Friedman-Schwartz vs.Tobin:

A Modern Reassessment of the Great Depression

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Abstract

We revisit the Friedman-Schwartz vs. Tobin debate about the Federal Reserve's role in the Great Depression by using modern econometric and quantitative-modeling tools. We calibrate a general equilibrium model with a banking sector and an interbank market, building off Bianchi and Bigio (2022). Our model offers novel contributions to the literature through its banking-focused approach that interconnects money, credit, and output. This framework allows us to leverage aggregate banking data from the era, including interbank rates, to examine the Federal Reserve's policy pass-through into the aggregate economy. The model allows us to weigh the relative importance of various shocks affecting banks and the economy during the period. It is well-suited for conducting counterfactual analyses of policies proposed in Friedman and Schwartz's "A Monetary History of the United States, 1867-1960," particularly an expansion of discount window lending, while accounting for the constraints imposed by the gold standard.

1 Introduction

Many models have been proposed to understand the role of monetary forces and other financial shocks in worsening the Great Depression. They are largely situated in the context of the claims made by Friedman-Schwartz. The Friedman-Schwartz narrative highlighted the particular negative role of the precipitous decline in the money supply and inaction of the Federal Reserve as outlined in their *A Monetary History of the United States, 1867 to 1960* (henceforth, *Monetary History*). James Tobin on the other hand argued that much of the severity of the Great Depression stemming from the banking system may not have been supply driven but could have been driven by firms whose weakening position during the period caused a lack of demand for bank intermediation. [Maybe include a famous line or two from F&S]

These models either abstract from or provide an ad-hoc characterization of the banking system despite it playing a crucial role in the Great Depression according to both Friedman-Schwartz and Tobin. They fail to model the bank's liquidity management, i.e. the choice of the ratio of reserves to deposits in their portfolio, the very assets crucial to the story of Friedman-Schwartz. In addition, they omit the connection of this problem to settlement in the interbank market and subsequent use of the discount window of the central bank. Since household decisions and central bank policy affect the liquidity management problem and its downstream effects, these models are unable to capture how such frictions that arise in the banking system can transmit themselves in a general equilibrium context to macro aggregates and contribute to such a sustained contraction.

By modeling the bank liquidity management problem and role of settlement in the interbank with a novel data set of historical interbank rates, we document the precise role that the banking system, money supply and Federal Reserve action had in worsening the Great Depression. This in turn allows us to reassess the strength of the famous argument between Friedman-Schwartz and Tobin. In order to do this, we adapt the general equilibrium banking model of Bianchi and Bigio (2022) and calibrate it to data from the most severe portion of the Great Depression which is the Great Contraction that begins with the stock market collapse in October 1929 and ends with the banking holiday in March 1933. The model explicitly includes these features of the banking system left out by previous models including a bank liquidity management problem, matching in the interbank market and a discount window managed by the central bank for those banks that are unable to settle their outflows in the interbank market. The model also includes a central bank that conducts open market operations and exogenous supply and demand schedules of households and firms. As a result, the model micro-founds all the links among economic agents, their relevant constraints and the banking system during Great Depression.

After outlining the model, we solve the bank optimality conditions to elucidate the mechanisms of how the liquidity management problem of the bank and frictions in the interbank market propagate to the the model's key equilibrium rates. In order to this, we simplify the model by imposing linear utility and impose a two period structure for clearer elucidation. The results show that banks must be indifferent between making loans and issuing reserves and deposits on the margin due to the liquidity benefit of reserves and the liquidity risk of deposits as represented by the rate spread on each. This in turn sets the supply and demand schedules of households and firms for deposits and loans, linking the optimality conditions of the banks to the other key economic agents which in turn allows the model to properly calibrate the interconnections in the model estimation and application the Great Depression.

We map our model to aggregate banking and macro data to estimate the role of key financial shocks during the Great Depression to the model setting using a maximum likelihood estimation approach. Uniquely, we are the first to use a newly digitized series on interbank rate data from Anbil et al. (2021) in a model of the Great Depression. For the remaining data, we largely draw on the comprehensive records found in the Federal Reserve's *Banking and Monetary Statistics* for Federal Reserve member bank data and draw on widely used indices for macro data. From this data, reduced form structure and certain model moments, we then both internally and externally estimate model parameters to asses the role of each model shock.

Our current results highlight the import of modeling these frictions in the banking system as they imply a smaller role for monetary forces in worsening the Great Depression than that argued by Friedman-Schwartz. Even through more sustained open market operations that increase the money supply, the effect on firms' borrowings from banks remain muted. Instead, banks merely hold additional excess reserves from these monetary shocks without deploying them into the economy due to increased concern they will not find a bank to support them in the interbank market should they fail to meet their regulatory constraints. Rather, our calibrations point to a greater role for decreases in firm loan demand and solvency, similar to the arguments made by Tobin, in spurring the severity of the Great Depression as seen in the model's decline in loan activity despite a drop in the nominal loan rate.

The paper contributes to a few key strands of literature relating to the Great Depression. One key area is the use of quantitative equilibrium models to asses the relative contributors to the Great Depression. Key related papers that aim to do this are Bordo, Erceg, and Evans (2000), Cole and Ohanian (2000), Christiano, Motto, and Rostagno (2003), Cole and Ohanian (2007), and Bordo and Sinha (2023). The paper's main contributions in this regard are in two respects. This previous literature largely used Neoclassical and New Keynesian models with ad hoc additions of the banking system and minimal financial frictions. The paper's model explicitly captures the bank portfolio problem and its downstream connections to the interbank market and discount window. This allows the to model to micro-found the mechanisms for the transmission of shocks through the banking system to the price level and aggregate lending.

The paper also contributes to the larger body of literature on the empirical findings relating to the money and banking hypothesis for the Great Depression. This literature includes Belongia and Ireland (2015), Mitchener and Richardson (2019), and Cohen, Hachem, and Richardson (2021).[1] The paper's contribution in relation to these is by focusing on the dynamics in the interbank system, using newly digitized data concerning the Fed Funds rate (via Anbil et al. (2021)) from the period in a general equilibrium model with a banking sector. This in turn allows us to better estimate and understand policy counterfactuals during the period. The paper also adds to a body of work that discusses the actions and inaction of Federal Reserve policy in worsening the Great Depression. Along with Bordo, Erceg, and Evans (2000) and Christiano, Motto, and Rostagno (2003), this literature includes McCallum (1990), Bordo, Choudhri, and Schwartz (1995, 2002), Hsieh and Romer (2006), Bordo and Rockoff (2013), and Hanes (2019). We add to these works by being able to run counterfactuals about different policies the Federal Reserve should have taken to mitigate the Great Depression and the mechanisms for these policies effects through the banking system and into the aggregate economy.

The paper is organized as follows. Section 2 presents the model, and section 3 provides theoretical results. Section 4 presents a discussion on data sources and results of the calibration and Section 5 provides the model's reassessment of the Great Depression. Section 6 concludes. Appendix section consists of related proofs and extensions.

2 Model

We adapt the general equilibrium banking model of Bianchi and Bigio (2022) to the banking setting of the Great Depression by layering on the gold system and reserve constraints for both commercial banks and the central bank. The model incorporates a bank liquidity management problem and an interbank market, with a discount window for those that fail to borrow in the interbank market. In addition, the model is closed with demand and supply systems of households and firms and a central bank. The inclusion of these micro banking dynamics alongside a characterization of a general equilibrium with all the assets, agents and policy constraints from the period allow the model to capture the channels of propagation for financial shocks during the Great Depression.

1. Earlier works in this literature include Bernanke (1983), Wicker (1996), Calomiris and Mason (2003a), Calomiris and Mason (2003b), and Hanes (2006).

2.1 Banks

The bank is modeled in a manner that captures the dynamics of the banking system, allowing it to micro-founds shocks from the banking system to the aggregate economy during the Great Depression. Banks have a portfolio problem in which they optimally choose their holdings of deposits, loans, and reserves subject to their budget constraint and reserve requirement. When choosing such a portfolio, banks anticipate how exogenous idiosyncratic liquidity shocks stemming from deposits inflows and outflows may lead to a violation of their constraints, leading to settlement in the interbank market. However, frictions in the interbank market prevent every bank from settling and meeting their constraints. This leads some banks to solve their constraints in the discount window controlled by the central bank, exposing banks directly to monetary policy of the central bank through its control of the discount window, reserve requirement and overall money supply.

The model environment consists of a continuum of banks who are initially identical before the idiosyncratic liquidity shock occurs. Time is discrete, indexed by t, and of infinite horizon. All assets and rates are nominal which is denoted with capital letters, X_t^b with upper script b to denote bank holdings. P_t is the price level. Banks' preferences over a stochastic stream of dividend payments Div_t^b are given by

$$\mathbb{E}_0 \sum_{t \geq 0} \beta^t U(Div_t^b) \tag{1}$$

where $\beta < 1$ is the time discount factor. $U(Div_t^b) \equiv \frac{(Div_t^b)^{1-\frac{1}{\Psi}}-1}{1-\frac{1}{\Psi}}$ is the utility function over dividends with $\Psi \geq 0$ and $1/\Psi$ governing the elasticity of equity funding to rates of return.

Each period in the model is divided into two stages: a portfolio and a balancing stage. In the portfolio stage, banks make portfolio decisions. In the balancing stage, banks experience random idiosyncratic withdrawals of deposits. A deposit withdrawn from one bank is transferred to another bank. This transaction must be settled with reserves in this period. If banks lack reserves to settle that transaction, they can borrow reserves from other banks in the interbank market. If they fail to settle in that market, banks then go to the Federal Reserve's discount window to meet their constraint but pay at a penalty rate for needing to so. We now describe each of these stages in further detail.

Banks enter the lending stage with a nominal portfolio of assets and liabilities. During this initial period, banks collect and make associated interest payments on their portfolios. Their two assets are illiquid loans, L_t^b, and liquid reserves, M_t^b issued by the central bank. On the liability side, banks issue demand deposits, D_t^b, borrow discount window loans, W_t^b, from the central bank and hold a net interbank loan position, F_t^b. F_t^b is a positive on the right hand side of the bank's budget constraint if the bank has borrowed funds and negative if the bank has lent funds. Banks also choose dividends, Div_t^b, and a portfolio for the following period. The portfolio is a choice $\{L_{t+1}^b, M_{t+1}^b, D_{t+1}^b\}$ which corresponds to holdings of loans, reserves, and deposits, respectively. Discount window loans and interbank loans are assumed to mature once they are paid off. They are not an active choice variable of banks since they depend on other banks in the interbank market and the Federal Reserve at the discount window.

Given this sequence of event and portfolio choices, the problem of a bank in the lending stage is to choose a portfolio and dividend payments, subject to the following budget constraint (2):

$$P_t Div_t^b + L_{t+1}^b + M_{t+1}^b - D_{t+1}^b = (1+I_t^{\ell})L_t^b + (1+I_t^m)M_t^b - (1+I_t^d)D_t^b - (1+\bar{I}_t^f)F_t^b - (1+I_t^w)W_t^b \quad (2)$$

where I_t^{ℓ} and I_t^d are nominal returns on loans and deposits. The nominal policy rates the discount window loans set by the central bank, I_t^w and, interest on reserves, I_t^m. I_t^m was not paid by the Federal Reserve until 2008. We will relax the usage of this rate when we formally calibrate to the Great Depression below. These rates satisfy $I_t^w \geq I_t^m$; otherwise, there is a pure arbitrage to the detriment of the central bank. The rate $\bar{I}_t^f$ represents the interbank market rate which is the average rate at which banks borrow in the interbank market whose OTC nature is explained below. All interest rates indexed with t are accrued between period $t-1$ and t in that interest is paid out in the beginning of the period on last period's portfolio.

