The real effects of financial disruptions in a monetary economy

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ABSTRACT

A large literature in macroeconomics concludes that disruptions in financial markets have large negative effects on output and (un)employment. Though diverse, papers in this literature share a common characteristic: they all employ frameworks where money is not explicitly modeled. This paper argues that the omission of money may hinder a model's ability to evaluate the real effects of financial shocks, since it deprives agents of a payment instrument that they *could* have used to cope with the resulting liquidity disruption. In a carefully calibrated New-Monetarist model with frictional labor, product, and financial markets, we show that the existence of money dampens or even nearly eliminates the real impact of financial shocks, depending on the nature of the shock. We also show that the propagation of financial shocks to the real economy depends on the inflation level: high inflation regimes magnify the real effects of adverse financial shocks.

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1 Introduction

There is a large literature in macroeconomics studying the effects of financial turbulence on the real economy (Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Wasmer and Weil, 2004). Many papers in this literature reach the conclusion that disruptions in financial markets have large negative effects on output and employment (Jermann and Quadrini, 2012; Christiano, Motto, and Rostagno, 2014; Petrosky-Nadeau, 2014). Another common thread running through most of these papers is that they employ frameworks where money is not explicitly modeled. However, the absence of money may limit the models' ability to accurately capture the real effects of financial disruptions, for at least two reasons. First, it may overstate the impact of financial turmoil on real variables, since it deprives agents of a payment instrument that they *could* have used to cope with the resulting liquidity disruption. Second, a moneyless model does not allow the study of real-financial linkages under different inflation regimes, a subject that has recently become topical and of policy interest.

In this paper, we revisit the effects of financial shocks on the real economy within the context of a model where money plays an essential role. Specifically, we build a New Monetarist model with frictional labor, product, and financial markets. As is typical in these models, a medium of exchange (or collateral) is necessary for transactions in the product market. This role is played by fiat money and corporate bonds that are issued by firms to cover their recruiting and operating expenses. As a result, the liquidity services of corporate bonds are reflected in their price, which affects firms' borrowing costs, entry decisions, and, ultimately, output and unemployment. In this environment, we find that the existence of money dampens or even nearly eliminates the real impact of financial shocks, depending on the nature of the shock. The reason behind this result is the agents' ability to increase their money holdings and *substitute* the liquidity foregone due to the financial disruption. Hence, working with a moneyless model does not come without loss of generality. We also show that the size of the transmission mechanism between financial shocks and the real economy depends on the inflation level, which further highlights the importance of explicitly modeling money.

Moving on to a more detailed description of the environment, we employ the model of Berentsen, Menzio, and Wright (2011), extended to include issuance of corporate bonds with a liquidity role. Firms face costs to enter the labor market (recruiting costs), as well as additional expenses in order to engage in production (operating costs). These costs are covered by selling corporate bonds that firms issue with the assistance of financial underwriters. Unemployed workers and firms search for counterparties in a

Diamond-Mortensen-Pissarides (Diamond, 1982; Mortensen and Pissarides, 1994) labor market. The firms that have been successful in recruiting a worker produce a special good that they sell in a decentralized goods market where, due to standard frictions (such as anonymity and imperfect commitment), exchange needs to be facilitated by assets, as in Lagos and Wright (2005).

As we have already mentioned, in our model corporate bonds serve alongside money as media of exchange or collateral. Varying the pledgeability/acceptability of bonds in the decentralized market is our *first* way of capturing the notion of "disruptions in financial markets"; we dub this the "liquidity shock". The *second* way of capturing financial disruptions is by shocking the ability of firms to meet underwriters and issue corporate bonds; we dub this the "funding shock". These two financial shocks represent disruptions to "market" and "funding" liquidity, echoing the concepts introduced in the seminal work Brunnermeier and Pedersen (2009). Both types of financial disruptions affect real variables through two channels: i) the *asset price channel*, which refers to the lower ability of firms to raise funds when the liquidity premium of corporate bonds decreases, and ii) the *portfolio channel*, which lowers firms' product market revenue due to the reduced effective liquidity of consumers.

To highlight the role of money for the transmission of financial shocks in a transparent manner, we compare the propagation of the aforementioned shocks in the baseline model to an economy without money. An economy without money is attained by setting the pledgeability of money to zero, which makes this version of our model comparable to the moneyless models in the existing literature. The quantitative analysis of the paper consists of four steps: first, we calibrate the baseline economy with money to salient features of US data. Second, we follow the accounting procedure of Jermann and Quadrini (2012) to measure liquidity and funding shocks in the data. Third, we use the empirical estimates of the shocks to study the effects of unanticipated liquidity and funding shocks on real variables, as well as the role of money and inflation in the transmission of financial shocks. Finally, we feed the whole series of the estimated financial shocks in the model and simulate time series for output, unemployment, and sales. By comparing the model-generated time series with the actual data, we evaluate the model's performance and gauge the importance of financial shocks to account for the observed behavior of real economic variables over time.

We find that the real effects of financial disruptions are much smaller in the baseline model with money than those in the moneyless benchmark. This is precisely due to *asset substitution*: in the economy with money, agents can substitute away from bonds and into money to mitigate the negative impact of an adverse financial shock. This is especially true for liquidity shocks, since they directly affect the pleadgeability of corporate bonds. To give a quantitative sense, the increase of unemployment in the model with money is only 10% of the increase found in the moneyless model after an adverse liquidity shock of equal magnitude; similarly, the drop of output in the model with money is 24% of the drop found in the moneyless benchmark. Funding shocks, however, affect firms' ability to secure financing altogether and, as a result, hinder firms' capacity to hire and retain workers. Consequently, the mitigating impact of asset substitution is bound to be smaller, since this channel cannot alleviate the resulting increase in job separations and forgone job creation. In terms of magnitudes, the increase of unemployment in the model with money is 7% lower than that found in the moneyless model after a negative funding shock; the drop of output in the model with money is 9% lower than the drop found in the moneyless benchmark.

Our second main result is that the real effects of financial shocks depend on the level of inflation. Intuitively, when inflation is high, the cost of holding money is also high, which, in turn, makes the substitution away from assets and into money harder when financial shocks occur. As a result, the higher inflation is, the stronger the effects of financial shocks on the real side of the economy. For example, we find that a negative liquidity shock of the same magnitude would raise unemployment twelve times more under an annual inflation of 10% than it would under an annual inflation of 1%. Similarly, output drops by four times as much when inflation is 10% than when it is 1%. It is important to highlight that carrying out exercises of this nature would be impossible in a model without money.

In the last part of our quantitative exercise, we investigate the importance of financial shocks for explaining the observed time series for GDP, unemployment, and sales. We show that the monetary economy does better in replicating the empirical patterns for all three series, especially for sales. This result testifies to the external validity of our model since the empirical GDP series was not included in the data used to back out financial shocks in our accounting exercise. Moreover, we show that liquidity shocks alone can explain a large fraction of the variation in GDP, which shows that liquidity shocks have important macroeconomic effects. Also, we find that the difference between the series of GDP and unemployment generated by the monetary and the moneyless model is not trivial. Finally, since the asset substitution channel is missing in the model without money, the responses of that model can be interpreted as our counterfactual estimates of the impact of financial shocks when the liquidity buffer provided by money is absent. Our results suggest that in the absence of this buffer, the financial recessions in 2001 and 2008 would have been even more severe: the unemployment rate would have increased by an additional 0.2-0.4 percentage points and GDP would have dropped by an additional 0.6-0.8 percentage points.

Our model features a key theoretical mechanism, the portfolio substitution between money and bonds, and delivers testable implications: financial shocks induce agents to seek increased money holdings, and they have stronger real effects at higher inflation levels. As part of our quantitative analysis, we provide empirical evidence for both. First, we use aggregate data to document that during the financial crises of 2001 and 2009 money holdings indeed increased both as a fraction of GDP and as a fraction of financial assets.[1] Second, we follow the approach of Jordà, Schularick, and Taylor (2013) and provide empirical evidence that the real effects of financial shocks are stronger under higher inflation regimes. Using a cross-country panel dataset from 14 advanced economies from 1870 to 2008, we confirm that GDP drops more and unemployment rises more when anticipated inflation is higher at the onset of a financial crisis.

