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Discussion Paper No. 2025-E-17

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JAPAN

IMES Discussion Paper Series 2025-E-17
December 2025

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Abstract

Banking crises are infrequent macroeconomic events with the potential to inflict significant and lasting harm on the real economy. Drawing from the empirical literature, this paper highlights five facts on banking crises from a macroeconomic perspective. It conducts a targeted review of the literature on financial frictions and banking crises in a dynamic general equilibrium framework, and introduces a dynamic general equilibrium model of bank runs. The model' s ability to account for the five facts is examined, alongside its implications for policy. Finally, the paper explores the challenges of integrating macroprudential policy into the model.

Keywords: Banking crises; macroeconomic models; macroprudential policy
JEL classification: E32, E44, G21, G28

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This paper is prepared for a chapter in the *Research Handbook of Macroprudential Policy*, edited by David Aikman and Prasanna Gai, forthcoming from Edward Elgar Publishing. The authors are grateful for comments and discussions from David Aikman, Prasanna Gai, and conference or seminar participants at the Research Handbook of Macroprudential Policy Conference and the IMES. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan.

1 Introduction

Financial intermediation is an activity through which funds are channeled to the real economy in need and its smooth functioning is essential for the stable growth of the real economy. Banks have been the main financial intermediaries that perform this function, collecting and providing funds by issuing short-term debt such as demand deposits. What makes banks special is their short-term debt and this very feature is the source of vulnerabilities inherent to banks. A banking crisis occurs when funds stop flowing in the banking sector. Once it occurs, it severely damages the real economy and morphs into a deep recession. Despite policy effort, a banking crisis is yet to be a thing of the past, but it continues to be a potential risk facing the banking sector and the real economy.

Against this background, the empirical literature has uncovered several salient features of banking crises. At the same time, to understand the underlying mechanisms of banking crises and derive implications for regulations, supervisions, and macroprudential policy as well as monetary policy, a macroeconomic model of banking crises is required.

Thus motivated, this paper aims to provide the groundwork that is useful for developing a macroeconomic model of banking crises that can be usable for policy analyses. The paper is organized as follows. Section 2 introduces five facts about banking crises. Section 3 provides a brief summary of the literature on macroeconomic models with financial frictions and banking crises. Section 4 presents our recent work on a dynamic general equilibrium model of banking crises, which has the potential to explain the five facts, and Section 5 shows the main results of the model. Policy implications and challenges are discussed in Section 6, and the paper is concluded in Section 7.

2 Five facts on banking crises

Empirical facts are essential in building a macroeconomic model. In the empirical literature, a banking crisis is defined as an event during which a banking sector experiences bank runs, sharp increases in default rates and non-performing loans, or the closure, merging, takeover or large-scale government assistance of important financial institutions (Reinhart and Rogoff, 2009; Schularick and Taylor, 2012; Laeven and Valencia, 2013). Based on the literature, five facts are presented. Some of them are established and well-accepted, but the others are relatively new and may b controversial. A brief discussion is provided for each fact.

Fact 1 (Bank runs) *Banking crises tend to feature bank runs.*

Bank runs are a typical feature of banking crises. Prior to the existence of central banks, banking crises were always bank runs (Gorton, 2012). Over the period of 1970–2007, more than 60 percent of the banking crises experienced bank runs — sharp reductions in total deposits (Laeven and Valencia, 2013). The global financial crisis (GFC) of 2007–08 is no exception. The crisis began with a run on short-term money market instruments such as repo and asset-backed commercial paper (Gorton, 2012). That said, not all banking crises involve bank runs, and the recent study by Baron et al. (2020) emphasizes bank equity crashes as an important feature that precedes severe economic consequences. However, as the March 2023 banking turmoil highlighted, a sudden and massive outflow of deposits and a roll-off of short-term debt continue to be a structural vulnerability facing banks that can trigger a banking crisis.[1]

Fact 2 (Credit booms) *Banking crises tend to occur during credit booms.*

Banking crises are not an idiosyncratic event but a systematic event nested in financial and business cycles. The empirical literature has uncovered that banking crises do not happen randomly, but typically occur near the peak of the business cycle (Gorton, 1988), the financial cycle (Borio, 2014), or the credit cycle (Aikman et al., 2015). Gourinchas and Obstfeld (2012) and Schularick and Taylor (2012) statistically show that banking crises tend to occur following consecutive years of high credit growth.[2] The fact that credit growth predicts banking crises does not necessarily mean that other variables are less important. For example, Kiley (2021) emphasizes the role of equity and house prices and a widening of the current account deficit. In practice, various indicators are employed in assessing the vulnerabilities of the financial system.[3]

Fact 3 (Procyclical leverage) *Leverage in a bank balance sheet is procyclical.*

Bank leverage is procyclical: banks expand their asset size by increasing leverage, where leverage is defined as the ratio of total assets to equity in a bank balance sheet. Specifically,

[1]See Basel Committee on Banking Supervision (2023) for the an assessment of the causes of the banking turmoil, including deposit outflow of distressed banks.

[2]See Sufi and Taylor (2022) for the survey on financial crises, including the literature on financial crisis predictability.

[3]See, e.g., Adrian et al. (2015) and Aikman et al. (2017) for the United States and Ito et al. (2014) for Japan.

a change in bank assets is positively related with a change in bank leverage. Put differently, a change in bank assets is not related with a change in bank equity, or in short, bank equity is sticky. Adrian and Shin (2010, 2011) report that leverage was procyclical for banks, in particular for investment banks, in the United States. Laux and Rauter (2017) confirm it with a larger sample even after controlling for a large set of economic and bank-specific drivers of leverage.

It is worth emphasizing a difference between book leverage and market leverage. Fact 3 pertains to book leverage. Market leverage can be defined similarly to book leverage by using market capitalization instead of bank equity in a balance sheet. Book and market leverage diverge especially during crises, driven by a divergence between book and market equity values (Begenau et al., 2021). During crises market equity values plummet and market leverage shoots up, while book equity values are relatively stable.

Fact 4 (Interest rate path) *A sharp increase in short-term interest rates that was preceded by low interest rates often coincides with an onset of banking crisis.*

A U-shaped path of short-term interest rates – interest rate hikes preceded by low interest rates – has been often observed during a credit boom and bust that results in a banking crisis. The GFC is a typical example. Analyzing 17 countries over 150 years, Jiménez et al. (2022) argue that rate cuts in the first part of the U-shape increase the likelihood of credit booms, while subsequent rate hikes tend to trigger crises. The argument that a low interest rate environment can fuel credit booms that could give rise to a crisis is found, e.g., in Okina et al. (2001) and Borio and Lowe (2002), and is empirically examined by Jordà et al. (2015) using a dataset of 17 countries over 150 years.

Fact 5 (Slow recoveries) *Recoveries from banking crises tend to be slow.*

Banking crises cause a significant loss in output and employment, often followed by deep and prolonged recessions. Cerra and Saxena (2008) and Reinhart and Rogoff (2009) show that financial crises tend to be followed by slow recoveries in which GDP scarcely returns to its pre-crisis growth trend and thus cause a considerable economic loss. Laeven and Valencia (2018) show that the duration of banking crises can be longer than five years, where the end of a crisis is defined as a period in which both output and credit have grown for two consecutive years.

3 Literature on Financial Frictions and Banking Crises

With the five facts presented above kept in mind, we briefly summarize the literature on financial frictions and banking crises in a dynamic general equilibrium framework that has been developed since the late 1990s. The literature is vast and diverse, so we aim to mention papers that are closely related to the model that has the potential to explain the five facts, to be presented in Section 4.