After choosing its portfolio $\{L_{t+1}^b, M_{t+1}^b, D_{t+1}^b\}$, banks enter the balancing stage in which they experience an idiosyncratic withdrawal shock, ω_t to their holdings of deposits. The shock ω_t is drawn from a continuous distribution with CDF Φ_t. Depositors transfer funds from one bank to another, and banks need to settle these payments in reserves. By the end of the balancing stage, banks must maintain a minimum reserve balance

$$M_{t+1}^b \geq \varrho D_{t+1}^b, \varrho \in [0,1]. \quad (3)$$

where ϱ relates to a policy reserve requirement set by the central bank. This constraint is based level of deposits which a bank has remaining in its balance sheet following the idiosyncratic withdrawal shock. As a result, the net reserve holdings for each bank denoted with superscript j after settling these transfers are given by the following expression:

$$s_t^j \equiv M_{t+1}^b + \omega_t^j D_{t+1}^b - (1+\omega_t^j)\varrho D_{t+1}^b \tag{4}$$

where $\omega_t > 0$ occurs when a bank receives an inflow of deposits and $\omega_t < 0$ occurs when banks an receive outflow of deposits. The surplus S_t^j expression reflect both aspects of the liquidity shock. On the one hand, transfers of deposits between banks are settled with bank reserves. As a result, banks that experience an positive shock, receive in effect an inflow of reserves, while those that experience a negative shock have an outflow of reserves. However, banks that receive an inflow of deposits now have a higher deposit base for which they need to meet the minimum reserve balance (3), while those that receive an outflow have a smaller base. If a bank faces a withdrawal, it must raise reserves to be able to satisfy (3). As a result, if this surplus is negative, banks need to borrow additional reserves. At the same time, other banks will have a positive surplus which they may lend.

The model layers on an interbank market where these withdrawal shocks that generate a distribution of reserve surpluses and deficits across banks are first addressed. This market is modeled as an OTC market with matching frictions, following Bianchi and Bigio (2022). It consists of a bargaining problem between banks in deficit and those in surplus. There are multiple trading rounds, in which banks trade with each other.

When the interbank market opens, banks with a surplus want to lend, and banks with a deficit want to borrow. Because of the matching frictions, a bank with surplus is only able to lend a fraction, Ψ_t^+, to other banks. Conversely, a bank that has a deficit is only able to borrow a fraction, Ψ_t^-, from other banks. The fractions Ψ_t^+ and Ψ_t^- represent these matching probabilities and are endogenous to the market. They depend on the level of market tightness which is given by the aggregate reserve deficit balances relative to surplus balances.[2]

The interbank market tightness at the opening of the interbank market can be characterized using the surplus expressions (4) in the following way[3]

$$\theta_t = -\frac{\overbrace{S_t^-}^{\text{deficit}}}{\underbrace{S_t^+}_{\text{surplus}}} = -\frac{\int \min\left\{s_t^j, 0\right\} d\omega}{\int \max\left\{s_t^j, 0\right\}) d\omega} \tag{5}$$

Throughout the trading, the terms of trade given by the interbank rate at which banks borrow

2. In terms of the underlying parameters that form the basis of the matching probabilities $\{\Psi_t^+, \Psi_t^-\}$, we follow those outlined in Bianchi and Bigio (2022) and are given in appendix section A.

3. Notice that we take the shock ω_t as large enough such that if the negative shock is realized, the bank will be in deficit. In other words, there is no case where a negative shock is realized but a bank remains in surplus.

and lend depend on these probabilities of finding a match in a future period.[4] If banks remain unmatched after trading rounds, those in deficit borrow from the discount window at the penalty rate I_t^w, while those with a surplus deposit their excess reserves at the central bank and earn interest I_t^m.

As shown in appendix section A, the functional forms for the matching probabilities (Ψ^-, Ψ^+) depend on two structural parameters: the matching efficiency, λ, and the bargaining power, η. In particular, for given θ, a higher efficiency leads to higher fractions of matches (Ψ^-, Ψ^+), and a higher η increases the effective bargaining power of banks in deficit, lowering the fed funds rate.

We summarize the benefit of having a surplus and the cost of having a deficit upon facing the withdrawal shock through the following liquidity yield functions:

$$\chi_{t+1}(S_t;\theta_t) = \begin{cases} \chi_{t+1}^- \cdot S_t & \text{if } S < 0 \\ \chi_{t+1}^+ \cdot S_t & \text{if } S \geq 0 \end{cases} \tag{6}$$

where the liquidity yield functions are given by

$$\begin{aligned} \chi_{t+1}^+ &\equiv \Psi_t^+(\theta_t)(\bar{I}_{t+1}^f(\theta_t) - I_{t+1}^m) \\ \chi_{t+1}^- &\equiv \Psi_t^-(\theta_t)(\bar{I}_{t+1}^f(\theta_t) - I_{t+1}^m) + (1 - \Psi_t^-(\theta_t))(I_{t+1}^w - I_{t+1}^m). \end{aligned}$$

When $S_t > 0$, the bank earns an yield χ_t^+ and when $S^b < 0$, the bank pays an yield χ^-. These liquidity yield functions are linear so they are the marginal or per unit cost of deficit and benefit of surplus. Since a bank that borrows from the interbank market or from the discount window holds reserves at the Fed which receive interest on reserves, the net cost of borrowing is given by the difference between the borrowing rate and the interest on reserves as seen in the formula for χ^-. Similarly, the net benefit of a surplus is given by the difference between the interbank market rate and the interest on reserves.

Upon formalizing the optimization problem, we make the following adjustments to the model. We express it in terms of real portfolio holdings and real rates. Real holdings are denoted as $x_{t+1} = X_{t+1}/P_t$ and real gross rates are denoted as $R_{t+1}^x = (1 + I_{t+1}^x)/(1 + \pi_{t+1})$ where $1 + \pi_{t+1} \equiv P_{t+1}/P_t$. We have the following real asset variables $\{div_t, \ell_{t+1}^b, m_{t+1}^b, d_{t+1}^b\}$. As shown in Bianchi and Bigio (2022), the problem of each bank experiencing idiosyncratic withdrawal shocks aggregates to a representative bank due to the linear budget constraints and homothetic preferences, despite a kink in their liquidity yield functions. As a result, the bank problem write can be written through one

4. We use I_t^f in the budget constraint (2) to denote the average interbank market rate at which banks trade.

representative bank. Furthermore, since the composition of the bank's portfolio problem doesn't affect the bank's decision problem, we simplify the problem with a single state variable which is aggregate net bank equity, e^b_{t+1}.

We can now formally state the problem of the bank given the presence of these withdrawal shocks and frictions in the interbank market. When choosing such a portfolio, banks anticipate how withdrawal shocks may lead to a surplus or deficit of reserves and the associated costs and benefits of ending with these positions. Thus, given its initial equity, the bank problem consists of choosing the real portfolio and its dividends to maximize its value subject to its balance sheet given as follows:

Problem 1: The representative bank choose its portfolio $\{div_t, \ell^b_{t+1}, m^b_{t+1}, d^b_{t+1}\}$ to solve

$$V(e^b_t) = \max_{\{div^b_t, \ell^b_{t+1}, m^b_{t+1}, d^b_{t+1}\}} u(div^b_t) + \beta \mathbb{E}\left[V(e^b_{t+1})\right] \tag{7}$$

s.t. to its balance sheet and equity condition

$$e^b_t + d^b_{t+1} = m^b_{t+1} + \ell^b_{t+1} + div^b_t \tag{8}$$

$$e^b_t \geq div^b_t \tag{9}$$

where the evolution of bank net equity is given by

$$e^b_{t+1} = R^\ell_{t+1}\ell^b_{t+1} + R^m_{t+1}m^b_{t+1} - R^d_{t+1}d^b_{t+1} + \overbrace{\mathbb{E}\left[\chi_{t+1}(s_t, \theta_t, P_t)\right]}^{\text{Settlement Costs}}. \tag{10}$$

The equity condition clarifies that the model assumes that in order to pay its dividends the bank is limited to its current equity and cannot raise new equity. In addition, the evolution of bank equity depends not only on the realized return of the bank's portfolio of assets, but also on the realized settlement costs from the withdrawal shock. The costs which are set by the liquidity yield function reflect that they are function of the real return.

2.2 Non-financial Sector

The model closes with a characterization of a general equilibrium setting with links to all the financial assets and agents from the period. This allows the model to speak directly to levers argued by Friedman-Schwartz that could have helped mitigate the Great Depression, providing a link from the banking channel to the real economy. It does this by including exogenous supply and demand schedules of various financial assets of representative firms and households. The model also adds a central bank that conducts open market operations and controls both the discount window rate and bank reserve requirement.

The household holds two real financial assets: bank deposits, $\{d^h_{t+1}\}$ and currency $\{m^h_{t+1}\}$. These represented the main financial assets possessed by households during the Great Depression. The firm holds real loans $\{\ell^f_{t+1}\}$. Each has an exogenously given and non-substitutable supply and demand schedule based on their respective real returns, R^x_{t+1}. They can be generally characterized for both the household and firm as follows:

$$x_{t+1} = \bar{x}(R^x_{t+1})^{\epsilon^x} \tag{11}$$

where $\bar{x}$ is an exogenous supply and demand shifter. ϵ^x is a semi-elasticity of substation for each asset for which the model assumes for each asset separately if it is positive or negative. We take these schedules as given, but Bianchi and Bigio (2022) show how they can be micro-founded for households.

As it relates to the currency held by the household, the model make the following assumptions about it. Given the period was one in which there were still multiple valid forms of currency, the model assumes that $\{m^h_{t+1}\}$ refers in particular to Federal Reserve Bank Notes. This assumption was made since the Federal Reserve only maintained direct control over issuance of this forms of currency. Its real rate of return R^c_{t+1} equals the inverse of the rate of inflation, $\{\frac{1}{1+\pi_{t+1}}\}$. ϵ^m is assumed to be > 0 to reflect that demand for money increases as inflation decreases, effectively increasing the real return on money. We exogenously assume that $\epsilon^d > 0$, reflecting their upward sloping supply curve.

In terms of the the firm demand for loans, we assume that firms require financing for their working capital needs such as to pay for its payroll. As a result, these loans are short term loans such as commercial paper. Using working capital loans allows the model to follow the convention in the literature and focus on liquidity driven aspects of the firm loan rate. In the model, these loans will typically be financed by real bank loans, $\{\ell^b_{t+1}\}$. However, through the open market operations, the central bank will also be able to provide such financing on a nominal basis, $\{\mathscr{L}^{fed}_{t+1}\}$. We exogenously assume that $\epsilon^\ell < 0$, reflecting their downward sloping demand curve.

The model setting closes with the inclusion of a central bank given by the Federal Reserve. In the model's setting, the central bank actively sets the nominal interest on reserves, I^m_{t+1} and the nominal discount window rate, I^w_{t+1}. It also conducts open market operations (OMO), both conventional and unconventional through its control of the nominal money supply, M^{fed}_{t+1}. The model assumes that the central bank purses OMO in a fully backed manner so that when it increases the money supply, its fully backed by purchases of commercial loans, $\mathscr{L}^{fed}_{t+1}$. This formally implies that $M^{fed}_{t+1} = \mathscr{L}^{fed}_{t+1}$. In addition, supply of Fed liabilities M^{fed}_{t+1} can be held as currency by households or as bank reserves, so that $M_{t+1}^{fed} = M_{t+1}^{b} + M_{t+1}^{h}$. In addition, the central bank issues discount window loans W_{t+1}^{fed} for banks that do not settle in the interbank market and transfers all profits, T_t.