Our results highlight the importance of liquidity substitution for a complete understanding of the connection between real and financial variables. Through the lens of our model, financial crises can be mitigated as long as there is no binding scarcity of liquid assets. Even if agents routinely rely on bonds for payments, what matters is to be able to substitute this liquidity with something else when needed. In our model, agents achieve this with money. In this sense, the macroprudential prescription of our model is close to what central banks actually do in times of financial turmoil: flood the balance sheets of market participants with liquid assets to ensure that there is no liquidity scarcity in the system. Our analysis implies that those financial shocks that do result in deep recessions are those in which liquidity dries up so severely that agents cannot quickly substitute into different asset classes. This discussion highlights another policy-relevant message of our paper: high inflation regimes, like the ones many developed economies have recently experienced, raise the likelihood of a financial *shock* turning into a severe financial *crisis*.

1.1 Related Literature

A central ingredient of our analysis is that firms need to issue corporate bonds in order to finance production and worker recruitment. We choose to focus on this aspect of corporate financing, because issuing bonds is one of the main avenues firms have to cover

[1] Our finding is also in line with recent micro evidence from investor portfolios provided by Gabaix, Koijen, Mainardi, Oh, and Yogo (2023). The authors show that portfolio flows toward risky assets fall, while portfolio flows towards money increase during times of financial turmoil. As they explain, money is both a safe financial asset and a liquidity buffer used to smooth liquidity shocks, similar to the money-bond substitution margin in our model.

their borrowing needs. The corporate bond market has almost tripled in size since 2008 (reaching 20% of nominal GDP in 2019; see Kaplan et al. 2019 and Bochner, Wei, and Yang 2020), which indicates that firms rely heavily on bond issuance as a source of funding for new projects and job creation.[2] Moreover, the finance literature has documented that liquidity considerations are of first order importance for explaining corporate bond yields (Bao, Pan, and Wang, 2011; Lin, Wang, and Wu, 2011; He and Milbradt, 2014; d'Avernas, 2018). For these reasons, the issuance of corporate bonds and the careful consideration of their liquidity aspects are at the core of our analysis.

Our paper belongs to a growing body of work that extends the New Monetarist framework (see Lagos, Rocheteau, and Wright 2017 for a comprehensive review) to include a frictional labor market and study the effects of monetary and financial channels on equilibrium unemployment. The seminal paper in this strand of the literature is Berentsen et al. (2011), which we extend by adding issuance of (liquid) corporate bonds and different types of liquidity shocks. Other papers in this line of work include Rocheteau and Rodriguez-Lopez (2014), Bethune, Rocheteau, and Rupert (2015), Branch, Petrosky-Nadeau, and Rocheteau (2016), Dong and Xiao (2019), Jung and Pyun (2020), Branch and Silva (2021), Bethune and Rocheteau (2021), Lahcen, Baughman, Rabinovich, and van Buggenum (2022), and Gu, Jiang, and Wang (2023). The majority of these papers focus on the relationship between inflation and unemployment. To the best of our knowledge, this is the first paper to examine the real effects of financial shocks in a model where money is essential, and under different inflation regimes.

Our paper is also related to the recent New Monetarist literature that highlights the importance of liquidity for the determination of asset prices; see Geromichalos, Licari, and Suárez-Lledó (2007), Lagos (2011), Nosal and Rocheteau (2013), Andolfatto, Berentsen, and Waller (2014), Geromichalos and Simonovska (2014), Hu and Rocheteau (2015), and Lee (2020).[3] Moreover, since we perform a calibration and numerical analysis of the model, our paper is also linked to several New Monetarist papers with a quantitative focus. Examples include Chiu and Molico (2010), Aruoba and Schorfheide (2011), Aruoba, Waller, and Wright (2011), and Venkateswaran and Wright (2013). Finally, our work is related to the literature initiated by Duffie, Gârleanu, and Pedersen (2005), which studies how frictions in OTC markets affect asset prices and trade; examples include

[2] According to balance sheet data from the US Flow of Funds, in the last five years corporate bonds comprised 56% of the total liabilities (debt securities and loans) of non-financial corporate businesses.

[3] A more recent strand of this literature assumes that assets do not serve directly as means of payment or collateral, but they are indirectly liquid, as agents can sell them for cash in a secondary market. This approach is explored in several recent papers, such as Berentsen, Huber, and Marchesiani (2014), Mattesini and Nosal (2016), Geromichalos and Herrenbrueck (2016), and Madison (2019). Our "direct" liquidity approach can be thought of as a stand-in for the indirect liquidity specification.

Weill (2007, 2008), Lagos and Rocheteau (2009), Chang and Zhang (2015), Üslü (2019), and Gabrovski and Kospentaris (2021).

Our paper is conceptually related to recent work by Lagos and Zhang (2022) who highlight the importance of explicitly modeling money for macroeconomic outcomes. The authors show that the existence of money provides additional bargaining power to sellers of goods versus financial intermediaries, and that this channel is significant even when the share of monetary transactions in the economy is arbitrarily small. Our question is different, since we focus on the effects of financial disruptions on real economic variables, but our main message is very similar: moneyless models do not come without a loss of generality. Thus, we view our work as complementary to the papers studying real-financial linkages without explicitly modeling money, such as Monacelli, Quadrini, and Trigari (2011), Jermann and Quadrini (2012), Christiano et al. (2014), Petrosky-Nadeau (2014), Buera, Jaef, and Shin (2015), and Dong (2022).

The rest of the paper proceeds as follows. In Section 2, we describe the model environment, and, in Section 3, we analyze the equilibrium of the model. In Section 4, we describe and implement our calibration strategy. In Section 5, we perform the numerical exercises and provide quantitative results as well as empirical evidence in support of our main mechanism and key model prediction. Section 6 concludes the paper. In Appendix A, we present the equilibrium of the model out of steady state, while Appendix B provides details for the empirical evidence in Section 5.

2 The Model

Time is discrete and the horizon is infinite. There are two types of agents, firms and households. Households are infinitely lived and their measure is normalized to the unit; the measure of firms is determined by free entry. Each period consists of four sub-periods where different economic activities take place. In the first sub-period, a labor market à la Pissarides (2000) opens where firms search for workers. In the second sub-period, agents visit a decentralized goods market as in Kiyotaki and Wright (1993), where frictions, such as anonymity and imperfect commitment, make a medium of exchange necessary. In the third sub-period, firms visit a financial market where they seek the assistance and expertise of financial institutions (or underwriters) in order to issue corporate bonds, in the spirit of Wasmer and Weil (2004).[4] During the fourth sub-period, economic activity takes place in a Walrasian or centralized market, which is the settlement market of Lagos

[4] Thus, technically, there is a third type of agents, the financial underwriters. However, as we shall see shortly, the role of these agents is quite mechanical, and there is no need to explicitly study their behavior.

and Wright (2005) (henceforth, LW). For brevity, we refer to these markets as LM (labor market), GM (goods market), FM (financial market), and CM (centralized market).

All agents discount the future between periods at rate $\beta \in (0,1)$. Households consume in the GM and the CM and work in the LM and CM sub-period. Their preferences within a period are given by $\mathcal{U}(X,H,q) = X - H + u(q)$, where H is labor in the CM, X consumption of *general good* in the CM, and q consumption of *special good* in the GM.[5] We assume that households can turn one unit of labor in the CM into one unit of the general good. In contrast, the special good must be purchased from firms in the GM. Firms consume only the general CM good, and they produce both the CM good and the GM good. Their preferences are given by $\mathcal{V}(X,H) = X - H$, where X, H are as above. As is the case with households, firms can turn one unit of labor into one unit of the general good in the CM. However, to produce the GM good firms must hire a worker in the LM. Following Berentsen et al. (2011), we assume that firms who are matched with a worker in the LM produce y units of output, measured in units of the CM good (the numéraire), which they ultimately use as an input for production in the GM. Specifically, if a firm sells q units in the GM, $y - q$ is left over to bring to the next CM. We assume that the utility function of the special good u is twice continuously differentiable with $u' > 0$, $u'(0) = \infty$, $u'(\infty) = 0$, and $u'' < 0$. Let q^* denote the optimal level of production in the GM, i.e., $q^* \equiv \{q : u'(q^*) = 1\}$.

With the exception of the CM, which is a frictionless competitive market, all other markets are characterized by *search* and *bargaining*. To keep notation consistent, we assume that the matching technology in each market is characterized by a function $f_j(b_j, s_j)$, where b_j and s_j represent the measures of buyers and sellers, respectively, searching for a trading partner in market $j \in \{L, G, F\}$ ("L" for Labor market, "G" for Goods market, and "F" for Financial market).[6] These matching functions exhibit constant returns to scale and are increasing in both arguments. Regarding bargaining, we adopt the proportional bargaining solution of Kalai (1977), and in line with our earlier notation choice, we will let $\eta_j \in [0,1]$ denote the bargaining power of the seller in market $j \in \{L, G, F\}$.

