank and helps to motivate the subsequent empirical analysis.

2.1. Timeline of events

There are two time periods. The first one lasts from $t=0$ until $t=1$ and the second from $t=1$ till $t=2$ (See Fig. 1). There are three types of agents: a bank, depositors and the regulator. The regulator is only active from $t=1$ on if there is a banking crisis.

- At $t=0$ the bank raises k of equity and $1-k$ of debt with maturity of one period. It makes 1 unit of loans to firms that invest into two-period projects.
- At $t=1$ the bank and the regulator observe the quality of bank loans. A proportion of loans $1-q$ is good; the remaining q are bad loans. Depositors may withdraw. If the bank cannot obtain funding it liquidates the loans as much as necessary to repay depositors. The liquidation value of both good and bad loans is $\lambda < 1$ per unit of a loan. If the bank can secure funding for the second period, it makes a decision about the bad loans. It either rolls them over as if they were good loans or liquidates them and lends the proceeds to new firms.
- At $t=2$ the bank collects loan repayments. Good loans repay a cash flow R with certainty. Bad loans that were liquidated and reinvested repay λR per unit of initial lending, with certainty. Bad loans that were not liquidated repay R with probability p and zero otherwise. Depositors are repaid. Bank shareholders get the residual.

2.2. Depositors

Depositors are risk neutral and in expectation require a gross return equal to the risk free rate, which is normalized to 1. At $t=0$ the bank raises $D=1-k$ of deposits, which it promises to repay

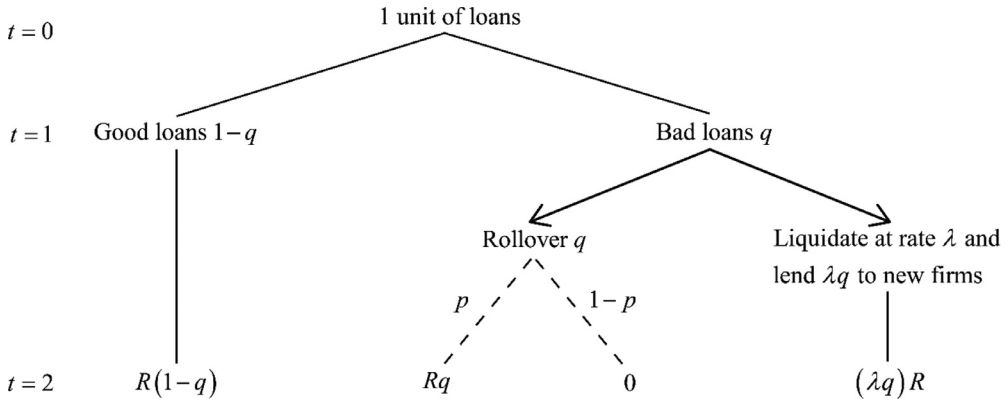

Fig. 1. At $t=0$ the bank makes 1 unit of loans. At $t=1$ the bank and the regulator observe the quality of loans. A proportion of loans $1-q$ is good; the remaining q are bad loans. At $t=2$ good loans repay with certainty a cash flow R per unit of lending. If the bank rolls over the bad loans, they repay R with probability p and zero otherwise. If the bank liquidates bad loans it gets λ per unit of liquidated bad loans. The proceeds from liquidation are lent to new firms at a rate R.

at $t=2$ or at $t=1$ if depositors withdraw early. If they withdraw at $t=1$, the bank tries to raise new debt in the amount of D to repay the existing depositors. In case it cannot repay the promised amount, the depositors get all cash flows the bank can collect. If the bank is insolvent at $t=1$, the depositors get λ since the bank has to liquidate its entire loan portfolio. If the bank is insolvent at $t=2$, which can occur when bad loans did not perform well, the depositors get $R(1-q)$.

2.3. Bank

The bank pursues the interests of its shareholders. It is assumed that an incentive structure is in place that insures that the interests of bank managers do not diverge from those of bank shareholders. At $t=0$ bank shareholders pay in k of equity, on which they require an expected return strictly larger than the risk free rate, in line with the riskiness of equity. The higher required return gives bank shareholders an incentive to lever up as much as possible. Bank shareholders are residual claimants on cash flows at $t=2$ and have limited liability. If the bank liquidates bad loans the payoff to bank shareholders is $R(1-q)+R\lambda q-D$. If the bank rolls over bad loans, the payoff to bank shareholders is $R-D$ if the bad loans perform and zero if they do not.

2.4. Bad loans

By liquidating bad loans we mean a decision with which the bank sacrifices a part of the outstanding claim for a higher probability of being repaid the remainder. The liquidation parameter λ is the amount that the bank can collect per unit of liquidated loans so the liquidation value isλR. It is socially optimal to liquidate bad loans: leaving them as they are is risky and has a lower expected payoff than the payoff from liquidation (and new lending) under the assumptions made so far:[2]

$$pR < \lambda R \tag{1}$$

For simplicity it is assumed that the bank extracts all value from the firms to which it lends. The total amount collected from lending is then equal to the aggregate output. Despite the liquidation of bad loans being socially optimal, the bank may choose to roll them over if bank shareholders do not fully internalize the losses when bad loans fail. The bank chooses to liquidate bad loans if liquidation and subsequent lending to new firms brings a higher expected payoff to bank shareholders than does rolling over of bad loans. This is the case if (with $R_{roll\ over}$ being the outcome of rolled-over bad loans):

$$R(1-q)+R\lambda q-D > E[\max(R_{rollover}-D,0)] \tag{2}$$

Computing the expected payoffs gives the liquidation incentive constraint:[3]

$$R(1-q)+R\lambda q-D > p(R-D) \tag{3}$$

If the liquidation incentive constraint (3) is not satisfied, the bank chooses to roll over bad loans.

2.5. Equilibrium in stable times

The lending rate R, the proportion of bad loans q, the liquidation value λ and the probability that bad loans repay p are public knowledge at $t=0$. The analysis focuses on the case where parameter values are such that banking is only viable if bad loans are liquidated in stable times. We therefore assume that if the bank holds on to bad loans the total expected return from lending is less than 1:

$$R(1-q)+Rpq < 1 < R(1-q)+R\lambda q \tag{4}$$

Thus depositors and bank shareholders can both earn at least the risk free rate only if bad loans are liquidated. Therefore in equilibrium bad loans have to be liquidated. If bad loans are liquidated, the loan repayments at $t=2$ are certain. Hence, with the risk free rate being equal to 1, the promised repayment to depositors is equal to their initial investment $D=1-k$. To insure that bad loans are liquidated, the incentive constraint (3) has to be satisfied. It can be expressed as a constraint on the bank capital ratio k.

$$k > 1-\frac{R(1-p-q(1-\lambda))}{1-p} \tag{5}$$

The only way for the bank to commit to liquidate bad loans is to have a sufficiently high capital ratio. Since bank shareholders require a return strictly larger than the risk free rate, they have an incentive to increase bank leverage as much as possible, so in equilibrium the incentive constraint is binding. The required capital ratio is increasing in the proportion of bad loans q and decreasing in the liquidation value λ.

[2] The insights of the model would remain the same if good loans and new lending were risky but the variance of their repayment would be lower than the variance of bad loans that are rolled over.

[3] The incentive constraint only "bites" when debt obligations are so high that bank shareholders get zero in case bad loans fail. Note that for simplicity we assume that liquidation proceeds that are lent out again receive R with certainty. Assuming that a fraction q of those loans is likely to fail again makes no material difference to any of the results.