The complete budget constraint of the central bank is then given by the following expression:

$$\frac{1+i_t^m}{1+\pi_t}\frac{M_t^b}{P_{t-1}} + \frac{1}{1+\pi_t}\frac{M_t^h}{P_{t-1}} + \frac{\mathscr{L}_{t+1}^{fed}}{P_t} + \frac{W_{t+1}^{fed}}{P_t} = \frac{M_{t+1}^{fed}}{P_t} + \frac{1+i_t^{\ell}}{1+\pi_t}\frac{\mathscr{L}_t^{fed}}{P_{t-1}} + \frac{1+i_t^w}{1+\pi_t}\frac{W_t^{fed}}{P_{t-1}} + \frac{T_t}{P_{t-1}} \tag{12}$$

which is return in nominal terms to reflect that it conducts policy nominally. It is assumes that the central banks transfers all its net profit, while using the money supply to fully fund future holdings of assets including discount window loans and commercial loans.

The competitive equilibrium is defined as follows: Given initial conditions and central bank policies $\left\{\mathscr{L}_t^{fed}, M_t^{fed}, W_t^{fed}, T_t, i_t^m, i_t^w, \varrho_t\right\}$, a competitive equilibrium consists of a sequence for the price level $\{P_t\}$, real returns for reserves, discount window loans, interbank loans, bank loans, deposits, and currency $\{R_t^m, R_t^w, R_t^f, R_t^{\ell}, R_t^d, R_t^c\}$, a sequence of bank policies $\{m_{t+1}^b, d_{t+1}^b, \ell_{t+1}^b, div_t^b\}$, interbank and discount window loans $\{f_t^b, w_t^b\}$, market tightness $\{\theta_t\}$, aggregate firm loans $\{\ell_{t+1}^f\}$ and aggregate household deposits and currency holdings $\{d_{t+1}^h, m_{t+1}^h\}$ such that:

(i) Representative bank chooses its portfolio to solve optimization problem as in (B.9)-(B.10).

(ii) Households are on their supply and demand schedules and firms are on their loan demand schedule as in (11).

(iii) Central bank maintains its budget constraint (12).

(iv) Markets clear for:

1. money: $m_{t+1}^b + m_{t+1}^h = \frac{M_{t+1}^{fed}}{P_t}$,
2. loans: $\frac{\mathscr{L}_{t+1}^{fed}}{P_t} + \ell_{t+1}^b = \ell_{t+1}^f$,
3. deposits: $d_{t+1}^h = d_{t+1}^b$,
4. interbank markets: $\Psi_t^+ S_t^+ = \Psi_t^- S_t^-$.

(v) Market tightness $\{\theta_t\}$ is consistent with the portfolios and the distribution of withdrawals, while the matching probabilities $\{\Psi_t^+, \Psi_t^-\}$ and real interbank market rate $\{R_t^f\}$ are consistent with market tightness $\{\theta_t\}$.

3 Theoretical Analysis

We solve the bank optimality conditions to explain the mechanisms of how the liquidity management problem of the bank and frictions in the interbank market propagate to the the model's key equilibrium rates. These in turn set the supply and demand schedules of households and firms for deposits and loans as outlined in equation 11.

In order to solve the model, we make a few simplifying assumptions. First, we modify the bank's utility function to be linear, $U(div_t^b) = div_t^b$. This allows us to easily remove the model's state variable in the solution of the bank's optimality conditions as linear utility implies $V(e_t) = e_t$ is the solution to the value function. However, to allow for endogenous variation in the loan rate and ensure it is not merely equal to $1/\beta$ due to the linear utility assumption, we relax the equity condition (B.3). We assume that the bank has limited equity in that $e_t = div_t^b$, so that banks do not accumulate equity from period to period. Rather, they pay out all of their realized previous-period profits as dividends.

Second, we convert the model from an infinite horizon environment to a two-period setting to highlight that the shocks are treated as one-time, unexpected and not persistent. As a result, each bank is endowed with an initial portfolio of assets and liabilities that pay off at the beginning of period 0. After the initial payments are settled, the bank chooses its new portfolio and only then is affected by liquidity shocks which both occur during period 1. Relatedly, we assume that future prices are fixed so that expected inflation is constant. Dropping time subscripts and substituting the budget constraint directly into the problem, we rewrite the bank problem in the following fashion:

Problem 2:

$$0 = \max_{\ell^b, m^b, d^b} d^b - m^b - \ell^b + \beta\left(\mathbb{E}\left[e^{b'}\right]\right)$$

where the evolution of bank net equity is given by

$$e^{b'} = R^\ell \ell^b + R^m m^b - R^d d^b + \mathbb{E}[\chi(s;\theta;P)]$$

Third, we assume the idiosyncratic withdrawal shock, ω is drawn from the following two sided distribution:

$$\omega = \begin{cases} -\delta & \text{with probability } 0.5 \\ \delta & \text{with probability } 0.5 \end{cases}. \tag{13}$$

This allows us to tractably provide closed form solutions to the general model. We can now characterize the interbank market tightness in the following manner:

$$\theta \equiv -\frac{m^b - \delta d^b - \rho(1-\delta)d^b}{m^b + \delta d^b - \rho(1+\delta)d^b} \tag{14}$$

which is written explicitly with the shocks to those banks in deficit and surplus.

We solve the bank's optimality conditions in two steps and characterize them in terms of their liquidity properties. First, we substitute the evolution of bank net equity directly into the objective function to remove the need of any multiplier when taking the first-order conditions. Second, we substitute the loan first-order condition into that of the other two conditions to characterize the bank optimality conditions through the following two expressions:

$$R^\ell = R^m + \mathscr{L}^m \tag{15}$$

$$R^\ell = R^d + \mathscr{L}^d \tag{16}$$

We can see that we can express the first-order conditions of deposits and reserves as spreads relative to the rate on loans as determined by each asset's liquidity properties. These properties are determined as follows:

$$\mathscr{L}^m(s;\theta;P;\rho) \equiv E\left[\frac{\partial}{\partial m^b}\chi(s;\theta;P)\right] = \frac{1}{2}[\chi^+ + \chi^-] \tag{17}$$

$$\mathscr{L}^d(s;\theta;P;\rho) \equiv -E\left[\frac{\partial}{\partial d^b}\chi(s;\theta;P)\right] = -\frac{1}{2}[-\rho(\chi^+ + \chi^-) + (1-\rho)\delta(\chi^+ - \chi^-)] \tag{18}$$

The conditions imply that the bank must be indifferent between making loans and issuing reserves and deposits on the margin due to the liquidity service of reserves and the liquidity risk of deposits as each of these liquidity functions are > 0.[5] In equilibrium, the loan rate must be greater than both the deposit and interest on reserve rate so that $R^\ell > R^d$ and $R^\ell > R^m$. The liquidity terms through the real liquidity yield functions which are dependent on both the price level and extent of tightness in the interbank market will govern the magnitude to which the loan rate exceeds these other rates.

4 Calibration and Estimation of Model

We map our model to aggregate banking and macro data to estimate the role of proposed financial shocks to the model setting. We calibrate our model directly to this data by linearly estimating our model to filter and estimate the unobserved shocks, while also relying on both internal and

5. [Add proof to this in appendix.]

external estimation approaches to estimate the models parameters. This allows us to assess both the actual role of a variety of financial shocks during the Great Depression and run various historical counterfactuals as argued by Friedman and Schwartz.

4.1 Modifications to Model

In order to directly map the model setting to the data, we employ the simplifications to the model discussed above in the previous section as well as a few others. This includes the assumption of linear utility and and limited equity. This then directly implies that the bank's real budget constraint simplifies to:

$$d_{t+1}^{b} = m_{t+1}^{b} + \ell_{t+1}^{b}. \tag{19}$$

As a result, banks finance their assets of reserves and loans solely with household deposits. Aside from these modifications, the bank problem is the same.

Second, we modify the Federal Reserve's open market operations rule. Instead of open market operations being fully backed by the entirety of the money supply, we assume it is backed by the money supply net of real household currency holdings so that it follows this rule

$$\mathscr{L}_{t+1}^{fed}/P_t = M_{t+1}^{fed}/P_t - m_{t+1}^{h}. \tag{20}$$

This expression reflects the fact that the Federal Reserve conducts open market operations in nominal terms. In addition, it specifies that alterations in the money supply due to open market operations are not through direct helicopter drops to households but through loans of banks and firms. This is done as it is the focus of the potential role monetary policy could have played according to Friedman-Schwartz and Tobin.

4.2 Shock Processes

We deduce shocks to deposit withdrawal volatility, matching efficiency and bargaining power in the interbank market, as well as, shocks to the schedule of the supply of deposits and demand for currency by households. In particular during each period, there are distributions of deposit withdrawal shocks σ_t, the scale of currency $\bar{m}_t^h$ and deposits $\bar{d}_t^h$ and efficiency and bargaining in the interbank market (λ_t, η_t). In addition, we assume that there are shocks to the money supply M_t^{fed} and the nominal discount window rate, I_t^w.

In terms of the distributions and process for these shocks, we adopt a parametric form for the distributions of deposit withdrawal volatility shocks, Φ. We assume the Φ is a two-sided exponential distribution indexed by a σ volatility parameter. Each possible distribution is indexed by a single dispersion parameter σ and the distribution is centered at zero. For the remaining shocks, we assume that they follow a log AR(1) process given by:

$$\ln(x_t) = \left(1-\rho^x\right)\ln(x_{ss}) + \rho^x \cdot \ln(x_{t-1}) + \Sigma^x \varepsilon_t^x \tag{21}$$

where ρ^x is the mean-reversion rate of x and Σ^x its standard deviation of innovations. Overall, we then have seven shocks and fourteen parameters.

From the model's perspective, the money supply and nominal discount window rate (M_t^{fed}, I_t^w) are policy variables that have observable counterparts, so their processes can be directly estimated. By contrast, the remaining shocks $(\sigma_t, \bar{m}_t^h, \bar{d}_t^h, \lambda_t, \eta_t)$ are unobservables that we deduce these using a Kalman filter and whose persistence and variance parameters we estimate. Thus, we have a total of two observable policy variables, and five unobservable shocks.

4.3 External and Internal Calibration

We set the values for the the semi-elasticities of the household currency demand, firm loan demand and deposit supply schedules following the range found in the empirical literature with these corresponding to an annualized rate of 2.5. We follow Bianchi, Bigio, and Engel (2025) paper in setting the steady state interbank bargaining power and persistence and variance parameters (ρ, Σ) for the unobservable model shocks $(\sigma_t, \bar{m}_t^h, \bar{d}_t^h, \lambda_t, \eta_t)$. The parameters values are listed in Table 1.

Table 1: Calibrated Parameters

Parameter	Value	Description	Source
Panel A: External Calibration			
ϵ^ℓ	-35	Loan demand elasticity	Literature
ϵ^m	35	Currency demand elasticity	Literature
ϵ^d	35	Deposit supply elasticity	Literature
η_{ss}	0.5	Steady state interbank bargaining power	Bianchi, Bigio, and Engel (2025)
$\rho^{\bar{x}}$, $x \in (d^h, m^h)$	0.991	Persistence for supply and demand shifters	Bianchi, Bigio, and Engel (2025)
ρ^x, $x \in (\sigma, \lambda, \eta)$	0.989	Persistence for liquidity shock and interbank paramters	Bianchi, Bigio, and Engel (2025)
$\Sigma^{\bar{x}}$, $x \in (d^h, m^h)$	0.017	Persistence for supply and demand shifters	Bianchi, Bigio, and Engel (2025)
Σ^x, $x \in (\sigma, \lambda, \eta)$	0.100	Persistence for liquidity shock and interbank paramters	Bianchi, Bigio, and Engel (2025)
Panel B: Internal Calibration			
$\bar{\ell}_{ss}$	17.614	Steady state loan demand shifter	Steady state moment targets
$\bar{m}_{ss}^h$	3.867	Steady state currency demand shifter	Steady state moment targets
$\bar{d}_{ss}^h$	14.644	Steady state deposit supply shifter	Steady state moment targets
σ_{ss}	0.800	Steady state liquidity volatility	Steady state moment targets
λ_{ss}	3.441	Steady state interbank matching efficiency	Steady state moment targets

In order to parameterize the steady state values of the remaining four shocks processes (σ_t, $\bar{m}_t^h$, $\bar{d}_t^h$, λ_t), we extrapolate their implied values by matching data targets in certain model equilibrium equations. Across this internal calibration, we assume an economy with zero steady state inflation and adjust all nominal rates to deliver the real rates observed in the data. This implies that the real gross rates become set to $R^x = 1 + I^x$. In addition, we calibrate these and the entire steady state values of the model used to extrapolate the unobserved figures to the time-series averages between April 1928 through September 1929. The latter period is the period before the stock market crash. The former period is chosen to ensure a a complete panel time series across are observable data series.