There are two assets in the economy, fiat money and corporate bonds. Agents can choose to hold any amount of money at the (real) ongoing price φ_t. The supply of money is controlled by the monetary authority, and it evolves according to $M_{t+1} = (1+\mu)M_t$,

[5] One should not take literally the idea that the GM is only a market for tangible goods. It is meant to capture all transactions that are subject to the frictions that make a medium of exchange or collateral necessary. This includes goods, services, intermediate goods, or even transactions of financial nature.

[6] For instance, in the LM, s_L represents the measure of unemployed workers trying to match with a firm (workers sell their labor), and b_L stands for the measure of vacant firms searching for a worker. In the GM, s_G is the measure of firms selling the special good, and b_G the measure of households buying that good. Finally, in the FM, s_F is the measure of financial institutions selling their underwriting services, and b_F the measure of firms seeking a financial institution who will assist them with the issuance of bonds.

with $\mu > \beta - 1$. New money is introduced, or withdrawn if $\mu < 0$, via lump-sum transfers to households in the CM. Corporate bonds are issued by firms in order to fund their recruiting efforts and production. Recall that in order to issue bonds firms must first meet an underwriter. We assume that the meeting process takes place in the FM, however, the issuing of bonds takes place in the CM, which is precisely why we have chosen this specific timing of events.[7] Thus, we think of the CM as the primary market where these bonds are issued by the firms (with the help of an underwriter they met in the preceding FM) and purchased by households. Households can purchase any amount of bonds at the (real) price ψ_t. These are one-period real bonds, i.e., each unit of the bond purchased in period t's CM will deliver one unit of the numeraire in the CM of $t+1$. The supply of corporate bonds is endogenous, as it depends on the profit maximizing behavior of firms.

We now move on to the discussion of one of the most important elements of the model, that of liquidity. To capture the empirically relevant observation that corporate bond prices include a liquidity component (or premium), we assume that bonds serve alongside money as means of payment or collateral that can facilitate trade in the GM. To capture the idea that money and corporate bonds need not be equally effective liquid assets, we assume that the *pledgeability* (or acceptability) of money is $\lambda_m \in [0,1]$, while the pledgeability of bonds (assets) is $\lambda_a \in [0,1]$. These terms denote the fraction of money and bonds, respectively, that can be used for transactions in a GM trade. Assuming that $\lambda_m = 1$, i.e., assuming that money is universally accepted as a medium of exchange, seems natural. However, one of the main goals of the paper is to show that the real effects of financial shocks are less significant in a model where agents have access to money. We believe that the transparency of this exercise would improve if we can also show that the effectiveness of our mechanism weakens as agents have "less access" to money, and this is precisely what a diminishing value of λ_m captures.[8]

Next, consider the FM. The only economic activity in this market is the search and matching between firms and underwriters. Firms who wish to enter the FM and search for an underwriter must pay an entry fee κ_F per period. Notice that the term b_F (the mass of "buyers" in the FM) will include existing firms who wish to issue bonds to fund their next period production, and new entrants who wish to issue bonds to fund their recruiting *and* production. Firms that are not successful at finding an underwriter must

[7] In that sense, one could think of the FM not as a distinct fourth market, but as the "first stage" of the CM. These would be equivalent specifications.

[8] Put differently, allowing λ_m to vary, allows us to capture different levels of "money availability" in the model, including the limit as $\lambda_m \to 0$, which one can interpret as a *moneyless* economy. This is an interesting benchmark, as it coincides with the vast majority of the existing literature, where money is not explicitly modeled. We would like to thank an anonymous referee and the editor for suggesting this experiment.

exit. Since the role of underwriters is trivial, i.e., they provide their expertise to help firms issue bonds, we keep this market as simple as possible: we set the measure of underwriters equal to the unit ($s_F = 1$), and do not explicitly model their preferences or actions.[9] Despite our strategy to suppress the role of underwriters, it should be clear that the FM plays an important role in our model. Specifically, in Section 5, we study the effects of two types of "financial shocks". The first is a shock in the pledgeability of the bonds (the term λ_a), and the second is a shock in the ability of firms to raise funding, which in our model amounts to a shock in the efficiency of matching in the FM.

Any given match in period t's LM is terminated in the next period with probability δ, i.e., $\delta \in (0, 1)$ is the economy's *exogenous* job separation rate. But firms also need to exit if they do not find an underwriter in the FM. Thus, an existing job in period t remains active in $t+1$ with an effective probability $(1-\delta)f_F/b_F$. Firms that enter the market to search for workers must pay recruiting costs κ_R and operating costs κ_O, and firms that are already matched with a worker only pay the latter. These costs must be funded through issuance of corporate bonds, as discussed. Since the focus of our paper is on bond liquidity, and how it affects firm entry, we abstract away from firm default. Specifically, firms who entered the market and were able to issue bonds to fund recruitment and production (i.e., they matched in the FM), but were not able to match with a worker in the LM, will not be able to produce in the LM (or the GM); nevertheless, we assume that they can repay their debt by working more in the CM. One can think that this assumption captures the idea that firms can sell assets (such as buildings or machines) to repay their debtors.[10] Firms that are matched and productive in the LM pay a wage w to the worker. Following Berentsen et al. (2011), we assume that w is paid in numeraire good in the CM. Unemployed workers enjoy an unemployment benefit b also delivered in the CM.

Figure 1 summarizes the main economic activities in our model and clarifies the timing of the various shocks. Notice that the exogenous job separation shock and the LM matching take place at the very end of each period (or, equivalently, at the very begin-

[9] It is also implicitly assumed that underwriters do not get a fraction of the surplus generated through the issuance of bonds, i.e., $\eta_F = 0$. See also Footnote 7, and the related discussion.

[10] One could assume that firms which do not meet a worker, and therefore cannot produce in the LM, default on their debt. We could easily deal with this setup if we paired it with the assumption that households do not buy firm-specific debt, but purchase a mutual fund or a composite bond of all firms. Then, even if a fraction x of firms default every period, the households expect it, and the only thing that would change in our analysis is that the fundamental value of the bond would now be $(1-x)\beta$, as opposed to just β. That is not to say that modeling debt default in a (more) meaningful way is not interesting. But recent literature reveals that studying the relationship between asset riskiness/default and liquidity properly is a complicated task; see for example Geromichalos, Herrenbrueck, and Lee (2023). Since the focus of this paper is on the liquidity properties of corporate bonds and how they affect job entry and (un)employment, we think it is best to shut down debt default altogether, rather than introducing it in an uninteresting way.

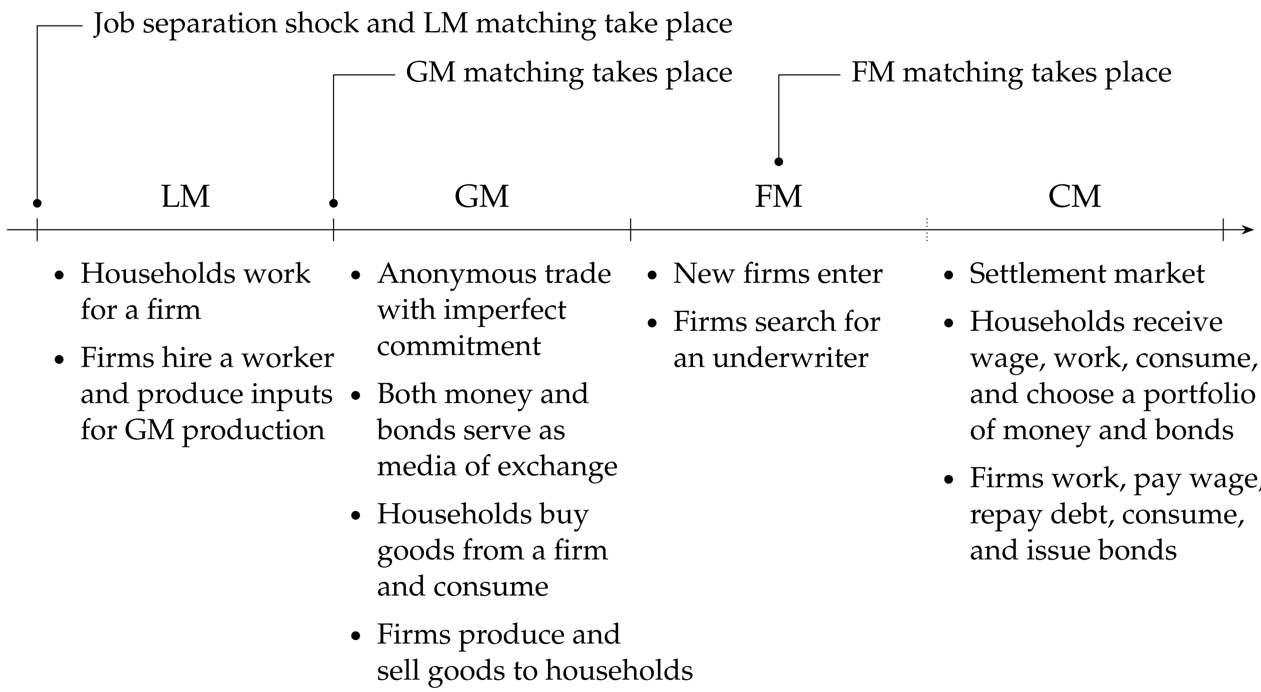

Figure 1: Timing of Events.

ning of the next period). Let us point out that a worker/household who just lost their job cannot search for a new job right away; they need to spend one period in unemployment.