2.6. A banking crisis

Our focus is on ex-post intervention so we model a banking crisis as a zero-probability unanticipated event, as in Allen and Gale (2000).[4] A banking crisis differs from stable times in that the proportion of bad loans turns out to be unexpectedly high. Neither the bank nor the depositors expect a shock to the amount of bad loans, so at $t=0$ their behavior is exactly the same as in stable times. At $t=1$ the bank (and the regulator) observe that the proportion of bad loans is $q+\xi$, with $\xi > 0$ being the shock. It still is socially optimal to liquidate bad loans and lend to new firms. But the incentive constraint is no longer satisfied for the new, higher proportion of bad loans. The new capital ratio k' that would satisfy the incentive constraint given the higher proportion of bad loans, is larger than the existing capital ratio k:

$$\begin{aligned} k' &= 1 - \frac{R(1-p-(q+\xi)(1-\lambda))}{1-p} \\ &= 1 - \frac{R(1-p-q(1-\lambda))}{1-p} + \frac{R\xi(1-\lambda)}{1-p} \\ &> k \end{aligned} \tag{6}$$

Depositors recognize that the bank has been hit but do not observe the size of the shock. They cannot coordinate their actions. If all existing depositors withdraw, potential new depositors are not willing to lend to the bank either. Because the depositors do not know the size of the shock, a new deposit contract at a different rate is not feasible.[5] If the bank cannot obtain new deposits, it liquidates its loan portfolio at a rate λ to repay the existing deposits. If λ is less than the amount of debt $1-k$, depositors are not fully repaid. Whether $\lambda < 1-k$ depends on the equilibrium value of k; in what follows we will assume this to be the case.

The regulator, representing the central bank and the government, does observe the size of the shock. It cannot require the bank to liquidate bad loans but it can possibly improve total welfare by intervening in the bank. Total welfare is defined as the sum of repayments to depositors, bank shareholders and the losses or gains realized by the regulator. In the absence of intervention, the entire bank is liquidated. The loans are then sold to outside investors. Depositors place the proceeds into riskless government securities. Total welfare is then equal to λ. This scenario implies efficiency losses because good loans are liquidated at a loss and because the proceeds from liquidation of loans are not lent on to new firms as the bank has gone out of business. Consider next the impact of a recapitalization of the adversely affected bank(s).

2.7. Bank recapitalization

Bank shareholders do not have an incentive to recapitalize the bank at $t=1$ after it has been hit by a shock; recapitalization would then mostly benefit the depositors. The regulator, however, can improve total welfare by recapitalizing the bank before the bank makes the decision about the bad loans. The incentive constraint of the bank can be satisfied if the regulator injects an amount of capital g into the bank, where g follows from:

$$k+g > 1 - \frac{R(1-p-q(1-\lambda))}{1-p} + \frac{R\xi(1-\lambda)}{1-p} \tag{7}$$

The minimum amount of capital that satisfies this inequality is $\bar{g} = \frac{R\xi(1-\lambda)}{1-p}$. We assume that g will be used to repay part of the existing deposits. Deposits in the second period are then only $1-k-g$. When the incentives for liquidating bad loans are restored, the value of bank assets at $t=2$ is $R(1-q-\xi)+R\lambda(q+\xi)$. This outcome maximizes total welfare for two reasons: (i) no good loans are liquidated (as would happen in the case of bank failure) and (ii) bad loans are liquidated (unlike what happens under interventions that prevent bank runs but do not increase bank capital). The regulator can recoup the costs of the equity injection at $t=2$ from the cash flow remaining after depositors are repaid. How the residual claim is split between the regulator and bank shareholders depends on the terms of recapitalization.[6]

To be effective, a recapitalization has to be implemented before the bank makes the decision about bad loans. If it is done after the bank has already rolled over the bad loans, it has no beneficiary effect on incentives: ex post recapitalization only covers the losses from failed bad loans. Second, the recapitalization needs to be high enough so that with $k+g$ of equity liquidation of bad loans becomes in the interest of bank shareholders. Finally there should be a ban on subsequent dividend payouts: existing bank shareholders would prefer an immediate payout and a continued gamble with the bad loans.

Note that alternative interventions, like for example providing deposit insurance, blanket guarantees on bank liabilities or open ended liquidity support will prevent bank failures as the bank is able to obtain debt financing despite being undercapitalized or even insolvent. But they do not remedy the incentive problems caused by asset losses and the ensuing erosion of bank capital. Therefore the bank will continue to gamble for resurrection rather than liquidate the bad loans.

2.8. Macroeconomic consequences

To sketch the macroeconomic consequences of the different intervention strategies, assume that economic recovery is related to positive project outcomes and new investments. Expected future output in the context of our model equals:

$$\begin{aligned} \mathrm{E}y_Z &= R(1-q) + qpR \\ &= (1-q(1-p))R \end{aligned} \tag{8}$$

in case zombie banks are not recapitalized. But if incentives encourage liquidation and new lending, expected output becomes:

$$\begin{aligned} \mathrm{E}y_R &= (1-q)R + \lambda qR \\ &= (1-q(1-\lambda))R \end{aligned} \tag{9}$$

So the recovery gains from recapitalizing banks are:

$$\begin{aligned} \mathrm{E}y_R - \mathrm{E}y_z &= (\lambda - p)qR \\ &> 0 \end{aligned} \tag{10}$$

The inequality follows from Eq. (1).

Conceivably expansionary fiscal policy could be a substitute for recapping banks by stimulating a recovery which would reverse the increase in q triggering the debt overhang. However Kirchner and van Wijnbergen (2016) provide evidence against that view by demonstrating that fiscal multipliers are much reduced in the presence of undercapitalized banks. This suggests that for fiscal policy to be effective, banks need to be recapitalized first.

[4] Note that introducing a crisis as anticipated in potentiality but as very low probability event would add complexity without materially affecting the results.

[5] This assumption rules out equilibria where the deposit rate is adjusted for risk or where the bank shrinks. Such equilibria are only possible if the shock is small enough that bank shareholders can earn a positive return after readjustment.

[6] See Hoshi and Kashyap (2010) for a critical examination and comparison of recapitalization methods used in the US in 2008/2009 and earlier in Japan. Philippon and Schnabl (2013) discuss the optimal way of restructuring banks in the presence of adverse selection problems. Landier and Ueda (2009) provide an extensive overview of bank restructuring options.

3. Empirical methodology and data

3.1. Empirical methodology

Our dataset is a panel of systemic banking crises where index i denotes a crisis and t refers to a particular quarter of a recession. For each crisis, the sample includes all quarters when a country was in a recession and the quarter in which it recovered. The time index t indicates how many quarters a recession has already lasted. In the first recession quarter $t=0$. At the time of recovery $t=T_i$; the completed recession duration of a crisis i is T_i. We define y_{it} as an indicator of whether a country is in recession in a given quarter or it has just recovered.

$$y_{it} = \begin{cases} 1 & \text{recession ends} \\ 0 & \text{recession is ongoing} \end{cases}$$

In duration models the probability that a process ends is typically referred to as the hazard rate. In our case the hazard rate is the probability that a recession ends in a particular quarter conditional on that it has not ended in any of the previous quarters and conditional on the values of explanatory variables x_{it} and a crisis specific fixed effect c_i. It is given by the following equation:

$$\begin{aligned} \lambda(t, x_{it}, c_i) &= \Pr(y_{it} = 1 | y_{it-1} = 0, \ldots, y_{i1} = 0, x_{it}, c_i) \\ &= G(x_{it}\beta + \gamma_t + c_i) \end{aligned} \tag{11}$$

where $G(\bullet)$ is a cumulative distribution function and $\gamma_t = \gamma(t)$ is a function of elapsed duration.[7] It is crucial for our estimation approach to control for crisis severity, because crisis severity may well influence the intervention chosen and thereby bias the estimates of the impact of the intervention enacted on the subsequent evolvement of the crisis. It is prima facie reasonable to expect that intervention measures in banking crises are endogenous to crisis severity, in more severe crises different measures may be used than in mild crises, or the extent to which they are used may be correlated with severity. If intervention was completely determined by crisis severity, identification of effects of intervention would be difficult since crisis severity is obviously also a major determinant of recession duration. There is, however, likely to be some randomness and asymmetry in the relation between crisis severity and intervention, in particular with respect to its timing. Severity information that comes after the intervention has taken place clearly cannot have an impact on that decision to intervene anymore.

We take advantage of that randomness and time asymmetry to eliminate any correlation between independent variables and the error terms by assuming crisis severity has two components: a time invariant crisis specific component c_i, which represents the shock that has caused a banking crisis to begin with, and a time dependence $\gamma_t = \gamma(t)$ describing the pattern severity follows over time in the absence of intervention. So if there is no intervention, c_i determines the initial level of probability of recovery and γ_t describes how the probability changes over time. We expect γ_t to be an increasing function of time although not necessarily monotonically increasing. To allow for that we use a cubic specification $\gamma_t = \gamma_0 + \gamma_1 t + \gamma_2 t^2 + \gamma_3 t^3$. We let the initial shock c_i be correlated with intervention measures, while γ_t is not crisis specific and is assumed not to have an impact on the intervention chosen. This means that intervention measures by assumption depend on the (severity of the) shock that caused the banking crisis, but not on exogenous factors that affect the level of severity later on. The component c_i is a fixed effect in a duration model.