In order to calibrate the steady state values of the supply and demand shifters, we use the steady state versions of equation 11. For the currency demand shifter $\bar{m}_t^h$, it becomes set to the steady state value of currency holdings of households since its real return is set to the inverse of inflation which is set to zero. For the deposit supply shifter $\bar{d}_t^h$, we initially find implied steady state values for the two main equilibrium objects that determine this shiftier which are d_t^h and R_t^d. For the former, we use data moments from market clearing equations and for the latter, we use the deposit demand first order condition in equation 16. Using these estimates, we then use the form of the deposit supply in equation 11 to directly estimate a steady state value for $\bar{d}_t^h$. Similarly for the loan demand shiftier, we directly estimate it from the loan demand schedule from equation 11 based on both data moments for loans and the mode equilibrium value for R_t^ℓ based on the reserve first order condition in equation 15.

For the steady state of the remaining interbank parameters ($\lambda_{ss}, \sigma_{ss}$), we solve them following a sequential method as employed in Bianchi and Bigio (2022). In order to obtain an initial estimate for the matching efficiency in the interbank λ_t, we infer the probability that a reserve deficit position is matched in the interbank market, using $\Psi_t^- = F_t/(W_t + F_t)$ based on data moments for interbank volumes, F_t. As a result, we obtain the two following two expressions for λ based on the level of interbank market tightness, θ_t

$$\ln\left(\frac{1}{1-\Psi_t^-\theta_t}\right) \text{ if } \theta > 1 \tag{22}$$

$$\ln\left(\frac{1}{1-\Psi_t^-}\right) \text{ if } \theta \leq 1 \tag{23}$$

This relationship follows by inverting condition (A.4) in the appendix for the interbank probabilities. In the final step, we use this initial value for the interbank market matching efficiency to jointly estimate the steady state of the matching efficiency and withdrawal volatility (λ_t, σ_t). In order to this, we target moments in the equilibrium output of aggregate discount window lending and the real interbank rate. They can be shown to simplify to the two following expressions:

$$W_t = \frac{D_t}{1-\rho}(1-\Psi_t^-)S_t^- \tag{24}$$

$$R_t^f = R_t^m + (1-\bar{\eta}(\theta_t))(\iota) \tag{25}$$

where $\iota = R_t^w - R_t^m$, representing the corridor rate or spread between the discount window rate and the interest on reserves. After calibrating these two expressions with the steady state values of observed data moments and our externally calibrated variables, the remaining unknowns are these last two interbank parameters.

After obtaining these steady state values of the model parameter trough the calibration, we use a Kalman filter on the linearized version of the model to filter the unobserved shocks and produce a time series for them. Furthermore, we use the following data series to inform the filter. Following the processes outlined above, we use the data series for money supply and nominal discount window rates outlined in the data section 4.4 for the shocks to M_t^{fed} and I_t^w. For the the demand and supply shifters $(\bar{d}_t^h, \bar{m}_t^h)$, we use data on household deposits and currency holdings. Last for the interbank and liquidity shock parameters $(\lambda_t, \eta_t, \sigma_t)$, we use data from the nominal interbank rate and discount window borrowings.

4.4 Data

In order to map the remaining model variables to data, we use aggregate money and banking data from the Great Depression. We largely draw on the comprehensive records found in the Federal Reserve's *Banking and Monetary Statistics* (FRB 1943) for Federal Reserve member bank data and widely used indices for macro data. Uniquely, we are the first to use a newly digitized data series on the Federal Funds rate from the period as constructed in Anbil et al. (2021) in a calibration of the Great Depression.

We set the frequency of data used for the calibration to be monthly to allow us to use data for all Federal Reserve member banks.[6] In terms of the time frame considered, we calibrate the model to the period from April 1928 through March 1933. We start at that date as that is the earliest period in which we are able to obtain data for all our aggregate data counterparts, allowing for a complete panel time series as explained previously. We conclude with March 1933 as that is the end of the Great Contraction portion of the Great Depression period as termed by Friedman and Schwartz (1963) that culminated with the Bank Holiday of 1933, representing the trough of the depression as

6. The Federal Reserve's *Banking and Monetary Statistics* has select data at a weekly frequency but that only covers weekly reporting banks and not the entire member system.

measured by Gross National Product data found in to Balke and Gordon (1986).

For aggregate bank balance sheet figures, we use data for all Federal Reserve member banks as primarily found in FRB (1943). We prefer using this portion of the banking system as opposed to data relating to all commercial bank balance sheets as all data for the latter banks is aggregated and maintained at a call report frequency which typically only occurred three to four times per year. However, data for all Federal Reserve member banks as it relates to reserves and discount window borrowing occurs at a monthly frequency. We directly use its time series for discount window borrowing to calibrate our models notion of discount borrowing, W^b. For our measure of bank reserves M^b, we use the time series from FRB (1943) but net out discount window loans. This allows us to measure free reserves as the reserve data also includes borrowed reserves. We make this distinction as the model notion of free reserves is meant to asses how much reserves the banks in surplus had to lend in the interbank market before any borrowings from the interbank or discount window. For our measure of excess bank reserves EM^b, we use the time series from FRB (1943). This refers to the amount of reserves held in aggregate by banks over their reserve requirement. However the data on excess reserves only begins at a monthly frequency in 1929.

We use the series from Friedman and Schwartz (1963) of demand deposits for our measure of D^b in the model. It should be noted that they extrapolate the data to produce a monthly time series from call report-frequency. We exclude time deposits due to our focus on liquidity related shocks. The ratio of bank reserves to deposits is what we refer to as μ in figure 5 and is meant to parallel the ratio that is a central concept found in Friedman and Schwartz (1963). Last, as it relates to bank lending L^b, we do not use the explicit time series for bank loans in FRB (1943) but determine it as a balance sheet residual from deposits net of free reserves. This follows from the manner that we simplified the bank balance sheet in equation 19. This allows us to estimate short term lending which would have been financed with demand deposits and not time deposits. This method is in line with the approach of Christiano, Motto, and Rostagno (2003). As it relates to trading volume in the interbank market F, we rely on Willis (1967) who provides estimates of gross daily trading volumes from the period.

In terms of savings and lending rates, we use a variety of different sources. We use as comparison the nominal bank lending rate I^ℓ to the rate on prime four to six month commercial paper issued in New York. We chose this rate since it was the most active commercial paper market as found in FRB (1943). This short term rate thus allows to capture liquidity driven source for rate differentials with less concern of default risk driving loan rate premias. In addition as noted by Christiano, Motto, and Rostagno (2003), no current dataset exists of deposit rates from the period. As a result, we use a proxy for the nominal deposit rate I^d by using total demand deposit expenses noted in FRB

(1943) and dividing by the average level of aggregate demand deposits for a given year. We then linearly interpolate the data to create a monthly time series. This follows the approach outlined in Friedman and Schwartz (1970) to reconstruct deposit rates from the period. For the interbank rate I^f, we use the newly developed dataset of Anbil et al. (2021). They reconstruct the Federal Funds rate time series from those reported in the New York Herald Tribune and the Wall Street Journal from the time. They digitized both a low and high value reported each day from these sources, from which we use the average between the two points.

For macro aggregates, we use CPI-U as our measure for the price level and inflation (P, π) as computed by the Bureau of Labor Statistics. Since the model is calibrated at a monthly frequency, inflation π is the twelve month change in the price level during a given month. For household currency holdings M^h, we rely on Friedman and Schwartz (1963). To obtain the filtered time series for the unobservable shocks $(\sigma, \bar{m}^h, \bar{d}^h, \lambda, \eta)$, we draw on these above mentioned data sources (I^f, M^h, D^b, W^b) which are equilibrium objects in the model.

We use the following variables for the Federal Reserve policy related tools. For the nominal discount rate I^w, we calibrate to the discount window rate at the New York Federal Reserve branch as found in FRB (1943). This was done since it was the most active discount window among the Federal Reserve districts. During the Great Depression, each of the twelve Federal Reserve branches maintained different discount window rates unlike in the modern period in which they are set uniformly. Since the Federal Reserve did not pay interests on reserve at the time, we set the nominal policy rate I^m to zero.

The measure of money supply M^{fed} in our model relates to the aggregate monetary base, M0. This is defined as the sum of currency holdings by the public and bank reserves. However, since we are only calibrating to Federal Reserve member banks and not all commercial banks, we construct a modified measure of the monetary base that is the sum of all household currency holdings and the measure of free reserves outlined above from Federal Reserve member banks. In addition, we do not directly calibrate to open market operations $\mathscr{L}^g$ but measure it based on the money supply net of household currency as outlined in equation 20. Using these data time series, we directly estimate the steady state, ρ and Σ of the discount window rate I^w and the money supply M^{fed}.

As it relates to the reserve requirement ρ, we use a blended average from the period. Due to the pyramid structure of the banking system during the period, each layer of the system was subjected to different reserve requirements on its demand deposits ranging from 7% to 13%. Since we calibrate the model to all Federal Reserve member banks, we compute the implied reserve requirement based on the data series of required reserves proportional to actual reserves as found in FRB (1943). We then take the historical average from 1929 through the Bank Holiday in 1933 of 12.4% as our measure of the reserve requirement for deposits. We begin here since as mentioned above data on required reserves only begins at a monthly frequency in 1929. In appendix section C, we outline the exact source and location for each of the data sources mentioned in this section.

Table 2: Comparison of Model and Data Steady States

Variable	Description	Target	Data	Model
Panel A: Rates				
I^{ℓ}	Loan rate	4-6 month commercial paper rate from FRB (1943)	5.65	3.54
I^{d}	Deposit rate	Annual demand deposit expenses from FRB (1943)	1.49	2.89
I^{f}	Interbank rate	Fed Funds rate from Anbil et al. (2021)	5.18	3.38
I^{w}	Discount window rate	FRBNY discount window rate from FRB (1943)	5.00	5.00
Panel B: Bank Portfolio				
L^{b}	Bank loans	Balance sheet residual of $D^{b} - M^{b}$	14.58	14.58
D^{b}	Bank deposits	Demand deposits at Fed Member Banks from Friedman and Schwartz (1963)	15.95	15.95
M^{b}	Bank reserves	Bank reserves at Fed member banks from FRB (1943)	1.37	1.37
W^{b}	Discount window loans	Bills discounted at Fed member banks from FRB (1943)	0.97	0.97
EM^{b}	Excess bank reserves	Excess bank reserves at Fed member banks from FRB (1943)	0.02	0.36
ϱ	Reserve requirement	Required reserves at Fed member banks from FRB (1943)	12.42	12.42
Panel C: Macro Aggregates				
M^{fed}	Money supply	Monetary base, M0	5.25	5.25
M^{h}	Household currency holdings	Household currency from Friedman and Schwartz (1963)	3.88	3.88
π	Inflation	Twelve month change in CPI-U	-0.64	0.00

Portfolio and Macro variables are in nominal bn$. Rate variables are nominal annual net rates. Inflation is also a nominal net rate. Only the variables outlined in figure 3 were directly calibrated, while the remaining the variables above are untargeted in the model.