3 Analysis of the Model

3.1 Value Functions

Households In the CM, a household can be employed ($e = 1$) or unemployed ($e = 0$). For an employed household with m units of money and a units of bonds, the CM value function is

$$W_1^h(m,a) = \max_{X,H,m',a'} X - H + \beta\left[\frac{f_F}{b_F}(1-\delta)\,U_1^h(m',a') + \left(1 - \frac{f_F}{b_F}(1-\delta)\right)U_0^h(m',a')\right]$$
$$\text{s.t.} \quad X + \varphi m' + \psi a' = H + \varphi m + a + w + T,$$

where m' and a' are money and bond holdings for the next period, and U_e^h is the next period's LM value function. The next period's employment status depends on the job separation shock δ as well as the FM matching outcome of the firm employing the household. The household will still be employed if the firm finds an underwriter in the FM (so that it can issue bonds in the CM) *and* if the match does not get destroyed. Otherwise, the household will be unemployed in the next period. The household also receives the monetary lump-sum transfer T. Moving on to the CM value function of an unemployed household, we have

$$W_0^h(m,a) = \max_{X,H,m',a'} X - H + \beta\left[\frac{f_L}{s_L}U_1^h(m',a') + \left(1 - \frac{f_L}{s_L}\right)U_0^h(m',a')\right]$$
$$\text{s.t.} \quad X + \varphi m' + \psi a' = H + \varphi m + a + b + T.$$

Notice that in the last expression whether the household will be employed or unemployed in the next period depends on the outcome of the LM matching process. Also, note that the value function W_e^h is linear, that is, $W_e^h(m,a) = \varphi m + a + W_e^h(0,0)$, as is standard in models that build on LW. This result follows from (quasi-)linear preferences.

We now move to the LM value functions. For a household at state e, we have

$$U_e^h(m,a) = V_e^h(m,a), \quad e = 0, 1,$$

where V_e^h denotes this household's GM value function and is given by

$$V_e^h(m,a) = \frac{f_G}{b_G}\Big(u(q) + W_e^h(m-\xi, a-\chi)\Big) + \left(1 - \frac{f_G}{b_G}\right)W_e^h(m,a), \quad e = 0, 1.$$

If matched with a firm in the GM (with probability f_G/b_G), the household gets the opportunity to consume in the GM. The household pays the firm ξ units of money and χ units of bonds to purchase q units of the GM good. If not matched, the household proceeds to the CM without trading.

Firms Consider first a firm that wants to open a vacancy. Opening a vacancy requires covering the recruiting and operating costs, and the firm must finance these costs by selling bonds. To do so, the firm must look for an underwriter in the FM who will help with issuing and selling bonds. As we have already explained, the FM can be viewed as the first stage of the CM, where bonds are effectively issued and sold. (See Footnote 7.) Thus, we start by describing the consolidated FM-CM value function of the typical firm, which is given by

$$W_v^f = -\kappa_F + \frac{f_F}{b_F}\cdot\beta\left[\frac{f_L}{b_L}U_1^f(d') + \left(1 - \frac{f_L}{b_L}\right)U_0^f(d')\right], \quad \text{where} \quad d' = \frac{\kappa_R + \kappa_O}{\psi}.$$

Looking for an underwriter in the FM incurs the entry costs κ_F, and the firm can find one with probability f_F/b_F. If successfully matched with one, the firm issues and sells bonds in the CM to cover the recruiting and operating costs. Specifically, the firm must finance the total cost $\kappa_R + \kappa_O$ by selling bonds at the price ψ. Hence, its resulting debt, denoted d', is $(\kappa_P + \kappa_O)/\psi$. After that, the firm continues to the LM, opens a vacancy, and looks for a worker. The LM value function is denoted U_e^f, which depends on whether the firm is matched with a worker ($e = 1$) or not ($e = 0$).

The FM-CM value function of a firm that is currently matched with a worker is

$$W_1^f(n, m, a, d) = \max_{X,H} X - H - \kappa_F + \frac{f_F}{b_F}(1-\delta) \cdot \beta U_1^f(d')$$
$$\text{s.t.} \quad X = H + n + \varphi m + a - d - w \quad \text{and} \quad d' = \frac{\kappa_O}{\psi},$$

where n is the amount of the LM output leftover after GM production has concluded (that is, $n = y - q$), m and a are the amounts of money and bonds the firm received in the GM, and d is the debt from issuing bonds in the previous period. This firm must raise funds to cover the operating costs. To do so, it again needs to look for an underwriter in the FM, which incurs the entry costs κ_F. If the firm finds an underwriter *and* the existing match with a worker survives (with probability $f_F/b_F \cdot (1-\delta)$), it issues bonds and proceeds to the LM.[11] Note that the value function W_1^f is linear, that is, $W_1^f(n, m, a, d) = n + \varphi m + a - d + W_1^f(0, 0, 0, 0)$, as was the case for the consumer's CM value functions.

Inspection of these value functions highlights the *first channel* discussed in the introduction: a higher pledgeability of bonds leads to a higher issue price (ψ), which, in turn, allows firms to raise funds at more favorable rates, thus increasing profitability and encouraging entry.

The last type of firm we need to consider in the CM is the one that opened a vacancy in the previous period but was not able to find a worker. This firm cannot produce but must still repay its debt, and therefore its CM value function is given by

$$W_0^f(d) = \max_{X,H} X - H \quad \text{s.t.} \quad X = H - d.$$

We now move on to the LM. The LM value function of a matched firm is

$$U_1^f(d) = V_1^f(d),$$

[11] If the firm cannot find an underwriter or the current match gets destroyed, it will exit the market and get a payoff of 0, which is why the term U_0^f does not appear.

where V_1^f is the GM value function of a matched firm. The LM value function of an entrant firm that did not find a worker is

$$U_0^f(d) = W_0^f(d).$$

Finally, the GM value function of a firm (matched with a worker) is

$$V_1^f(d) = \frac{f_G}{s_G} W_1^f(y - q, \xi, \chi, d) + \left(1 - \frac{f_G}{s_G}\right) W_1^f(y, 0, 0, d).$$

If matched with a household/customer (with probability f_G/s_G), the firm sells q units of the GM good and receives ξ units of money and χ units of bonds. If not matched, the firm proceeds to the CM without trading.

