The Great Depression and the Friedman-Schwartz Hypothesis (Preliminary and Incomplete. Please do not quote without the permission of the authors.)

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1. Introduction

Was the US Great Depression of the 1930s due to bungling at the Fed? In their classic analysis of US monetary history, Friedman and Schwartz (1963) conclude that the answer is 'yes'. To be sure, they do admit that if the Fed had not been part of the problem we would have seen at least one, maybe more, recessions in the 1930s. But, they would have been the usual garden-variety slowdowns, not the spectacular collapse that actually occurred. The Friedman and Schwartz answer is a comforting one. Under the assumption that the Fed is smarter now than it was then, we don't have to worry about the possibility of a repeat.

Or do we? Is there anything the Fed can do to undo an event of the order of magnitude of the Great Depression? A recent analysis by Sims (1999) concludes 'no'. He argues that if a modern central banker had somehow been transported back into the 1930s and made chairman of the Fed, the Great Depression would have unfolded pretty much the way it did. For example, using a similar style of reasoning as Sims, Christiano (1999) argued that it would have made little difference if the Fed had acted to prevent the fall in $M1$. This seems inconsistent with a centerpiece of Friedman and Schwartz's argument: that the Great Depression was so severe, in part because the Fed allowed $M1$ to collapse. Although this argument creates a doubt, it is at best only suggestive because it is made by manipulating a subset of equations in a vector autoregression, without worrying about the possible consequences for other equations.

Our purpose is to do the relevant experiment 'right'. For this, we require a structural model of the economy that captures the essential features emphasized by Friedman and Schwartz. There is a variety of elements that this model must incorporate, to be interesting. First, there must be some model of credit market frictions that allow us to capture the effects of the enormous fall in stock market value that occurred. For this, we incorporate the credit market frictions described in Bernanke, Gertler and Gilchrist (1999) (BGG).[1] In addition to possibly helping the model account for the low investment that occurred in the Great Depression, financial frictions may help give $M1$ the kind of 'kick' it needs if the Friedman and Schwartz hypothesis is to have a chance. This is because BGG argue that the financial market frictions they describe provide a mechanism whereby the impact of expansionary monetary policy on the economy is amplified. Second, an important component of the Friedman and Schwartz argument is that the Fed did not act to prevent the decline in M1 that occurred as people converted demand deposits into currency. Also, Friedman and Schwartz argue that later in the depression, the Fed failed to appreciate the fact that banks wanted to hold excess reserves in conducting monetary policy. Thinking that the high levels

[1] This work builds on Townsend (1979), Gale and Hellwig (1985), Williamson (1987). Other recent contributions to this literature include Fisher (1996) and Carlstrom and Fuerst (1997, 2000).

of reserves the banks held were potentially inflationary, they increased reserve requirements. This was highly contractionary, when it turned out that the excess reserves banks were holding were desired. To model these features of the time, we need to incorporate a banking sector with demand deposits, currency, bank reserves and bank excess reserves. For this, we use the banking model of Chari, Christiano and Eichenbaum (1995) (CCE). Finally, we incorporate these banking and net worth considerations into the model environment described in Altig, Christiano, Eichenbaum and Linde (2002) (ACEL). This model seems appropriate for the task, since it captures key aspects of what we know about the monetary transmission mechanism. Another potentially feature of this model is that it incorporates market power on the part of firms and households. Cole and Ohanian (2001) have argued that changes in market power resulting from provisions of the National Recovery Act may have played an important role in prolonging the Great Depression.

Our analysis fundamentally has two steps. In the first step, we estimate the model parameters and principal shocks driving the Great Depression. In the second step, we examine the effects of some counterfactual policy the Fed could have undertaken, to see if the policy might have ameliorated the Great Depression. The policy that we focus on in particular is one that prevents M1 from falling.

In this draft of the paper, we report the results of the first step. We show that our model does a reasonably good job at capturing key features of the data.

2. The Model Economy

In this section we describe our model economy and display the problems solved by intermediate and final good firms, entrepreneurs, producers of physical capital, banks and households. Final output is produced using the usual Dixit-Stiglitz aggregator of intermediate inputs. Intermediate inputs are produced by monopolists who set prices using a variant of the approach described in Calvo (1983). These firms use the services of capital and labor. We assume that a fraction of these variable costs ('working capital') must be financed in advance through banks.

Labor services are an aggregate of specialized services, each of which is supplied by a monopolist household. Households set wages, subject to the type of frictions modeled in Calvo (1983).[2] Capital services are supplied by entrepreneurs who own the physical stock of capital and determine its rate of utilization. Our model of the entrepreneurs follows BGG. In particular, the entrepreneurs only have enough net worth to finance a part of their holdings of physical capital. The rest must be financed by a financial intermediary. Entrepreneurs are risky because they are subject to idiosyncratic productivity shocks. Moreover, while the

[2]This aspect of the model follows CCE, who in turn build on Erceg, Henderson and Levin (2000).

realization of an individual entrepreneur's productivity shock is observed freely by the entrepreneur, the intermediary must pay a monitoring cost to observe it. The contract extended by the intermediary to the entrepreneur is a standard debt contract. As is standard in the costly state verification (CSV) framework with net worth, we need to make assumptions to guarantee that entrepreneurs do not accumulate enough net worth to make the CSV technology irrelevant. We accomplish this by assuming that a part of net worth is exogenously destroyed in each period.

The actual production of physical capital is carried out by capital producing firms, who combine old capital and investment goods to produce new, installed, capital. The capital owned by entrepreneurs is purchased from these firms.

All financial intermediation activities occur in a 'bank'. They receive two types of deposits from households. Demand deposits are used to finance the working capital loans. To maintain deposits requires the use of capital and labor resources. This aspect of the model follows CCE. The bank also handles the intermediation activities associated with the financing of entrepreneurs. To finance this, the bank issues 'time deposits' to households. The maturity structure of bank liabilities match those of bank assets exactly. There is no risk in banking.

The timing of decisions during a period is important in the model. At the beginning of the period, shocks to the various technologies are realized. Then, wage, price, consumption, investment and capital utilization decisions are made. In addition, households decide how to split their financial assets between currency and deposits at this time.[3] After this, various financial market shocks are realized and the monetary action occurs. Finally, goods and asset markets meet and clear. See Figure 1 for reference.

2.1. Firm Sector

A final good, Y_t, is produced by a perfectly competitive, representative firm. It does so by combining a continuum of intermediate goods, indexed by $j \in [0,1]$, using the technology

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj \right]^{\lambda_{f,t}} .$$

Here, $1 \leq \lambda_{f,t} < \infty$, and Y_{jt} denotes the time t input of intermediate good j. Let P_t and P_{jt} denote the time t price of the consumption good and intermediate good j, respectively. The firm chooses Y_{jt} and Y_t to maximize profits, taking prices as given. The parameter, $\lambda_{f,t}$, is a realization of a stochastic process, to be discussed below. Fluctuations in $\lambda_{f,t}$ give rise in fluctuations in the market power of intermediate good firms.

[3]By adopting this timing convention for household portfolio allocation, we follow the literature on limited participation models, as discussed in CCE.

The j^{th} intermediate good is produced by a monopolist who sets its price, P_{jt}, subject to Calvo-style frictions that will be described shortly. The intermediate good producer is required to satisfy whatever demand materializes at its posted price. Given quantity demanded, the intermediate good producer chooses inputs to minimize costs. The production function of the j^{th} intermediate good firm is:

$$Y_{jt} = \begin{cases} \epsilon_t K_{jt}^{\alpha} \left(z_t l_{jt}\right)^{1-\alpha} - \Phi z_t & \text{if } \epsilon_t K_{jt}^{\alpha} \left(z_t l_{jt}\right)^{1-\alpha} > \Phi z_t \\ 0, & \text{otherwise} \end{cases}, \; 0 < \alpha < 1,$$

where Φ is a fixed cost and K_{jt} and l_{jt} denote the services of capital and labor. The variable, z_t, is the trend growth rate in technology, with $z_t = \exp(\mu_z) z_{t-1}$. The variable, ϵ_t, is a standard, stationary shock to technology. The time series representation of ϵ_t is discussed below.

Intermediate good firms are competitive in factor markets, where they confront a rental rate, Pr_t^k, on capital services and a wage rate, W_t, on labor services. Each of these is expressed in units of money. Also, each firm must finance a fraction, ψ_k, of its capital services expenses in advance. Similarly, it must finance a fraction, ψ_l, of its labor services in advance. The interest rate it faces is R_t

We adopt the variant of Calvo pricing proposed in CEE. In each period, t, a fraction of intermediate good firms, $1 - \xi_p$, can reoptimize its price. The complementary fraction must set its price equal to what it was in period $t-1$, scaled up by the inflation rate from $t-2$ to $t-1$.

2.2. Capital Producers

There is a large, fixed, number of identical capital producers. They are competitive and take prices as given. They are owned by households, who receive any profits or losses in the form of lump-sum transfers. Capital producers purchase previously installed capital, x, and investment goods, I_t, and combine these to produce new installed capital. Investment goods are purchased in the goods market, at price P_t. The time t price of previously installed capital is denoted $Q_{\bar{K}',t}$. New capital, x', is produced using the following technology:

$$x' = x + F(I_t, I_{t-1}).$$

The presence of lagged investment reflects that there are costs to changing the flow of investment. Since the marginal rate of transformation from previously installed capital into new capital is unity, the price of new capital is also $Q_{\bar{K}',t}$. The firm's time t profits are:

$$\Pi_t^k = Q_{\bar{K}',t} \left[x + F(I_t, I_{t-1})\right] - Q_{\bar{K}',t} x - P_t I_t.$$

The capital producer's problem is dynamic because of the adjustment costs. It solves:

$$\max_{\{I_{t+j},x_{t+j}\}} E\left\{\sum_{j=0}^{\infty}\beta^j\lambda_{t+j}\Pi_{t+j}^k|\Omega_t\right\},$$

where Ω_t is the firm's time t information set. This is composed of all time t shocks, except the monetary policy shock.

Let $\bar{K}_{t+j}$ denote the beginning-of-period $t+j$ physical stock of capital in the economy and let δ denote its rate of depreciation. From the capital producer's problem it is evident that any value of x_{t+j} whatsoever is profit maximizing. Thus, setting $x_{t+j} = (1-\delta)\bar{K}_{t+j}$ is consistent with profit maximization and market clearing. The stock of capital evolves as follows

$$\bar{K}_{t+1} = (1-\delta)\bar{K}_t + F(I_t, I_{t-1}).$$

2.3. Entrepreneurs

The period t installed stock of capital, $\bar{K}_{t+1}$, is purchased by entrepreneurs from capital producers (see Figure 2). When an entrepreneur purchases capital, his state is summarized by the level of net worth, N_{t+1}. The underlying source of funds is the rent earned as a consequence of supplying capital services to the period t capital rental market and the sales proceeds from selling the undepreciated component of the physical stock of capital to capital goods producers. The uses of funds include repayment on debt incurred on loans in period $t-1$ and expenses for capital utilization. Net worth is composed of these sources minus these uses of funds.

After entrepreneurs sell their capital a randomly selected fraction, $1-\gamma$, die. The period t newly produced stock of physical capital is purchased by the γ surviving entrepreneurs and by $1-\gamma$ entrepreneurs who are newly born. The surviving entrepreneurs finance their purchases with their net worth and a loan from the bank. The newly-born entrepreneurs finance their purchases with a transfer payment received from the government and a loan from the bank.

The entrepreneur with net worth, N_{t+1}, who purchases a quantity of installed capital, $\bar{K}_{t+1}^N$, from the capital goods producers at the price, $Q_{\bar{K}',t}$, in period t, experiences an idiosyncratic shock to the size of his purchase. After the purchase, the size of capital changes from $\bar{K}_{t+1}^N$ to $\omega\bar{K}_{t+1}^N$. Here, ω is a unit mean, log-normal random variable distributed independently over time and across entrepreneurs. The standard deviation of $\log(\omega)$ at date t, σ_t, is itself a stochastic process. Its properties are described below. We write the distribution function of ω as F_t :

$$\Pr\left[\omega \leq x\right] = F_t(x).$$

After observing Ω_{t+1}, the entrepreneur decides on the period $t+1$ level of capital utilization, and then rents out capital services. High rates of capital utilization generate high costs, according to the following expression:

$$P_{t+1}a(u_{t+1}^N)\omega\bar{K}_{t+1}^N,\ a', a'' > 0.$$

As in BGG, we suppose that the entrepreneur is risk neutral. As a result, the entrepreneur chooses u_{t+1}^N to solve:

$$\max_{u_{t+1}^N} E\left\{\left[u_{t+1}^N r_{t+1}^k - a(u_{t+1}^N)\right]\omega\bar{K}_{t+1}^N P_{t+1}|\Omega_{t+1}\right\}.$$

The rate of return, $R_{t+1}^{k,\omega}$, on capital purchased in period t is:

$$\begin{aligned} 1 + R_{t+1}^{k,\omega} &= \frac{\left[u_{t+1}r_{t+1}^k - a(u_{t+1})\right] + (1-\delta)q_{t+1}}{q_t}\frac{P_{t+1}}{P_t}\omega \\ &= (1 + R_{t+1}^k)\omega, \end{aligned}$$

where

$$q_t = \frac{Q_{\bar{K}',t}}{P_t}.$$

Here, R_{t+1}^k is the average rate of return on capital across all entrepreneurs.