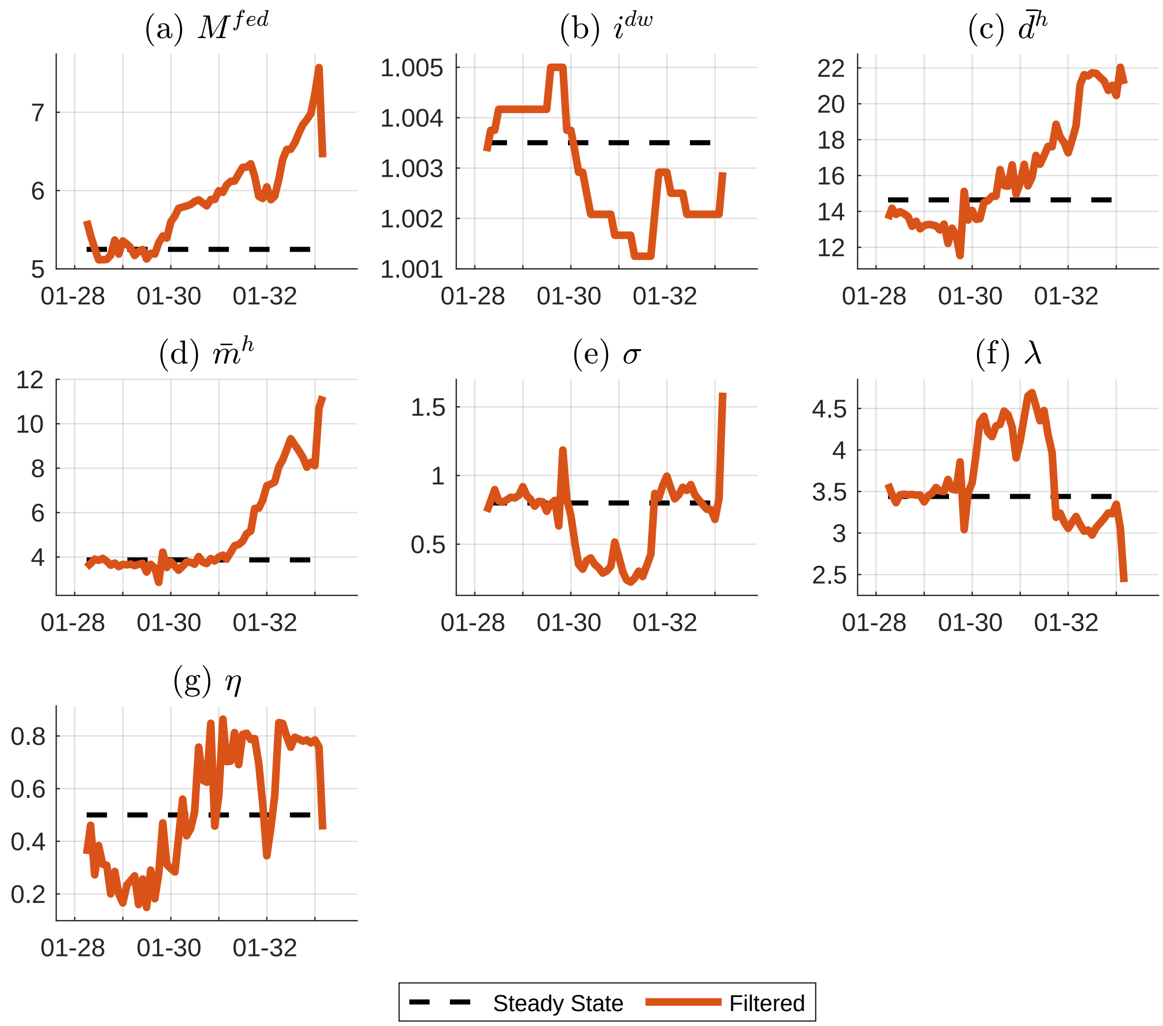
5 Reassessment of the Great Depression

We conclude with a final section that presents the results of our calibration alongside an interpretation of the financial shocks that contributed to the Great Contraction, the initial phase of the Great Depression. Within the framework of the model's specified shocks and economic agents, the calibration supports the core contention of Friedman and Schwartz regarding the proximate causes of bank distress and the accompanying liquidity crisis during this period. However, consistent with the critique raised by Tobin and other detractors, the findings do not identify this channel as the dominant driver of the Depression's severity, nor do they establish a definitive transmission mechanism through which it propagated into broader macroeconomic aggregates.

5.1 Financial Shocks

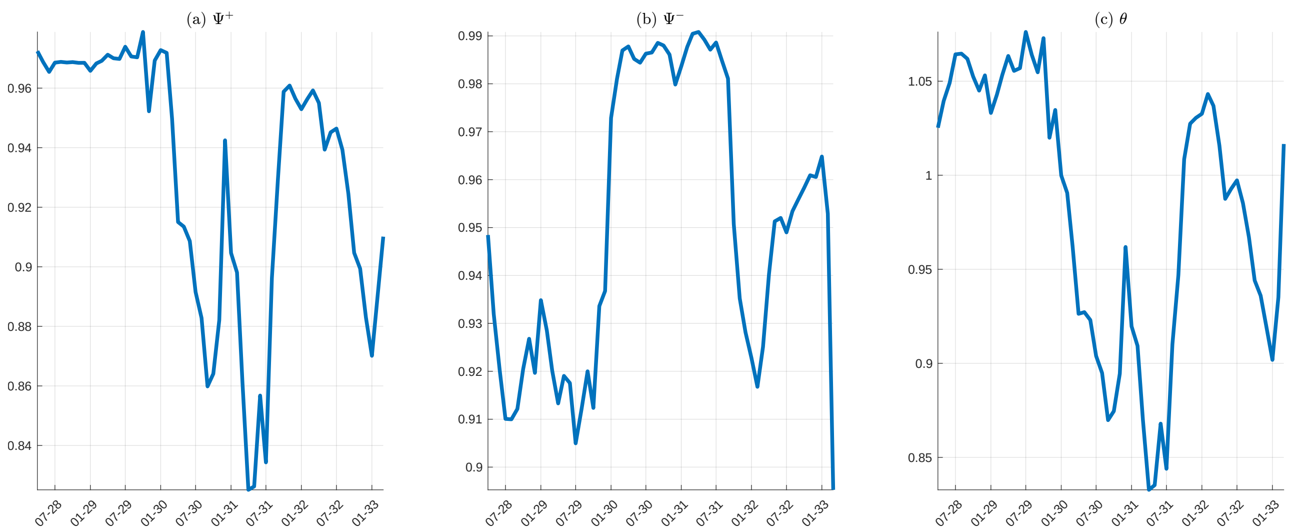
We present the implied filtered time series for the shocks that plagued the financial system during the Great Depression in figure 1. As mentioned earlier, we deduce shocks to federal reserve policy relating to the nominal money supply (M^{fed}) and the nominal discount window rate (I^{dw}). We also consider shocks to the schedule of the supply of deposits ($\bar{d}^{h}$) and demand for currency by households ($\bar{m}^h$). Last, we consider shocks to the interbank market spurred by changes in the deposit withdrawal volatility (σ), matching efficiency (λ) and bargaining power (η).

Figure 1: Model Shocks



When looking at panels (g)-(i) in figure 1, we observe that shocks to the interbank market underwent three distinct shifts during the period. In the lead up to the Great Depression, deposit withdrawal volatility and interbank matching efficiency were in steady state. After a brief spike in each at the onset of the Great Depression during the last quarter of 1929, they both move markedly away from steady state with the former sharply dropping and the other notably increasing. This happens in our setting as the interbank environment shifts from being in aggregate deficit to surplus of reserves in the banking system. This is seen in our calibration by the ratio of aggregate banks in deficit to surplus denoted by θ, dropping my more than 20% from the onset of the Great Contraction through the middle of 1931 as seen in in panel (e) of figure 2. This is accompanied by an increase in Ψ^- (panel (b) of figure 2) during this period due to the decrease in frictions in the interbank market as seen in the increase in λ, allowing for more deficit banks to match with those in surplus during the period (panel (h) of figure 1). In addition, since θ drops below one, the nominal interbank market rate drops too to allow for the interbank market to clear. Last, since deficit banks are abler to clear in the interbank market, they do not need to access the Federal Reserve's discount window which as a result in this initial period, sees a dramatic drop in its outstanding discount window lending.

Figure 2: Unobserved Interbank Series



However, beginning in late 1931, deposit withdrawal volatility σ increases , leading to a shift of θ back above 1. This is accompanied by in increase in interbank matching frictions λ which leads to a decrease in the likelihood of those in deficit matching in the interbank as seen in the contemporaneous decrease in Ψ^-. This culminates in an increase in the nominal interbank rate through the end of 1931. In addition, the interbank market is not able to fully match those in deficit with those in surplus due to the extent to which λ has decreased. As a result, there is also an increase in the number of banks going to the Federal Reserves' discount window as seen in panel (d) in figure 3. This is despite the discount window rate steeply increasing during the latter half of 1931 as seen in panel (c) of figure 1.

After hovering around steady state, liquidity concerns with the banking system dramatically increase with a spike seen in deposit withdrawal volatility σ in the beginning of the first quarter of 1933. This of course is the period that culminates with the Bank Holiday of 1933 and is where the calibration period for the paper ends. After trending downward in the lead up to 1933, θ once again increases back over 1, reflecting the increase in banks that are now in deficit in their liquidity position. Similar to the previous period, this is accompanied by in increase in interbank matching frictions λ which decreases the likelihood of those in deficit matching as seen in Ψ^- dropping to its lowest level during the Great Depression. In turn, the nominal interbank rate increases for the interbank market to clear as seen in the closing portion of panel (e) of figure 3. In addition, there is not nearly enough banks to meet the liquidity demand od those in deficit, leading to a spike in the number of banks going to the Federal Reserve's discount window as seen in panel (c) of figure 1.