Financial accelerator Pioneering work on a dynamic general equilibrium model with financial frictions focused on a mechanism that generates amplified and persistent responses of aggregate variables to exogenous shocks. Against the background of the standard real business cycle (RBC) model falling short of generating such responses, Kiyotaki and Moore (1997) show that a collateral constraint amplifies the effects of technology shocks and helps generate persistent responses. Carlstrom and Fuerst (1997) embed the costly state verification problem studied by Townsend (1979) into *the supply side* of capital in a RBC model and show that the financial friction helps generate a hump-shaped and persistent response of output to a technology shock. Bernanke et al. (1999) embed the same problem but into *the demand side* of capital in a New Keynesian model and show that the friction gives rise to an financial accelerator that amplifies the effects of technology, demand and monetary policy shocks. Aoki et al. (2004) and Iacoviello (2005) build on the models developed by Bernanke et al. (1999) and Kiyotaki and Moore (1997), respectively, and emphasize the role of housing and financial frictions as an amplifier of demand and monetary policy shocks.

Financial shocks The next generation of the literature has focused on the role of financial frictions as a source of shocks rather than as an amplifier of other shocks to explain the Great Recession of 2008–09. The shocks originating from the financial sector in this literature — the so-called "financial shocks" — include a shock to firms' borrowing capacity that is based on their collateral constraints (Jermann and Quadrini, 2012); a shock to the riskiness of borrowers' investment projects in a framework of Bernanke et al. (1999) (Christiano et al., 2014) and in a dynamic model that embeds adverse selection in a borrower-lender problem (Ikeda, 2020); a dispersion shock that aggravates adverse selection in a buyer-seller problem (Kurlat, 2013; Bigio, 2015); a shock to spread charged by financial intermediaries (Ajello, 2016); a liquidity shock that governs how much liquidity is obtained from collateral

(Kiyotaki and Moore, 2019). These shocks affect the tightness of financial frictions and thus affect credit or liquidity conditions by changing borrowing capacity for investment, liquidity that can be used for financing investment, or lenders'/buyers' stance on the supply of credit/liquidity.

In line with the development of these models that focus on financial shocks, models with financial frictions and disruptions have been developed to study the unconventional monetary policy (UMP) tools that were employed during and after the GFC. These models include Gertler and Kiyotaki (2010), Gertler and Karadi (2011, 2013), and Del Negro et al. (2017). See also Christiano and Ikeda (2013) for various financial frictions models with UMP in a simple two-period framework.

Occasionally binding constraints Another strand of the literature has focused on a non-linear change in the tightness of financial fictions. Mendoza (2002, 2010) and Bianchi (2011) study an open economy model with an occasionally binding credit constraint to explain "sudden stops" — sharp and sudden adjustments in access to foreign financing — observed in many emerging economies. Using a continuous time approach, He and Krishnamurthy (2013, 2019) consider the role of an occasionally binding equity constraint and Brunnermeier and Sannikov (2014) consider the role of endogenous risk in the states of the economy that are far away from the steady state. Akinci and Queralto (2022) incorporate an occasionally binding credit constraint into the models studied by Gertler and Kiyotaki (2010) and Gertler and Karadi (2011).

The papers mentioned above pertain to an occasionally binding constraint for borrowers: the demand side of funds. There are also papers that focus on the supply side of funds. In particular, due to adverse election, lenders may stop supplying funds and retain funds, leading to market freezes. For this type of models in a dynamic general equilibrium, see Kurlat (2013), Boissay et al. (2016), and Boissay et al. (2022). See also Justiniano et al. (2019) who emphasize the supply side of credit in explaining the housing boom that preceded the GFC.

Bank runs In light of Fact 1 that banking crises tend to feature bank runs, the new stream of the literature has emerged by incorporating bank runs in dynamic general equilibrium models. The most of the literature has focused on panic runs that are caused by a sunspot — something exogenous that makes all depositors to run — in the spirits similar to Diamond and Dybvig (1983). Gertler and Kiyotaki (2015) embed bank runs in a

RBC framework and Gertler et al. (2020) extend it to incorporate monetary policy in a New Keynesian framework.[4] Many extensions have emerged: Gertler et al. (2016), Poeschl (2023), and Rottner (2023) incorporate shadow banking, Aoki et al. (2019) focus on the low interest rate environment, Paul (2020) incorporates long-term loans, Faria-e-Castro (2020) studies the role of macroprudential policy, and Poeschl and Mikkelsen (2024) focus on macroeconomic uncertainty. Christiano et al. (2022) discuss some challenges facing these models of panic runs.

The papers mentioned above can explain under what conditions the economy falls into a vulnerable region where a banking crisis occurs if all depositors run, but it remains unknown under what conditions such a run occurs in a vulnerable region. In practice, as highlighted by the March 2023 banking turmoil, no bank would be able to withstand a full-blown run where the majority of depositors withdraw deposits simultaneously. If banks are almost always in a vulnerable region, the papers mentioned above are silent about why a banking crisis occurs, because it is assumed that a run that causes a banking crisis is sunspot driven.

Against this backdrop, Ikeda and Matsumoto (2025) develop a business cycle model of bank runs in a global game framework. A global game allows run probability in a vulnerable region to be determined endogenously as a function of bank fundamentals such as leverage, a bank asset return, and interest rates. In the following sections, we will introduce the model studied by Ikeda and Matsumoto (2025) and argue that the model has potential to explain Facts 1–5 on banking crises.[5]

Other developments Before moving onto the model in Section 4, it would be useful to mention some papers about a macroeconomic model of banking crises, which are related to some of the five facts on banking crises and our model to be introduced in Section 4.

Related to bank runs as a key feature of banking crises (Fact 1), Gorton and Ordoñez (2014) argue that a bank run is an event where information *insensitive* debt becomes information *sensitive* and develop a dynamic model of banking crises as informational events. In our model, bank runs are also informational events in a global game framework, where information about bad fundamentals triggers a bank run.

Related to credit booms and banking crises (Fact 2), Gertler et al. (2020) extend the

[4] Early work on bank runs in a dynamic economy includes Ennis and Keister (2003) and Martin et al. (2014), both of whom build on Diamond and Dybvig (1983), and Angeloni and Faia (2013), who incorporate the bank run model studied by Diamond and Rajan (2000).

[5] de Groot (2020) introduces a global game in a dynamic general equilibrium model with a banking sector, focusing on how coordination failures arising from a global game amplify a macroeconomic shock.

panic run model of Gertler and Kiyotaki (2015) by incorporating bankers' optimistic expectations about fundamentals in the future and study bad booms that end up with banking crises and good booms that do not. See Gorton and Ordoñez (2019) about good and bad booms. While our model does not rely on optimistic expectations, there may be room for introducing such non-rational expectations in explaining credit booms.[6]

Regarding procyclical leverage (Fact 3), Nuño and Thomas (2017) incorporate banks' risk-shifting moral hazard studied by Adrian and Shin (2014) into a dynamic general equilibrium model and study a positive comovement between leverage, bank assets, and output. Our model introduces sticky bank capital in a simple manner to explain procyclical leverage.

Regarding the effects of short-term interest rates on the likelihood of banking crises (Fact 4), Boissay et al. (2022) build a New Keynesian model that features endogenous market shutdowns as in Boissay et al. (2016). They argue that keeping the policy rate too low for too long causes overaccumulation of capital and lowers the return earned by borrower firms, and if it is followed by sharp rises in the interest rate, the firms cannot borrow, precipitating a shutdown in credit markets.

Regarding slow recoveries after banking crises (Fact 5), most of the models mentioned thus far, including our model to be presented in Section 4, keep the standard neoclassical framework where the economy fluctuates around a growth path except for the periods of banking crises. These models can explain deep and prolonged recessions, but cannot explain a permanent loss of output, which has been observed after financial crises in many countries (Cerra and Saxena, 2008). To explain such a pattern, the literature on financial shocks has been further extended to incorporate endogenous growth: see Bianchi et al. (2019), Ikeda and Kurozumi (2019), Guerron-Quintana and Jinnai (2019), and Queralto (2020).