3.2 Terms of Trade

Terms of trade in the GM Consider a meeting between a household with m units of money and a units of bonds and a matched firm with y units of LM output. The two parties bargain over the quantity of the GM good q to be produced by the firm and the cash payment ξ and the bond payment χ to be made by the household. The household's surplus from a successful trade is

$$S^h = u(q) + W_e^h(m - \xi, a - \chi) - W_e^h(m, a) = u(q) - \varphi\xi - \chi,$$

and the firm's surplus is

$$S^f = W_1^f(y - q, \xi, \chi, d) - W_1^f(y, 0, 0, d) = -q + \varphi\xi + \chi,$$

where, in both cases, the second equalities have exploited the linearity of W_e^h and W_1^f. The terms of GM trade (q, ξ, χ) are determined by proportional bargaining, where the firm's bargaining power is η_G:

$$\max_{q,\xi,\chi} S^f \quad \text{s.t.} \quad S^f = \frac{\eta_G}{1 - \eta_G} S^h, \;\; \xi \leq \lambda_m m, \;\; \chi \leq \lambda_a a, \;\; \text{and} \;\; q \leq y.$$

The constraints $\xi \leq \lambda_m m$ and $\chi \leq \lambda_a a$ state that the household's cash and bond payment cannot exceed the pledgeable amount of money and bond holdings. The constraint $q \leq y$ states that GM production uses LM output as an input and that the firm cannot leave with a negative amount of LM output. We assume, as in Berentsen et al. (2011), that y is sufficiently large and that $q \leq y$ does not bind. The Kalai constraint implies

$$\varphi\xi + \chi = \eta_G\, u(q) + (1-\eta_G)q \equiv \sigma(q),$$

where $\sigma(q)$ is the real value of payment (ξ, χ) needed to purchase q units of the GM good. If the real value of the household's portfolio (m, a) is sufficient to purchase q^* units of the GM good, the optimal quantity will be traded with any payment $(\tilde{\xi}, \tilde{\chi})$ whose real value equals $\sigma(q^*)$. Otherwise, the household will spend all the pledgeable amount of money and bond holdings. That is, the bargaining solution is given by

$$q(m,a) = \begin{cases} q^*, & \text{if } \lambda_m \varphi m + \lambda_a a \geq \sigma(q^*) \\ \sigma^{-1}(\lambda_m \varphi m + \lambda_a a), & \text{otherwise,} \end{cases}$$

$$\big(\xi(m,a), \chi(m,a)\big) = \begin{cases} (\tilde{\xi}, \tilde{\chi}) \;\text{ s.t. }\; \varphi\tilde{\xi} + \tilde{\chi} = \sigma(q^*), & \text{if } \lambda_m \varphi m + \lambda_a a \geq \sigma(q^*) \\ \qquad\qquad\quad \tilde{\xi} \leq \lambda_m m, \quad \tilde{\chi} \leq \lambda_a a, & \\ (\lambda_m m, \lambda_a a), & \text{otherwise.} \end{cases}$$

The bargaining solution reflects the *second channel* discussed in the introduction: a higher pledgeability of bonds increases the consumers' effective liquidity (and purchasing power in the GM), which, in turn, increases the firms' profitability and encourages entry.

3.3 Optimal Portfolio Choice

Households choose their optimal portfolio in the CM independently of their trading histories in previous markets, as is standard in models that build on LW. To analyze the households' optimal behavior, we substitute their LM and GM value functions into their CM value function, collect the terms relevant to choice variables, and obtain the objective function in the CM:

$$J(m', a') = -(\varphi - \beta\varphi')m' - (\psi - \beta)a' + \beta\,\frac{f_G}{b_G}\Big[u(q(m',a')) - \varphi\xi(m',a') - \chi(m',a')\Big].$$

The interpretation is straightforward. The first two negative terms represent the cost of choosing a portfolio (m', a'), net of their payout in the next period's CM. The portfolio also offers certain liquidity benefits, but these will only be relevant if the household gets the opportunity to consume in the GM; thus, the rest of the terms are multiplied by f_G/b_G. The term in the square bracket represents the surplus of the household from GM trade.

3.4 Equilibrium

In our economy, the money growth rate μ affects the economy via the transformation $i \equiv (1+\mu)/\beta - 1$, which can be interpreted as the opportunity cost of holding money, or as a benchmark yield on a completely illiquid asset. (Thus, i should not be thought of as representing, for instance, the yield on T-bills; see Geromichalos and Herrenbrueck, 2022 and Herrenbrueck, 2019.) But while using i makes the following equations easier to read, the exogenous monetary policy instrument is still the money growth rate μ.

Money and bond market equilibrium The equilibrium price of money clears the money market, and the real balances are given by

$$z = \varphi M.$$

The bond market clears ($a = A$) and the bond supply is endogenously determined by

$$A = b_L \frac{\kappa_R + \kappa_O}{\psi} + (1 - s_L)\frac{f_F}{b_F}(1-\delta)\frac{\kappa_O}{\psi}. \tag{1}$$

In the GM, the following quantity of the GM good is traded:

$$q = \min\{q^*,\, \sigma^{-1}(\lambda_m z + \lambda_a A)\}. \tag{2}$$

The households' optimal portfolio choice characterizes the demands for money and bonds. The money demand is given by

$$i \geq \lambda_m \frac{f_G}{b_G}\left[\frac{u'(q)}{\sigma'(q)} - 1\right], \tag{3}$$

where the equality holds if $z > 0$. The left-hand side, $i > 0$, represents the cost of carrying money, whereas the right-hand side is the marginal benefit of bringing one more unit of money. If the cost of carrying money is too high, that is, if i exceeds the right-hand side evaluated at $z = 0$, households will not carry any money and we have a non-monetary equilibrium where $\varphi = 0$ and $z = 0$, with the inequality holding strictly. If i is not too high, we have a monetary equilibrium where $z > 0$ equates both sides of the inequality.[12]

[12] This result is quite intuitive. In this type of environment, money has a direct competitor as a means of payment: bonds. Thus, if the monetary authority pushes inflation (or the interest rate i) above a certain threshold, agents will choose to carry out their transactions using bonds exclusively, which is to say that the equilibrium becomes non-monetary. As for the value of that threshold, it depends on the bond supply and the degree of substitutability between money and bonds (which here depends on the terms λ_m and λ_a. For more details, see Geromichalos et al. (2007) and Lester, Postlewaite, and Wright (2012).

Given supply, the households' bond demand determines the equilibrium bond price:

$$\psi = \beta\left(1 + \lambda_a \frac{f_G}{b_G}\left[\frac{u'(q)}{\sigma'(q)} - 1\right]\right). \tag{4}$$

The fundamental value of bonds is β, and their liquidity premium is defined as the percentage difference between their price and fundamental value. The second term in the parentheses represents the liquidity premium of bonds, which is a product of three terms: first, the pledgeability of bonds λ_a; second, the probability of GM matching f_G/b_G; and third, the marginal surplus of the match, that is, the net utility gain in the GM from bringing one more real unit of the pledgeable amount of portfolio. Thus, there are two cases where the liquidity premium is zero: the pledgeability of bonds becomes 0 ($\lambda_a = 0$), or bonds are so plentiful that spending one more unit of the GM good does not create any additional surplus ($q = q^*$ and $u'(q^*)/\sigma'(q^*) = 1$). In the latter case, bonds are still "liquid", but their liquidity is inframarginal and does not affect the price.

Labor and financial market equilibrium Free entry to the FM implies $W_v^f = 0$; that is,

$$\kappa_F = \beta\,\frac{f_F}{b_F}\left[\frac{f_L}{b_L}\,U_1^f\left(\frac{\kappa_R + \kappa_O}{\psi}\right) + \left(1 - \frac{f_L}{b_L}\right)U_0^f\left(\frac{\kappa_R + \kappa_O}{\psi}\right)\right].$$

Notice that $U_0^f(d) = -d$ and that

$$\begin{aligned}
U_1^f(d) &= \frac{f_G}{s_G}W_1^f(y - q, \xi, \chi, d) + \left(1 - \frac{f_G}{s_G}\right)W_1^f(y, 0, 0, d) \\
&= W_1^f(y, 0, 0, d) + \frac{f_G}{s_G}\left(W_1^f(y - q, \xi, \chi, d) - W_1^f(y, 0, 0, d)\right) \\
&= y - d - w - \kappa_F + \beta\frac{f_F}{b_F}(1 - \delta)U_1^f\left(\frac{\kappa_O}{\psi}\right) + \frac{f_G}{s_G}\,\eta_G(u(q) - q).
\end{aligned}$$

We define

$$R \equiv y + \frac{f_G}{s_G}\,\eta_G(u(q) - q),$$

which represents the firm's expected revenue, net of production costs. From above, we can solve for $U_1^f(\frac{\kappa_O}{\psi})$:

$$U_1^f\left(\frac{\kappa_O}{\psi}\right) = \frac{R - w - \frac{\kappa_R}{\psi} - \kappa_F}{1 - \beta\frac{f_F}{b_F}(1 - \delta)}.$$

The linearity of $U_1^f(d)$ implies $U_1^f(\frac{\kappa_R+\kappa_O}{\psi}) = U_1^f(\frac{\kappa_O}{\psi}) - \frac{\kappa_R}{\psi}$. Plugging $U_1^f(\frac{\kappa_R+\kappa_O}{\psi})$ back to the free entry condition yields

$$\frac{\kappa_R+\kappa_O}{\psi} + \frac{f_L}{b_L}\frac{\beta\frac{f_F}{b_F}(1-\delta)}{1-\beta\frac{f_F}{b_F}(1-\delta)}\frac{\kappa_O}{\psi} + \left(\frac{1}{\beta\frac{f_F}{b_F}} + \frac{f_L}{b_L}\frac{1}{1-\beta\frac{f_F}{b_F}(1-\delta)}\right)\kappa_F = \frac{f_L}{b_L}\frac{R-w}{1-\beta\frac{f_F}{b_F}(1-\delta)}. \tag{5}$$

This equation plays the role of the job creation curve in the economy. On the left-hand side are the expected costs a firm faces when contemplating entry. The first term is the cost of creating and operating the vacancy for the initial period the firm is created. The second term is the present discounted value of the operating costs the firm expects to pay over the lifetime of the job. The third term is the expected discounted sum of costs the firm will incur to search for financing. Since the first two terms represent costs that the firm pays through the means of issuing bonds, the bond price ψ affects them directly. In particular, as the bond liquidity increases and the price goes up, firms can cover their recruiting and operating costs with fewer bonds (i.e., with a lower future debt), a channel that encourages more firms to enter the market.