We suppose that $N_{t+1} < Q_{\bar{K}',t}\bar{K}_{t+1}^N$, where $Q_{\bar{K}',t}\bar{K}_{t+1}^N$ is the cost of the capital purchased by entrepreneurs with net worth, N_{t+1}. Since the entrepreneur does not have enough net worth to pay for its capital, he must borrow the rest:

$$B_{t+1}^N = Q_{\bar{K}',t}\bar{K}_{t+1}^N - N_{t+1} \geq 0. \tag{2.1}$$

We suppose that the entrepreneur receives a standard debt contract from the bank. This specifies a loan amount, B_{t+1}^N, and a gross rate of interest, Z_{t+1}^N, to be paid if ω is high enough that the entrepreneur can do so. Entrepreneurs who cannot pay this interest rate, because they have a low value of ω must give everything they have to the bank. The parameters of the $N_{t+1}-$type standard debt contract, B_{t+1}^N Z_{t+1}^N, imply a cutoff value of ω, $\bar{\omega}_{t+1}^N$, as follows:

$$\bar{\omega}_{t+1}^N\left(1 + R_{t+1}^k\right)Q_{\bar{K}',t}\bar{K}_{t+1}^N = Z_{t+1}^N B_{t+1}^N. \tag{2.2}$$

The bank finances its period t loans to entrepreneurs, B_{t+1}^N, by borrowing from households. We assume the bank pays households a rate of return, R_{t+1}^e, that is not contingent upon the realization of $t+1$ shocks.[4] In the usual way, the parameters of the entrepreneur's debt contract are chosen to maximize entrepreneurial utility, subject to zero profits for the bank and to the requirement that R^e_{t+1} be uncontingent upon period $t+1$ shocks. This implies that Z^N_{t+1} and $\bar{\omega}^N_{t+1}$ are both functions of period $t+1$ shocks. A feature of the contract is that

$$\frac{Q_{\bar{K}',t}\bar{K}^N_{t+1}}{N_{t+1}}$$

is independent of N, the entrepreneur's net worth. A consequence of this linearity is that aggregation is straightforward. The equilibrium is a function only of aggregate net worth, $\bar{N}$:

$$\bar{N}_{t+1} = \int_0^\infty N f_{t+1}(N) dN,$$

where $f_{t+1}(N)$ is the density of entrepreneurs having net worth level N_{t+1}. The law of motion for $\bar{N}_{t+1}$ is

$$\begin{aligned}\bar{N}_{t+1} &= \gamma\{\left(1+R^k_t\right) Q_{\bar{K}',t-1}\bar{K}_t \\ &\quad - \left[1+R^e_t + \frac{\mu\int_0^{\bar{\omega}_t}\omega dF_{t-1}(\omega)\left(1+R^k_t\right)Q_{\bar{K}',t-1}\bar{K}_t}{Q_{\bar{K}',t-1}\bar{K}_t-\bar{N}_t}\right](Q_{\bar{K}',t-1}\bar{K}_t-\bar{N}_t)\} + W^e_t,\end{aligned} \tag{2.3}$$

where W^e_t is the transfer payment to entrepreneurs. The object in square brackets is the average gross rate of return paid by all entrepreneurs on period $t-1$ loans, $(Q_{\bar{K}',t-1}\bar{K}_t - \bar{N}_t)$. This aggregates over payments received from entrepreneurs who are bankrupt, as well as those who are not. The $(1-\gamma)$ entrepreneurs who are selected for death, consume:

$$P_tC^e_t = \Theta(1-\gamma)V_t.$$

Following BGG, we define the 'external finance premium' as the ratio involving μ in square brackets in (2.3). It is the difference between the 'internal cost of funds', $1+R^e_t$, and the expected cost of borrowing to an entrepreneur. The reason for calling $1+R^e_t$ the internal

[4]Given our setup of the model, the restriction that R^e_{t+1} is not a function of time $t+1$ shocks is likely to be binding. Chari has pointed out to us that in a world with full competition in contracts, risk neutral entrepreneurs would in effect shoulder some of households' consumption risk. In such a world, households' rate of interest, R^e_{t+1}, would covary positively with the marginal utility of consumption. As in all other aspects of the model of model of entrepreneurs, we follow BGG in assuming R^e_{t+1} is state independent. One interpretation of this assumption is that it is motivated by concern for institutional realism. In a private communication, Mark Gertler has conjectured that if R described an alternative Another, emphasize that if R^e_{t+1} were allowed to covary positively with the marginal utility of consumption, then the accelerator effect associated with net worth constraints emphasized by BGG would be amplified.

cost of funds is that in principle one could imagine the entrepreneur using its net worth to acquire time deposits, instead of physical capital (the model does not formally allow this). In this sense, the cost of the entrepreneur's own funds, which do not involve any costly state verification, is $1 + R_t^e$.

2.4. Banks

We assume that there is a continuum of identical, competitive banks. Each operates a technology to convert capital, K_t^b, labor, l_t^b, and excess reserves, E_t^b, into real deposit services, D_t/P_t. The production function of the representative bank is:

$$\frac{D_t}{P_t} = x^b \left(\left(K_t^b\right)^{\alpha} \left(z_t l_t^b\right)^{1-\alpha} \right)^{\xi_t} \left(\frac{E_t^r}{P_t} \right)^{1-\xi_t} \tag{2.4}$$

Here $0 < \alpha < 1$ and x^b is a constant. In addition, $\xi_t \in (0,1)$ is a shock to the relative value of excess reserves, E_t^r. The stochastic process governing this shock will be discussed later. We include excess reserves as an input to the production of demand deposit services as a reduced form way to capture the precautionary motive of a bank concerned about the possibility of unexpected withdrawals.

We now discuss a typical bank's balance sheet. The bank's assets consist of cash reserves and loans. It obtains cash reserves from two sources. Households deposit A_t dollars and the monetary authority credits households' checking accounts with X_t dollars. Consequently, total time t cash reserves of the banking system equal $A_t + X_t$. Bank loans are extended to firms and other banks to cover their working capital needs, and to entrepreneurs to finance purchases of capital.

The bank has two types of liabilities: demand deposits, D_t, and time deposits, T_t. Demand deposits, which pay interest, R_{at}, are created for two reasons. First, there are the household deposits, $A_t + X_t$ mentioned above. We denote this by D_t^h. Second, working capital loans made by banks to firms and other banks are granted in the form of demand deposits. We denote firm and bank demand deposits by D_t^f. Total deposits, then, are:

$$D_t = D_t^h + D_t^f.$$

Time deposit liabilities are issued by the bank to finance the standard debt contracts offered to entrepreneurs and discussed in the previous section. Time and demand deposits differ in three respects. First, demand deposits yield transactions services, while time deposits do not. Second, time deposits have a longer maturity structure. Third, demand deposits are backed by working capital loans and reserves, while time deposits are backed by standard debt contracts to entrepreneurs.

We now discuss the demand deposit liabilities. We suppose that the interest on demand deposits that are created when firms and banks receive working capital loans, are paid to the recipient of the loans. Firms and banks just sit on these demand deposits. The wage bill isn't actually paid to workers until a settlement period that occurs after the goods market.

We denote the interest payment on working capital loans, net of interest on the associated demand deposits, by R_t. Since each borrower receives interest on the deposit associated with their loan, the gross interest payment on loans is $R_t + R_{at}$. Put differently, the spread between the interest on working capital loans and the interest on demand deposits is R_t.

The maturity of period t working capital loans and the associated demand deposit liabilities coincide. A period t working capital loan is extended just prior to production in period t, and then paid off after production. The household deposits funds into the bank just prior to production in period t and then liquidates the deposit after production.

We now discuss the time deposit liabilities. Unlike in the case of demand deposits, we assume that the cost of maintaining time deposit liabilities is zero. Competition among banks in the provision of time deposits and entrepreneurial loans drives the interest rate on time deposits to the return the bank earns (net of expenses, including monitoring costs) on the loans, R_t^e. The maturity structure of time deposits coincides with that of the standard debt contract, and differs from that of demand deposits and working capital loans. The maturity structure of the two types of assets can be seen in Figure 3. Time deposits and entrepreneurial loans are created at the end of a given period's goods market. This is the time when newly constructed capital is sold by capital producers to entrepreneurs. Time deposits and entrepreneurial loans pay off at the end of next period's goods market, when the entrepreneurs sell their undepreciated capital to capital producers (who use it as a raw material in the production of next period's capital). The payoff on the entrepreneurial loan coincides with the payoff on time deposits. Competition in the provision of time deposits guarantees that these payoffs coincide.

The maturity difference between demand and time deposits implies that the return on the latter in principle carries risks not present in the former. In the case of demand deposits, no shocks are realized between the creation of a deposit and its payoff. In the case of time deposits, there are shocks whose value is realized between creation and payoff (see Figure 3). Since time deposits finance assets with an uncertain payoff, someone has to bear the risk. We follow BGG in focusing on equilibria in which the entrepreneur bears all the risk. The ex post return on time deposits is know with certainty to the household at the time the deposit decision is made.

We now discuss the assets and liabilities of the bank in greater detail. We describe the banks' books at two points in time within the period: just before the goods market, when the market for working capital loans and demand deposits is open, and just after the goods market. At the latter point in time, the market for time deposits and entrepreneurial loans is open. Liabilities and assets just before the goods market are:

$$D_t + T_{t-1} = A_t + X_t + S_t^w + B_t, \tag{2.5}$$

where S_t^w denotes working capital loans. The monetary authority imposes a reserve requirement that banks must hold at least a fraction τ of their demand deposits in the form of currency. Consequently, nominal excess reserves, E_t^r, are given by

$$E_t^r = A_t + X_t - \tau D_t, \tag{2.6}$$

where τ denotes the bank reserve requirement. The bank's 'T' accounts are as follows:

Assets	Liabilities
Reserves	
A_t	D_t
X_t	
Short-term Working Capital Loans	
S_t^w	
Long-term, Entrepreneurial Loans	
B_t	T_{t-1}

After the goods market, demand deposits are liquidated, so that $D_t = 0$ and $A_t + X_t$ is returned to the households, so this no longer appears on the bank's balance sheet. Similarly, working capital loans, S_t^w, and 'old' entrepreneurial loans, B_t, are liquidated at the end of the goods market and also do not appear on the bank's balance sheet. At this point, the assets on the bank's balance sheet are the new entrepreneurial loans issued at the end of the goods market, B_{t+1}, and the bank liabilities are the new time deposits, T_t.

At the end of the goods market, the bank settles claims for transactions that occurred in the goods market and that arose from it's activities in the previous period's entrepreneurial loan and time deposit market. The bank's sources of funds at this time are: net interest from borrowers and $A_t + X_t$ of high-powered money (i.e., a mix of vault cash and claims on the central bank).[5] Working capital loans coming due at the end of the period pay R_t in interest and so the associated principal and interest is

$$(1 + R_t)S_t^w = (1 + R_t)\left(\psi_l W_t l_t + \psi_k P_t r_t^k K_t\right).$$

Loans to entrepreneurs coming due at the end of the period are the ones that were extended in the previous period, $Q_{\bar{k}',t-1}\bar{K}_t - N_t$, and they pay the interest rate from the previous

[5]Interest is not paid by the central bank on high-powered money.

period, after monitoring costs:

$$\left(1+R_t^e\right)\left(Q_{\bar{K}',t-1}\bar{K}_t-N_t\right)$$

The bank's uses of funds are (i) interest and principle obligations on demand deposits and time deposits, $(1+R_{at})D_t$ and $(1+R_t^e)T_{t-1}$, respectively, and (ii) interest and principal expenses on working capital, i.e., capital and labor services. Interest and principal expenses on factor payments in the banking sector are handled in the same way as in the goods sector. In particular, banks must finance a fraction, $\psi_{k,t}$, of capital services and a fraction, $\psi_{l,t}$, of labor services, in advance, so that total factor costs as of the end of the period, are $\left(1+\psi_{k,t}R_t\right)P_t r_t^k K_t^b$. The bank's net source of funds, Π_t^b, is:

$$\begin{aligned}
\Pi_t^b \;=\;& (A_t+X_t)+(1+R_t+R_{at})S_t^w-(1+R_{at})D_t \\
& -\left[\left(1+\psi_{k,t}R_t\right)P_t r_t^k K_t^b\right]-\left[\left(1+\psi_{l,t}R_t\right)W_t l_t^b\right] \\
& +\left[1+R_t^e+\frac{\mu\int_0^{\bar{\omega}_t}\omega dF(\omega)\left(1+R_t^k\right)Q_{\bar{K}',t-1}\bar{K}_t}{Q_{\bar{K}',t-1}\bar{K}_t-N_t}\right]B_t \\
& -\mu\int_0^{\bar{\omega}_t}\omega dF(\omega)\left(1+R_t^k\right)Q_{\bar{K}',t-1}\bar{K}_t-\left(1+R_t^e\right)T_{t-1} \\
& +T_t-B_{t+1}
\end{aligned} \tag{2.7}$$

Because of competition, the bank takes all wages and prices and interest rates as given and beyond its control.