4 Model

This section introduces a dynamic general equilibrium model of bank runs, developed by Ikeda and Matsumoto (2025). The model is based on a standard business cycle model, modified to incorporate banks, financial frictions, and bank runs in a global game framework. The way banks are embedded into the model is based on Bernanke et al. (1999) and the global game is based on Rochet and Vives (2004). Thus, the model features a financial

[6]See, e.g., Bordalo et al. (2022) for introducing diagnostic expectations in macroeconomic models to explain boom-bust dynamics of key time series.

accelerator mechanism and the endogenous probability of bank runs. In the following, the basic structure of the model is presented. See Ikeda and Matsumoto (2025) for the details.

4.1 Households

There is a representative household, which consists of a continuum of family members with measure unity. Each family member, indexed by $j \in [0,1]$, is either a depositor or a banker. Depositors manage deposits and make a run decision, while bankers manage banks and lend to firms. As family members, both depositors and bankers supply labor to firms. The population of depositors and bankers is fixed at $0 < \zeta < 1$ and $1-\zeta$, respectively. Depositors and bankers switch their occupations with an exogenous probability in a way that each population stays constant over time.

Each family member has GHH preferences (Greenwood et al., 1988) over consumption $c_{j,t}$ and hours worked $h_{j,t}$ in period $t = 0, 1, 2, ...$, given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \log \left(c_{j,t} - \psi \frac{h_{j,t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right), \tag{1}$$

where $0 < \beta < 1$ is a preference discount factor, $\nu > 0$ is the Frisch labor supply elasticity, $\psi > 0$ is a coefficient on the disutility of labor, and E_0 is an expectation operator conditional on information in period $t = 0$.

The household's budget is managed by its leader. The leader lacks ability of directly lending to firms, thereby the only means of saving/investment that can be chosen by the leader is bank deposits. The leader provides equity to banks, but its provision is limited as will be elaborated later. Accordingly, the household leader chooses $\{c_{j,t}\}_{j=0}^{1}$, $\{h_{j,t}\}_{j=0}^{1}$, and d_t to maximize the expected sum of household member utility (1) over $j \in [0,1]$,

$$E_0 \sum_{t=0}^{\infty} \beta^t \int_0^1 \log \left(c_{j,t} - \psi \frac{h_{j,t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right) dj, \tag{2}$$

subject to the flow budget constraint, given by

$$c_t + d_t \leq R_t d_{t-1} + w_t h_t + \Theta_t, \tag{3}$$

where $c_t \equiv \int_0^1 c_{j,t} dj$ is the household's total consumption, R_t is the deposit interest rate, w_t

is the wage, $h_t \equiv \int_0^1 h_{j,t} dj$ is the household's total hours worked, and Θ_t is the sum of lump-sum taxes imposed by the government and the net lump-sum transfer from banks. The deposit interest rate is state-contingent: in the case of no bank default, the non-contingent interest rate $\bar{R}_{t-1}$ is paid to depositors, i.e., $R_t = \bar{R}_{t-1}$; in the case of bank default, only ta fraction $0 \leq v_t < 1$ of the promised interest rate is paid, i.e., $R_t = v_t \bar{R}_{t-1}$.

4.2 Production and goods market

There is a representative firm, which has nothing but production technology. The firm produces output y_t by combining physical capital k_t and labor h_t, given by

$$y_t = A_t k_t^{\alpha} h_t^{1-\alpha}, \quad 0 < \alpha < 1, \tag{4}$$

where A_t is the total factor productivity (TFP) and $a_t \equiv \log(A_t)$ follows an AR(1) process: $a_t = \rho_a a_{t-1} + \epsilon_{a,t}$ with $\epsilon_{a,t} \sim N(0, \sigma_a^2)$ and $0 \leq \rho_a < 1$. The productivity shock $\epsilon_{a,t}$ is the only aggregate shock in the economy. The firm is competitive and therefore solves $y_t - r_t^k k_t - w_t h_t$ subject to equation (4), taking as given the rental cost of capital r_t^k and the wage w_t.

For simplicity, we assume full capital depreciation. Then, the newly installed physical capital in period t is given by $k_{t+1} = i_t$, where i_t is investment. Since there is no friction between firms and banks, the rental rate r_t^k becomes equal to banks' asset return. The good market clearing condition is given by $y_t = c_t + i_t$.

4.3 Bank runs

Timing of events There is a representative bank and events surrounding a run on the bank unfold as follows. At the beginning of period t, the aggregate shock $\epsilon_{a,t}$ is realized. At this point, however, no one knows the realized value and each depositor j receives a private signal, $s_{j,t}$, about the log of the bank asset return, $\hat{r}_t^k \equiv \log(r_t^k)$, given by

$$s_{j,t} = \hat{r}_t^k + \epsilon_{j,t}, \tag{5}$$

where $\epsilon_{j,t}$ is a noise that follows a normal distribution: $\epsilon_{j,t} \sim N(0, \sigma_\epsilon^2)$. Using the private signal, each depositor decides whether to run or stay. Subsequently, the aggregate shock $\epsilon_{a,t}$ becomes common knowledge. In the case of bank survival after a run, if any, the bank pays the promised interest rate $\bar{R}_{t-1}$ per unit of deposits withdrawn early. In the case of bank default, the bank capital is wiped out, the bank assets are liquidated, and deposits are reimbursed their pro-rata share. The banking system restarts with a small amount of capital injected by the government, as will be described in Section 4.4.

Run decisions Each depositor j formulates the probability of bank default conditional on the private signal (5), denoted as $P_{j,t}$, and decides to run on the bank if doing so is beneficial. Specifically, depositor j runs on the bank if and only if

$$P_{j,t}\Gamma_1 + (1 - P_{j,t}) \times 0 > P_{j,t}\Gamma_0 + (1 - P_{j,t})\Gamma_0 = \Gamma_0, \tag{6}$$

where Γ_1 is the benefit of running on the bank relative to not doing so in the case of bank default and Γ_0 is the cost of withdrawing deposits early. The cost Γ_0 pertains to transaction costs in switching between banks (Klemperer, 1987) or changing portfolios (Constantinides, 1986; Duffie and Sun, 1990). The benefit Γ_1 pertains to a situation in which those who did not withdraw incur a cost in securing claims as a depositor, e.g., in the bankruptcy process, as assumed in Eisenbach (2017).

Since the benefit of running on the bank in the case of bank survival is zero, the left-hand side of (6) corresponds to the expected benefit of running on the bank and the right-hand side of (6) corresponds to the expected cost of doing so. If the former is greater than the latter, that is

$$P_{j,t} > \Gamma_0/\Gamma_1 \equiv \gamma, \tag{7}$$

the depositor runs on the bank. See Ikeda and Matsumoto (2025) for the details of how these considerations are fit into the problem of depositors as household family members.

Conditional probability of bank default Given depositor j's run decision rule (7), the question is how the conditional probability of bank default $P_{j,t}$ is formulated. To address the question, we now consider when the bank defaults.

The bank has equity n_t, takes in deposits d_t from the household, and lends the sum of equity and deposits to the firm. Thus, the bank balance sheet is given by

$$k_{t+1} = n_t + d_t = L_t n_t, \tag{8}$$

where $L_t = (n_t + d_t)/n_t$ is the bank leverage. The left-hand side is the bank assets, and the right-hand side is the bank liabilities. The log return of bank lending $\hat{r}^k_{t+1}$ follows a normal distribution because of GHH preferences (1) and the productivity shock that follows a normal distribution.