The wage curve is determined through wage bargaining in the LM. The worker's surplus from successful bargaining is $U_1^h(m,a) - U_0^h(m,a)$, and the firm's surplus is $U_1^f((\kappa_R + \kappa_O)/\psi) - U_0^f((\kappa_R+\kappa_O)/\psi)$. Proportional bargaining, where the worker's bargaining power is η_L, implies

$$\eta_L\left[U_1^f\left(\frac{\kappa_R+\kappa_O}{\psi}\right) - U_0^f\left(\frac{\kappa_R+\kappa_O}{\psi}\right)\right] = (1-\eta_L)\left[U_1^h(m,a) - U_0^h(m,a)\right].$$

Observe, on the left-hand side, that

$$U_1^f\left(\frac{\kappa_R+\kappa_O}{\psi}\right) - U_0^f\left(\frac{\kappa_R+\kappa_O}{\psi}\right) = U_1^f\left(\frac{\kappa_O}{\psi}\right) + \frac{\kappa_O}{\psi},$$

and, on the right-hand side, that

$$U_1^h(m,a) - U_0^h(m,a) = w - b + \beta\left(\frac{f_F}{b_F}(1-\delta) - \frac{f_L}{s_L}\right)\left[U_1^h(m',a') - U_0^h(m',a')\right].$$

From above, using the fact that $U_1^h(m,a) - U_0^h(m,a) = U_1^h(m',a') - U_0^h(m',a')$ in steady state, we can solve for $U_1^h(m,a) - U_0^h(m,a)$. With these two observations, from the bargaining solution, we can derive the wage curve:

$$w = \frac{(1-\eta_L)\big(1-\beta\frac{f_F}{b_F}(1-\delta)\big)b + \eta_L\big(1-\beta\big(\frac{f_F}{b_F}(1-\delta)-\frac{f_L}{s_L}\big)\big)\big(R-\beta\frac{f_F}{b_F}(1-\delta)\frac{\kappa_O}{\psi}-\kappa_F\big)}{1-\beta\frac{f_F}{b_F}(1-\delta)+\eta_L\,\beta\,\frac{f_L}{s_L}}. \tag{6}$$

Finally, the Beveridge curve is given by

$$(1-s_L)\left(1-\frac{f_F}{b_F}(1-\delta)\right) = f_L. \tag{7}$$

Measures of sellers and buyers We close the model with the accounting identities for the sellers and buyers at different markets. The measures of successful matches in the LM, GM, and FM are determined, respectively, by the matching technologies $f_L = f_L(b_L, s_L)$, $f_G = f_G(b_G, s_G)$, and $f_F = f_F(b_F, s_F)$, where $s_G = 1 - s_L$, $b_G = 1$, $s_F = 1$, $b_F = \epsilon + 1 - s_L$, $b_L = \epsilon \cdot f_F/b_F$, and ϵ denotes the measure of new entrants to the FM.

We now define the steady-state equilibrium of the model. An equilibrium out of steady state can be analogously defined using the equations derived in Appendix A.

Definition 1. The steady-state equilibrium of the model corresponds to a constant sequence (s_L, ϵ, q, z, A, ψ, w) such that equations (1), (2), (3), (4), (5), (6), and (7) hold.

4 Calibration

We calibrate the model at a monthly frequency. Several parameters are set exogenously to their direct empirical counterparts or following the literature. The discount factor β is set to $0.9975 = 1/1.03^{1/12}$, consistent with a 3% annual real return, as in Bethune, Choi, and Wright (2020) and Herrenbrueck (2019). Regarding the annual nominal rate, we cannot use any observed interest rate since no traded asset is perfectly illiquid. Instead, we use an estimate of 7%, based on time preference, expected real growth, and expected inflation, following Herrenbrueck (2019).[13] (Equivalently, we set the annual growth rate of money supply μ to 4%.) We set the match output y in the labor market to 1, following Berentsen et al. (2011), and the value of unemployment b to 0.71, following Hall and Milgrom (2008). Finally, we set the GM matching efficiency α_G as well as the pledgeability of money λ_m to 1. The former is standard in New Monetarist models; see Kiyotaki and Wright (1993)

[13] As a comparison, Berentsen et al. (2011) use an annual rate of 7.4% (the average rate on AAA corporate bonds), while the average in Lucas and Nicolini (2015) data is 6.28%.

Parameter	Description	Value
	Externally Calibrated Parameters	
β	Discount Rate	0.9975
i	Nominal Interest Rate (Annual)	7%
μ	Growth Rate of Money Supply (Annual)	7%
y	Match Output in the LM	1
b	Unemployment Flow Value	0.71
λ_m	Pledgeability of Money	1
α_G	Matching Efficiency in the GM	1
	Internally Calibrated Parameters	
B	Household's Utility Coefficient	0.9368
γ	Household's Utility Elasticity	0.1483
δ	Job Separation Shock	0.0233
α_L	Matching Efficiency in the LM	1.41
α_F	Matching Efficiency in the FM	1.9567
η_L	Worker's Bargaining Power in the LM	0.3333
η_G	Firm's Bargaining Power in the GM	0.9329
κ_R	Firm's Recruiting Costs	0.1030
κ_O	Firm's Operating Costs	0.0593
κ_F	Firm's Entry Costs in the FM	0.1688
λ_a	Pledgeability of Bonds	0.5304

Table 1: Calibrated Parameters.

and Berentsen et al. (2011), among others. Regarding the latter, in Section 5, we explore a moneyless version of our model by setting λ_m to 0. The top panel of Table 1 summarizes the externally set parameter values.

Next, we specify the functional forms used in the calibrated model. As in much of the New Monetarist literature, e.g., Berentsen et al. (2011) or Bethune et al. (2020), we work with the constant-relative-risk-aversion (CRRA) form for the household's utility of the GM good: $u(q) = Bq^{1-\gamma}/(1-\gamma)$. Our model features three frictional markets for which we need to specify matching functions. We parameterize all matching functions symmetrically with the constant-return-to-scale (CRS) functional form: $f_j(b_j, s_j) = \alpha_j b_j s_j/(b_j+s_j)$, where $j \in \{L, G, F\}$. Matching probabilities f_j/b_j (for buyers) and f_j/s_j (for sellers) are truncated at 1.

In total, this leaves us with eleven parameters to be calibrated through the lens of the model: the households' utility function parameters, B and γ; the job separation shock, δ; the matching efficiency in the labor and financial market, α_L and α_F; the bargaining shares of sellers in the labor and product market, η_L and η_G; the firms' recruiting and operating costs, κ_R and κ_O; the firms' entry costs in the financial market, κ_F; and, finally, the pledgeability of bonds, λ_a.