We now describe the bank's optimization problem. The bank pays Π_t^b to households in the form of dividends. It's objective is to maximize the present discounted value of these dividends. In period 0, its objective is:

$$E_0\sum_{t=0}^{\infty}\beta^t\lambda_t\Pi_t^b,$$

where λ_t is the multiplier on Π_t^b in the Lagrangian representation of the household's optimization problem. It takes as given its time deposit liabilities from the previous period, T_{-1}, and its entrepreneurial loans issued in the previous period, B_0. In addition, the bank takes all rates of return and λ_t as given. The bank optimizes its objective by choice of $\left\{S_t^w,\ B_{t+1},\ D_t,\ T_t,\ K_t^b,\ E_t^r; t\geq 0\right\}$, subject to (2.4)-(2.6).

In the previous section, we discussed the determination of the variables relating to entrepreneurial loans. There is no further need to discuss them here, and so we take those as given. To discuss the variables of concern here, we adopt a Lagrangian representation of the bank problem which uses a version of (2.7) that ignores variables pertaining to the entrepreneur. The Lagrangian representation of the problem that we work with is:

$$\max_{A_t, S_t^w, K_t^b, l_t^b} \left\{ R_t S_t^w - R_{at}\left(A_t + X_t\right) - R_t^b F_t - \left[\left(1+\psi_{k,t} R_t\right) P_t r_t^k K_t^b\right] - \left[\left(1+\psi_{l,t} R_t\right) W_t l_t^b\right] \right\}$$
$$+\lambda_t^b \left[h(x_t^b, K_t^b, l_t^b, \frac{A_t + X_t + F_t - \tau\left(A_t + X_t + S_t^w\right)}{P_t}, \xi_t, x_t^b, z_t) - \frac{A_t + X_t + S_t^w}{P_t} \right]$$

where

$$\begin{aligned} h(x_t^b, K_t^b, l_t^b, e_t^r, \xi_t, x_t^b, z_t) &= a^b x_t^b \left(\left(K_t^b\right)^\alpha \left(z_t l_t^b\right)^{1-\alpha} \right)^{\xi_t} \left(e_t^r\right)^{1-\xi_t} \\ e_t^r &= \frac{E_t^r}{P_t} = \frac{A_t + X_t + F_t - \tau\left(A_t + X_t + S_t^w\right)}{P_t} \end{aligned}$$

Here, F_t is introduced to allow us to define an interbank loan rate, R_t^b, in the model. The quantity, F_t, corresponds to reserves borrowed in an interbank loan market. Note that borrowing F_t creates a net obligation of $R_t^b F_t$ at the end of the period. On the plus side, it adds to the bank's holdings of reserves. Of course, since our banks are formally identical, market clearing requires $F_t = 0$ in equilibrium.

The clearing condition in the market for working capital loans is:

$$S_t^w = \psi_l W_t l_t + \psi_k P_t r_t^k K_t \tag{2.8}$$

Here, S_t^w represents the supply of loans, and the terms on the right of the equality in (2.8) represent total demand.

2.5. Households

There is a continuum of households, indexed by $j \in (0,1)$. Households consume, save and supply a differentiated labor input. The sequence of decisions by the household during a period is as follows. First, it makes its consumption decision after the non-financial shocks are realized. In addition, it allocates its financial assets between currency and deposits. Second, it purchases securities whose payoffs are contingent upon whether it can reoptimize its wage decision. Third, it sets its wage rate after finding out whether or not it can reoptimize. Fourth, the current period monetary action is realized. Fifth, after the monetary action, and before the goods market, the household decides how much of its financial assets to hold in the form of currency and demand deposits. At this point, the time deposits purchased by the household in the previous period are fixed and beyond its control. Sixth, the household goes to the goods market, where labor services are supplied and goods are purchased. Seventh, after the goods market, the household settles claims arising from its goods market experience and makes its current period time deposit decision.

Since the uncertainty faced by the household over whether it can reoptimize its wage is idiosyncratic in nature, households work different amounts and earn different wage rates. So, in principle they are also heterogeneous with respect to consumption and asset holdings. A straightforward extension of arguments in Erceg, Henderson and Levin (2000) and Woodford (1996), establish that the existence of state contingent securities ensures that in equilibrium households are homogeneous with respect to consumption and asset holdings. Reflecting this result, our notation assumes that households are homogeneous with respect to consumption and asset holdings, and heterogeneous with respect to the wage rate that they earn and hours worked. The preferences of the j^{th} household are given by:

$$E_t^j \sum_{l=0}^{\infty} \beta^{l-t} \left\{ u(C_{t+l} - bC_{t+l-1}) - \zeta_{t+l} z(h_{j,t+l}) - \upsilon_t \frac{\left[\left(\frac{P_{t+l}C_{t+l}}{M_{t+l}} \right)^{\theta_{t+l}} \left(\frac{P_{t+l}C_{t+l}}{D_{t+l}^h} \right)^{1-\theta_{t+l}} \right]^{1-\sigma_q}}{1-\sigma_q} - H\left(\frac{M_{t+l}}{M_{t+l-1}}\right) \right\}, \tag{2.9}$$

where E_t^j is the expectation operator, conditional on aggregate and household j idiosyncratic information up to, and including, time $t-1$; C_t denotes time t consumption; h_{jt} denotes time t supply of a specialized labor service; υ_t is a unit mean stochastic process; and ζ_t is a shock with mean unity to the preference for leisure. This shock is isomorphic to a shock to the household's degree of monopoly power in the supply of h_{jt}. To help assure that our model has a balanced growth path, we specify that u is the natural logarithm. When $b > 0$, (2.9) allows for habit formation in consumption preferences. Various authors, such as Fuhrer (2000), and McCallum and Nelson (1998), have argued that this is important for understanding the monetary transmission mechanism. In addition, habit formation is useful for understanding other aspects of the economy, including the size of the premium on equity. The term in square brackets captures the notion that currency and demand deposits contribute to utility by providing transactions services. Those services are an increasing function of the level of consumption. Finally, H represents an adjustment costs in holdings of currency. We assume that $H' = 0$ along a steady state growth path, and $H'' > 0$ along such a path. The assumption on H' ensures that H does not enter the steady state of the model. Given our linearization strategy, the only free parameter here is H'' itself.

We now discuss the household's period t uses and sources of funds. Just before the goods market in period t, after the realization of all shocks, the household has M_t^b units of high powered money which it splits into currency, M_t, and deposits with the bank:

$$M_t^b - (M_t + A_t) \geq 0. \tag{2.10}$$

The household deposits A_t with the bank, in exchange for a demand deposit. Demand deposits pay the relatively low interest rate, R_{at}, but offer transactions services.

The central bank credits the household's bank deposit with X_t units of high powered money, which automatically augments the household's demand deposits. So, household demand deposits are D_t^h :

$$D_t^h = A_t + X_t.$$

As noted in the previous section, the household only receives interest on the non-wage component of its demand deposits, since the interest on the wage component is earned by intermediate good firms.

The household also can acquire a time deposit. This can be acquired at the end of the period t goods market and pays a rate of return, $1+R_{t+1}^e$, at the end of the period $t+1$ goods market. The rate of return, R_{t+1}^e, is known at the time that the time deposit is purchased. It is not contingent on the realization of any of the period $t+1$ shocks.

The household also uses its funds to pay for consumption goods, P_tC_t and to acquire high powered money, Q_{t+1}, for use in the following period. Additional sources of funds include profits from producers of capital, Π_t^k, from banks, Π_t^b, from intermediate good firms, $\int \Pi_t^j dj$, and $A_{j,t}$, the net payoff on the state contingent securities that the household purchases to insulate itself from uncertainty associated with being able to reoptimize its wage rate. Households also receive lump-sum transfers, $1-\Theta$, corresponding to the net worth of the $1-\gamma$ entrepreneurs which die in the current period. Finally, the households pay a lump-sum tax to finance the transfer payments made to the γ entrepreneurs that survive and to the $1-\gamma$ newly born entrepreneurs. These observations are summarized in the following asset accumulation equation:

$$\begin{aligned}
&\left[1+\left(1-\tau^D\right)R_{at}\right]\left(M_t^b - M_t + X_t\right) - T_t \\
&-\left(1+\tau^c\right)P_tC_t + \left(1-\Theta\right)\left(1-\gamma\right)V_t - W_t^e + Lump_t \\
&+\left[1+\left(1-\tau^T\right)R_t^e\right]T_{t-1} + \left(1-\tau^l\right)W_{j,t}h_{j,t} + M_t + \Pi_t^b + \Pi_t^k + \int \Pi_t^f df + A_{j,t} - M_{t+1}^b \geq 0.
\end{aligned} \tag{2.11}$$

The household's problem is to maximize (2.9) subject to the timing constraints mentioned above, the various non-negativity constraints, and (2.11). The household chooses C_t, M_{t+1}^b, M_t and T_t to maximize (2.9) subject to (2.10) and (2.11).

We now discuss the household's wage setting behavior, which follows closely the setup in Erceg, Henderson and Levin (2000). At date t a randomly selected fraction, $1-\xi_w$, of households sets it wage optimally. The complementary fraction sets its wage time t wage to what it was in the previous period, scaled up by $\pi_{t-1}\mu_z$. Denote the wage rate set by the household that has the option to reoptimize in period t by $\tilde{W}_t$. The household takes into account that if it cannot reoptimize its wage for l periods, then its wage l periods from now will be

$$\pi_t \times \pi_{t+1} \times \cdots \times \pi_{t+l-1} \mu_z^l \tilde{W}_t.$$

Let $\tilde{W}_{t+l}$ denote the wage rate l periods in the future of a household that optimized in period t and has not been able to reoptimize since. The demand for the services of such a household, l periods in the future is:

$$h_{j,t+l} = \left(\frac{\tilde{W}_{t+l}}{W_{t+l}} \right)^{\frac{\lambda_w}{1-\lambda_w}} l_{t+l} = \left(\frac{\tilde{W}_t \mu_z^l}{w_{t+j} z_{t+j} P_t} X_{t,j} \right)^{\frac{\lambda_w}{1-\lambda_w}} l_{t+l}, \tag{2.12}$$

where

$$X_{t,l} = \frac{\pi_t \times \pi_{t+1} \times \cdots \times \pi_{t+l-1}}{\pi_{t+1} \times \cdots \times \pi_{t+l}} = \frac{\pi_t}{\pi_{t+l}},$$

and W_t is an aggregate wage index:

$$W_t = \left[(1 - \xi_w) \left(\tilde{W}_t \right)^{\frac{1}{1-\lambda_w}} + \xi_w \left(\pi_{t-1} \mu_{z,t} W_{t-1} \right)^{\frac{1}{1-\lambda_w}} \right]^{1-\lambda_w}. \tag{2.13}$$

Also, l is an aggregate index of employment:

$$l = \left[\int_0^1 (h_j)^{\frac{1}{\lambda_w}} dj \right]^{\lambda_w}, \ 1 \leq \lambda_w < \infty.$$

The household takes the aggregate wage and employment index as given. The household that reoptimizes its wage, $\tilde{W}_t$, does so to optimize (neglecting irrelevant terms in the household objective):

$$E \sum_{l=0}^{\infty} (\beta \xi_w)^{l-t} \{ -\zeta_{t+l} z(h_{j,t+l}) + \lambda_{t+l} (1 - \tau^l) W_{j,t+l} h_{j,t+l} | \Omega_t \}.$$

We impose the following functional form:

$$z(h) = \psi_L \frac{h_t^{1+\sigma_L}}{1 + \sigma_L}$$

The presence of ξ_w by the discount factor reflects that in its selection of $\tilde{W}_t$, the household is only concerned with the future states of the world in which it cannot reoptimize.

2.6. Monetary Policy

The law of motion for the monetary base is:

$$M_{t+1}^b = M_t^b (1 + x_t),$$

where x_t is the net growth rate of the monetary base. Monetary policy is characterized by a feedback from $\hat{x}_t$ $(= (x_t - x)/x)$ to an innovation in monetary policy and to the innovation in all the other shocks in the economy. Let the $p-$ dimensional vector summarizing these innovations be denoted $\hat{\varphi}_t$, and suppose that the first element in $\hat{\varphi}_t$ is the innovation to monetary policy. Then, monetary policy has the following representation:

$$\hat{x}_t = \sum_{i=1}^{p} x_{it},$$

where x_{it} is the component of money growth reflecting the i^{th} element in $\hat{\varphi}_t$. Also,

$$x_{it} = \theta_i^1 x_{i,t-1} + \theta_i^0 \hat{\varphi}_{it} + \theta_i^2 \hat{\varphi}_{i,t-1}, \tag{2.14}$$

for $i = 1, ..., p$, with $\theta_1^0 \equiv 1$.