In the beginning of period $t+1$, some depositors may withdraw funds from the bank. In response, the bank has to liquidate its assets by terminating some lending. But early liquidation is costly. The assets are liquidated by selling to the household at a discounted value of only a fraction $1/(1+\lambda)$ of the bank asset return r^k_{t+1} per unit of assets liquidated, where $\lambda \geq 0$ governs the degree of the discount. This costly liquidation captures the idea of fire sales and the illiquidity of bank assets.

Let $x_{t+1} \in [0,1]$ denote the size of a bank run – a fraction of deposits that are withdrawn early. Then, the bank defaults if and only if it cannot pay the promised interest rate $\bar{R}_t$ to the depositors:

$$r^k_{t+1}(n_t + d_t) - (1+\lambda)x_{t+1}\bar{R}_t d_t < (1 - x_{t+1})\bar{R}_t d_t. \tag{9}$$

The left-hand side is what the bank has after liquidating assets early to respond to early withdrawals, and the right-hand side is the liabilities to the remaining depositors who did not withdraw. The default condition (9) can be rewritten in terms of the bank asset return as

$$r^k_{t+1} < \bar{R}_t \left(1 - \frac{1}{L_t}\right)(1 + \lambda x_{t+1}). \tag{10}$$

Since the log of bank asset return follows a normal distribution, the conditional probability of bank default can be derived as the probability that the bank asset return satisfies condition (10) conditional on the private signal $s_{j,t+1}$.

Global game and threshold strategy Depositor j makes a run decision by formulating conditional probability of bank default that depends on the run size x_{t+1} as is clear from condition (10), which in turn depends on other depositors' run decisions. In this situation of a global game among depositors, as shown by Rochet and Vives (2004), there is a unique equilibrium in which depositor j runs if and only if $s_{j,t+1} < s^*_{t+1}$ for a certain threshold s^*_{t+1} among depositors under standard regularity conditions. Under this strategy, the bank defaults if and only if its asset return is lower than a certain threshold: $r^k_{t+1} < r^{k*}_{t+1}$.

The run size and the probability of a banking crisis (bank default) are determined as $x_{t+1} = Pr(s_{j,t+1} < s^*_{t+1})$ and $Pr(r^k_{t+1} < r^{k*}_{t+1})$, respectively. As shown by Rochet and Vives (2004) and Ikeda and Matsumoto (2025), the thresholds s^*_{t+1} and r^{k*}_{t+1} are increasing in bank leverage and the deposit interest rate. Therefore, with other things being equal, an increase in leverage or a rise in the interest rate increases the run size and so does the probability of a banking crisis, making the banking system more vulnerable to bank runs.

4.4 Banks

This subsection describes the behavior of the representative bank and how the bank balance sheet variables such as deposits, bank capital, and assets are determined.

Bank problem The representative bank is managed by bankers and its objective is to maximize the bank's expected profits in each period.[7] We assume that neither bank leverage nor risk is observable to depositors as in Acharya (2009) and Mendicino et al. (2020). In this situation, bank leverage is not contractible and thereby the bank maximizes the expected profits given the deposit interest rate.[8] In period t, the bank chooses leverage L_t to maximize the expected profits taking into account the effects of its chosen leverage on the run size and accompanying costs of early liquidation:

$$\max \int_{\hat{r}^{k*}(L_t)}^{\infty} \left\{ e^{\hat{r}^k_{t+1}} L_t - \bar{R}_t \left[1 + \lambda x \left(\hat{r}^k_{t+1}, s^*(L_t)\right)\right] (L_t - 1) \right\} n_t dF_t(\hat{r}^k_{t+1}), \tag{11}$$

where $x(\cdot)$ denotes the run size, which is written as a function of the log of bank asset return and the run threshold explicitly, and F_t denotes a normal distribution function for the log of bank asset return. The thresholds are also written explicitly as a function of leverage. The first term in the integral is the gross return on bank assets and the second term captures the interest rate cost of deposits and the costs associated with early liquidation.

In this problem, since the deposit interest rate $\bar{R}_t$ is taken as given for an individual banker, the risk of bank default is not priced on margin, although it is priced on average. The bank ignores the effect of their choice of risk – leverage – on the interest rate. This leads to bank risk shifting similar in spirit to that described by Jensen and Meckling (1976). In addition, as shown by Ikeda (2024), the presence of the interest rate in the cost of early liquidation leads to a pecuniary externality that causes further excessive leverage.

Bank capital There is a financial friction that limits flows of bank capital into/out of the bank. Specifically, the bank is assumed to distribute profits to the household following

[7]The assumption that banks, or borrowers in general, maximize their expected profits is also adopted by Bernanke et al. (1999), Christiano et al. (2014), and Mendicino et al. (2020) in their dynamic general equilibrium models.

[8]See Ikeda (2024) for the bank problem in which bank leverage is contractible.

a certain rule: it pays a fraction $1 - \chi_0$ of net profits, if any, to the household. The net profits are given by

$$\pi_t^b = r_t^k L_{t-1} n_{t-1} - \bar{R}_{t-1}(1 + \lambda x_t)(L_{t-1} - 1)n_{t-1} - n_{t-1}. \tag{12}$$

If the net profits are negative, the bank does not pay any dividend. After the payment, a fraction $1-\chi_1$ of bankers become depositors and take home their portion of bank capital to the household. The same number of depositors become bankers and receive an exogenous equity $n_0 > 0$ from the household in aggregate to start their business. Then, the bank capital evolves following

$$n_t = \begin{cases} \chi_1 \left[\chi_0 \pi_t^b + (1 - \chi_0)\pi_t^b \mathbf{1}_{\{\pi_t^b < 0\}} + n_{t-1}\right] + n_0 & \text{if no default, i.e., } \hat{r}_t^k \geq \hat{r}_t^{k*} \\ \bar{n} & \text{if default, i.e., } \hat{r}_t^k < \hat{r}_t^{k*} \end{cases} \tag{13}$$

where $\mathbf{1}_{\{\pi_t^b < 0\}}$ is an indicator function taking unity if $\pi_t^b < 0$ and zero otherwise. In the case of a banking crisis, the bank defaults and its capital is wiped out. It is assumed that, in the case of bank failure, new bank capital $\bar{n} > 0$ is injected into the bank from the government, which finances the capital injection by lump-sum taxes on the household.

4.5 Equilibrium

Limit equilibrium The global game literature often assumes a limiting case of vanishing noise of private signals for analytical tractability. We follow the convention and consider the case of $\sigma_e \to 0$. As shown by Ikeda and Matsumoto (2025), this assumption not only makes the bank's equilibrium condition tractable but also helps the model keep a representative framework.

Competitive equilibrium Under the assumption of the limiting case of $\sigma_\epsilon \to 0$, a typical definition of a competitive equilibrium applies. Given a sequence of prices, the exogenous aggregate shock, and the rule for bank capital (13), the representative household maximizes the utility; the representative firm maximizes its profits; the representative bank maximizes its profits; all markets clear; and the global game among depositors is solved.