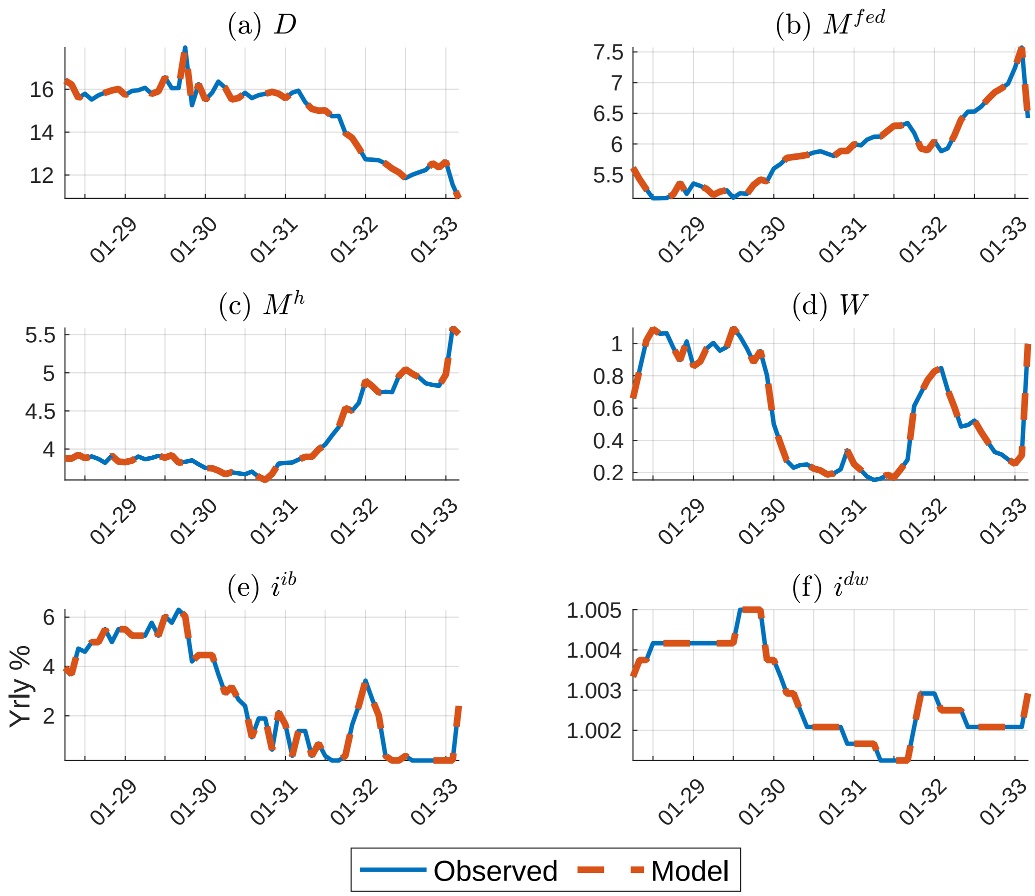
We also inspect the path of shocks of the nominal money supply (M^{fed}) as seen in panel (a) of figure 1. Recall that our object is the monetary base which is composed of bank reserves net of discount window borrowing and household currency. As a result, much of the positive shock to the money supply being deduced in the model is coming from the steady and persistent increase in household demand for currency throughout the period as seen in panel (f) of figure 1. However in line with the later two periods discussed above in the context of the interbank market, the two periods of negative shocks to the money supply in the model occur during the end of 1931 and the first quarter of 1933 which reflect struggles with the liquidity position of the banking system in the form of a decline in bank reserves. This can be seen in panel (d) of figure 5 in which μ which represents the ratio of bank reserves to deposits in the banking system declines. This is the case despite a contemporaneous drop in bank deposits in the system which further exacerbated the liquidity position of the banking system as discussed above in relation to the path of deposit withdrawal volatility σ.

The path of household shocks to the supply and demand schedules of deposits and currency as seen in panel (d) and (f) of figure 1 overall point to an increased demand for liquidity outside of the banking system. The demand shifter for currency increases by threefold over the period, with sharp rises occurring during the periods of notable stress in the banking system in the second half of 1931 and in the beginning of 1933. This stems from households pulling their assets in the form of bank deposits out of the banking system and into currency. This can be seen in the data in which the aggregate bank deposit level more precipitously falls during these periods (panel (a) of figure 3). It is notable that despite this shift in asset composition our model still registers an overall increase in the supply shifter of households for bank deposits albeit at a much lower magnitude than seen for household currency. This is the case as due to the significant deflation during the period as seen in figure 6, the implied real return on deposits had increased significantly. As a result, the model to reconcile an increase in the real return of deposits with a decrease in aggregate bank deposits deduces an increase in the the supply shifter of households for deposits as implied by their supply schedule in equation 11.

5.2 Households, Banks and Federal Reserve during the Great Depression

These results about the path and determinants of the financial shocks that plagued the economy and banking system during the Great Contraction period of the Great Depression—especially with the advantage of insight into the interbank market—enable a reassessment of several core arguments proposed by Friedman-Schwartz and their critics. In particular, this reassessment includes a deeper evaluation of how different economic agents—households, banks, and the Federal Reserve—responded to and propagated these shocks, shedding light on the transmission channels and the relative roles of policy versus private-sector dynamics.

Figure 3: Model Fit of Targeted Variables



5.2.1 Households

The first area that we provide a reassessment is that of the actions of households during the Great Contraction. Friedman-Schwartz repeatedly argue that instability in the banking system reduced the overall willingness of households to keep their money in the form demand deposits in banks.

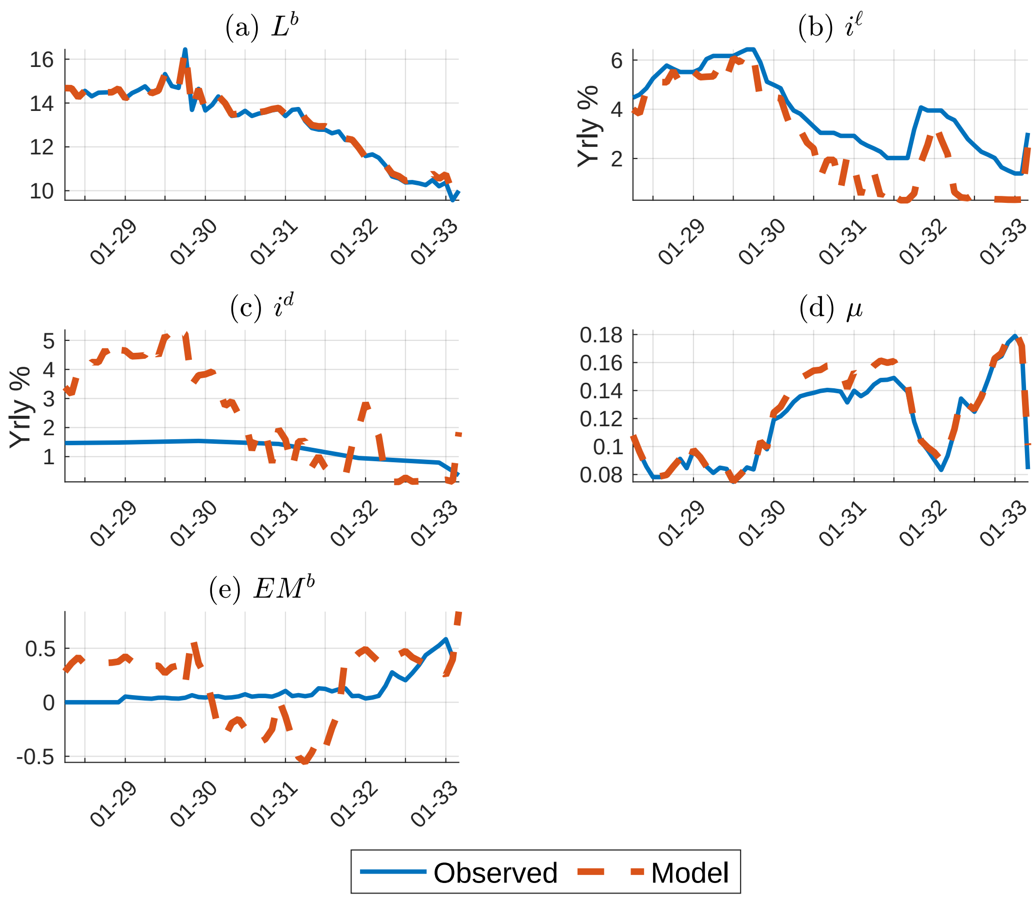
They argue in their chapter on the Great Contraction (Friedman and Schwartz 2008) that:

"The bank failures made deposits a much less satisfactory form in which to hold assets than they had been before in the United States or than they remained in Canada. That, of course, is the reason they produced such a shift in the deposit-currency ratio in the United States."

— *The Great Contraction*, pg.96

Our results partially support this claim, arguing that there was a relative shift in the demand from household concerning the composition of their liquid assets to currency but not an absolute shift. On the one hand, the demand shifter for currency as seen in panel (f) of figure 1 uniformly increases over the period. In particular, the largest increases to the demand shifter for currency occur during periods of notable instability in the banking system in late 1931 and early 1933 leading up to the banking holiday, both of which are time periods explicitly discussed by Friedman-Schwartz. Furthermore, the supply shifter for deposits drop notably during these two periods.

Figure 4: Model Fit of Untargeted Variables



On the other hand, despite this shift to currency, our results also imply an overall increase in the household supply shifter for deposits which is unlike the Friedman-Schwartz argument above that argues for an absolute decrease in the supply shifter for deposits. Nonetheless, it increases by a magnitude less than currency, arguing for a relative shift from deposits to currency but not an absolute3e shift. Building on the argument outlined in the previous section, should households have followed the same supply schedule they were on before the Great Contraction, we would have expected to see a decline in aggregate deposits stemming from a decline in the real return on deposits. However, since there was a decline in bank deposits but an overall increase in the real return, the model deduces a shift in the overall supply shifter of households for deposits, cutting against the view of Friedman-Schwartz.

These results about the path of currency demand allow us to reject a critique of the Friedman-Schwartz by Paul Temin. In Temin's seminal work "Did Monetary Forces Cause the Great Depression?" (Temin 1976), he critiqued the Friedman-Schwartz position by noting that they failed to separate between money supply and demand when attributing such weight to failures in the banking system in propagating the Great Depression. He asserts that they assume that there were only changes to the money supply function from banks and not the money demand function from households. However, there could have equivalently been shifts downward in money demand from households that led to the decline in the overall level of money. While it is true that Friedman-Schwartz do not adequately distinguish between the two, the results of our calibration reject Temin's critique as we specify a money demand function of households that is clearly shown to increase during the period as seen in panel panel (f) of figure 1. As a result, we argue that changes in the monetary base more likely propagated through changes in supply stemming from banks and the Federal Reserve who both directly and indirectly are the only actors that affect the level of the money supply.

5.2.2 Banks, Interbank Market and The Federal Reserve

We then asses the various implications from our calibration of banks, the interbank market, and Federal Reserve monetary policy as it relates to the arguments put forward by Friedman-Schwartz and their detractors. One of the key points of difference was how to view the path of excess reserves of banks. This which refers to the the amount of reserves that banks held in excess of the reserve requirement set by the Federal Reserve. As seen in panel (e) of figure 5, aggregate excess reserves started to increase at the beginning of 1932 and continued to increase through the end of the calibration period through the Bank Holiday of 1933.

James Tobin (Tobin 1965) argued that this increase may reflect a decline in demand on the part of firms for loans. He argued this could be seen by a decline in aggregate bank lending (panel (a) in figure 5) despite a dramatic drop in the nominal loan rate (panel (b) in figure 5). This left banks with little opportunity to lend their assets and instead resulted in an increase in their reserve position.