2.7. Final Goods Market Clearing

We follow Tak Yun (1996) in developing an aggregate resource constraint for this economy, relating the quantity of final goods produced to the quantity of aggregate labor and capital (see also CEE). In particular,

$$Y = (p^*)^{\frac{\lambda_f}{\lambda_f - 1}} \left[z^{1-\alpha} \epsilon \left(\nu K\right)^{\alpha} \left(\nu \left(w^*\right)^{\frac{\lambda_w - 1}{\lambda_w}} L \right)^{1-\alpha} - z\phi \right],\ w^* = \frac{W^*}{W},\ p^* = \frac{P^*}{P}.$$

Here, K and L are the unweighted integral of all labor and capital in the economy. The endogenous variable, ν, indicates the fraction of labor and capital used in the goods producing sector. The objects, W^* and W represent different weighted integrals of W_{jt} over all j, and similarly for P^* and P. When all wages and intermediate good prices are equal, then $p^* = w^* = 1$ and efficient intersectoral allocation of resources occurs. Because of the price and wage frictions, $p^* = w^* = 1$ only holds in a nonstochastic steady state. The reasoning in Tak Yun (1996).can be used to show that in the type of linear approximation about steady that we study here, we can set $p^* = w^* = 1$.We do this from here on.

To complete our discussion, final goods are allocated to monitoring for banks, utilization costs of capital, last meals of entrepreneurs selected to die, government consumption, household consumption and investment:

$$\begin{aligned} & \mu \int_0^{\bar{\omega}_t} \omega dF(\omega) \left(1 + R^k\right) Q_{\bar{K}',t-1} \bar{K} + a(u)\bar{K} + \Theta(1-\gamma) v_t z_t + G_t + C_t + I_t \quad (2.15) \\ \leq \; & \left[z^{1-\alpha} \epsilon \left(\nu K\right)^{\alpha} \left(\nu L\right)^{1-\alpha} - z\phi \right], \end{aligned}$$

Here, government consumption is modeled as follows:

$$G = zg,$$

where g is a constant.

2.8. Exogenous Shocks

There are seven exogenous shocks in the model. These are the monopoly power parameter, $\lambda_{f,t}$, corresponding to intermediate good firms; the parameter controlling bank demand for excess reserves, ξ_t; the parameter controlling household preferences for currency versus demand deposits, θ_t; the monopoly power parameter for household labor supply, ζ_t; the parameter governing household demand for liquidity, υ_t; the productivity shock to intermediate good firms, ϵ_t; and the shock to the riskiness of entrepreneurs, σ_t.

Two of our variables, ξ_t and θ_t, are required to lie in the unit interval. If we let y_t denote one of these variables, then we think of it as being generated by a stochastic process, x_t, via the following transformation:

$$y_t = \frac{1}{1 + \exp(-x_t)}.$$

Note that $x_t \in (-\infty, \infty)$ maps y_t into the unit interval. If we let dx_t denote a small perturbation of x_t about its nonstochastic steady state value, and let $\hat{y}_t = dy_t/y$, where y is the nonstochastic steady state of y_t, then

$$\hat{y}_t = (1 - y)\, dx_t.$$

For the case when y_t is ξ_t or θ_t, we model dx_t as being a scalar first order autoregressive, moving average (ARMA(1,1)). We also model $\hat{\lambda}_{f,t}$, $\hat{\upsilon}_t$, $\hat{\zeta}_t$, $\hat{\sigma}_t$ and $\hat{\epsilon}_t$ as following scalar ARMA(1,1)'s (here, a '$\hat{}$' over a variable is defined analogously to $\hat{y}_t$). Consider, for example, $\hat{\lambda}_{f,t}$. The joint evolution of this variable and its monetary response, $x_{f,t}$, are given by:

$$\begin{pmatrix} \hat{\lambda}_{f,t} \\ \epsilon_{f,t} \\ x_{f,t} \end{pmatrix} = \begin{bmatrix} \rho_f & \eta_f & 0 \\ 0 & 0 & 0 \\ 0 & \theta_f^2 & \theta_f^1 \end{bmatrix} \begin{pmatrix} \hat{\lambda}_{f,t-1} \\ \epsilon_{f,t-1} \\ x_{f,t-1} \end{pmatrix} + \begin{pmatrix} \hat{\varphi}_{ft} \\ \hat{\varphi}_{ft} \\ \theta_f^0 \hat{\varphi}_{ft} \end{pmatrix}.$$

We model $\hat{\upsilon}_t$, $\hat{\zeta}_t$, $\hat{\epsilon}_t$ and the dx_t's corresponding to ξ_t and θ_t in the same way. Because at time t, $\hat{\sigma}_{t-1}$, enters the model (see (2.3)), and because of the nature of the computational methods we use to solve the model, we find it convenient to handle $\hat{\sigma}_t$ somewhat differently. In particular,

$$\begin{pmatrix} \hat{\sigma}_t \\ \hat{\sigma}_{t-1} \\ x_{\sigma,t} \end{pmatrix} = \begin{bmatrix} \rho_\sigma & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \theta_\sigma^2 \end{bmatrix} \begin{pmatrix} \hat{\sigma}_{t-1} \\ \hat{\sigma}_{t-2} \\ x_{\sigma,t-1} \end{pmatrix} + \begin{pmatrix} \hat{\varphi}_{\sigma,t} \\ 0 \\ \theta_{\sigma\hat{\varphi}\sigma,t}^0 \end{pmatrix}.$$

We stack all our random variables into the 21 by 1 vector, Ψ_t, which evolves as follows:

$$\Psi_t = \rho\Psi_{t-1} + D\hat{\varphi}_t,$$

where ρ is 21 by 21 and D is 21 by 7.

2.9. Equilibrium and Model Solution

We adopt a standard sequence of markets equilibrium concept, and we use the method in Christiano (2003) to develop a linear approximation to the equilibrium quantities and prices. The solution is a set of matrices, A, B_1 and B_2, and a core set of 23 endogenous variables contained in the vector, $\tilde{z}_t$, satisfying

$$\tilde{z}_t = A\tilde{z}_{t-1} + B_1\Psi_t + B_2\Psi_{t-1}.$$

Here, A is 23 by 23 and B_i are 23 by 21 for $i = 1, 2$. The vector, $\tilde{z}_t$, is defined in the appendix. Each element in $\tilde{z}_t$ is expressed as a percent deviation from a steady state value, so that, in nonstochastic steady state, $\tilde{z}_t = 0$. From the variables in $\tilde{z}_t$ and the various equilibrium relationships in the model, it is possible to compute any desired equilibrium variable. Suppose these are contained in the vector, X_t.After linearization, let the relationship of X_t to $\tilde{z}_t$ and Ψ_t be expressed as follows:

$$X_t = \alpha + \tau z_t + \tau^s\Psi_t + \bar{\tau} z_{t-1} + \bar{\tau}^s\Psi_{t-1}.$$

The set of variables of interest in our analysis is:

$$X_t = \begin{pmatrix} \log\left(\frac{\bar{N}_{t+1}}{P_t Y_t}\right) \\ \log(\pi_t) \\ \log(l_t) \\ R_t^b \\ \Delta \log(Y_t) \\ \log\left(\frac{W_t}{P_t Y_t}\right) \\ \log(\frac{I_t}{Y_t}) \\ \log(V_t^1) \\ \log(V_t) \\ \log(\frac{C_t}{Y_t}) \\ P_t^e \\ \log(d_t^c) \\ \log(d_t^r) \end{pmatrix}. \tag{2.16}$$

Here, V_t^1 and V_t are the time t velocity of $M1$ and the monetary base, respectively. Also, d_t^c and d_t^r represent currency to demand deposit ratio and the bank reserves to demand deposit ratio, respectively. Finally, P_t^e is the external finance premium.

3. Model Parameter Values

We divide the model parameters into two sets: (i) those that govern the evolution of the exogenous shocks and the monetary response to them, and (ii) the rest. We discuss the non-stochastic parameter values, (ii), first. We then estimated the parameters in (i) by a maximum likelihood method, conditional on (ii).

3.1. Parameters of Nonstochastic Part of Model

The non-stochastic model parameters are listed in Table 1, and various properties of the model's steady state are reported in Tables 2-4. In many cases, the corresponding sample averages for both US data from the 1920s and for the post war period are also reported. The parameters in Table 1 are grouped according to the sector to which they apply. We begin by discussing how the parameter values were selected. After reporting the parameter values we work with, we provide some indication about the resulting properties of the model. To a first approximation, the magnitudes in the model match those in the data reasonably well. The relative size of the banking sector, ratios such as consumption to output and various velocity measures roughly line up with their corresponding empirical counterparts.

3.1.1. Parameter Values

In selecting the parameter values, we were guided by two principles. First, for the analysis to be credible, we require that the degree of monetary non-neutrality in the model be empirically plausible. Because we have some confidence in estimates of the effects of monetary policy shocks in post-war data, we insist that the model be consistent with that evidence.[6] Our second guiding principle is that we want the model to be consistent with various standard ratios: capital output ratio, consumption output ratio, equity debt ratio, various velocity statistics, and so on. In one respect, we found that these two principles conflict. In particular, we found that to obtain a large liquidity effect, we required that the fraction of currency in the monetary base is higher than what is observed in the data. Because we assigned a higher weight to the first principle (and lack some confidence in the accuracy of our monetary data), we chose to go with the high currency to base ratio.

Our strategy for assigning values to the parameters requires numerically solving the model for alternative candidate parameter values. This requires first computing the model's nonstochastic steady state and then computing the model's approximate linear dynamics in a neighborhood about the steady state.[7] We found that, conditional on a specific set of values for the model parameters, computing the steady state is difficult. The reason is that this involves solving a system of equations which, as far as we can determine, has little recursive structure. A more convenient computational strategy was found by specifying some of the economically endogenous variables to be exogenous for purposes of the steady state calculations. In particular, we set the steady state ratio of currency to monetary base, m, the steady state rental rate of capital, r^k, the steady state share of capital and labor in goods production, ν, and the steady share of government consumption of goods, G/Y. These were set to $m = 0.95$, $r^k = 0.045$, $\nu = 0.01$, $G/Y = 0.07$, respectively. The latter two values can be defended on the basis of the data for the 1920s (see Table 2). Each of the former two are probably a little high. The currency to base ratio was already mentioned. The value of r^k, conditional on the share in goods production of capital (see α in Table 1) implies a slightly low value for the capital output ratio (see Table 2). We nevertheless chose this value for r^k because a lower one generated an excessively high value for the debt to equity ratio. To make

[6] The evidence on the effects of monetary policy shocks that we have in mind requires identification assumptions. These are that monetary policy shocks have no contemporaneous impact on aggregate measures of the price level or economic activity. This assumption holds as an approximation in our model. After a monetary policy shock, output and employment change a small amount because the frequency of bankruptcy is affected by the shock, and this affects the amount of goods used and produced in monitoring bankrupt entrepreneurs.

[7] Our intention is to eventually obtain higher order approximations to the model solution, using perturbation methods. However, we have so far taken the first step in this direction, by obtaining the linear approximation.

these four variables exogenous for purposes of computing the steady state required making four model parameters endogenous. For this purpose, we chose ψ_L, x^b, ξ and g. Details on how the steady state was computed appear in Appendix A below.

Consider the household sector first. The parameters, β, λ_w, σ_L and b were simply taken from ACEL. The values of σ_q and H'' were chosen to allow the model to produce a persistent liquidity effect after a policy shock to the monetary base. Numerical experiments suggest that setting $H'' > 0$ is crucial for this. A possible explanation is based on the sort of reasoning emphasized in the literature on limited participation models of money: $H'' > 0$ ensures that after an increase in the monetary base, the banking sector remains relatively liquid for several periods. Regarding the goods-producing sector, all but one of the parameters were taken from ACEL. The exception, ψ_k, was set to 0.7 in order to have greater symmetry with ψ_l (in ACEL, $\psi_k = 0$).

The Calvo price stickiness parameters, ξ_w and ξ_p imply that the amount of time between reoptimization for wages and prices is 1 year and 1/2 years, respectively. As noted in ACEL, these values are consistent with survey evidence on price frictions.

Our selection of parameter values for the entrepreneurial sector were based on the calibration discussion in BGG. Following them, we assume that the idiosyncratic shock to entrepreneurs, ω, has a log-normal distribution. We impose on our calibration that the number of bankruptcies corresponds roughly to the number observed in the data. In our calibration, $F(\bar{\omega})$ is 0.02, or 2 percent quarterly.[8] To understand how we were able to specify $F(\bar{\omega})$ exogenously, recall that the log-normal distribution has two parameters - the mean and variance of $\log \omega$. We set the mean of $\log \omega$ to zero. We are left with one degree of freedom, the variance of $\log \omega$. Conditional on the other parameters of the model, this can be set to ensure the exogenously set value of $F(\bar{\omega})$. The value of this variance is reported in Table 1.[9] As noted above, the two parameters of the banking sector were an output of the steady state calculations.

3.1.2. Steady State Properties of the Model

The implications of the model for various averages can be compared with the corresponding empirical quantities in Tables 2 - 4. For almost all cases, we have the empirical quantities that apply to the US economy in the 1920s. As a convenient benchmark, we also report the corresponding figures for the post-war US data.

[8] BGG assert that the annual bankruptcy rate is 3 percent. The number we work with, 2 percent quarterly, is higher. We encountered numerical difficulties using smaller bankruptcy rates. We intend to study smaller values of $F(\bar{\omega})$ in the future.