To estimate a specification with fixed effects in a nonlinear model we use the approach of Mundlak (1978). We regauge Eq. (11) using the y_{it} as an indicator of the latent probability of recovery in place of the hazard rate, with $y_{it} = Index[y^*_{it} > 0]$. $Index[...]$ is an index function equaling 1 if $y^*_{it} > 0$ and 0 otherwise, while y^*_{it} follows:

$$y^*_{it} = x_{it}\beta + \gamma_t + c_i + e_{it} \tag{12}$$

The assumption that initial crisis severity has an impact on the intensity and mode of intervention is captured by specifying c_i explicitly as a function of the average values of explanatory variables over time within a crisis and a random component v_i

$$c_i = \bar{x}_i\delta + v_i \tag{13}$$

Then including Eq. (13) into Eq. (12) yields:

$$y^*_{it} = x_{it}\beta + \bar{x}_i\delta + \gamma_t + v_i + e_{it}. \tag{14}$$

This is the transformation proposed by Mundlak (1978). In effect it enables the estimation of a fixed effects model with a random effects procedure. It can be applied also to nonlinear models such as logit or complementary log–log models that are commonly used in duration analysis. It is important to realize that the impact of the variables of interest x_{it} is captured by the vector of coefficients β only. $\bar{x}_i\delta$ is a part of the fixed effect eliminating any reverse dependence. The estimates of δ give an indication of the correlation between the likelihood that a particular intervention is undertaken and crisis severity, but have no implication for its impact on recession duration. From an econometric point of view, if the δ is not significantly different from zero, correlation is not a problem and a regular random effects specification can be used.

In the next step we use the estimated parameters from Eq. (14) to obtain predicted probabilities of recovery, which we then use to compute expected recession durations. The following equations describe predicted probabilities for three estimation models with different distributional assumptions: the complementary log–log (15), the logit (16) and the linear probability (17) model respectively:

$$\begin{aligned} \hat{P}(y_{it} &= 1 | y_{it-1} = 0, \ldots, y_{i1} = 0, x_{it}, c_i) \\ &= 1 - \exp(-\exp(x_{it}\hat{\beta} + \bar{x}_i\hat{\delta} + \hat{\gamma}_t)) \end{aligned} \tag{15}$$

$$\hat{P}(y_{it} = 1 | y_{it-1} = 0, \ldots, y_{i1} = 0, x_{it}, c_i) = \frac{\exp(x_{it}\hat{\beta} + \bar{x}_i\hat{\delta} + \hat{\gamma}_t)}{1 + \exp(x_{it}\hat{\beta} + \bar{x}_i\hat{\delta} + \hat{\gamma}_t)} \tag{16}$$

$$\hat{P}(y_{it} = 1 | y_{it-1} = 0, \ldots, y_{i1} = 0, x_{it}, c_i) = x_{it}\hat{\beta} + \bar{x}_i\hat{\delta} + \hat{\gamma}_t \tag{17}$$

A desirable characteristic of the complementary log–log model is that it assumes that the underlying process (recession) is continuous but can only be observed at discrete points in time, while the logit or the linear probability model require the assumption that the duration process is discrete. Therefore we use the complementary log–log specification as our basic approach and the other two in robustness checks. The probabilities given by the equations above are conditional on that the recession has not ended in any of the previous quarters and on x_{it} and c_i. Hence, we refer to these probabilities as to conditional probabilities of recovery. In contrast, we use the term unconditional probability of recovery for the predicted probability of recovery that is conditioned only on the values of explanatory variables until then $X_{i\{1\ldots t\}}$ and c_i but not on the recession not having ended before. The unconditional probability of recovery is the product of the probability of recovery conditional on recession lasting until t and the unconditional probability that the recession has not ended in the previous quarter.

$$\begin{aligned} P(y_{it} = 1 | X_{i\{1,\ldots,t\}}, c_i) = P(y_{it} &= 1 | y_{it-1} = 0, \ldots, y_{i1} = 0, x_{it}, c_i) \\ &\cdot (1 - P(y_{it-1} = 1 | X_{i\{1,\ldots,t-1\}}, c_i)) \end{aligned} \tag{18}$$

The unconditional probability that the recession has not ended in the previous quarter can be expressed as the corresponding

[7] For additional details on duration models see Online Appendix A.

conditional probability of that quarter (conditional on the recession not having ended the quarter before) and the unconditional probability of no recovery a quarter before. This procedure can be repeated all the way back to the first quarter when the conditional probability of recovery is equal to the unconditional probability as there is no preceding quarter. This gives an expression for the unconditional probability of recovery in quarter t as a product of conditional probabilities of no recovery in all previous quarters.

$$P(y_{it}=1|X_{i\{1,\ldots,t\}},c_i)=P(y_{it}=1|y_{it-1}=0,\ldots,y_{i1}=0,x_{it},c_i)\cdot (1-P(y_{it-1}=1|y_{it-2}=0,\ldots,y_{i1}=0,x_{it-1},c_i)) \cdot\ldots\cdot (1-P(y_{i1}=1|x_{i1},c_i)) \quad (19)$$

The expected recession duration $E[T_i]$ is the product of the predicted unconditional probabilities of recovery in any period and their respective durations, which range from $t=0$ up to $t=t_{MAX}$.

$$E[T_i]=\sum_{t=1}^{t_{MAX}}[t\cdot\hat{P}(y_{it}=1|x_{i\{1,\ldots,t\}},c_i)] \quad (20)$$

The limit t_{MAX} is set at a value where the numerically computed probability of recession lasting until then is equal to zero.

3.2. Banking crises

Our dataset covers 69 systemic banking crises from the period 1980–2014, of which 40 are from the period before 2007 and 29 belong to the recent global financial crisis. For each banking crisis the panel includes the quarters in which a country was in a recession, and the quarter when it recovered. We start with the list of 65 systemic banking crises described by Laeven and Valencia (2013b) and add four additional crises that meet the same criteria.[8] A crisis is considered systemic if two conditions are satisfied. Firstly, there has to be major distress in the banking system such as bank runs, large losses of bank capital or bank liquidations. Secondly, there need to be significant policy interventions in response to the problems in the banking sector. This condition is met if at least 3 of the following measures were used:

- Extensive liquidity support (claims of the central bank on deposit money banks larger than 5% of deposits and liabilities to nonresidents);
- Gross bank restructuring costs at least 3% of GDP;
- Significant bank nationalizations;
- Significant guarantees on bank liabilities;
- Asset purchases amounting to at least 5% of GDP;
- Deposit freezes or bank holidays.

When both conditions are met a crisis is considered systemic. If just 2 types of measures from the list above were used, Laeven and Valencia (2013b) report it as a borderline case. All crises in the 1980–2006 period listed in their dataset were systemic according to the above definition. In the recent global financial crisis 18 countries were classified as having a systemic banking crisis and 8 as borderline cases. Three countries, Portugal, Slovenia and Spain, experienced two recessions linked to distress in the banking sector in the period after 2007. We treat these recessions as separate crisis episodes.

The starting date of a banking crisis is the quarter in which major distress in the banking sector was observed. The date when a crisis becomes systemic is the quarter when the conditions mentioned above are fulfilled. Table 1 lists the systemic banking crises from the period 1980–2006. Countries that experienced a systemic banking crisis (or were classified as a borderline case) during the recent global financial crisis are listed in Table 2.

[8] We add the following crises: Cyprus 2011 Q3, Portugal 2010 Q4, Slovenia 2011 Q3 and Spain 2011 Q3.

Some banking crises were not followed by a recession. These crises are included in the tables although they cannot be analyzed with recession duration models. In total there are 11 such crises, 10 in the period before 2007 and one after. Next we describe the variables used in the regression analysis. Additional details about data sources and descriptive statistics are provided in the Online Appendix.