Friedman-Schwartz famously disagreed and felt that this increase was out of a self-insurance motive on the part of banks for proper liquidity as they no longer had confidence that the Federal Reserve could effectively act in its role as the lender of last resort through its use of the discount window or open market operations. They argue in their chapter on the Great Contraction (Friedman and Schwartz 2008) that:

> *"Excess reserves were interpreted by many as a sign of lack of demand for bank funds, as meaning that monetary authorities could make "credit" available but could not guarantee its use, a position most succinctly conveyed by the saying, "monetary policy is like a string; you can pull on it but you can't push on it." In our view, this interpretation is wrong. The reserves were excess only in a strictly legal sense. The banks had discovered in the course of two traumatic years that neither legal reserves nor the presumed availability of a "lender of last resort" was of much avail in time of trouble."*
>
> — *The Great Contraction*, pg.88-89

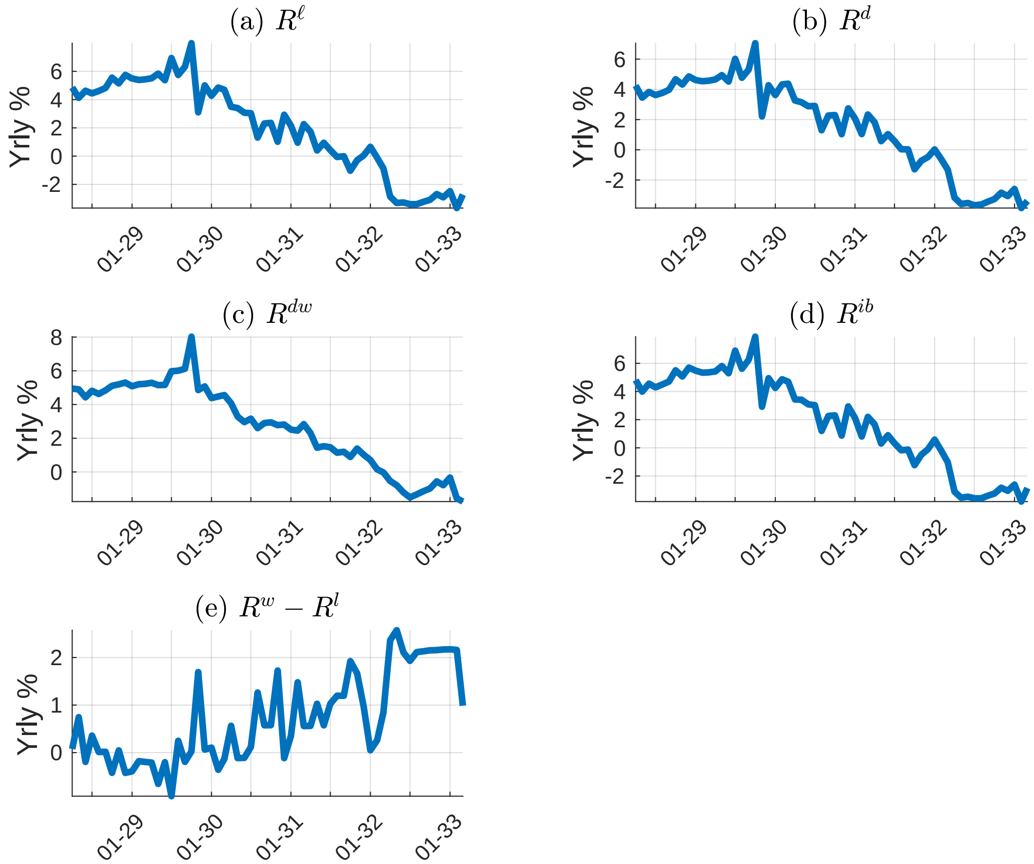
They particularly argue that the Federal Reserve did not engage in adequate and frequent enough open market operations. In addition, they mismanaged the discount window by both allowing its rate to rise above the nominal rate on commercial paper and did not extend enough discount window loans to meet demand from banks in distress in their liquidity position.

Our calibration lends support to the argument of Friedman and Schwartz concerning the motive of banks to increase the reserve position. In our calibration, we see that the excess reserve position of banks begins to increase following the moment the spread between the discount window loan (panel (c) in figure 1) and commercial paper rate (panel (b) in figure 5) becomes negative. This reflects that financing in the capital markets was cheaper than from the Federal Reserve. The banks saw this divergence as mismanagement by the Federal Reserve and as a result increased their own liquidity holdings.

In contrast, Tobin's argument that centers drop in loan demand finds less support in our calibration. He misses the point that the real loan rate remained quite high. A drop in aggregate bank lending may have been due to a movement along the firm demand line, a change in quantity demanded and not absolute demand. As a result, their may have been adequate lending opportunities should banks have felt confident in originating loans and adjusting their loan rates.

In terms of the functioning of the interbank market and its relation to the Federal Reserve's management of the discount window, we build on the discussion in the previous section regarding the path of interbank shocks and focus on the period when the interbank rate noticeably increased toward

Figure 5: Real Financing Rates and Spreads [Need to fix - these are nominal rates]



the end of 1931 as an illustrative example. The calibration's interpretation of this period is that following a period of sustained bank failures in October 1931 (highlighted by Friedman-Schwartz in *The Great Contraction*, pg.39), banks turned to the interbank market for increased liquidity so that θ flipped to be above 1. Due to increased matching frictions above its steady state (panel (h) in figure 1), the nominal interbank rose through the end of 1931 (panel (e) in figure 3) and was not able to fully match those in deficit with those in surplus. As a result, there was also an increase in the number of banks going to the Federal Reserves' discount window as seen in panel (d) in figure 3 to solve their liquidity deficit.

This interpretation of these sequence of events that culminated in increased discount window lending by banks cuts against the narrative of Friedman-Schwartz since it is a clear instance where distress in the banking system that first filtered through the interbank market was positively addressed by the Federal Reserve through increased issuance of discounted bills. Friedman-Schwartz solely consider the fact that the Federal Reserve increased the discount window rate during the latter half of 1931, while diminishing the reality that nonetheless the Federal Reserve still increased their issuance during the period. On the other hand, it may have been that there was still more excess demand for discount window borrowing that did not clear in the interbank market that was not addressed by the Federal Reserve since they increased the discount window rate. Friedman-Schwartz seem to take this view when they note that banks did not borrow enough during this period due to their "aversion of borrowing" (*The Great Contraction*, pg.41) from the Federal Reserve. Our calibration results do point to this possibility as following this period in 1931, the level of banks in deficit as measured by θ (pane (e) in figure 2) did not return to the previous level it was at before this period of bank failures through out the rest of the Great Contraction.

We last turn to the calibration implications concerning the impact of Federal Reserve open market operations. Friedman-Schwartz argue that the Federal Reserve's failure to consistently conduct purchases of treasury bills from banks to inject them with needed liquidity was perhaps the biggest failure of the Federal Reserve. They repeatedly claim that had the Federal Reserve conducted more “extensive open market purchases" (*The Great Contraction*, pg.40) through a “vigorous expansion in the stock of money, they could have been converted into sustained recovery" (pg.33). They point to the one large scale open market operations in the first quarter of 1932 as “a major factor accounting for monetary improvement” (pg.49) which ultimately was not as effective due to its brevity. This underlined their view that a principal cause of the severity of the Great Depression was the Federal Reserve's allowance for the money supply as measured by M1 to severely contract.

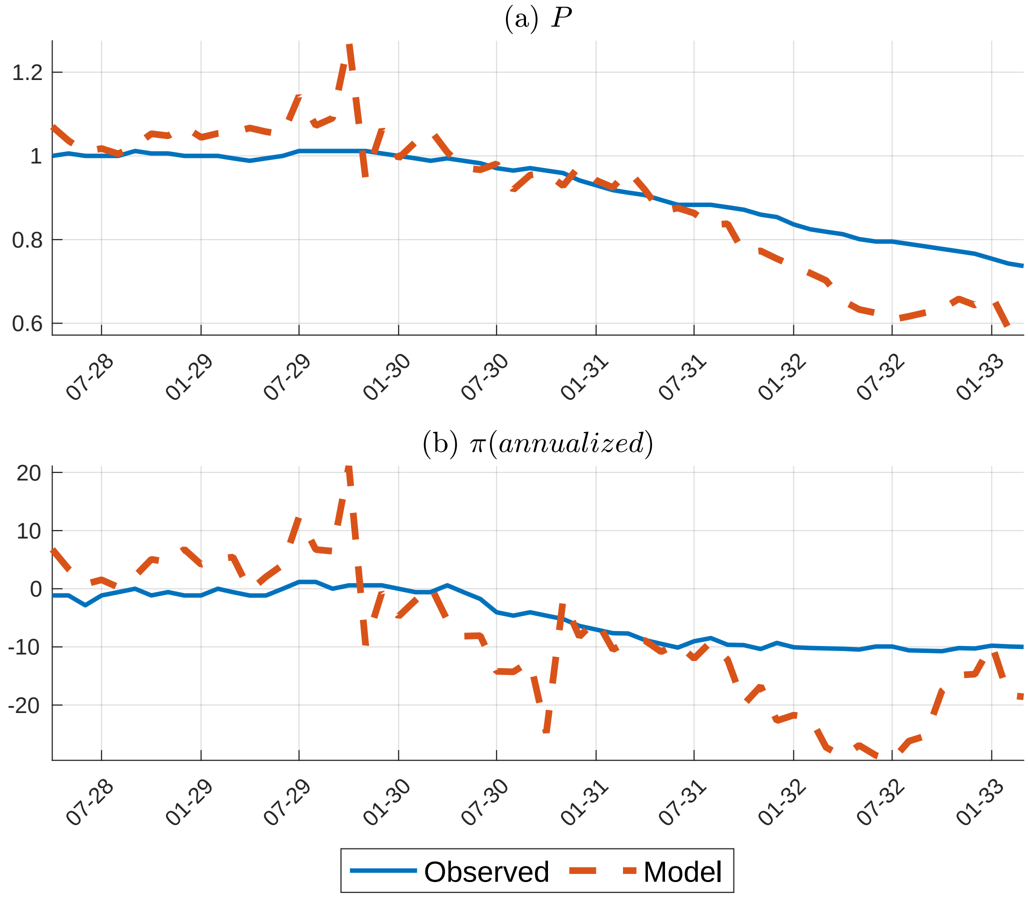
James Tobin on the other hand disagreed with the emphasis Friedman-Schwartz placed on the effectiveness of open market operations in particular and the money supply in general. In a famous critique of Friedman-Schwartz's *Monetary History*, he claims that

> *"But in their zeal and exuberance Friedman and his followers, often seem to go...beyond their own logic and statistics to the other extreme, where the stock of money becomes the necessary and sufficient determinant of money income. Much as I admire their work, I cannot follow them there."*
>
> — Tobin 1965, pg. 481

He in contrast argued that pure monetary policy without a supporting fiscal policy would not be as effective in spurring economic activity during the period (1965, pg 467). Money created directly through fiscal policy that would create more banks loans would have a greater effect on output than money created through swapping the Treasury securities of banks.

Our model captures the positive impact that the lone extended open market operations in the first quarter of 1932 had on the banking system and interbank market. Following this large scale open market operations, the liquidity position of the aggregate banking sector improved as seen in the ratio of bank reserves to demand deposits denoted by μ in panel (d) of 5, nearly doubling over the period from early 1932 through the beginning of 1933. In particular, the amount of banks in deficit in their liquidity position drops substantially as seen in θ dropping below 1 in panel

Figure 6: Model Fit of Untargeted Price Dynamics



(e) of 2 following this operation. In addition, this was accompanied by a stabalization of deposit withdrawal volatility and frictions in the interbank around their steady state values as seen in panel (g) and (h) of figure 1. As a result, more banks in deficit were able to find matching banks in the interbank market to improve their liquidity position. This culminated in a drop in the nominal interbank rate and a decrease in the amount of discount window borrowing needed, as seen in panels (e) and (d) of figure 3.

Overall, this suggests that open market operations stabilized the banking system. In turn, this increased confidence in the household sector to keep their assets in banks, consistent with the core of Friedman-Schwartz's argument about the effectiveness of open market operations and general increases to the money supply. Our calibration registers this in the steep increase in the household deposit supply shifter in panel (d) of figure 1 that occurs following this operation in early 1932, in addition to the stabilization of the aggregate deposit level in the banking system through the end of 1932 seen in panel (a) of figure 3.

However, our results seem to counter the view of Friedman-Schwartz and bolster that of Tobin as it relates to the transmission of open market operations to macro aggregates. In particular, this open market operations shock transmitted in our model through increases to the money supply does not register any improvement to the price level and overall deflation following the operations as seen in panels (a) and (b) of figure 6. The model calibration actually implies an expected price level following this operation that is even lower than what transpired. This underscores Tobin's point that increases to the money supply will not inherently spur general expansions.[7]

In addition, our model provides a different interpretation to that of Friedman-Schwartz for the periods in which discount window borrowing dropped during the period, in particular after the open market operations in 1932. Friedman-Schwartz argue that there was pent up demand up for liquidity by banks so that observed reductions in discount window lending merely reflected stigma from banks hesitant to borrow from the discount window as referenced earlier. They also further argued that these reductions negated any open market operations by the Federal Reserve since they led to a netting out of the overall Federal Reserve Credit Outstanding and the general money supply (*The Great Contraction*, pg.33 and 162). However, our model and its calibration argues that such reductions actually reflect a successful operation in improving the liquidity needs of the banking system. Banks following these operations were able to more likely source their liquidity needs in the interbank market as seen by the decrease in Ψ^- in panel (b) of figure 2. This then in equilibrium culminated to a drop in the clearing rate in the interbank market.