[9] The variance reported by BGG, 0.28, is higher than ours. We intend to explore the reasons for this discrepancy.

There are five things worth noting about Table 2. First, as noted above, the capital output ratio in the model is a little low. Corresponding to this, the investment to output ratio is low, and the consumption to output ratio is high. Second, note that $N/(\bar{K}-N)$ is slightly above unity in the model's steady state. This corresponds well with the data if we follow BGG in identifying N with equity and $N-\bar{K}$ with debt. Third, the relative size of the banking sector, which is quite small, conforms roughly with the size of the actual banking sector. Fourth, although we have not obtained data on the fraction of GDP used up in bankruptcy costs, we suspect that the relatively low number of 0.84 percent is not be far from the mark. Finally, note that inflation in the 1920s is very low, by comparison with inflation in the post-war period. We nevertheless imposed a relatively high inflation rate on the model in order to stay away from the zero lower bound on the interest rate.

Table 3 reports the consolidated asset and liability accounts for our banks. Several things are worth noting here. First, in the model most demand deposits are created in the process of extending working capital loans. These deposits are what we call 'firm demand deposits', and they 47 times larger than the quantity of demand deposits created when households deposits their financial assets with banks (i.e., 'household demand deposits'). It is hard to say whether this matches data or not. As is typical in a discrete-time framework, the model does not restrict exactly where the deposits sit during the period. For example, if firms pay their variable input costs early in the period, then what we call 'firm demand deposits' are actually in the hands of households most of the time. We do not have data on the relative holdings of deposits by households and firms for the 1920s, but we do have such data for the post-war period. These data indicate household and firm holdings of demand deposits are a similar order of magnitude. Again, it is hard to know what to make of this, relative to our model.

Second, the results in the table suggest that the amount of bank reserves in our model is too small. The second row of the table displays the ratio of reserves to a very narrow definition of bank assets: reserves plus working capital loans. Since working capital loans account for essentially all of bank demand deposits, and these are the only reservable liabilities of our banks, the entry corresponding to required reserves is basically our assumed reserve requirement. Note that the corresponding figure in the data is an order of magnitude higher. This suggests to us that the mismatch between reserves in our model and the reserves in the data does not necessarily reflect that reserves are too little in our model. More likely, we have not identified all the reservable liabilities of banks in the data.

Table 4 reports various monetary and interest rate statistics. The left set of columns shows that the basic orders of magnitude are right: base velocity and $M1$ velocity in the model and the data match up reasonably well with the data. The ratio of currency to demand deposits is also reasonable. However, the fraction of currency in the monetary base is high, for reasons noted above. The interest rate implications of the model could be improved.

3.1.3. A Monetary Policy Shock

Figure 4 compares the effects of a monetary policy shock with the corresponding estimates (and plus/minus two standard error bands) reported in ACEL.[10] The specification of monetary policy underlying the model results reported in Figure 4 is (2.14) with $i = 1$:

$$x_{1t} = \rho_1 x_{1,t-1} + \hat{\varphi}_{1t} + \theta_1^1 \hat{\varphi}_{1,t-1},$$

where $\sigma_{\hat{\varphi}}$ is the standard deviation of the policy shock. We use the parameter estimates reported in ACEL: $\rho_1 = 0.27$, $\theta_1^1 = 0$, $\sigma_{\hat{\varphi}} = 0.11$. To understand the magnitude of $\sigma_{\hat{\varphi}}$, recall from (2.14) that an innovation to x_{1t} is an innovation to $\hat{x}_t$, the percent change in the net growth rate of the base. Since the percent change in the monetary base is related to $\hat{x}_t$ by $(x/(1+x))\,\hat{x}_t$, it follows that a 0.11 shock to monetary policy corresponds to an immediate 0.11 percent shock to the monetary base. Given the specified value of ρ_1, this shock creates further increases in subsequent periods, with the base eventually being up permanently by 0.15 percent.[11]

Another way to understand the nature of the monetary policy shock is as follows. In the impact period, the monetary policy shock takes the form of an increase in the money growth rate, x_t, from its steady state value of 0.010 (4.1 percent per year) to 0.011 (4.5 percent per year). The growth rate then declines and is very nearly back to steady state within four quarters. With one caveat, this is ACEL's estimate of the nature of a monetary policy shock in the postwar period. The caveat is that ACEL measure the monetary policy shock in terms of its impact on $M2$, not the monetary base. [further discussion will appear in a later draft]

Consider first the model results, shown in the form of the solid line in Figure 4. The impact of the shock on the growth rate of $M1$ and on the growth rate of the base are

[10] The basic identification assumption in the ACEL analysis is that a monetary policy shock has no contemporaneous impact on the level of prices or measures of aggregate economic activity. This assumption holds as an approximation in our model. As we will see, there is a very small contemporaneous impact of a monetary policy shock on aggregate employment and output.

[11] To see this, use the fact

$$\frac{M_{t+1}}{M_t} = 1 + x_t,$$

so that the percent change in the growth rate of the base, $d\log(M_{t+1}/M_t)$, is:

$$d\log\frac{M_{t+1}}{M_t} \simeq \frac{dx_t}{1+x} = \frac{x\hat{x}_t}{1+x},$$

where the identity, $x\hat{x}_t = dx_t$ has been used. The 0.15 percent figure in the text reflects our assumption, $x = 0.10$, so that $x/(1+x) = 0.0099$. Then, the percent change in the base from a one standard deviation innovation in policy is $100 \times 0.0099 \times 0.10 \simeq 0.11$. The eventual impact on the level of the base, in percent terms, is obtained from the fact that this is $0.11/(1-\rho_1)$.

exhibited in the bottom left graph. Note how the growth rate of $M1$ hardly responds in the impact period of a monetary policy shock. This reflects that $M1$ is dominated by demand deposits created in the process of extending working capital loans to firms. The latter are largely predetermined in the period of a monetary policy shock.[12] In subsequent periods, as working capital loans expand, $M1$ starts to grow. The fact that the impact on the model's monetary base is similar to the initial response of $M2$, in the data holds by construction of the monetary policy shock. In the periods after the shock, all three money growth figures are close to each other in that each lies inside the gray area.

Note that, with some small exceptions, the responses of the model closely resemble the ones estimated in the data. In particular, the interest rate drops substantially in the period of the shock and stays low for over a year. Output displays a hump-shape with peak response of about 0.2 percent occurring after about a year. The same is true for investment, consumption and hours worked. Inflation displays a very slow response to the monetary policy shock, with peak response occurring around 7 quarters after the shock. Interestingly, inflation does not display the dip that occurs briefly in the data after a positive monetary policy shock. This contrasts with the results in ACEL, where the inflation rate of the model follows the estimated inflation process closely, including the dip. The reason this happens in the ACEL model is that in that model the interest rate that enters marginal costs of price-setting firms, is the one that appears in the top right figure, and which drops so significantly in the aftermath of a positive monetary policy shock. In contrast, the federal funds rate in our model does not directly enter marginal costs. Instead, it is the loan rate on working capital loans, R_t, which enters. As it happens (see below), the fall in this interest rate after a positive monetary policy shock is very small.

There are two places where the model misses. First, the empirical evidence in Figure 4 suggests that real wages rise after a monetary policy shock, while the impact in the model is only slight. Second, velocity in the data displays a substantial drop, while we do not see this in the model's $M1$ velocity. Base velocity performs somewhat better in the impact period.[13] This discrepancy between base velocity and $M1$ velocity in the model in the impact period of a shock reflects the observations made above, that the base responds immediately to a shock, while $M1$ responds hardly at all.

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[12] Actually, there is a tiny fall in $M1$. This reflects that there is a similarly small fall in working capital loans. This in turn reflects a slight decline in the labor for two reasons. First, the abundance of excess reserves allows banks to substitute away from labor to some extent. Second, the reduction in bankruptcies that the money injection causes results in a lower demand for goods to cover bankruptcy costs. We stress that both these effects are very small and, to a first approximation, are zero.

[13] We define base velocity as $Y_t P_t / M_{t+1}^b$, i.e., relative to the end of period base. This corresponds to the measurement in the data, where stocks like money are generally measured in end-of-period terms.

Overall, the results in Figure 4 is consistent with the notion that the degree of non-neutrality in the model is empirically plausible. The variables described above as well as other variables in the model are displayed in Figure 5. Rates of return in that figure are reported at an annual rate, in percentage point terms (not basis points). Quantities like investment, i, consumption, c, the physical stock of capital, $kbar$, the real wage rate, w, and output are presented in percent deviations from their unshocked, steady state growth path.

Several things are worth noting in this figure. First, all but one of the interest rates react the way the Federal Funds rate is estimated to react. Each drops by about 50 basis points. The exception is the rate on working capital loans, R, which falls by less than one basis point. Second, the monetary injection has an interesting set of implications for entrepreneurs. It drives up the price of capital, q, which creates an immediate capital gain for owners of capital. This can be seen in the large initial rise in the rate of return to capital, R^k. The unexpected jump in R^k is the reason for the three percent jump in entrepreneurial net worth, n. The increase in purchases of capital spurs the rise in investment. At the same time, in spite of the rise in net worth, bank lending to entrepreneurs drops (a little) relative to total bank assets. This is because the prospective capital losses on capital as q returns to its steady state makes the return on capital after the initial period low. This fall in the return to capital exceeds the fall in the time deposit interest rate, and by itself would produce a fall in lending.[14] Finally, note the small rise in TFP.

3.2. Parameters of Exogenous Stochastic Processes

We describe our estimation strategy first. We then display the results.

3.2.1. Estimation Strategy

We estimate the parameters governing the stochastic processes using empirical measurements on the elements of X_t, as defined in (2.16). We use quarterly data covering the period 1923I-1939IV. We follow the standard state-observer setup in supposing that the measured data corresponds to X_t plus a measurement error that is independently distributed over time and across variables. We interpret this measurement error as some combination of actual measurement error and model specification error. We then estimate the unknown parameters using a standard maximum likelihood procedure.

For convenience, we describe our system using the notation in Hamilton (1994, chapter

[14]BGG show that, in this environment, loans as a fraction of entrepreneurial net worth are an increasing function of the ratio of the return on captial to the interest rate on time deposits.

13). Let the state vector, ξ_t, be:

$$\xi_t = \begin{pmatrix} \tilde{z}_t \\ \tilde{z}_{t-1} \\ \Psi_t \\ \Psi_{t-1} \end{pmatrix}.$$

Then, the state equation is:

$$\begin{pmatrix} \tilde{z}_{t+1} \\ \tilde{z}_t \\ \Psi_{t+1} \\ \Psi_t \end{pmatrix} = \begin{bmatrix} A & 0 & B_1\rho + B_2 & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & \rho & 0 \\ 0 & 0 & I & 0 \end{bmatrix} \begin{pmatrix} \tilde{z}_t \\ \tilde{z}_{t-1} \\ \Psi_t \\ \Psi_{t-1} \end{pmatrix} + \begin{pmatrix} B_1 D \\ 0 \\ D \\ 0 \end{pmatrix} \hat{\varphi}_{t+1},$$

or, in obvious, compact notation,

$$\xi_{t+1} = F\xi_t + v_{t+1}.$$

The observation equation is

$$y_t = H\xi_t + w_t,$$

where

$$H = \begin{bmatrix} \tau & \bar{\tau} & \hat{\tau}^s & \hat{\bar{\tau}}^s \end{bmatrix}.$$

Note that with this construction of H, we have $H\xi_t = X_t$. We interpret the 13 variables on which we have observations as y_t in the above system. The objects captured in the model are the variables in X_t.

To complete the description of the state space system, we must also specify the variance covariance matrices of v_t and the measurement error, w_t. We suppose that both these objects are *iid*. In addition, we suppose that w_t is orthogonal to y_t and ξ_t at all leads and lags. The variance covariance matrix of w_t is R. The variance covariance matrix of v_t has some structure in our setting:

$$Ev_t v_t' = E \begin{pmatrix} B_1 D\hat{\varphi}_{t+1} \\ 0 \\ D\hat{\varphi}_{t+1} \\ 0 \end{pmatrix} \begin{pmatrix} \hat{\varphi}_{t+1}' D' B_1' & 0 & \hat{\varphi}_{t+1}' D' & 0 \end{pmatrix} = \begin{bmatrix} B_1 D V_\varepsilon D' B_1' & 0 & B_1 D V_\varepsilon D' & 0 \\ 0 & 0 & 0 & 0 \\ D V_\varepsilon D' B_1' & 0 & D V_\varepsilon D' & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}.$$

So, the 'free' parameters in the variance covariance matrix of v_t are the ones in V_ε. Our system is completely characterized by (F, H, R, V_ε). We think of F and H as being functions of the parameters governing the exogenous shocks, which we wish to estimate. Denote these by the vector, β. There is obviously a mapping from β (and the other model parameters, which we here hold fixed) to F, H. So, we can also think of the system as being characterized by $(\beta, R, V_\varepsilon)$. We choose these parameters to maximize the Gaussian density function, as discussed in Hamilton (1994, section 13.4).