3.3. The recession indicator

The recession indicator is the dependent variable in our duration model. It is equal to 0 if a country is in a recession in a given quarter and equal to 1 if it has just recovered from it. For countries that are not in a recession at the time of the banking crisis start, the start of the recession is defined as the first quarter with negative GDP growth after the start of the banking crisis. This quarter needs to be either part of a sequence of at least two consecutive negative growth quarters or a sequence of positive and negative quarters where a positive quarter is always preceded and succeeded by a negative quarter and there are at least two consecutive negative quarters in that sequence. The recession needs to start at latest 6 quarters after the start of a banking crisis to be considered related to the banking crisis. Two consecutive positive growth quarters mark the end of a recession. The first of these two quarters is the recovery quarter in which the recession indicator turns 1. The recession period is composed of quarters with negative growth but may include few positive growth quarters within the sequence of negative growth quarters. Such a definition is used as one positive growth quarter does not mean that a recession is really over. Applying this definition to determine the start and end of the recent recession in the US gives the same dates as the ones announced by the National Bureau of Economic Research. NBER (2012) uses multiple indicators and judgment to define the date of a peak and a trough, which mark the start and the end of a recession. The recent recession in the US began with the peak in December 2007 and ended with the through in June 2009. In the first quarter of 2008 GDP growth was negative; in the second it was positive; then four quarters of negative growth followed. The recovery quarter was the third quarter of 2009. Some countries are already in a recession in the quarter when the banking crisis starts. In this case consecutive negative growth quarters before the start of the banking crisis are counted as a part of the recession.

The sources of GDP data are the World Economic Outlook and the International Financial Statistics databases provided by the IMF. Whenever available we use seasonally adjusted quarter-over-quarter GDP growth rates from the WEO. For crises for which these data are not available, we complement it with quarterly GDP growth rates from the IFS and use X-12 ARIMA procedure provided by the U.S. Census Bureau (2011) to seasonally adjust it. For 5 crises used in the regression analysis we use annual GDP growth rates from the WEO as there is no quarterly data available.

3.4. Bank recapitalizations

The variable bank recapitalizations measures the cumulative amount of recapitalizations in the banking sector since the start of the crisis. The amounts are weighed by total assets of the banking sector. Recapitalizations are assumed to have an effect on the probability of recovery from the first quarter after they have been implemented until the end of the recession.

There is a variety of measures that could be considered a recapitalization. We count as recapitalization injections of common equity, preferred stock, conditionally convertible (CoCo) bonds or any Tier 1 qualifying instrument by the state, a bank restructuring agency or other government agency. We do not consider in-

Table 1
Systemic banking crises in the period 1980–2006.

Country	Crisis start	Systemic crisis date	Recession start	Recovery	Recess. duration	Duration of exist. recession	Bank recap date	Recap end of recession	Recap end of crisis
Argentina	1980 Mar	1980 May	1981 Q1	1983 Q1	8				
Argentina	1989 Dec	1989 Dec	1988 Q1	1990 Q3	10	7			
Argentina	1995 Jan	1995 Jan	1995 Q1	1995 Q4	3				
Argentina	2001 Nov	2001 Dec	2001 Q2	2002 Q2	4	2			
Bolivia	1994 Nov	1994 Nov							
Brazil	1990 Feb	1990 Feb	1990 Q1	1992 Q1	8				
Brazil	1994 Dec	1994 Dec	1995 Q1	1995 Q4	3				1.24
Bulgaria	1996 Jan	1996 Jun							
Chile	1981 Nov	1983 Mar	1981 Q4	1983 Q1	5				
Colombia	1982 Jul	1982 Jul							
Colombia	1998 Jun	1998 Jun	1998 Q3	1999 Q3	4			0.38	0.75
Cote d'Ivoire	1988	1988							
Croatia	1998 Mar	1998 Mar	1998 Q4	1999 Q2	2			0.96	8.37
Czech Republic	1996 Jun	1996 Jun	1996 Q4	1998 Q1	5				
Dominican Rep.	2003 Apr	2003 Apr	2003 Q1	2004 Q1	4	1			
Ecuador	1998 Aug	1998 Dec	1998 Q3	1999 Q4	5		1999 Q3	6.76	6.76
Estonia	1992 Nov	1992 Nov	1994 Q1	1994 Q3	2				
Finland	1991 Sep	1993 Feb	1990 Q2	1993 Q3	13	5	1992 Q4	2.89	3.46
Ghana	1982 Jan	1982 Jan	1982 Q1	1984 Q1	8				
Indonesia	1997 Nov	1997 Dec	1997 Q4	1999 Q1	5				45.43
Jamaica	1996 Dec	1997 Feb	1997 Q3	1998 Q2	3			1.51	1.51
Japan	1997 Nov	1997 Nov	1997 Q4	1998 Q3	3			0.15	0.75
Korea	1997 Aug	1997 Nov	1997 Q4	1998 Q3	3			0.87	3.33
Latvia	1995 Apr	1995 Apr	1995 Q2	1996 Q1	3		1995 Q3	4.54	4.54
Lithuania	1995 Dec	1995 Dec							
Malaysia	1997 Jul	1998 Mar	1997 Q4	1999 Q1	5			0.58	1.18
Mexico	1994 Dec	1995 Jan	1995 Q1	1995 Q3	2				
Nicaragua	2000 Aug	2001 Jan							
Norway	1991 Oct	1991 Oct	1992 Q4	1993 Q2	2			2.94	2.94
Paraguay	1995 May	1995 Jul							
Philippines	1997 Jul	1998 Mar	1997 Q3	1998 Q4	5				
Russia	1998 Aug	1999 Jan							
Sri Lanka	1989	1989							
Sweden	1991 Sep	1992 Sep	1991 Q1	1993 Q1	8	2	1992 Q2	3.26	5.31
Thailand	1997 Jul	1997 Oct	1997 Q3	1998 Q3	4				
Turkey	2000 Nov	2000 Dec	2001 Q1	2002 Q1	4				
Ukraine	1998 Aug	1998 Dec	1998 Q1	1999 Q1	4	2			
Uruguay	2002 Jan	2002 Apr	1999 Q1	2003 Q1	16	12			
Venezuela	1994 Jan	1994 Jan	1994 Q1	1995 Q1	4		1994 Q2	24.61	24.61
Vietnam	1997 Nov	1998 Oct							

Crisis start is the date when major distress in the banking sector was observed. Systemic crisis date is the date when the conditions for a banking crisis to be classified as systemic were met. Recession duration is in quarters. Duration of existing recession tells how long a recession has already been ongoing at the time of the banking crisis start. Bank recapitalization date is the time when the main part of bank recapitalizations has been completed. If recapitalizations were small or the main part of recapitalizations took place after the recession has already ended, recap date is reported as missing. Recap end of recession is the cumulative amount of bank recapitalizations at the end of the recession. Recap end of crisis is the total amount of bank recapitalizations in a banking crisis (it includes also bank recapitalizations after the recession has already ended). The recapitalization amounts are expressed in percent of total banking assets.

jections of subordinated debt, qualifying as Tier 2 capital, a recapitalization. Conversion of subordinated debt or other bank liabilities into equity and liability management exercises are counted as recapitalization. Write-offs of bank liabilities in the process of bank restructuring where creditors do not get any security in exchange are not counted as recapitalization although they are sometimes referred to as the contribution of bondholders toward recapitalization. In purchase and assumption deals the state often compensates the acquiring bank for the difference between the value of assets and liabilities of the bank that is being taken over in the process of restructuring. This amount is not counted as recapitalization as it merely brings the net asset value of the restructured bank to zero. It benefits the creditors of the distressed bank that would otherwise suffer losses in the process of restructuring and does not increase capital of the acquirer. If the acquiring bank receives an equity injection on top of that, the equity injection is counted as recapitalization. Sometimes both the state and private investors participate in bank equity issues. In those cases only the amount purchased by the state is counted as recapitalization for the purpose of our analysis.