Table 1: Parameter values

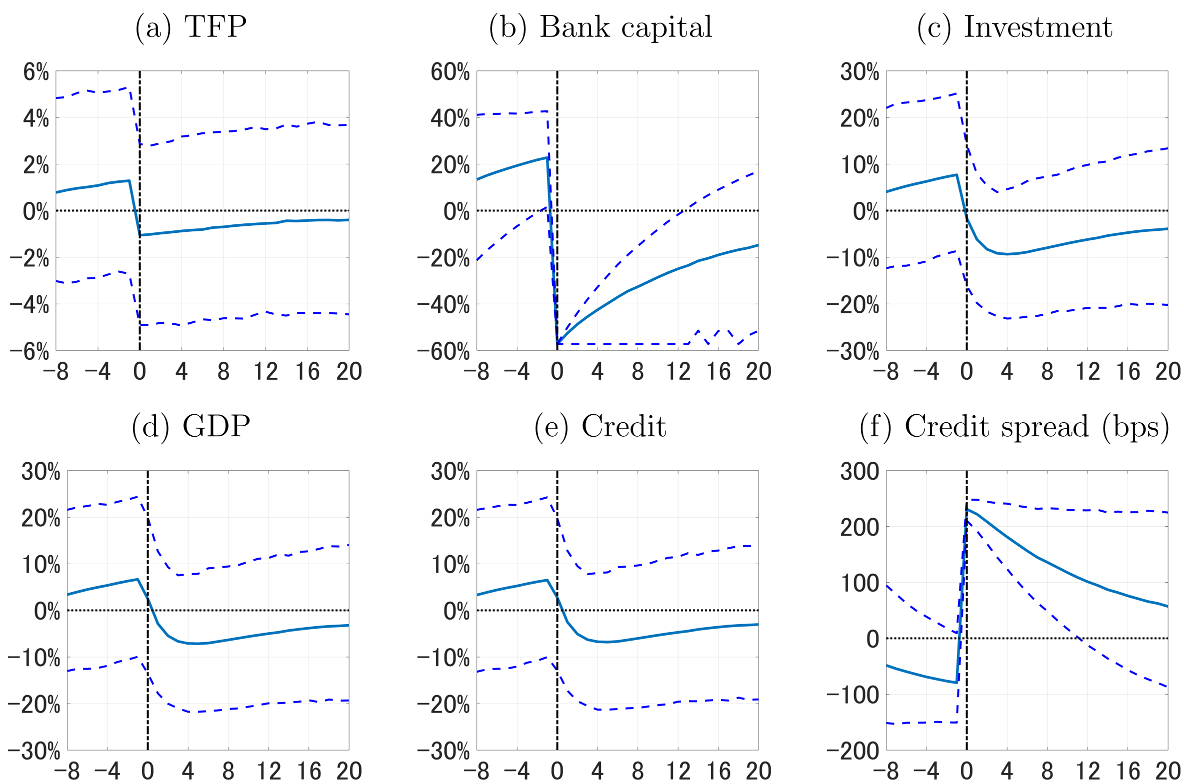
	Parameter description	Value	Target/Source
	Standard parameters		
β	Preference discount factor	0.9926	Steady state risk-free rate of 3%
ψ	Labor disutility coefficient	0.3830	Steady state labor supply of unity
ν	Labor supply elasticity	2	Keane and Rogerson (2012)
α	Capital share in production	0.33	Standard RBC literature
ρ_a	TFP shock persistence	0.95	Standard RBC literature
σ_a	TFP shock standard deviation	0.01	Standard RBC literature
	Banking sector parameters		
λ	Liquidation cost	0.1765	Liquidation discount by 15%
$\overline{n}$	Capital injection during a crisis	0.0055	30% of steady state bank capital
γ	Threshold default probability	0.5349	Crisis probability of annual 5%
n_0	New banker endowment	0.00085	Leverage of 10
χ_1	Law of motion for bank capital	0.95	Gertler and Kiyotaki (2015)
χ_0	Degree of retained earning	0.025	Leverage procyclicality

5 Quantitative Results

This section presents the quantitative performance of the model regarding Facts 1–5 on banking crises presented in Section 2. The model period is quarter. The model is calibrated to the U.S. economy and solved globally using a parameterized expectation algorithm. The model is then simulated for 100,000 periods by generating stochastic shocks with the model's initial condition given by its steady state. The simulated data, with the first 1,000 periods dropped, are used for assessing the quantitative performance of the model. The calibrated parameter values are shown in Table 1. The parameter values that play an important role in explaining the five facts will be mentioned below. For the details of the other parameter values and the solution method, see Ikeda and Matsumoto (2025).

We extract banking crisis events from the simulated data. In the model, a banking crisis is defined as a bank default event where 3 years (12 periods) or more have passed since the previous bank default, if any. This definition is similar in spirit to Laeven and Valencia (2013), whose empirical study defines that a banking crisis ends when output and credit have grown for two consecutive years.

Figure 1: The dynamics of banking crises



Note: The solid lines are the average path of each variable around the banking crises identified in the simulated data. The dashed lines are the 10th and 90th percentiles of the dynamics. All variables are expressed in percentage deviations from the mean of the simulated data, except for credit spread, which is expressed in differences from the mean.

Figure 1 plots the dynamics of the economy around the banking crises identified in the simulated data. The figure uncovers some patterns of banking crises. Bank runs are triggered by bad fundamental shocks (Panel (a)). Once a run erupts, the bank defaults, the bank capital is wiped out, and the banking sector has to restart with a small amount of capital (Panel (b)). The bank's capacity of financial intermediation is severely damaged, and investment and GDP fall sharply (Panels (c) and (d)). It is worth noting that in a run up to a crisis, there is a boom of credit (Panel (e)) and a compression of credit spread (Panel (f)) as well as the boom of the real economy (Panels (c) and (d)). These observations are qualitatively consistent with some of Facts 1–5.

In the following, the quantitative performance of the model is assessed for each fact, which is followed by a discussion on the model's key properties and parameter values that play a critical role in explaining the fact and challenges facing the model.

Fact 1 (Bank runs) In this model with a limit equilibrium, a bank run is a systemic event in which all depositors run on the bank, precipitating bank default. A bank run erupts when the bank fundamentals deteriorate enough, including the case of a fundamental default in which the bank defaults anyway even without a run. Thus, a collapse in the banking sector – bank default – always features a bank run in this model.

Admittedly, the model's feature that a banking crisis is always a bank run is a bit of stretch from Fact 1. To explain banking crises or distress that are not related to bank runs, one would need to introduce a mechanism that makes depositors perceive that deposits are safe, e.g., deposit insurance or government interventions, even if bank fundamentals deteriorate.

That said, the model captures an important property of banking crises, uncovering mechanisms underlying bank runs as will be discussed below. Perhaps, a more important challenge facing the model is to explain a partial run that paralyzes a whole banking sector. Since the model assumes the representative bank, i.e., a continuum of identical banks, all banks face bank runs at the same time. In practice, however, bank runs at several banks precipitate a banking crisis, as in the GFC and the Japanese banking crisis in the late 1990s.

Fact 2 (Credit booms) To test the empirical performance of our model against Fact 2, the two specifications that are employed by Schularick and Taylor (2012) are estimated by using the simulated data. The first specification is a simple OLS regression, given by

$$p_t = \beta_0 + \beta_1 \frac{d_{t-1} - d_{t-5}}{d_{t-5}} + \beta_2 \frac{d_{t-5} - d_{t-9}}{d_{t-9}} + \beta_3 \frac{d_{t-9} - d_{t-13}}{d_{t-13}} + \varepsilon_t,$$

where ε_t is an error term that is i.i.d. with mean zero. The dependent variable p_t takes 1 if a banking crisis happens within a year (four quarters), and 0 otherwise, given by

$$p_t = \begin{cases} 1 & \text{if a banking crisis occurs in the period from } t \text{ to } t+3, \\ 0 & \text{if no crisis.} \end{cases}$$

The three explanatory variables are the annual growth rate of deposits in the past three years. The second specification is a logit regression, given by

$$p_t = \frac{1}{1 + \exp\left(-\left(\beta_0 + \beta_1 \frac{d_{t-1}-d_{t-5}}{d_{t-5}} + \beta_2 \frac{d_{t-5}-d_{t-9}}{d_{t-9}} + \beta_3 \frac{d_{t-9}-d_{t-13}}{d_{t-13}}\right)\right)} + \varepsilon_t,$$

Table 2: Banking crisis regressions

Coefficient on credit growth	OLS	Logit
1 year ago	$0.120^{***}(0.044)$	$1.255^{***}(0.457)$
2 years ago	$0.160^{***}(0.044)$	$1.672^{***}(0.460)$
3 years ago	$0.187^{***}(0.043)$	$1.952^{***}(0.450)$

Note: *** denotes a 1% significance. Parentheses show standard deviations. $\partial p_t/\partial x_t$ denotes the marginal effects of the logit specification.

where the variables are defined similarly as in the OLS specification. The logit specification guarantees that the right-hand side takes a value between 0 and 1. Using these two regressions, we test whether an expansion in credit in the past three years can predict a banking crisis in the next year.