3.2.2. Estimation Results

A revealing way to display the estimation results is to graph $E(X_t|\Omega)$, for t corresponding to 1923I to 1939IV. Here, Ω corresponds to the actual data set, y_t for t corresponding to 1923I to 1939IV. We compute $E(X_t|\Omega)$ using the two-sided Kalman smoothing algorithm (see, e.g., Hamilton (1994, chapter 1994)) and the estimated model parameter values. Figure 6 graphs each of the 13 elements of y_t and the associated $E(X_t|\Omega)$. Note how the latter is generally smoother than the measured data. This is to be expected, given the smoothing properties of expectations. Note, too, that the estimated and smoothed results are similar. However, it is important to emphasize that before graphing the results, we have adjusted the mean values of the variables. The transformation of the variables is somewhat difficult to interpret. For this reason, we also report the analog of Figure 6 for the levels of variables. Note how in some cases, the match between X_t implied by the model and the data is so close that the two lines literally coincide. This is the case for the policy rate, $R_{b,t}$, and log, hours worked. In the case of some data, such at the premium, the match is simply extremely close.

Figure 8 presents $E(\Psi_t|\Omega)$ for the 7 shocks. Note how the market power of intermediate good firms, $\lambda_{f,t}$, comes down starting in 1929, and stays low in the 1930s. Also, the banking reserve demand shock, ξ_t, drops in 1933-1934, indicating a rise in the demand for excess reserves. By 1937, this quantity is back up to where it was before, if not a bit higher (actually, the shock has gone into the infeasible range, by exceeding unity). The parameter, θ_t drops a lot from 1929 until 1934. This helps the model account for the rise in the currency to deposit ratio. The labor supply parameter, ζ_t, rises in the 1930s. The estimates of ξ_t and $\lambda_{f,t}$ is consistent with the analysis of Cole and Ohanian, among others, who argue that the National Recovery Act helped increase the market power of labor suppliers relative to labor demanders. Note that the technology shock fluctuates very little, suggesting that it plays essentially no role in aggregate dynamics in this period. Finally, the parameter, σ_t, rises sharply in 1933, at roughly the same time as the rise in the premium.

Overall, this model appears to fit the data reasonably well. That is, together with the estimated shocks, the model provides a quantitatively accurate description of the course of the Great Depression.

4. Analysis of the Great Depression

Here, we will report the results of simulations in which $M1$ is held constant through the 1930s, to see if this would have made the Great Depression much less severe. Our interpretation of the Friedman and Schwartz hypothesis is that this policy would have averted the worst of the Great Depression.

5. Conclusion

6. Appendix A: Vector of Core Variables in Model Solution

The model solution strategy was described in section 2.9. That involves a set of core endogenous variables, $\tilde{z}_t$. We describe the variables in this this 23 by 1 vector here:

$$\tilde{z}_t = \begin{pmatrix} \hat{\pi}_t \\ \hat{s}_t \\ \hat{r}_t^k \\ \hat{\imath}_t \\ \hat{u}_t \\ \hat{\bar{\omega}}_t \\ \hat{R}_t^k \\ \hat{n}_{t+1} \\ \hat{q}_t \\ \hat{\nu}_t \\ \hat{e}_{\nu,t} \\ \hat{m}_t^b \\ \hat{R}_t \\ \hat{u}_{c,t}^z \\ \hat{\lambda}_{z,t} \\ \hat{m}_t \\ \hat{R}_{a,t} \\ \hat{c}_t \\ \hat{w}_t \\ \hat{l}_t \\ \hat{\bar{k}}_{t+1} \\ \hat{R}_{t+1}^e \\ \hat{x}_t \end{pmatrix} \tag{6.1}$$

Here, and throughout this paper, a '$\hat{}$' over a variable indicates percent deviation from nonstochatic steady state. Most of the variables in $\tilde{z}_t$ have been defined before. One exception is real marginal cost for intermediate good producers:

$$s_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} \frac{\left(r_t^k \left[1 + \psi_k R_t\right]\right)^{\alpha} \left(w_t \left[1 + \psi_l R_t\right]\right)^{1-\alpha}}{\epsilon_t}. \tag{6.2}$$

In addition, we adopt the following scaling of variables:

$$\begin{aligned} w_t &= \frac{W_t}{z_t P_t},\ q_t = \frac{Q_{\bar{K}',t}}{P_t},\ n_{t+1} = \frac{\bar{N}_{t+1}}{P_t z_t},\ \bar{k}_{t+1} = \frac{\bar{K}_{t+1}}{z_t},\ m_t^b = \frac{M_t^b}{P_t z_t}, \\ m_t &= \frac{M_t}{M_t^b},\ c_t = \frac{C_t}{z_t},\ i_t = \frac{I_t}{z_t}, \end{aligned}$$

Finally, $e_{v,t}$ is the ratio of real excess reserves to value-added in the banking sector:

$$e_{v,t} = \frac{\frac{A_t + X_t - \tau_t \left(A_t + X_t + S_t^w\right)}{P_t}}{\left(z_t \left(1 - \nu_t\right) u_t \bar{k}_t / \mu_z\right)^{\alpha} \left(z_t \left(1 - \nu_t\right) l_t\right)^{1-\alpha}}$$

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Table 1: Model Parameters (Time unit of Model: quarterly)		
Panel A: Household Sector		
β	Discount rate	$1.03^{-0.25}$
ψ_L	Weight on Disutility of Labor	153.76
σ_L	Curvature on Disutility of Labor	1.00
υ	Weight on Utility of Money	2e-008
σ_q	Curvature on Utility of money	-10.00
θ	Power on Currency in Utility of money	0.75
H''	Curvature on Currency Adjustment Cost	500.00
b	Habit persistence parameter	0.63
ξ_w	Fraction of households that cannot reoptimize wage within a quarter	0.70
λ_w	Steady state markup, suppliers of labor	1.05
Panel B: Goods Producing Sector		
μ_z	Growth Rate of Technology (APR)	1.50
S''	Curvature on Investment Adjustment Cost	7.69
σ_a	Curvature on capital utilization cost function	0.01
ξ_p	Fraction of intermediate good firms that cannot reoptimize price within a quarter	0.50
ψ_k	Fraction of capital rental costs that must be financed	0.70
ψ_l	Fraction of wage bill that must be financed	1.00
δ	Depreciation rate on capital.	0.02
α	Share of income going to labor	0.36
λ_f	Steady state markup, intermediate good firms	1.20
Panel C: Entrepreneurs		
γ	Percent of Entrepreneurs Who Survive From One Quarter to the Next	97.00
μ	Fraction of Realized Profits Lost in Bankruptcy	0.120
$F(\bar{\omega})$	Percent of Businesses that go into Bankruptcy in a Quarter	0.80
$Var(log(\omega))$	Variance of (Normally distributed) log of idiosyncratic productivity parameter	0.08
Panel D: Banking Sector		
ξ	Power on Excess Reserves in Deposit Services Technology	0.9960
x^b	Constant In Front of Deposit Services Technology	82.4696
Panel E: Policy		
τ	Bank Reserve Requirement	0.100
τ^c	Tax Rate on Consumption	0.00
τ^k	Tax Rate on Capital Income	0.29
τ^l	Tax Rate on Labor Income	0.04
x	Growth Rate of Monetary Base (APR)	4.060

Table 2: Steady State Properties of the Model, Versus US Data			
Variable	Model	US, 1921-29	US, 1964-2001
$\frac{k}{y}$	8.35	10.8[1]	9.79
$\frac{i}{y}$	0.20	0.24	0.25
$\frac{c}{y}$	0.73	0.67	0.57
$\frac{g}{y}$	0.07	0.07	0.19
r^k	0.043		
$\frac{N}{K-N}$ ('Equity to Debt')	1.029	1-1.25[2]	1-1.25[2]
$\frac{W^e}{py}$	0.057		
Percent of Goods Output Lost to Bankruptcy	0.365%		
Percent of Aggregate Labor and Capital in Banking	1.00%	1%[3]	2.5%[5]
Inflation (APR)	2.52%	-0.6%[4]	4.27%[6]

Note: [1]End of 1929 stock of capital, divided by 1929 GNP, obtained from CKM. [2]Masoulis (1988) reports that the debt to equity ratio for US corporations averaged 0.5 - 0.75 in the period 1937-1984. [3]Share of value-added in the banking sector, according to Kuznets (1941), 1919-1938. [4]Average annual inflation, measured using the GNP deflator, over the period 1922-1929. [5]Based on analysis of data on the finance, insurance and real estate sectors [6] Average annual inflation measured using GNP deflator.

Table 3: Consolidated Banking Sector Balance Sheet, Model versus US Data							
Variable	Model	1921-1929	1995-2001	Variable	Model	1921-1929	1995-2001
Assets (Fraction of Annual GNP)	1.269	0.722	0.604	Liabilities (Fraction of Annual GNP)	1.269		0.604
Total Reserves	0.103	0.152	0.081	Total Demand Deposits	1.000	1.0	1.0
∘ Required Reserves	0.100	0.118	0.052	∘ Firm Demand Deposits	0.897		0.523
∘ Excess Reserves	0.003	0.034	0.029	∘ Household Demand Deposits	0.103		0.477
Working Capital Loans	0.897	0.848	0.919				
∘ Capital Rental Expenses	0.254						
∘ Wage Bill Expenses	0.643						
Entrepreneurial Loans	0.803	0.525	0.828	Time Deposits	0.803	0.525	0.828

Notes on Table 3: Total assets consists of reserves plus working capital loans plus loans to entrepreneurs. The first line shows the ratio of these to annual goods output. With the exception of the bottom row of numbers, remaining entries in the table are expressed as a fraction of bank reserves plus working capital loans. The bottom row of numbers is expressed as a fraction of total assets.

Data for the period 1995-2001: we define working-capital loans as total demand deposits minus total reserves. This number is the same order of magnitude as the sum of short-term bank loans with maturity 24 months or less (taken from the Fed's 'Banking and Monetary Statistics') and commerical paper (Table L101 in Flow of Funds) Long-term entrepreneurial loans are defined as the total liabilities of the non-financial business sector (non-farm non-financial corporate business plus non-farm non-corporate business plus farm business) net of municipal securities, trade payables, taxes payables, 'miscellaneous liabilites' and the working capital loans. Source: With exception of required and excess reserves, the source is the Federal Reserves' Flow of Funds' data. Required and excess reserves are obtained from Federal Reserve Bank of St. Louis.

Data for the period 1921-1929: we define working-capital loans as total demand deposits minus total reserves for all banks. Entrepreneurial loans are constructed on the basis of all bank loans minus working capital loans plus outstanding bonds issued by all industries. Source: Banking and Monetary Statistics, Board of Governorns, September 1943, and NBER Historical Database.

Table 4: Money and Interest Rates, Model versus US Data							
Money	Model	1921-1929	1964-2002	Interest Rates (APR)	Model	1921-1929	1964-2002
Monetary Base Velocity	10.29	12	16.6	Demand Deposits	0.44		3.21
M1 Velocity	4.01	3.5	6.5	Time Deposits	7.18		6.96
				Rate of Return on Capital	9.47		17.33
Currency / Demand Deposits	0.29	0.2	0.3	Entrepeneurial Standard Debt Contract	7.85	5.74	8.95
Currency / Monetary Base	0.75	0.55	0.73	Interest Rate on Working Capital Loans	4.66	4.72	7.10
Curr. / Household D. Deposit	2.81			Federal Funds Rate	5.12	3.90	6.86

Notes to Table 4:

Data for 1921-1929: (1) 'Federal Funds Rate' is the average of Bankers' Acceptances Rate. (2) Interest rate on working capital loans is the commerical paper rate. (3) Rate on loans to entrepreneurs is the average between AAA and BAA corporate bonds. (4) Rate on time deposits is available only from 1933 onwards. Reported data in Board of Governors (1943) only cite the administrative rate (maximum rate) set by the Fed. The average of this rate was 2.7% over the period 1933-41. (5) There are no data available on the rate paid on demand deposits (to our knowledge).

Data for 1964-2002:

(1) The Federal Funds Rate is over the period 1964.3-2002.3. Source: Federal Reserve Board of Governors. (2) The rate on demand deposits is the 'Money Zero Maturity Own Rate' (1964.3-2002.3). Source: Federal Reserve Bank of Saint Louis. (3) The rate on loans to entrepreneurs is the average between AAA and BAA corporate bonds (1964.3-2002.3). Source: Federal Reserve Board of Governors. (4) The rate on time deposit is the rate on 3-month CDs (1964.3-2002.3). Source: Federal Reserve Board of Governors. (5) The rate of return on capital is the rate of profit on stockholders' equity for the manufacturing sector (1980.1-2001.4). Source: Bureau of the Census (2002), Table I. (6) The rate on Working Capital Loans is the rate on Commercial paper (dealer-placed unsecured short-term negotiable promissory note issued by companies with Aa bond ratings and sold to investors). Average over 1971.2-2002.3. Source: Federal Reserve Board of Governors. (7) The Currency to M1 ratio is an average over 1964.3-2002.3 (currency includes dollars held abroad). Source: Federal Reserve Bank of Saint Louis. (8) The Currency to Monetary Base ratio is the average over 1964.3-2002.3 (currency includes dollars held abroad). Source: Federal Reserve Bank of Saint Louis. (9) The Monetary Base and M1 velocities are averages over 1964.3-2002.3 (currency includes dollars held abroad). Source: Federal Reserve Bank of Saint Louis.