We collect the data about bank recapitalizations from various sources: IMF staff reports, European Commission decisions about state aid, webpages of central banks, restructuring agencies and annual reports of intervened banks. For the regression analysis, we need the total amount of recapitalizations in the banking sector in each quarter for all crises. Whenever possible we document the amount of recapitalization at bank level, a description of the measure and the month or quarter when the measure was implemented. For the recent crises almost all data has this level of detail. If bank-level data is not available, we collect data about the total amount of recapitalizations in each quarter of a recession. For some crises before 2007 IMF staff reports only include how much was spent on recapitalizations until a certain date. In such cases we use two rules to allocate the amounts across the quarters. If the names of banks or the number of banks intervened in a particular quarter are reported but not the amounts per bank, we assume that each of the intervened banks received an equal amount. If only the date when a bank restructuring program was approved by the government and the total amount of recapitalizations at a later point in time are known, we assume that recapitalization amounts are evenly spread across quarters between the start of the restructuring program and the time at which the cumulative amount of recapitalizations is reported. Tables 1 and 2 report the amounts of bank recapitalizations in the analyzed banking

Table 2
Systemic banking crises in the period 2007–2014.

Country	Crisis start	Systemic crisis date	Recession start	Recovery	Recess. duration	Duration of exist. recession	Bank recap date	Recap end of recession	Recap end of crisis
Austria	2008 Sep	2008 Dec	2008 Q2	2009 Q3	5	1	2009 Q2	0.99	1.35
Belgium	2008 Sep	2008 Oct	2008 Q3	2009 Q3	4		2008 Q4	1.95	3.14
Cyprus	2011 Jul	2013 Mar	2011 Q3	2015 Q1	14				
Denmark	2008 Sep	2009 Feb	2008 Q1	2010 Q1	8	2	2009 Q2	1.14	1.25
France	2008 Sep		2008 Q2	2009 Q3	5	1		0.41	0.63
Germany	2008 Sep	2009 Oct	2008 Q2	2009 Q2	4	1		0.7	1.15
Greece	2008 Sep	2009 May	2008 Q2	2015 Q1	27	1	2012 Q2	10.55	10.55
Hungary	2008 Sep		2008 Q3	2009 Q4	5			0.14	0.14
Iceland	2008 Sep	2008 Oct	2008 Q1	2010 Q4	11	2	2009 Q4	6.29	6.29
Ireland	2008 Sep	2009 Jan	2008 Q4	2011 Q1	9		2010 Q3	8.66	12.66
Italy	2008 Sep		2008 Q2	2009 Q3	5	1			0.26
Kazakhstan	2008 Sep	2010 Sep	2008 Q3	2009 Q1	2				
Latvia	2008 Sep	2008 Dec	2007 Q4	2010 Q4	12	3	2009 Q2	0.84	0.84
Luxembourg	2008 Sep	2008 Sep	2008 Q2	2009 Q3	5	1	2008 Q4	0.85	0.88
Mongolia	2008 Sep	2009 Nov	2009 Q1	2010 Q1	4				2.49
Netherlands	2008 Sep	2008 Oct	2008 Q3	2009 Q3	4		2008 Q4	0.88	1.41
Nigeria	2009 Aug	2011 Oct							4.16
Portugal	2008 Sep		2008 Q2	2009 Q2	4	1			
Portugal	2010 Dec		2010 Q4	2013 Q1	9		2012 Q2	1.88	2.21
Russia	2008 Sep		2008 Q3	2009 Q3	4		2009 Q2	1.02	1.02
Slovenia	2008 Sep		2008 Q3	2010 Q1	6				0.85
Slovenia	2011 Sep		2011 Q3	2013 Q2	7			2.34	13.1
Spain	2008 Sep	2011 Apr	2008 Q3	2010 Q1	6			0.05	0.35
Spain	2011 Sep	2012 Dec	2011 Q1	2013 Q3	10	2	2012 Q4	2.35	2.35
Sweden	2008 Sep		2008 Q3	2009 Q2	3				0
Switzerland	2008 Sep		2008 Q4	2009 Q3	3			0.31	0.31
Ukraine	2008 Sep	2009 May	2008 Q2	2009 Q2	4	1		3.23	7.31
United Kingdom	2007 Sep	2008 Nov	2008 Q2	2009 Q3	5			0.53	0.97
United States	2007 Dec	2008 Oct	2008 Q1	2009 Q3	6		2008 Q4	1.39	1.41

For explanations of the column headings see Table 1.

crises. For a complete list of recapitalizations including information on amounts per bank, dates and short descriptions of measures see Online Appendix B: Bank Recapitalizations.

In some regressions we use an indicator for bank recapitalizations, which turns from 0 to 1 in the quarter after the following two conditions are satisfied:

- The cumulative recapitalizations since the start of the crisis exceed half of the amount of recapitalizations in the whole banking crisis, which also includes recapitalizations after the recession has already ended.
- The cumulative recapitalizations exceed the threshold to be considered significant. This limit is 0.75% of total banking assets for crises in the period from 2007 to 2014 and 1.75% of total banking assets for crises from 1980 to 2006. It is roughly 50% of the median total amount of recapitalizations in banking crises where there were some recapitalizations.

The first condition determines the time when the main part of bank recapitalizations has been implemented. The second is necessary to avoid treating crises with minimal recapitalizations as having done a proper bank restructuring.

3.5. Guarantees on bank liabilities

We use an indicator for the presence of significant guarantees on bank liabilities other than deposits. It is equal to 1 in quarter t if guarantees were in place in the preceding quarter. The lag allows for some time for guarantees to have an effect on GDP growth. The indicator values are based on the dates of introduction of blanket guarantees and dates of removal reported in (Laeven and Valencia, 2013b) and documents of the European Commission about state aid decisions.

3.6. Liquidity support, monetary and fiscal policy

The data for liquidity support and monetary policy come from the International Financial Statistics database and for fiscal policy from World Economic Outlook Database. As a measure for liquidity support provided by central banks, we use the ratio of claims of monetary authorities on deposit money banks to total deposits, computed from end of quarter values lagged by one period. For monetary policy, we adopt two alternative measures. The preferred proxy, available for crises after 2007, is the decrease in real interest rates from quarter $t-2$ to $t-1$ (when the probability of recovery in quarter t is analyzed). In the analysis of crises before 2007 and of the full sample we employ the quarterly growth rate in reserve money as a proxy for monetary policy in order not to lose observations because interest rate data is not available for all pre-2007 crises. Similarly, the measure of fiscal policy, cyclically adjusted general government deficit, is available for most of the crises after 2007 but very few crises before 2007.

4. Results

4.1. Effects of intervention measures on the probability of recovery

We estimate the effect of bank recapitalizations, guarantees on bank liabilities, liquidity support, monetary policy and fiscal policy on the probability of recovery from recessions related to banking crises. The dependent variable is the recession indicator, which equals 1 if a recession has just ended and 0 otherwise. The explanatory variables are of three types. First, there are variables describing intervention. A positive estimated coefficient means that a higher value of the explanatory variable increases the probability of recovery. Second, there are averages of intervention variables, averaged over all time periods of a recession. Including the averages enables us to estimate a duration model

Table 3
Estimation results of the effects of intervention variables on the probability of recovery for the full sample of crises and the subsamples from the periods 1980–2006 and 2007–2014.

Recession indicator	Full sample 1980–2014 (1)	Past crises 1980–2006 (2)	Recent crises 2007–2014 (3)	Recent crises 2007–2014 (4)
Bank recapitalizations	0.7109***	1.2679***	1.3869***	2.1140***
	(3.47)	(2.72)	(2.59)	(3.22)
Guarantees on bank liabilities	0.2597	−2.4137	0.0477	0.2312
	(0.52)	(−1.61)	(0.06)	(0.24)
Liquidity support	2.1970	4.2111	3.1290	9.3538**
	(1.58)	(1.48)	(1.05)	(2.19)
Growth of reserve money	−0.5623	−1.1808	−0.9340	
	(−1.17)	(−1.39)	(−0.92)	
Real interest rate reduction				0.2587**
				(2.21)
Fiscal deficit, cyclically adj.				0.2251
				(1.21)
Average of bank recapitalizations	−1.2215***	−2.0576***	−3.5719**	−4.2634***
	(−3.27)	(−2.63)	(−2.55)	(−2.75)
Average of guarantees on bank liab.	−0.6396	3.8603*	−1.9509	−0.9739
	(−0.81)	(1.94)	(−1.54)	(−0.60)
Average liquidity support	−3.9050*	−2.1756	−6.5043	−22.8234***
	(−1.85)	(−0.69)	(−1.41)	(−2.78)
Average reserve money growth	0.4032	0.1717	6.0672**	
	(0.85)	(0.27)	(2.17)	
Average real interest rate reduction				−0.6639**
				(−2.26)
Average cyclically adj. fisc. def.				−0.6035**
				(−2.25)
Duration	1.5283***	10.6049**	1.8149***	2.2731***
	(4.26)	(2.56)	(3.36)	(3.98)
Duration^2	−0.1619***	−2.1800**	−0.1599***	−0.1739***
	(−3.71)	(−2.46)	(−2.99)	(−3.37)
Duration^3	0.0041***	0.1421**	0.0039***	0.0040***
	(3.44)	(2.39)	(2.84)	(3.08)
Constant	−4.6408***	−17.5726***	−5.1391***	−5.0802***
	(−5.45)	(−2.84)	(−3.52)	(−3.59)
Observations	361	147	214	215
Crises	54	26	28	28
Log likelihood	−101.6265	−37.4276	−48.3647	−43.4675