To pin down these parameters, we employ various labor, monetary, and financial moments. To begin with, we use two moments on separations to pin down δ and α_F. First, Shimer (2005) estimates a monthly separation rate for the US economy of 3%; the model's corresponding expression for this rate is given by $1 - (1 - \delta) f_F / b_F$. Second, Gabrovski, Kospentaris, and Lebeau (2023) estimate that 77.67% of separations are due to non-financial reasons; the model counterpart of this rate is δ. Together these two moments imply $\delta = 2.33\%$ and $1-(1-\delta) f_F / b_F = 3\%$, which in turn pins down α_F. Given the values of δ and α_F, the matching efficiency in the labor market α_L adjusts to match the long-run average of the unemployment rate in the US economy (Petrosky-Nadeau, 2013). Furthermore, the firm's entry costs κ_F are pinned down by matching the long-run average of the labor market tightness from the Job Openings and Labor Turnover Survey (JOLTS).[14]

Next, to pin down η_G, we follow Bethune et al. (2020) and target the average markup of 1.39 in the product market, whose model counterpart is given by $\sigma(q)/q$. Moreover, the firm's operating costs κ_O are informed by the corporate bond supply data. To pin down κ_O, we match the average issuance level of investment-grade bonds as a fraction of GDP from Refinitiv (which is equal to $\psi A/((1 - s_L)R)$ in the model).[15] Given this, the pledgeability of bonds λ_a adjusts to match the available measurement of the liquidity premium of corporate bonds. d'Avernas (2018) estimates that 30% of the corporate bond spread can be attributed to liquidity considerations, while Friewald, Jankowitsch, and Subrahmanyam (2012) estimate the spread of investment-grade bonds to be around 1%. These two numbers together give us an estimate of the liquidity premium of corporate bonds.

Regarding the utility function parameters, we follow the standard practice of the New Monetarist literature. The model object for the ratio of money holdings relative to

[14] One might wonder why the financial market parameters, α_F and κ_F, are used for the labor market moments. The reason is that, in our model, financial frictions are an important cause for firm-worker match dissolution. Thus, the likelihood of finding financing is tightly linked to separations. Moreover, vacancies in the labor market can only be opened if the firm has first secured financing. Thus, barriers to entry into the financial market are a key determinant of the labor market vacancy mass.

[15] We focus on investment-grade bonds since there is no default in the model and this bond category is considered practically default-free.

Target	Data	Source
Job Separation Rate	3%	Shimer (2005)
Separations due to Non-financial Reasons	77.67%	Gabrovski et al. (2023)
Unemployment Rate	6%	Petrosky-Nadeau (2013)
Labor Market Tightness	0.5	JOLTS
Product Market Markup	1.39	Bethune et al. (2020)
Issuance of Corporate Bonds over GDP	6.05%	Refinitiv
Liquidity Premium of Corporate Bonds	0.3%	d'Avernas (2018)
		Friewald et al. (2012)
Average Money Holdings over GDP	23.2%	Lucas and Nicolini (2015)
Elasticity of Money Demand wrt AAA Rate	−0.51	Lucas and Nicolini (2015)
Recruiting Costs as a Fraction of Wage	12.9%	Silva and Toledo (2009)

Table 2: Calibration Targets.

GDP is given by $z/((1-s_L)R)$. We pin down B and γ by targeting the average money holdings as a fraction of GDP (Bethune et al., 2020) and the elasticity of money holdings with respect to the return on AAA bonds (Berentsen et al., 2011), respectively, using the data shared by Lucas and Nicolini (2015). Furthermore, to pin down the firm's recruiting costs κ_R, we use the estimation of Silva and Toledo (2009) that the hiring cost is 12.9% of the monthly compensation of a newly hired worker. Finally, for η_L, we apply the Hosios condition (Hosios, 1990) and target the elasticity of the labor market matching function with respect to the measure of unemployed workers (evaluated at the equilibrium tightness).

The tractability of the model allows to exactly pin down the parameters that make the model consistent with the empirical targets of our calibration. The calibrated parameter values are collected in the bottom panel of Table 1, while Table 2 summarizes the empirical targets and their sources. We use the calibrated model as a laboratory for various quantitative exercises in the following section.

5 Quantitative Analysis

In this section, we present the quantitative implications of the model for the relationships between monetary, financial, and real economic variables. Financial conditions are reflected in two markets in the model: in the FM, where firms search for underwriters to issue bonds, and in the GM, where households use bonds to buy goods. Thus, we focus our analysis on shocks to two parameters, one for each market of interest: i) the FM matching efficiency α_F (the "funding shock", which affects the FM), and ii) the pledgeability of corporate bonds λ_a (the "liquidity shock", which affects the GM).[16] We proceed in three steps: first, we use some of the model restrictions as accounting devices to measure financial shocks in the data. Second, we use the empirical estimates of the shocks to study the effects of unanticipated liquidity and funding shocks on real variables, as well as the role of money and inflation in the transmission of financial shocks. Finally, we feed the whole series of financial shocks in the model and simulate time series for output, unemployment, and sales. By comparing the model-generated time series with the actual data, we evaluate the model's performance and gauge the importance of financial shocks to account for the observed behavior of real economic variables over time. We also estimate how much more severe the effects of financial shocks would have been without enough liquidity substitutes in the economy.

5.1 The Measurement of Financial Shocks

We follow the accounting procedure of Jermann and Quadrini (2012) to measure financial shocks in the data.[17] The goal is to build time series for the pledgeability of corporate bonds λ_a and the FM matching efficiency α_F mimicking the standard production function approach to construct Solow residuals. Instead of the production function, we use the FM matching function and the GM equilibrium condition as model constraints. Intuitively, since conditions in the FM directly impact job separations in our economy, the funding shock is identified using labor market data; we use product market data to identify the liquidity shock, as sales take place in the GM.

To be more precise, recall that the functional form of the FM matching function (together with the $s_F = 1$ normalization) implies that the FM matching efficiency is given by:

$$\alpha_F = \frac{f_F}{b_F}(1 + b_F)$$

from the definition of the f_F/b_F rate. Hence, we need to generate time series for f_F/b_F

[16] This terminology echoes the "market" and "funding" liquidity terms used by Brunnermeier and Pedersen (2009). In particular, their market liquidity refers to the ease with which an asset is traded, which is what our concept of bond pledgeability intends to capture in a reduced-form way. Moreover, when Brunnermeier and Pedersen (2009) refer to funding liquidity, they mean the ease with which financial traders can obtain funding. This is directly connected with how many borrowers they can serve, which is what the number of meetings in our FM market captures.

[17] Johannes Pfeifer publicly provides a MATLAB version of the GAUSS code of Jermann and Quadrini (2012); see Pfeifer (2016).

and b_F. To generate a series for f_F/b_F, we feed monthly data on worker separations from Current Population Survey (CPS) from 1992 to 2019 in the model expression for the separation rate:

$$sep = 1 - (1-\delta) f_F/b_F,$$

with δ at its calibrated value. To generate a series for b_F, we use its model expression:

$$b_F = 1 - s_L + \frac{b_L}{f_F/b_F},$$

together with two sources of data. For s_L, we feed the time series of the monthly unemployment rate from the Bureau of Labor Statistics (BLS) for 1992-2019. For b_L, we use the vacancy rate data from JOLTS for 2000-2019 and the data compiled by Petrosky-Nadeau and Zhang (2021) for 1992-1999. In total, this procedure yields a monthly time series for α_F from 1992 to 2019; we take its logarithm, linearly detrend it, and plot it in the top left panel of Figure 2.[18]

Next, we explain how we obtain the series for λ_a from the data. Recall that the GM equilibrium condition (equation 2) implies:

$$\sigma(q) = \lambda_m z + \lambda_a A,$$

since the GM output does not acquire its efficient level q^* (we checked that the constraint always binds after feeding the constructed shocks in the model). Next, since we have normalized $b_G = 1$, we can write this equation as:

$$f_G \sigma(q) = \frac{f_G}{b_G} \left(\lambda_m z + \lambda_a A \right).$$

The left-hand side of this equation denotes the value of aggregate GM sales in the model. We feed the monthly series for Total Business Sales from the U.S. Census Bureau from 1992 to 2019 as its empirical counterpart. Moving to the right-hand side, we set $\lambda_m = 1$ as in the calibrated model, since money is universally accepted as a liquidity instrument. For z, we use the M1 series of monetary aggregates made available by the Board of Governors of the Federal Reserve System. Taking the ratio of nominal GDP over M1 provides an empirical measure of the velocity of money, which we feed in the right-hand side as the empirical counterpart of the f_G/b_G ratio. Finally, to acquire a monthly empirical measure for A, we use the value of corporate bonds outstanding from the Mergent Fixed Income

[18] We plot the detrended data starting from October 1995 because we simulate the model from its steady state and October 1995 is when the data is at the steady-state (trend) level for the first time.