Figure 1: Timing in the Model

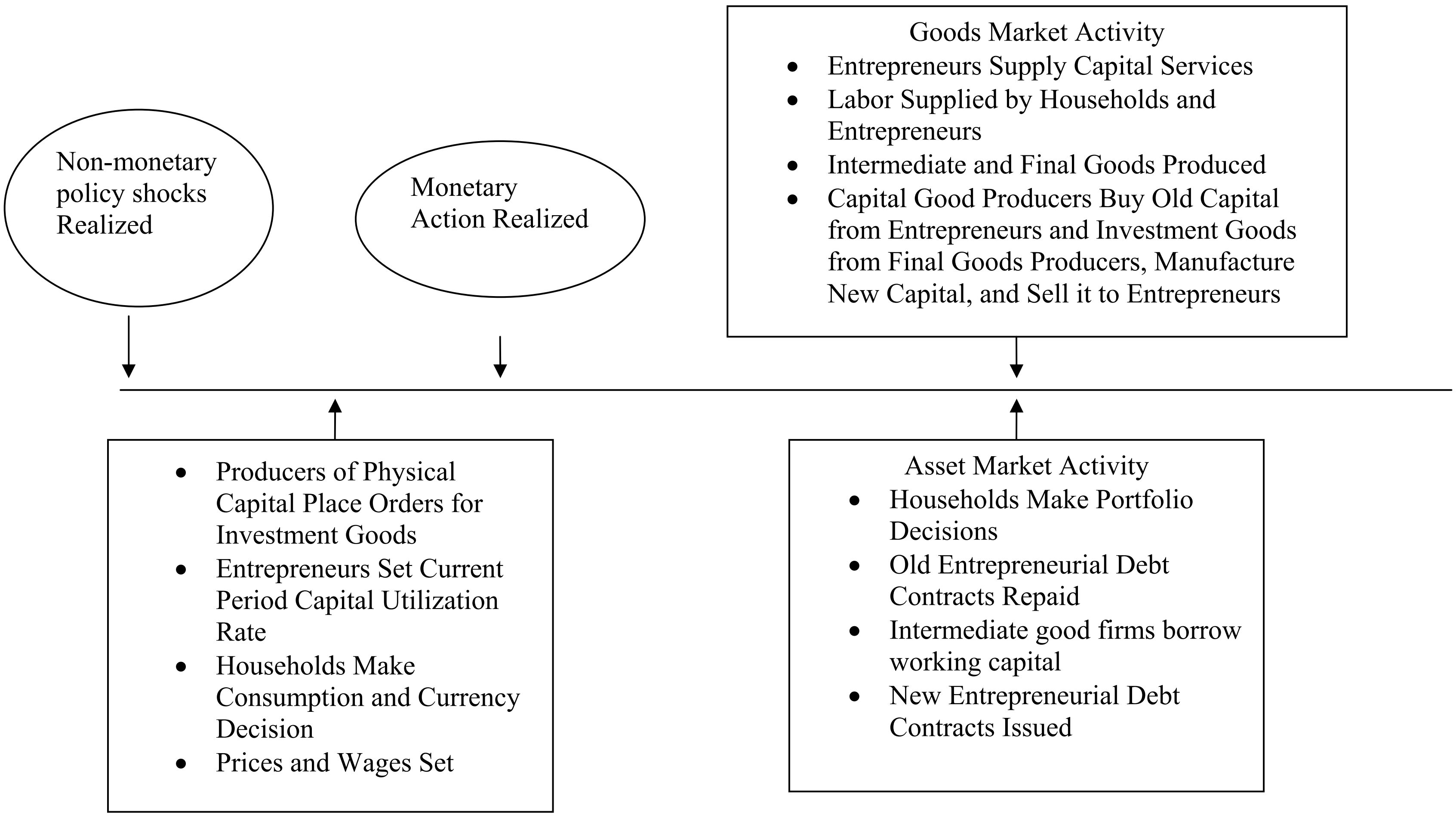
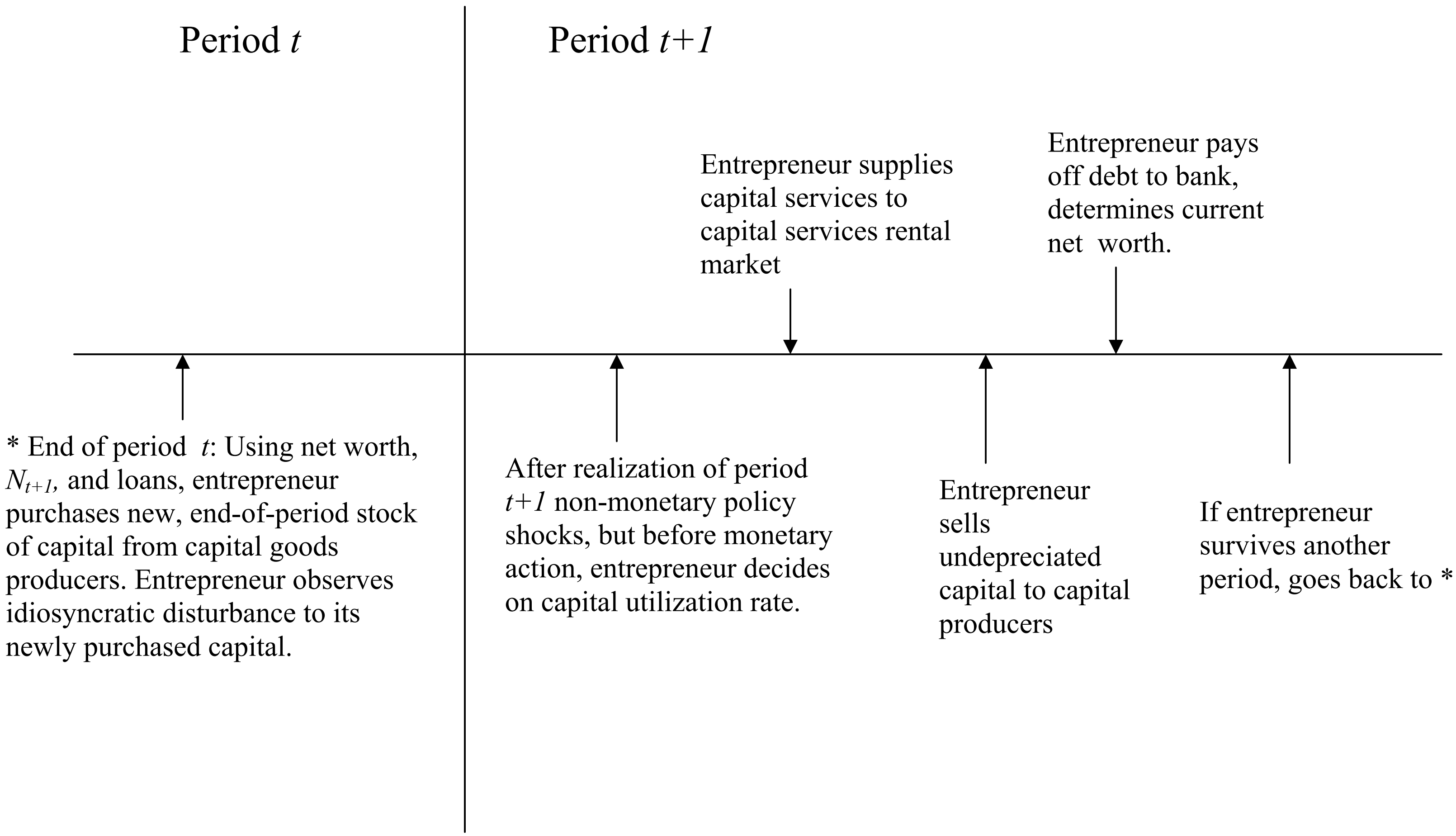


FIGURE 2: A Day in the Life of an Entrepreneur



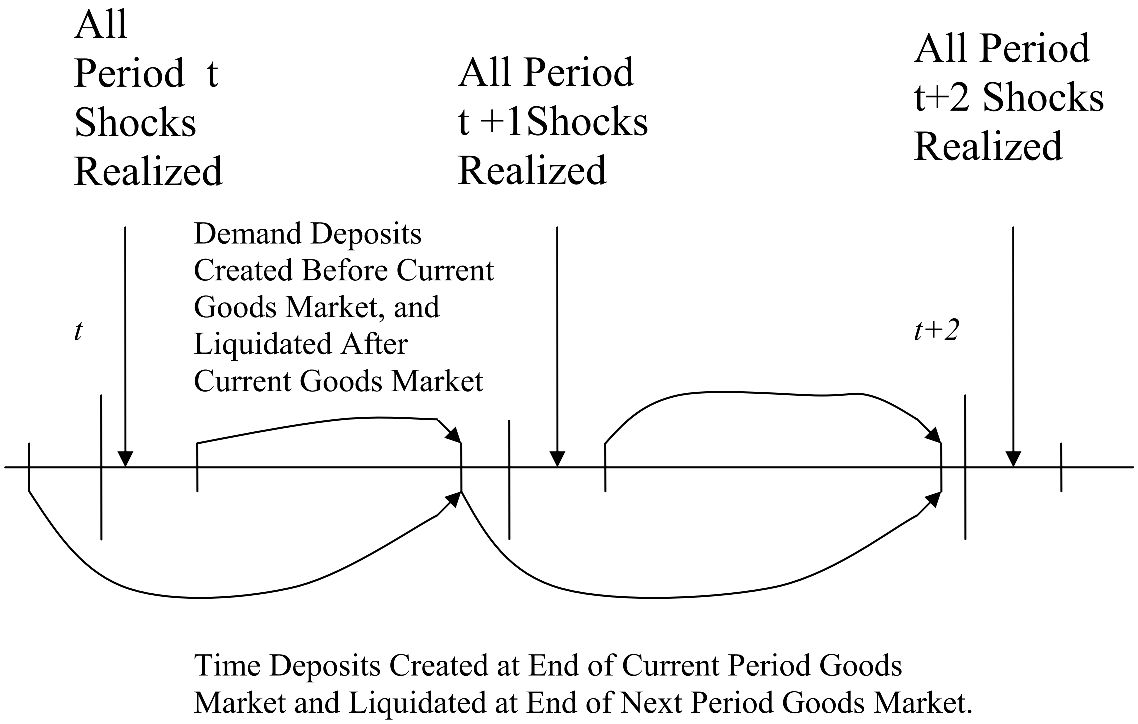


Figure 3: Maturity Structure of Time and Demand Deposits

Figure 4: Response, Policy Shock to Base (VAR: +, Model: Solid)