Recession indicator (the dependent variable) has value 1 if a country has just recovered from a recession and 0 if it is in a recession in a particular quarter. A positive regression coefficient means that a higher value of the explanatory variable increases the probability of recovery. Bank recapitalizations are the cumulative amount of recapitalizations since the start of the banking crises, weighted by total banking assets. Guarantees on bank liabilities are an indicator variable for the presence of guarantees. Liquidity support is the ratio of central bank claims on other depository corporations divided by the total deposits at other depository corporations. Growth of reserve money and Real interest rate reduction are measures of monetary policy. Cyclically adjusted fiscal deficit is a measure of discretionary fiscal policy. All policy variables except for fiscal deficit are lagged one quarter. Averages of intervention variables are included to allow for correlation between intervention and the time invariant component of unobservable crisis severity. Duration is the number of quarters a recession has already been ongoing until the period for which the probability of recovery is estimated. The specifications are estimated using a complementary log–log random effects procedure. In parentheses are *z*-values of the tests for significance of coefficients. Significance levels of 10%, 5%, and 1% are denoted by *, **, ***, respectively.

with fixed effects, which are necessary to control for the correlation between the time invariant component of crisis severity and intervention. Third, a linear, quadratic and cubic term of elapsed duration are included to flexibly account for the dependence of probability of recovery on the time that a recession has already lasted.

Table 3 reports the results estimated on three samples: the full sample of systemic banking crises from 1980 until 2014, and separately for the subsample of past crises from the period 1980–2006 and the subsample of recent crises from 2007 until 2014. Estimates for the 2007–2014 subsample are repeated with additional measures of macroeconomic policy (column 4 in Table 3). The samples include crises in which the recession began up to 4 quarters before the start of the banking crisis. The start of the banking crisis is defined as the quarter when major distress in the banking sector was observed. Crises that did not have a recession or crises where the country was already in a recession for more than 4 quarters before the banking crises started, are not included. This cutoff is used to exclude recessions where the problems in the banking system are not an important determinant of the probability of recovery for a large part of recession duration.

The estimates of the effect of bank recapitalizations on the probability of recovery are positive and significant in all samples: bank recapitalizations significantly increase the probability of recovery. Guarantees on bank liabilities on the other hand do not have a significant effect. Liquidity support has a positive and significant effect in the sample of recent crises but not in the other two samples. The estimates for growth of reserve money are negative and insignificant. We use growth in reserve money as a proxy of monetary policy in order to perform the analysis on the maximum possible number of crises. However, when we substitute it with the reduction in real interest rates in column (4), the estimated effect is positive and significant. The effect of fiscal policy approximated by the cyclically adjusted fiscal deficit is not significant.

Coefficients of *averages* of bank recapitalizations, guarantees on bank liabilities and real interest rate reduction are statistically significant for at least one sample, which confirms that, at least for that sample, policies are correlated to crisis severity. Hence their inclusion is necessary to obtain consistent estimates of the coefficients of interest. We stress that the coefficients on averages should not be interpreted as a part of the effect of policies on the

probability of recovery; on the contrary, they represent the reverse link, the impact of crisis severity on the likelihood and extent of intervention. However we are interested only in the impact of intervention once it has been undertaken, and the coefficients on the averages, which represent the reverse link, between crisis severity and the likelihood and intensiveness of intervention, are not part of that response. They are only a component of the fixed effect in the model specification.

The probability of recovery shows time dependence, i.e. it follows a characteristic pattern over time described by the coefficients on elapsed duration. The linear term of duration is positive, indicating that the longer a recession has already lasted, the more likely it is to end in the current quarter. The coefficient on the quadratic term is negative, so the marginal effect of duration on exit probability decreases as crises last longer. In other words, recessions that have already lasted some time are likely to be long. But every recession ends at some point, as is indicated by the positive sign on the cubic term's coefficient.

4.2. Expected recession duration

In many crises, recapitalizations are done at multiple times but with the largest amounts typically concentrated in one quarter. To approximate this, we rerun the regressions with an alternative proxy for bank recapitalization: we replace the continuous recapitalization variable with a *bank recapitalization indicator*, which equals 1 when a significant bank recapitalization took place and 0 otherwise; for a more precise definition see Section 3.4. If there were only minor recapitalizations or none at all, the value of the indicator is zero. Table 4 reports the results of the regressions performed with the indicator instead of the continuous bank recapitalization variable.[9] This simplification allows for a sharper comparison between the approach of adequately recapitalizing banks versus regulatory forbearance defined as the absence of recapitalization. The basic results of Table 3 are confirmed in Table 4: bank recapitalizations are the intervention with the most significant effect.

To investigate the size of the recapitalization's impact on recession duration, we compute expected recession durations based on the estimation results from Table 4, using Eqs. (15), (19) and (20). We do this for two representative crisis types: one representing the group of crises where substantial recapitalizations were done and the other representing the group with no or very little recapitalizations. The reason for introducing two representative crises is that the two groups of crises most likely differ in unobserved crisis severity. Banking crises where banks were recapitalized tended to be much more severe than those where recapitalizations were not done. We use the expression *severe representative crisis* to denote the representative crisis of the group with significant bank recapitalizations and *mild representative crisis* to refer to the representative crisis of the group with no or minor recapitalizations. We compute expected recession duration with and without bank recapitalization for both types of representative crises.

The inputs for the conditional probabilities of recovery are the estimated coefficients from Table 4 and the values of the explanatory variables for the two representative crises. For the purpose of these expected duration calculations, the explanatory variable values of the severe (mild) representative crisis are simply kept at the average of explanatory variables of crises where bank recapitalizations were (were not) done. This in particular holds for the averaged variables conditioning on crisis severity – this is the way the two crisis types are distinguished. For example, for mild crises the average value of the bank recapitalization indicator remains at zero while for the severe crises it is kept fixed at the positive sample average for that subgroup. The exceptions of course are the elapsed duration, which by definition increases every quarter, and the bank recapitalization indicator which we change from 0 to 1 in the quarter after the simulated bank recapitalization is implemented. The median time that the recession had already lasted when bank recapitalizations were done in our sample was 1 quarter in the past crises subsample and 2 quarters for the recent crises subsample. When computing the expected durations in the two different recession types, we assume that the bank recapitalization is done at $t=2$ and so has an effect on the probability of recovery from $t=3$ onwards.

Table 5 reports the expected durations computed based on estimates from Table 4. Column (1) of Table 5 refers to column (1) of Table 4 etc. The size of the effect of bank recapitalization becomes apparent when the expected recession durations are compared. For the sample of 2007–2014 crises in column (4) the expected duration of severe representative crisis with bank recapitalization is fairly close to the average observed duration of severe crises; similarly the average observed duration of mild crises is close to the expected recession duration of the mild representative crises if bank recapitalization is not done. So our benchmarks seem well chosen. The counterfactual durations, however, are very different. The severe representative crisis without bank recapitalization would last 14 quarters, instead of only 6 quarters when banks are recapitalized, so without recapitalization a full two years longer than with recapitalization. The expected recession of the mild representative crisis is reduced from 5.4 to 3 quarters by bank recapitalization. So bank recapitalization reduces expected recession duration of severe crises by 60% and mild crises by 40%.