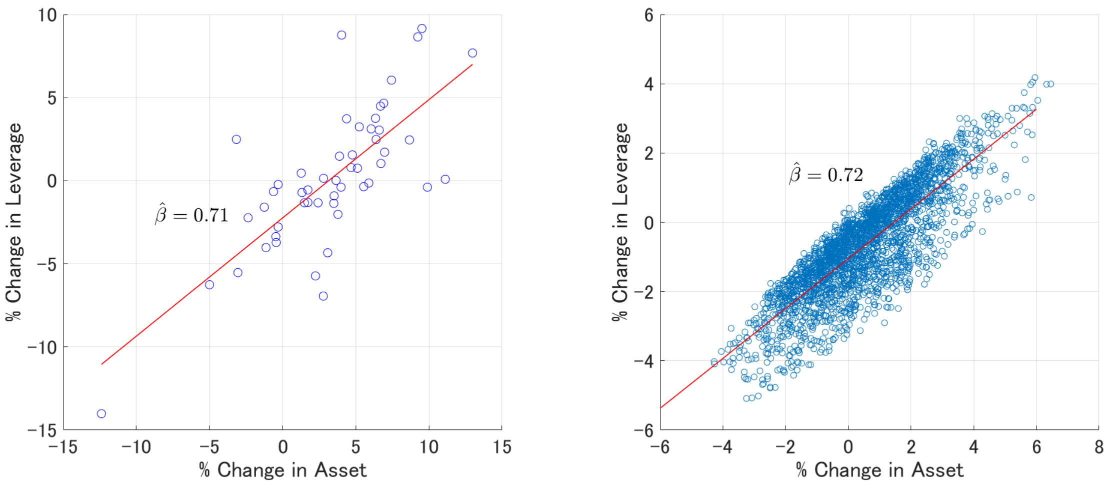
Table 2 presents the estimation results. In both specifications, all the explanatory variables are significant at 1 percent with a positive sign, implying that a credit expansion indicates a significantly high probability of a banking crisis in the next three years. The results indicate that one standard deviation increase in credit growth in the past three years raises the probability of a banking crisis in the next year by 1.8 percentage points (pp), which is substantial given that the probability of a banking crisis in the stochastic steady state is 5 percent. The results are consistent with those of Schularick and Taylor (2012), and thereby the model reproduces Fact 2 well.

What drives the model's success in explaining Fact 2? The most important contributor is a global game embedded in the model. It provides a tight link between the probability of a bank run and bank fundamentals such as the bank's asset return, deposit interest rate, and leverage as explained in Section 4.3. In particular, if high credit growth is driven by high leverage, the probability of a bank run increases during years of high credit growth. In this sense, procyclical leverage (Fact 3) – leverage that co-moves with bank assets and credit – is also a critical contributor to explaining Fact 2.

If there were no global game, the link between the probability of a bank run and bank fundamentals would break down. Multiple equilibria emerge and the literature such as Gertler and Kiyotaki (2015) typically addresses the issue by introducing a sunspot — something non-fundamental and exogenous that makes all depositors run upon observing it. In other words, once a bank falls into a vulnerable region where it can default if a run occurs, the probability of a run is given exogenously. Our model simulation indicates that

Figure 2: Procyclical leverage

(a) Data (b) Model



Note: On the left panel each data point is the weighted average of the following five major investment banks in the US before the GFC: Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley. The sample period is 1994Q2-2007Q3, where the starting period is chosen so that data for at least three of the five investment banks are available, and the end period corresponds to one period ahead of the Great Recession in the US. The recession periods of 2001Q1-2001Q4 are excluded to focus on 'normal' times. $\hat{\beta}$ indicates a linear regression coefficient.

Source: Securities and Exchange Commission, Form 10-Q.

the economy is almost always in the vulnerable region, consistent with a view that banks are inherently vulnerable to runs. Therefore, if the global game were removed, the model would fail to explain Fact 2.[9]

Fact 3 (Procyclical leverage) Figure 2 plots a percentage change in leverage against a percentage change in bank assets for data (left panel) and the model (right panel), where the data are the sum of major U.S. investment banks during the periods before the GFC. The data show a positive relationship between leverage and bank assets, which was initially pointed out by Adrian and Shin (2010, 2011) for U.S. investment banks and later confirmed by Laux and Rauter (2017) for U.S. commercial banks. The banks expand the supply of credit by increasing leverage. The model successfully replicates this relationship as shown

[9] The literature on panic runs such as Gertler and Kiyotaki (2015) and Gertler et al. (2020) generate a link between the probability of a banking crisis and bank fundamentals by calibrating a model in a way that the economy moves between the vulnerable region and a non-vulnerable region where a bank does not default even if all depositors run. The probability of falling into the vulnerable region depends on bank fundamentals, and once a bank falls into the vulnerable region the probability of a bank run is exogenous. Gertler and Kiyotaki (2015) mention a challenge of determining run probability endogenously in a dynamic general equilibrium framework.

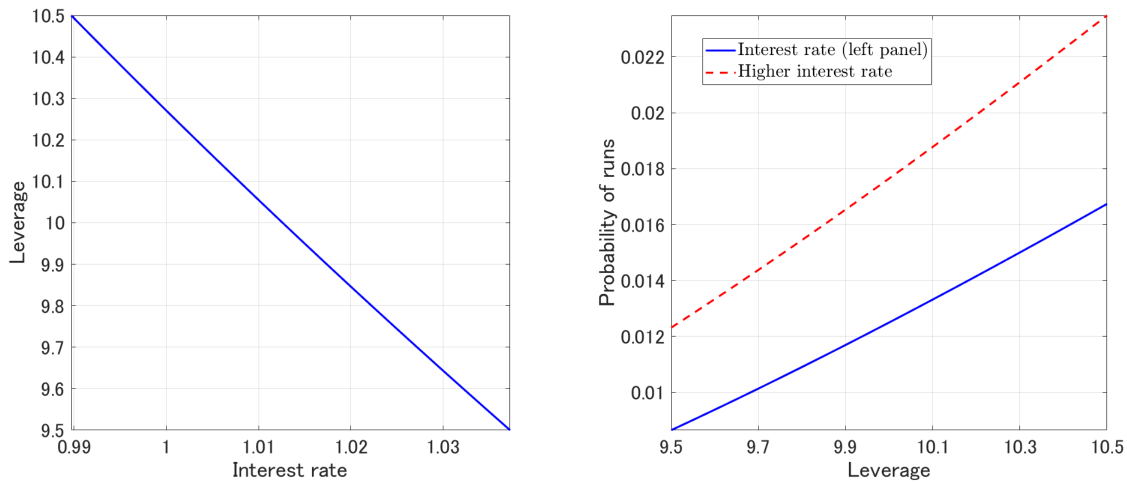
by the right panel. In this way, an expansion in credit is associated with an increase in leverage. Combined with the global game that was highlighted in discussing Fact 2, procylical leverage gives rise to an increase in the probability of a banking crisis during an expansion in bank credit.