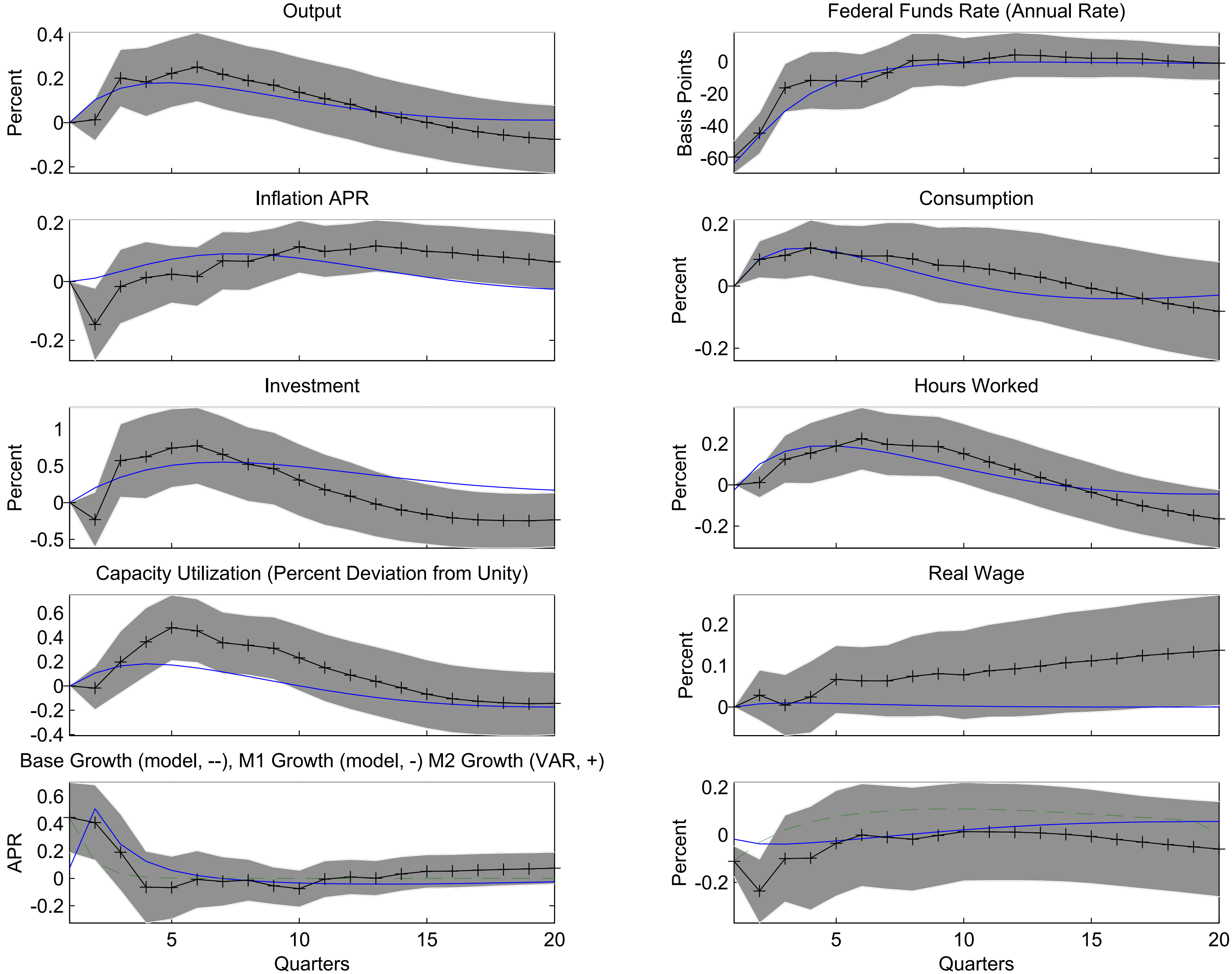


Figure 5: Monetary policy shock

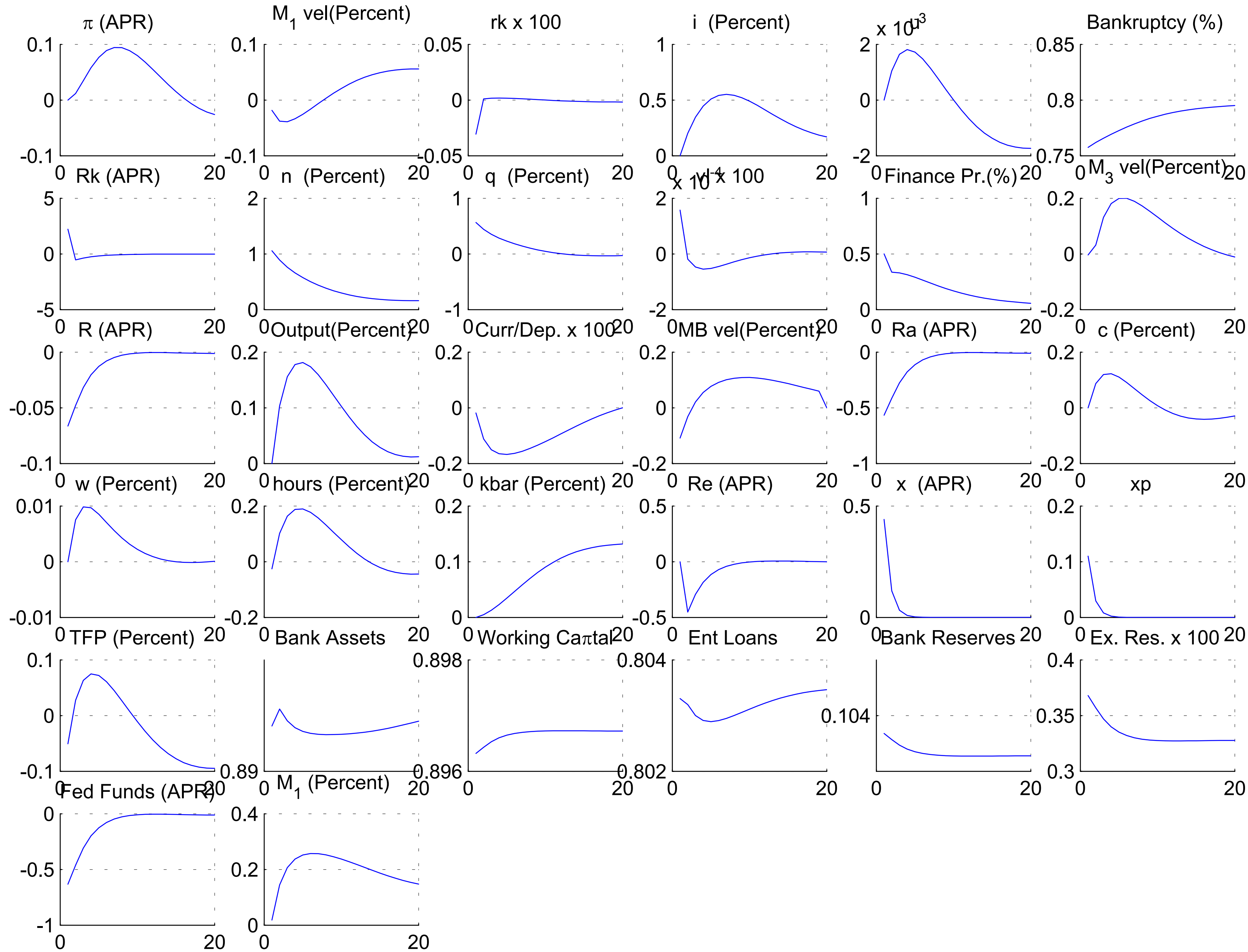


Figure 6: Measured X Versus Model X, Data (-), Smoothed Estimate (..)

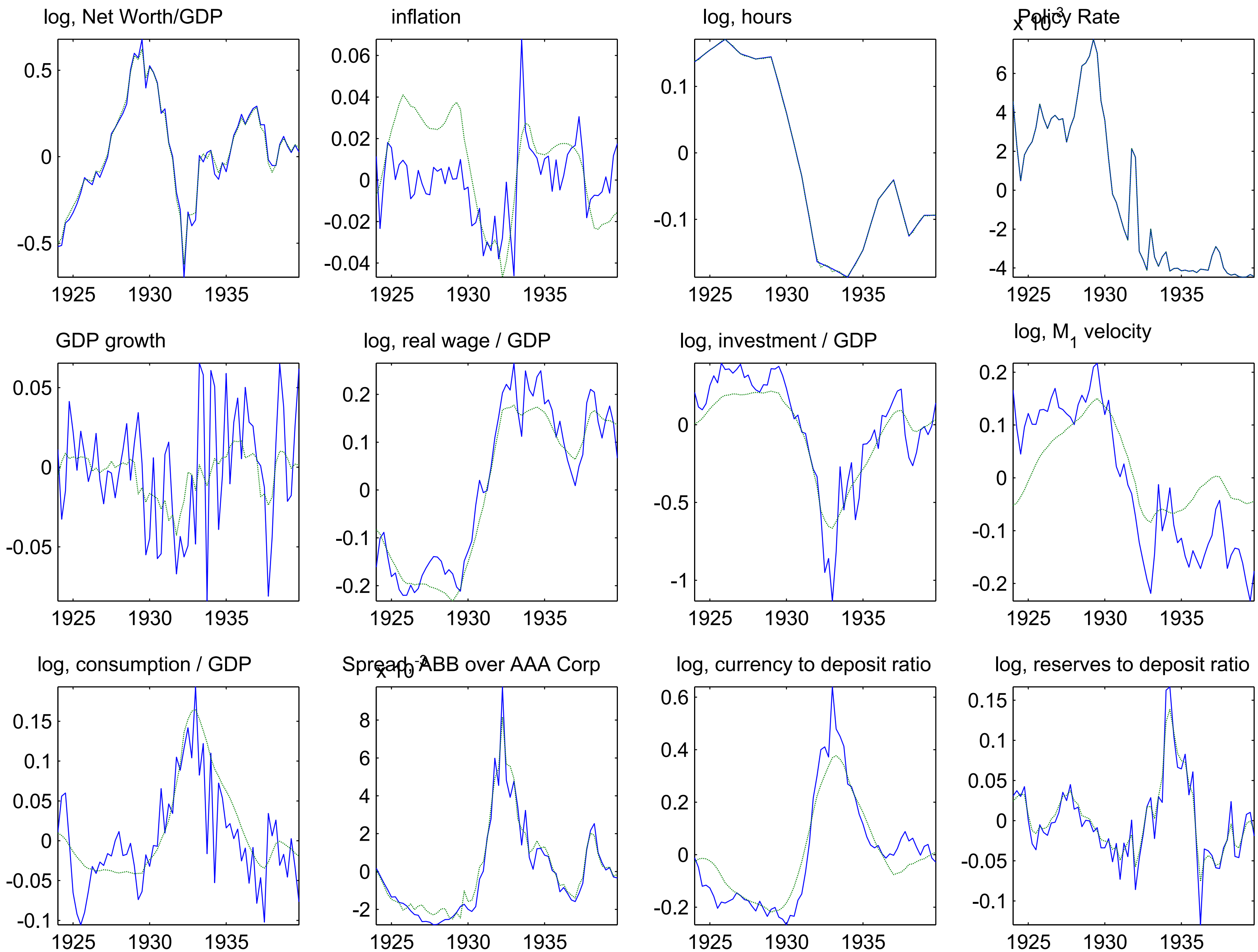


Figure 7: Variables in Levels, Data (-), Kalman Smoothed (--)

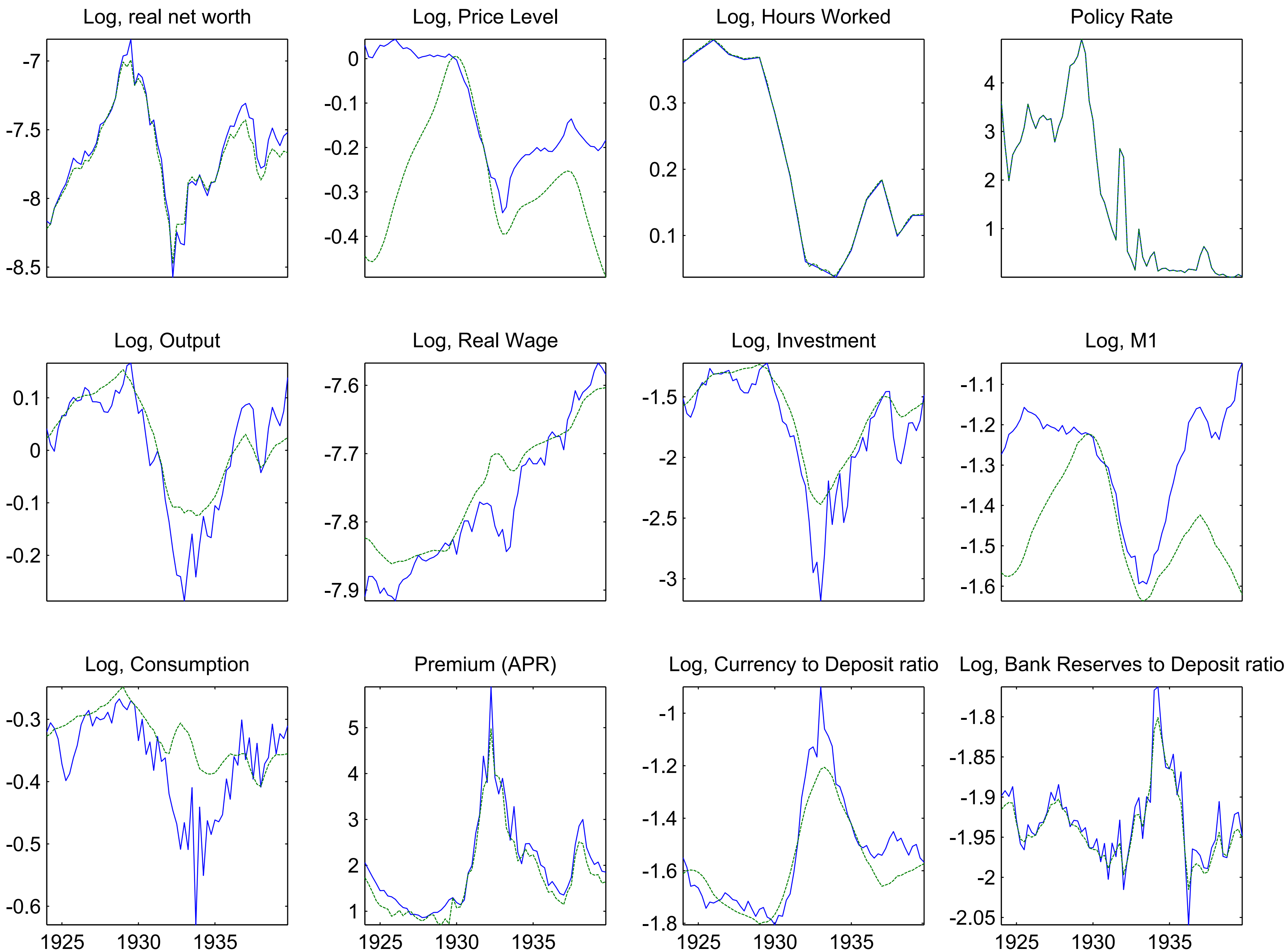


Figure 8: Estimated Value of Shocks