Another way of translating the regression results into an understandable metric is a comparison of exit probabilities over time with and without recapitalizations. We again have done this for severe and mild crises, as defined earlier, and for both the first (pre-Great Recession) period (1980–2006) and just for the recent period (2007–2014). We plot the predicted conditional probabilities, the same that were used to compute expected durations for past crises in column (2) and for the recent crises in column (4) of Table 5. Since the resulting four plots are structurally similar, we only show the results for the severe recession case, based on the sample of recent crises (Fig. 2) and present all four graphs (severe and mild crises for each of the subsamples separately) in Online Appendix F.

Initially, when a recession starts at $t=0$, the predicted probability of recovery is very low, then it gradually increases as time goes by. Eventually it approaches 1: even without intervention, recessions at some point come to an end. The shape of the curve is due to time dependence, which is captured by the duration terms in regression specification (14). In the absence of intervention, the initial shock that caused the banking crisis and subsequent time dependence determine the time pattern of exit probabilities and the expected duration of the recession. We implement the bank recapitalization at $t=2$, so the jumps in the plots occur at $t=3$. The plot demonstrates our earlier results very clearly: bank recapitalizations increase the probability of recovery substantially.

4.3. Robustness checks

To check the robustness of our results, we perform additional regressions and report them in the Online Appendix. We re-estimate regressions from Table 3 using an alternative lax and a strict recession definition. Under the lax definition we do not require a recession to include two consecutive negative growth quarters; a sequence of a negative, a positive and a negative quarter is also considered a recession. In addition, we do not exclude

[9] We exclude Greece from the sample when using the bank recapitalizations indicator. Greece had three rounds of large recapitalizations during its 27 quarter long recession. Representing them with a single dummy does not seem appropriate.

Table 4
Estimation results of the effects of intervention variables on the probability of recovery for the full sample of crises and the subsamples from the periods 1980–2006 and 2007–2014. The *bank recapitalization indicator* is used as a proxy for bank recapitalizations.

Recession indicator	Full sample 1980–2014 (1)	Past crises 1980–2006 (2)	Recent crises 2007–2014 (3)	Recent crises 2007–2014 (4)
Bank recapitalization indicator	2.5907***	2.4613**	3.2468***	3.4909***
	(3.76)	(2.13)	(2.73)	(2.58)
Guarantees on bank liabilities	0.2543	−2.4368	0.1756	0.5611
	(0.50)	(−1.46)	(0.22)	(0.59)
Liquidity support	2.1003	2.7520	1.2465	3.3228
	(1.34)	(1.02)	(0.37)	(0.81)
Growth of reserve money	−0.6394	−1.0170	−1.4800	
	(−1.14)	(−1.21)	(−1.19)	
Real interest rate reduction				0.1208
				(1.35)
Fiscal deficit, cyclically adj.				0.0644
				(0.30)
Average of bank recap. indicator	−5.6427***	−4.9578**	−6.6181**	−6.3138*
	(−3.37)	(−2.00)	(−2.25)	(−1.95)
Average of guarantees on bank liab.	−0.5618	3.5793	−0.8562	−0.8494
	(−0.72)	(1.64)	(−0.67)	(−0.58)
Average liquidity support	−3.6165*	−1.3133	−5.0539	−12.6438*
	(−1.66)	(−0.44)	(−1.05)	(−1.92)
Average reserve money growth	0.3734	0.0333	5.4530*	
	(0.80)	(0.05)	(1.79)	
Average real interest rate reduction				−0.4883**
				(−2.11)
Average cyclically adj. fisc. def.				−0.2576
				(−0.94)
Duration	3.1544***	8.6194**	3.4780***	2.9734***
	(4.04)	(2.41)	(2.66)	(2.63)
Duration^2	−0.4551***	−1.7740**	−0.4871**	−0.3596**
	(−3.69)	(−2.25)	(−2.51)	(−2.11)
Duration^3	0.0196***	0.1184**	0.0209**	0.0144*
	(3.44)	(2.16)	(2.44)	(1.91)
Constant	−7.1909***	−14.5225***	−8.1410***	−6.7823***
	(−4.73)	(−2.79)	(−2.95)	(−2.88)
Observations	333	147	186	187
Crises	53	26	27	27
Log likelihood	−96.9699	−42.8870	−45.1275	−43.4741

Bank recapitalization indicator turns from 0 to 1 after a significant recapitalization is implemented. All other variables are defined as in the legend of Table 3.

Table 5
Expected and average observed recession durations for severe and mild crises.

	Full sample 1980–2014 (1)	Past crises 1980–2006 (2)	Recent crises 2007–2014 (3)	Recent crises 2007–2014 (4)
Severe crises				
Average observed duration	*6.76*	*5.60*	*7.25*	*7.25*
Expected duration without bank recapitalization	12.24	7.14	13.54	13.98
Expected duration with bank recapitalization	4.59	3.77	5.18	6.01
Difference in expected duration	7.64	3.37	8.36	7.97
Mild crises				
Average observed duration	*4.72*	*4.43*	*5.13*	*5.13*
Expected duration without bank recapitalization	5.25	4.50	5.46	5.37
Expected duration with bank recapitalization	2.99	2.98	2.98	3.01
Difference in expected duration	2.26	1.52	2.48	2.36

Severe crises are crises where significant bank recapitalizations are done at some point. Mild crises are crises where significant bank recapitalizations were never done. Average observed duration is the average recession duration of the group of crises to which a representative crisis refers. Expected recession durations are computed based on estimates from Table 4. The expected durations in each column correspond to estimates in the same column of Table 4 (i.e. the results reported in column (1) of Table 5 are based on the regression reported in column (1) of Table 4 etc.). Expected durations with bank recapitalization are computed assuming that bank recapitalization is done in the third recession quarter. Columns (3) and (4) differ in the control variables included, see Table 4 for details.

recessions that started more than 4 quarters before the start of the banking crises. Under the strict definition only consecutive quarters with negative GDP growth are counted as recession. The main results do not change. Under both alternative definitions the effects of bank recapitalizations and real interest rate reduction are highly significant. We also re-estimate the regressions using a logit random effects procedure and a linear probability model with random effects. The estimates obtained with logit are very similar to the main results in Table 3. In the linear probability model the predicted probabilities can lie outside of the [0, 1] range but even then the effect of bank recapitalizations remains.

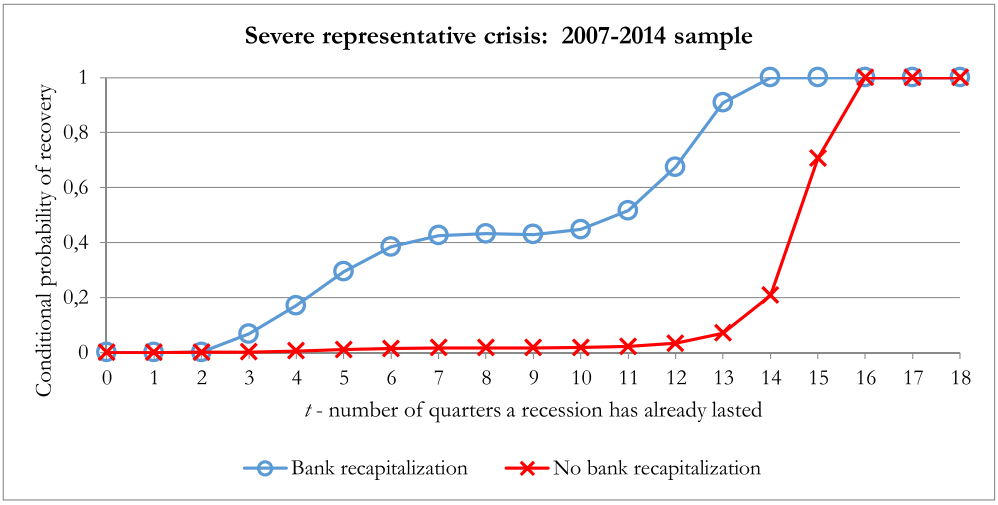

Fig. 2. Predicted conditional probabilities of recovery for a severe representative crisis.