5.3 Counterfactuals

6 Conclusion

7. This result is unlike that found in Bordo and Sinha (2023) who find a positive impact on the price level from the Federal Reserve's open market operations in 1932.

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A Expressions for Matching Probabilities and Slopes of Liquidity Yield

These formulas are reproduced from Bianchi and Bigio (2022) Appendix A and Bianchi, Bigio, and Engel (2025) Appendix C. This proposition provides formulas for the interbank rate, liquidity yield function and the matching probabilities as functions of the tightness of the interbank market.

The real average interbank rate is given by

$$R_t^{ib} = (1-\bar{\eta}(\theta))R^{dw} + \bar{\eta}(\theta)R^m. \tag{A.1}$$

where $\bar{\eta}(\theta)$ is an endogenous bargaining power given by

$$\bar{\eta}(\theta) \equiv \begin{cases} 1-\frac{\bar{\theta}-\theta^{1-\eta}\bar{\theta}^{\eta}}{\bar{\theta}-\theta} & \text{if } \theta > 1 \\ \eta & \text{if } \theta = 1 \\ 1-\frac{\theta^{-1}-\theta^{-\eta}\bar{\theta}^{\eta-1}}{\bar{\theta}^{-1}-\theta^{-1}} & \text{if } \theta < 1 \end{cases} \tag{A.2}$$

and η is a parameter associated with the bargaining power of banks with reserve deficits in each trade. The parameter $\bar{\theta}$ represents the market tightness after the interbank-market trading session is over:

$$\bar{\theta} \equiv \begin{cases} 1+(\theta-1)\exp(\lambda) & \text{if } \theta > 1 \\ 1 & \text{if } \theta = 1 \\ \left(1+\left(\theta^{-1}-1\right)\exp(\lambda)\right)^{-1} & \text{if } \theta < 1 \end{cases}. \tag{A.3}$$

The parameter λ captures the matching efficiency of the interbank market. Trading probabilities are given by

$$\Psi^{+} = \begin{cases} 1-e^{-\lambda} & \text{if } \theta \geq 1 \\ \theta\left(1-e^{-\lambda}\right) & \text{if } \theta < 1 \end{cases}, \quad \Psi^{-} = \begin{cases} \left(1-e^{-\lambda}\right)\theta^{-1} & \text{if } \theta > 1 \\ 1-e^{-\lambda} & \text{if } \theta \leq 1 \end{cases}. \tag{A.4}$$

We simplify the form of the interbank rate expressed in equation (A.1) as follows:

$$\begin{aligned} R_t^{ib} &= R^{dw} - \bar{\eta}(\theta) R^{dw} + \bar{\eta}(\theta) R^m \\ &= R^{dw} - \bar{\eta}(\theta)(R^{dw} - R^m) \\ &= R^{dw} + R^m - R^m - \bar{\eta}(\theta)(R^{dw} - R^m) \\ &= R^m + (1 - \bar{\eta}(\theta))(\iota) \end{aligned}$$

where $\iota = R^{dw} - R^m$, which expresses the real corridor rate as denoted earlier. This form for the interbank rate $\{R^{ib}\}$ converts its bargaining expression form to one that more directly parallels the form for the loan rate $\{R^\ell\}$ as some spread over the policy rate $\{R^m\}$.

In this paper, the bargaining parameter is set so that $\eta = \frac{1}{2}$. As a result, the the parameterized versions of the liquidity yield function χ written in real terms are given by the following two expressions:

$$\chi^+ = \iota \frac{\theta \left(\theta + (1-\theta)\exp(\lambda)\right)^{\frac{1}{2}} - \theta}{(1-\theta)\exp(\lambda)} \tag{A.5}$$

$$\chi^- = \iota \frac{\left(\theta + (1-\theta)\exp(\lambda)\right)^{\frac{1}{2}} - \theta}{(1-\theta)\exp(\lambda)}. \tag{A.6}$$

B Proofs for Theoretical Analysis

B.1 Revised Bank Problem

Recall the bank's problem had been characterized as follows:

$$V(e_t^b) = \max_{\{div_t^b, \ell_{t+1}^b, m_{t+1}^b, d_{t+1}^b\}} u(div_t^b) + \beta \mathbb{E}\left[V(e_{t+1}^b)\right] \tag{B.1}$$

s.t. to its balance sheet and equity condition

$$e_t^b + d_{t+1}^b = m_{t+1}^b + \ell_{t+1}^b + div_t^b \tag{B.2}$$

$$e_t^b \geq div_t^b \tag{B.3}$$

where the evolution of bank net equity is given by

$$e_{t+1}^b = R_{t+1}^\ell \ell_{t+1}^b + R_{t+1}^m m_{t+1}^b - R_{t+1}^d d_{t+1}^b + \overbrace{\mathbb{E}\left[\chi_{t+1}(s_t, \theta_t, P_t)\right]}^{\text{Settlement Costs}}. \tag{B.4}$$

We simplify this problem by assuming linear utility, $U(div_t^b) = div_t^b$. This allows us to remove the model's state variable in the solution of the bank's optimality conditions as linear utility implies $V(e_t) = e_t$. As a result the problem simplifies to:

$$e_t^b = \max_{\{div_t, \ell_{t+1}^b, m_{t+1}^b, d_{t+1}^b\}} div_t^b + \beta \mathbb{E}\left[e_{t+1}^b\right] \tag{B.5}$$

s.t. to its balance sheet and equity condition

$$e_t^b + d_{t+1}^b = m_{t+1}^b + \ell_{t+1}^b + div_t^b \tag{B.6}$$

$$e_t^b \geq div_t^b \tag{B.7}$$

where the evolution of bank net equity is given by

$$e_{t+1}^b = R_{t+1}^\ell \ell_{t+1}^b + R_{t+1}^m m_{t+1}^b - R_{t+1}^d d_{t+1}^b + \overbrace{\mathbb{E}\left[\chi_{t+1}(s_t, \theta_t, P_t)\right]}^{\text{Settlement Costs}}. \tag{B.8}$$

We then drop the limited equity assumption in equation B.7 and simplify the model to be a two period environment. As a result, by substituting the budget constraint into the problem for the value of current net bank equity, the problem simplifies to:

$$0 = \max_{\{div^b, \ell^b, m^b, d^b\}} d^b - m^b - \ell^b + \beta \mathbb{E}\left[e^{b\prime}\right] \tag{B.9}$$

where the evolution of bank net equity is given by

$$e^{b\prime} = R^\ell \ell^b + R^m m^b - R^d d^b + \overbrace{\mathbb{E}\left[\chi(s, \theta, P)\right]}^{\text{Settlement Costs}}. \tag{B.10}$$

B.2 First Order Conditions

C Data Sources

We largely obtain historical data from the Board of Governor's *Banking and Monetary Statistics, 1914-1941*. It is a comprehensive source for most banking related data especially as it relates to Federal Reserve member banks. Much of the relevant data has been digitized on the NBER: Macrohistory database. We have digitized the data when not available in the database. In particular, we use the following data series:

C.1 Bank Portfolio:

- Reserves: Total Member Bank Reserve Balances; Table 101 in *Banking and Monetary Statistics, 1914-1941*, pp. 369-372. Pulled in digitized version from 1920-1933 from NBER: Macrohistory database: https://data.nber.org/databases/macrohistory/rectdata/14/m14064.dat. We adapted this series by subtracting out parallel discount window borrowing amounts to construct a measure of free reserves.

- Excess Reserves: Excess reserves for all Federal Reserve Member Banks; Table 105 in *Banking and Monetary Statistics, 1914-1941*, pp. 396-399.

- Deposits: Demand Deposits; Table 36 in *A Monetary History of the United States, 1867-1960*, pp. 504-516. Pulled in digitized version from 1920-1933 from NBER: Macrohistory database: https://data.nber.org/databases/macrohistory/rectdata/14/m14166.dat. This source is used since it provides a monthly time series of demand deposits, while *Banking and Monetary Statistics, 1914-1941* provides this data only at a call period frequency which was generally three to four times per year.

- Loans: It is construed as a balance sheet residual from demand deposits net of free reserves. We do not use any explicit time series since our focus is on a liquidity shock and in turn, short term lending. As a result, we cannot use the aggregate time series in *Banking and Monetary Statistics, 1914-1941* for loans which includes those at least partially financed by time deposits.

- Discount Window Loans: Bills Discounted; Table 101 in *Banking and Monetary Statistics, 1914-1941*, pp. 369-372. Pulled in digitized version from 1920-1933 from NBER: Macrohistory database: https://data.nber.org/databases/macrohistory/rectdata/14/m14067.dat.

- Interbank loans: Daily-average gross purchases of Fed Funds; Table 1 in Willis (1967), pp. 10.

C.2 Interest Rates:

- Loan Rate: Prime Commercial Paper, 4 to 6 Months; Table 120 in *Banking and Monetary Statistics, 1914-1941*, pp. 448-451. This time series relates to the open market in New York City which was chosen as it was the most active market during the time period.

- Deposit Rate: We calculate it by using annual demand deposit expenses noted in Table 57 of *Banking and Monetary Statistics, 1914-1941* (pp. 262-263) and then divide by the average level of demand deposits over the year. This provides an annual average deposit rate which we then linearly interpolate to create a monthly time series.

- Interbank Rate: High/Low Value of the Federal Funds Rate for the Indicated Date Published in The New York Herald-Tribune from Anbil et al. (2021). We use the average between the high and low values. We pull the digitized version from 1928-1933 found on https://fred.stlouisfed.org/tags/series?t=anbil%2C%20sriya%3Bfunds&ob=pv&od=desc.

C.3 Macro Aggregates:

- Price Level and Inflation: Consumer Price Index for All Urban Consumers (CPI-U); Bureau of Labor Statistics. We use the monthly change in the price level to calibrate inflation. Pulled from FRED: https://fred.stlouisfed.org/series/CPIAUCNS.

- Household Currency: Currency Held by the Public; Table 27 in *A Monetary History of the United States, 1867-1960*, pp. 402-415. Pulled in digitized version from 1920-1933 from NBER: Macrohistory database: https://data.nber.org/databases/macrohistory/rectdata/14/m14125.dat.

- Output: Nominal Gross National Product (GNP); Appendix B: Table 2 in Balke and Gordon (1986), pp. 789-799. We linearly interpolate the quarterly series to create a monthly time series. Pulled in digitized version from 1920-1933 from NBER: Macrohistory database: https://www.nber.org/research/data/tables-american-business-cycle.

- Money Supply: Constructed modified version of aggregate monetary base, M0, which is is defined as the sum of of currency holdings by the public and bank reserves. Since we calibrate to Federal Reserve member banks, we cannot use actual aggregate time series which includes resereve holdings for all banks.

C.4 Monetary Policy:

- Discount Window Rate: Federal Reserve Bank Discount Rates in New York City; Table 115 in *Banking and Monetary Statistics, 1914-1941*, pp. 439-443. We calibrate to the discount window rate in New York City since it was the most active market during the period.

- Reserve Requirement: Implied reserve requirement for demand deposits based on required reserves proportional to total reserves; Table 105 in *Banking and Monetary Statistics, 1914-1941*, pp. 396-399. Due to the pyramid structure of the banking system during the period, each layer of the system was subject to different reserve requirements on its demand deposits ranging from 7% to 13% during the paper's focus period. We take the historical average from 1929-1933 from the implied measure as the reserve requirement.