What drives procyclical leverage in the model is sticky bank capital embedded in the law of motion for bank capital (13). Specifically, the parameter that governs the bank's behavior of accumulating capital organically is set to be low at $\chi_0 = 0.025$ as shown in Table 1. This makes bank capital sticky and less affected by bank profits. If the parameter were to be set at $\chi_0 = 1$ as often assumed in the literature such as Gertler and Kiyotaki (2015), leverage would become countercyclical and the model would fail to explain not only Fact 3 but also Fact 2. Although the modeling of sticky capital is a reduced form by introducing parameter χ_0, it highlights the importance of sticky bank capital in explaining Facts 2 and 3.[10] For the model that generates procyclical leverage in a structural manner, see, e.g., Nuño and Thomas (2017).

Fact 4 (Interest rate path) Although the current model abstracts away monetary policy and nominal aspects of the economy, it has the potential to explain Fact 4: sharp increases in interest rates followed by low interest rates tend to coincide with the onset of banking crises. The left panel of Figure 3 plots the relationship between the gross interest rate $\bar{R}_t$ and leverage L_t, implied by the bank's optimization problem. It shows that a low interest rate induces higher leverage. And the right panel (solid line) of Figure 3 shows that the high leverage induced by a low interest rate increases the probability of runs. Thus, the model suggests that a low interest rate environment can give rise to a credit boom with high leverage and increase the banking sector's vulnerability to runs. In addition, if the interest rate is increased, the probability of runs increases further as shown by the dashed line in the right panel of Figure 3. Although there is no uncertainty regarding the interest rate in the current model, if there were an unexpected increase in the interest rate, a resulting increase in the cost of the liabilities in the bank balance sheet could trigger a

[10] The parameter setting of $\chi_0 = 0.025$ literally implies a 97.5 percent dividend payout ratio in normal times, and it is too high in light of empirical evidence that the dividend payout ratio was about 40 percent from the late 1990s through 2006 for U.S. banks (Floyd et al., 2015). What is missing in the model (the right panel of Figure 2) is the asset growth trend observed in the data (the left panel of Figure 2). In the data, the average annual growth rate in assets is about 12 percent and the average return on equity (ROE) is just below 20 percent. This implies that, with a 40 percent dividend payout ratio, the bank capital would increase by 12 ($= 20 \times (1 - 0.4)$) percent, keeping the leverage unchanged, as the assets also grow at the same rate. In our model with no trend growth in assets, this situation corresponds to almost no retained capital.

Figure 3: Interest rate, leverage, and the probability of runs

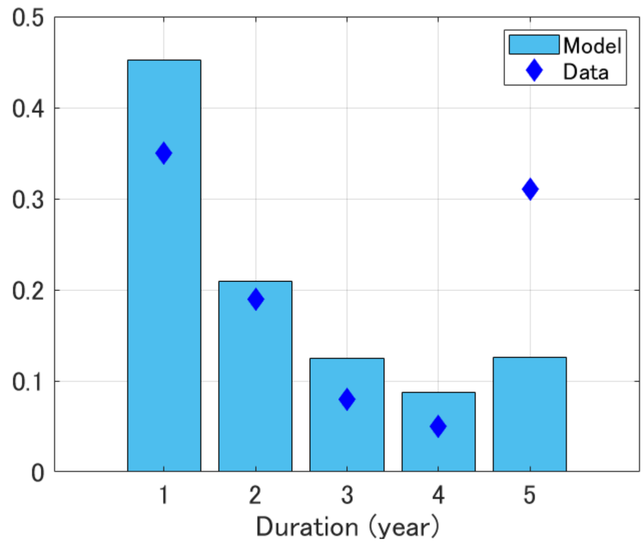


run. Hence, the model has the potential to articulate the following narrative: low interest rates fuel leverage, and if resulting high leverage meets a sharp increase in interest rates, that increases the likelihood of banking crises.

The link between the interest rate and the probability of runs arises from the global game embedded in the model. The potential of the model to explain Fact 4 highlights the importance of the global game.

Beyond the potential, a challenge facing the model in explaining Fact 4 is to explicitly incorporate monetary policy and to model a relationship between a policy interest rate and a deposit interest rate. The model introduced here is a real model and abstracts away monetary policy. The degree of how much a policy interest rate is passed through on a bank's deposit cost – so-called deposit beta – is also important in assessing the effect of monetary policy on the probability of runs through its effect on the deposit interest rate. Drechsler et al. (2021) estimate deposit beta for U.S. banks at about 0.35 — a 35 basis points increase in a bank's average deposit rate in response to a 100 basis points increase in a policy rate. Their estimate suggests that banks are resilient to interest rate risk on average. However, as highlighted by the March 2023 banking turmoil, a challenge is to understand when deposit beta can jump up suddenly for some banks. In addition, non-bank financial institutions tend to have a high sensitivity of the cost of liabilities to market interest rates, and some of them may be susceptible to runs, as in the case of the investment

Figure 4: The distribution of the duration of banking crises



Note: This figure plots the distribution of the duration of banking crises in the model (bars) and in the data (diamonds). The bar and diamond for five years include all crises that last for five years or longer.

banks that went bankrupt in the GFC.[11]

Fact 5 (Slow recoveries) Empirically it has been observed that recoveries from banking crises tend to be slow. To study the pattern using the data simulated from the model, we focus on the duration of banking crises, where the end of a crisis is defined as a period when both output and credit have grown for two consecutive years, following the definition used by Laeven and Valencia (2018). In this context slow recoveries are synonymous to long duration of banking crises.

For each banking crisis in the simulated data the duration of the crisis is calculated and its frequencies are plotted in Figure 4 along with its empirical counterpart calculated from the data of Laeven and Valencia (2018). Our model roughly tracks the pattern of the data: the duration of banking crises is the most frequent for one year, becomes less frequent up to the duration of four years, and then becomes more frequent at the duration of five years or longer.

The reason why the model successfully generates a significant number of banking crises that last three, four, five years or longer is that the model economy becomes even more vulnerable to a bank run after an initial banking crisis. Specifically, bank leverage shoots up after the onset of banking crises as it takes time for banks to build capital organically.

[11]See Financial Stability Board (2023b) for the recent policy work on NBFIs.

But high leverage increases vulnerability to a bank run. Indeed, in the simulated data, bank runs occur repeatedly, making the duration of some banking crises long as shown in Figure 4.

Some gaps between the model and data remain, however. The model overestimates the frequency of a banking crises that ends within a year and underestimates the frequency that ends within five years or longer. One reason could be that the model lacks a mechanism that generates a permanent loss of output as mentioned in Section 3, where it discusses other developments as a part of the related literature. Such a mechanism includes not only endogenous growth but also a change in beliefs about risks as argued by Kozlowski et al. (2020). In the model presented in this paper a change in beliefs would correspond to that about the distribution of bank asset return. If the bank asset return is perceived to be riskier, there would be less financial intermediation and a permanent loss of output. In addition, if there is a mechanism that makes depositors become more sensitive to another run as a result of the initial run, it would also contribute to explaining Fact 5. These hypotheses about a change in beliefs are consistent with the empirical finding by Aikman et al. (2022), who show that deep contractions that are not necessarily caused by financial crises also have highly persistent scarring effects.

6 Policy Implications and Challenges

This paper has shown that the model can explain some aspects of Facts 1–5 about banking crises. Now the next step would be to derive policy implications from the model. However, challenges remain since the model presented here does not have policy tools. In the following, we discuss how to extend the model to incorporate policy tools and point out its challenges, keeping in mind policy efforts that have been made in practice.