4.4. Transmission channel: evidence from bank balance sheets

In Section 2 we propose a possible transmission channel for the effect of bank recapitalizations on economic growth. Recapitalizations improve bank incentives for management of distressed loans, which in turn leads to higher output. Our results indeed show that bank recapitalization significantly increase the probability of recovery. For micro evidence pointing at this transmission channel we refer to a paper by Homar (2016) that analyzes the effects of bank recapitalizations on lending, funding and loan loss provisioning of European banks, using (a subset of) the same dataset on bank recapitalizations as we do in this paper. Controlling for bank distress with a measure of market implied capital shortfall, Homar (2016) finds that in the year when banks are recapitalized, they increase loan loss provisions. In the subsequent year they lend significantly more, attract additional deposits and increase loan loss reserves and charge-offs of non-performing loans. These results show that after a recapitalization banks speed up resolution of nonperforming loans and increase lending, which explains the strong effect of bank recapitalizations on economic recovery.

5. Conclusions

How much longer will a recession last if distressed banks are not recapitalized early on during a financial crisis? In other words, how costly is regulatory forbearance that allows zombie banks to continue to operate? We analyze recessions after 69 systemic banking crises in the period from 1980 to 2014 and find a positive and highly significant effect of bank recapitalizations on the probability of recovery. We do not find such effects for other intervention measures such as guarantees on bank liabilities or liquidity support. We take into account that intervention in banking crises may be endogenous to crisis severity because of a reverse link: since bank recapitalizations are costly, they are more likely in severe recessions, which can lead to spurious correlation. The impact of bank recapitalizations is shown to be especially large in severe crises where a timely recapitalization of distressed banks shortens the expected duration of the crisis related recession by a full two years.

The theoretical part of our paper offers a potential explanation of these results. Undercapitalized banks have incentives to roll over loans to distressed borrowers instead of restructuring or liquidating them. In that way zombie banks form a drag on economic recovery, they continue funding inefficient firms while rationing credit to new borrowers. Bank recapitalizations, by eliminating debt overhang, mitigate these adverse incentives and thereby shorten recessions. Other intervention measures such as guarantees on bank liabilities or liquidity support do not remedy the perverse incentives coming from undercapitalization.

Our findings thus show that recapitalizing banks early on in a recession significantly reduces the negative macroeconomic impact of a financial crisis. Of course such interventions may have adverse ex ante effects, but whether expectations of bailouts will trigger significantly more risk taking ex ante is likely to depend on the terms on which recapitalization measures are expected to take place, and the extent to which such anticipatory risk taking is restrained by prudential regulation.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jfi.2016.11.004.

References

Acharya, V.V, T. Eisert, C. Eufinger, C. Hirsch, and C. Eufinger. 2016. Whatever It Takes: The Real Effects of Unconventional Monetary Policy. Working Paper, NYU Stern School of Business.
Allen, F., Gale, D., 2000. Financial contagion. J. Polit. Econ. 108, 1–33.
Berger, A.N., T. Makaew, and R. Roman. 2016. Did Bank Borrowers Benefit from the TARP Program? The Effects of TARP on Loan Contract Terms. Working Paper. Available at SSRN: http://dx.doi.org/10.2139/ssrn.2736440.
Berger, A.N., and R.A. Roman. 2015. Did Saving Wall Street Really Save Main Street? The Real Effects of TARP on Local Economic Conditions. Forthcoming, Journal of Financial and Quantitative Analysis.
Berglof, E., Roland, G., 1995. Bank restructuring and soft budget constraints in financial transition. J. Jpn. Int. Econ. 9, 354–375.
Blanchard, O., E. Cerutti, and L. Summers. 2015. Inflation and Activity – Two Explorations and Their Monetary Policy Implications. IMF Working Paper 15/230.
Caballero, R.J., Hoshi, T., Kashyap, A.K., 2008. Zombie lending and depressed restructuring in Japan. Am. Econ. Rev. 98, 1943–1977.
Chodorow-Reich, G., 2014. The employment effects of credit market disruptions: Firm-level evidence from the 2008–09 financial crisis. Q. J. Econ. 129, 1–59.
Claessens, S., Klingebiel, D., Laeven, L., 2005. Crisis resolution, policies, and institutions: Empirical evidence. In: Honohan, P., Laeven, L. (Eds.), Systemic Financial Distress: Containment and Resolution. Cambridge University Press, Cambridge.
Dell'Ariccia, G., Detragiache, E., Rajan, R., 2008. The real effect of banking crises. J. Financ. Intermed. 17, 89–112.
Diamond, D.W., Rajan, R.G., 2011. Fear of fire sales, illiquidity seeking, and credit freezes. Q. J. Econ. 126, 557–591.
Farhi, E., Tirole, J., 2012. Collective moral hazard, maturity mismatch, and systemic bailouts. Am. Econ. Rev. 102, 60–93.
Gennaioli, N., Martin, A., Rossi, S., 2014. Sovereign default, domestic banks and financial institutions. J. Financ. 69, 819–866.

Giannetti, M., Simonov, A., 2013. On the real effects of bank bailouts: Micro evidence from Japan. Am. Econ. J. Macroecon. 5, 135–167.
Hoggarth, G., Reis, R., Saporta, V., 2002. Costs of banking system instability: Some empirical evidence. J. Bank. Financ. 26, 825–855.
Homar, T., 2016. Bank Recapitalizations and Lending: A Little Is Not Enough 1–45, Working Paper no 26, European Systemic Risk Board.
Honohan, P., Klingebiel, D., 2003. The fiscal cost implications of an accommodating approach to banking crises. J. Bank. Financ. 27, 1539–1560.
Hoshi, T., Kashyap, A.K., 2010. Will the U.S. bank recapitalization succeed? Eight lessons from Japan. J. Financ. Econ. 97, 398–417.
Howard, G., R. Martin, and B.A. Wilson. 2010. Are Recoveries from Banking and Financial Crises Really So Different? Board of Governors of the Federal Reserve System, International Finance Discusssion Papers no. 1037.
Kirchner, M., van Wijnbergen, S., 2016. Fiscal deficits, financial fragility and the effectiveness of government policies. J. Monetary Econ. 80, 51–68.
Kroszner, R., Laeven, L., Klingebiel, D., 2007. Banking crises, financial dependence, and growth. J. Financ. Econ. 84, 187–228.
van der Kwaak, C.G.F., van Wijnbergen, S.J.G., 2014. Financial fragility, sovereign default risk and the limits to commercial bank bail-outs. J. Econ. Dyn. Control 43, 218–240.
Laeven, L., Valencia, F., 2013a. The real effects of financial sector interventions during crises. J. Money Credit Bank. 45, 147–170.
Laeven, L., Valencia, F., 2013b. Systemic banking crises database. IMF Econ. Rev. 61, 225–270.
Landier, A., and K. Ueda. 2009. The Economics of Bank Restructuring: Understanding the Options. IMF Staff Position Note SPN/09/12, International monetary Fund.
Li, L., 2013. TARP funds distribution and bank loan supply. J. Bank. Financ. 37, 4777–4792.
Mundlak, Y., 1978. On the pooling of time series and cross section data. Econometrica 46, 69–85.
NBER. 2012. Statement of the NBER Business Cycle Dating Committee on the Determination of the Dates of Turning Points in the U.S. Economy.
Peek, J., Rosengren, E.S., 2005. Unnatural selection: Perverse incentives and the misallocation of credit in Japan. Am. Econ. Rev. 95, 1144–1166.
Philippon, T., Schnabl, P., 2013. Efficient Recapitalization. J. Financ. 68, 1–42.
Philippon, T., Skreta, V., 2012. Optimal interventions in markets with adverse selection. Am. Econ. Rev. 102, 1–28.
Poczter, S., 2016. The long-term effects of bank recapitalization: Evidence from Indonesia. J. Financ. Intermed. 25, 131–153.
Reinhart, C.M., Rogoff, K.S., 2009. The aftermath of financial crises. Am. Econ. Rev. 99, 466–472.
Schularick, M., Taylor, A., 2012. Credit booms gone bust: Monetary policy, leverage cycles and financial crises 1870–2008. Am. Econ. Rev. 102, 1029–1061.
Tirole, J., 2012. Overcoming adverse selection: How public intervention can restore market functioning. Am. Econ. Rev. 102, 29–59.
US Census Bureau. 2011. X-12-ARIMA Reference Manual. U.S. Census Bureau.
Watanabe, W., 2010. Does a large loss of bank capital cause evergreening? Evidence from Japan. J. Jpn. Int. Econ. 24, 116–136.