Capital requirements The model suggests that leverage is excessive due to risk shifting and a pecuniary externality, giving rise to excessive probability of banking crises. This consideration warrants imposing capital or leverage requirements. Ikeda and Matsumoto (2025) introduce such requirements to the model and show that the probability of banking crises can be reduced and social welfare can be improved. The leverage restrictions considered in the paper are always binding and time-varying: leverage is restricted by a certain fraction from the unrestricted level that would be chosen by the bank. This type of restrictions allows the bank to have high leverage when it is needed, especially during banking crises where the banking sector has less capital and need leverage to provide funds to the real economy.

Admittedly, such requirements differ from the actual capital requirements significantly. First, the capital requirements put in place in practice are not always binding: almost all banks keep a management buffer with which there is always a distance between the actual level of capital and its required level. Second, the actual capital requirements may not be so time-varying. In non-crisis times, the requirements are fixed except for countercyclical capital buffers (CCyBs). Even CCyBs tend to be adjusted less frequently as several jurisdictions employ the idea of a positive neutral level of CCyBs (Behn et al., 2023). Introducing a management buffer and modeling less volatile capital requirements are challenges facing the model. And addressing them would require a bank's incentive to keep a certain amount of a management buffer.[12]

Liquidity requirements In the model the bank's assets consist of loans only and it does not allow to hold any liquid assets. However, as studied by Ikeda (2024) in the two-period version of the model presented in Section 4, if the bank is allowed to hold safe assets, it holds them under plausible assumptions. The bank can use safe assets to satisfy early withdrawal requests without selling assets at firesale prices, which contributes to reducing a run risk and increasing the expected profits. In practice, as a part of Basel III, liquidity requirements of Liquidity Coverage Ratio and Net Stable Funding Ratio have been introduced. Although there remain some technical difficulties, introducing safe assets and studying liquidity requirements in the dynamic model presented in this paper are a promising extension. But again, as in capital requirements, modeling a management buffer for liquidity requirements remains a challenge. For the recent literature on bank liquidity and its requirements, see see those cited in Diamond and Kashyap (2016), Allen and Gale (2017), and Vo (2021).

Lender/market maker of last resort In the model simulation, all banking crises are illiquidity crises where the bank is solvent but illiquid. To be precise, being "solvent" means that a bank can survive if there is no run. To put differently, it means that a bank can survive even if there is a run, if banks can liquidate their assets at non-firesale prices, i.e., $\lambda = 0$ in the model. This warrants the role of lender of last resort as discussed by

[12] For a partial equilibrium model of banks that features an endogenous management buffer due to the banks' precautionary behavior to prevent binding regulatory constraints, see, e.g., Abad et al. (2025).

Rochet and Vives (2004). In the model presented in this paper, if a monetary authority provides liquidity by taking in bank assets as collateral, it will enable the bank to satisfy early withdrawal requests without realizing losses by selling assets. If the bank is solvent, the bank receives a lending interest rate and principal from borrower firms and uses them to pay back to the monetary authority. But in practice, there would always be uncertainty about the value of assets. And for central banks there are limits on the types of assets that can be taken as collateral. Moreover, if it is revealed that the bank used a liquidity facility, market participants and depositors may take it as a sign of the bank's hidden problems and run on the bank. Expecting this stigma in advance, banks may be hesitant to using a liquidity facility. Furthermore, without penalty to banks that use a liquidity facility, acting as a lender of last resort may cause moral hazard and induce excessive risk taking. These considerations would need to be incorporated into the modeling and discussions of the role of a lender of last resort.

In the model, the degree of discount of firesale prices is fixed at λ. One extension would be to allow for price elasticity with respect to the quantity sold as in, e.g., Eisenbach (2017). Another extension would be to introduce adverse selection in a buyer-seller setting as in Kurlat (2013) and Bigio (2015) and allow for the possibility of market shutdown. In these extensions, a monetary authority's role as a market maker of last resort could mitigate the severity of a banking crisis. Specifically, the purchase of bank assets by a monetary authority could underpin the price and make the price discount less severe.

Recapitalization and resolution In this type of model where a lack of bank capital is the cause of the dysfunction of the banking system, capital injection can be an effective policy tool. But such a conclusion may not be warranted because the model abstracts away why a bank has difficulty in raising capital by its own. It needs to be understood what a government or a monetary authority can and cannot do relative to a private sector. Specifically, if some frictions hinder a bank from raising capital, a government or a monetary authority may also face the same frictions. Although capital injection appears to be an effective policy, such a conclusion should be underpinned by the micro-founded analysis on why bank capital is scarce and a plausible explanation about what a government or a monetary authority can do and what the private sector cannot.

Ensuring orderly resolution of a systemic bank is a part of on-going policy efforts that have continued since the GFC.[13] In this regard, as mentioned in discussing Fact 1, the model

[13] See Financial Stability Board (2023a) for the recent policy work on international resolution framework.

in its current form cannot explain why a bankruptcy of a big bank can paralyze the whole banking system. In practice, however, such a possibility is well taken and that's why policy efforts have continued to ensure orderly resolution of a systemic bank. To understand the effectiveness of such policy efforts, the model needs to be extended to feature a systemic nature of a big bank with which a failure of one big bank can give rise to a crisis if its resolution is disorderly.

Deposit insurance Deposit insurance is a linchpin that has been introduced in many countries to prevent bank runs. However, in general, deposit insurance covers only a certain fraction of deposits, typically, deposits up to some upper limit; and the remaining deposits are uninsured. Thus, for large wholesale depositors, for example, most of the deposits are uninsured. The March 2023 banking turmoil in the U.S. and Switzerland saw the outflow of uninsured deposits at an unprecedented speed.

A deposit insurance system that perfectly insures deposits would eliminate bank runs in the model presented in this paper. Households with insured deposits would have no incentive to run on the bank. However, as long as there are uninsured deposits that account for a significant fraction of total deposits as is the case in practice, there continues to be a run risk. In addition, even for insured deposits, if households perceive that they may suffer a loss in the case of bank default, including the cost – time and efforts – required to secure deposits, households may run on their bank. Moreover, if the cost of deposit insurance is not born by banks appropriately, deposit insurance may induce the bank's moral hazard as in Kareken and Wallace (1978), leading to higher leverage and higher probability of banking crises.

Although the literature on bank runs in a dynamic general equilibrium framework often assumes no deposit insurance for simplicity, as in the model presented in this paper, understanding the effects of a deposit insurance system on banks' behavior and the likelihood of banking crises continues to be an important topic.[14] In doing so, uncovering banks' incentive underling their decisions on a portfolio of insured and uninsured deposits would also be an important research topic.

[14]See Federal Deposit Insurance Corporation (2023) for discussions on possible deposit insurance reform in response to the March 2023 banking turmoil.

7 Conclusion

This paper has introduced five facts about banking crises, presented a dynamic general equilibrium model that has the potential to explain those facts, and discussed the policy implications and challenges facing the model to further deepen our understanding on banking crises. Among the challenges mentioned in this paper, three are worth repeating in conclusion. First, uncovering mechanisms behind sticky bank capital is critical for understanding procyclical leverage. Second, introducing monetary policy explicitly is required to derive implications for monetary policy. Third, various policy tools including capital/leverage requirements need to be incorporated to derive policy implications in a dynamic framework.

More work needs to be done to understand banking crises through a lens of a dynamic general equilibrium model. This paper has conducted a quick stock-take of a dynamic general equilibrium model with financial frictions and banking crises and presented a specific model that is relevant to Facts 1–5 about banking crises. We hope that this paper will invite more academic and policy-related researchers to work on macroeconomic models of banking crises and tackle policy issues.

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