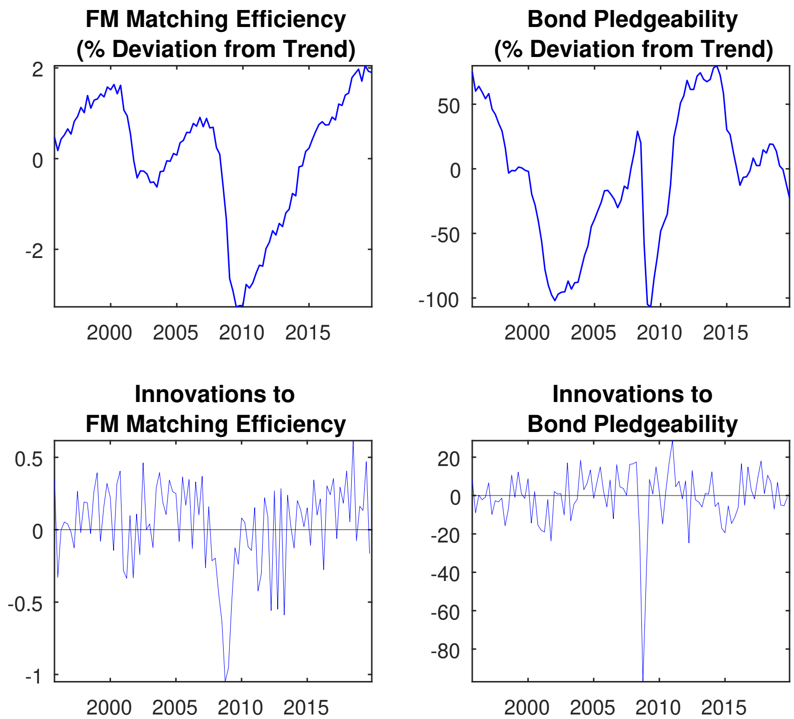

Figure 2: FM Matching Efficiency, Bond Pledgeability, and Financial Shocks (shown in quarterly frequency for legibility, but estimation is monthly).

Securities Database (FISD). In total, this procedure yields a monthly time series for λ_a from 1992 to 2019; we normalize it to be consistent with the long-run calibrated average of λ_a, take its logarithm, linearly detrend it, and plot it in the top left panel of Figure 2.

Having constructed the time series for α_F and λ_a, we proceed with the estimation of the funding and liquidity shocks. Following Jermann and Quadrini (2012), we estimate an autoregressive system of the following form:

$$\begin{bmatrix} \hat{\alpha}_{F,t+1} \\ \hat{\lambda}_{a,t+1} \end{bmatrix} = \mathbf{A} \begin{bmatrix} \hat{\alpha}_{F,t} \\ \hat{\lambda}_{a,t} \end{bmatrix} + \begin{bmatrix} \epsilon_{\alpha,t+1} \\ \epsilon_{\lambda,t+1} \end{bmatrix},$$

where $\hat{\alpha}_{F,t}$ and $\hat{\lambda}_{a,t}$ are percentage or log-deviations from the trend, while $\epsilon_{\alpha,t+1}$ and $\epsilon_{\lambda,t+1}$ are iid with standard deviations σ_α and σ_λ, respectively. The OLS estimates are:

$$\mathbf{A} = \begin{bmatrix} 0.9713 & 0.0007 \\ -1.0878 & 0.9914 \end{bmatrix}$$

for the coefficient matrix, as well as $\sigma_\alpha = 0.0030$ and $\sigma_\lambda = 0.0766$ for the standard deviations of the innovations. The bottom panels of Figure 2 plot the innovations $\epsilon_{\alpha,t}$ and $\epsilon_{\lambda,t}$.

Figure 2 offers several insights. To begin with, the behavior of α_F is quite different than the behavior of λ_a. The two processes have been identified using different data and, as a result, they reflect different forces: α_F captures firms' borrowing capacity (similar to the financial variable ξ in Jermann and Quadrini 2012, which gauges how tight is the borrowing constraint in their model), while λ_a directly reflects the assets' potential to be used as means of payment. As a result, the constructed time series have notable differences: early in the sample α_F, for example, shows a secular increase while λ_a shows a secular decrease. More importantly, the innovations in the two processes show significant differences in magnitude: σ_λ is an order of magnitude larger than σ_α. Intuitively, the model needs much smaller funding shocks to rationalize the observed movements in unemployment than the liquidity shocks needed to rationalize movements in total sales. As we will see with detail in the next section, this difference implies that the propagation of funding shocks is stronger than the propagation of liquidity shocks.

Another important implication of the bottom panel of Figure 2 is that two innovations do not hit the economy at the same time with the same direction or force (the correlation between the two shocks is 0.41). For example, there is a relatively large negative liquidity innovation in 2015, but the funding conditions were exactly on trend or even positive during that time. There are two important implications of the different timing in the shocks implied by our accounting exercise. First, through the lens of the model, both the 2001 and the 2009 crises were the result of a combination of funding and liquidity shocks. Second, there are instances of negative liquidity shocks in our sample which did not lead to prolonged financial crises affecting the real economy. Again, the shocks in 2015 stand out. Even though the precise reasons for why these shocks did not lead to a crisis are outside the scope of our diagnostic exercise, our framework does suggest potential answers: the inflation rate was very low during that time period, which points to an abundance of liquidity that mitigated the effects of the liquidity shock.

5.2 The Effects of Financial Shocks

We begin with the analysis of the impact of liquidity shocks on the real economy. That is, we consider the effects of a one-time unexpected drop in the bond pledgeability parameter, λ_a, on the unemployment rate, u, aggregate output, $(1-u)R$, and total sales, $f_G\sigma(q)$. The shock takes place at the end of the CM market, after the agents' decisions for next period have been made and its magnitude is equal to one standard deviation σ_λ. After the shock, λ_a follows the estimated autoregressive process and slowly returns to its initial steady state level. To understand how the existence of money changes the impact of liquidity shocks, we perform the experiment in the baseline model with money, as well as a

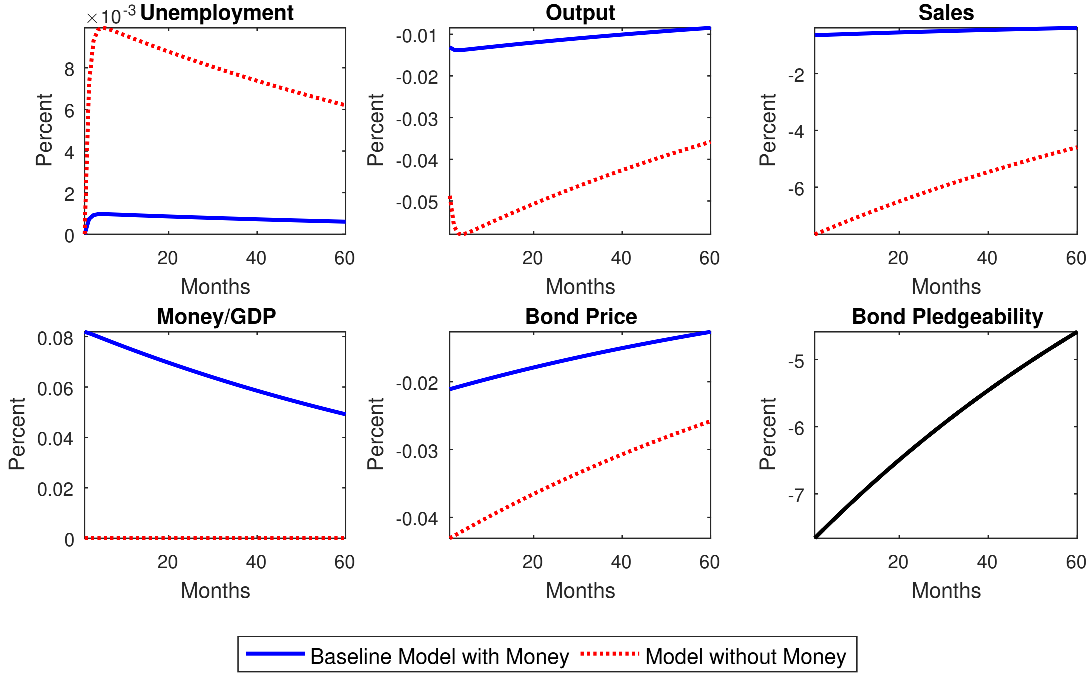

Figure 3: Liquidity Shocks.
Impulse response functions for an unexpected one standard deviation drop in the pledgeability of corporate bonds. Output, sales, bond price, and bond pledgeability are expressed as percentage deviations from steady state; unemployment and the money/GDP ratio are expressed as level deviations from steady state.

version of the model without a role for money (we achieve this by setting $\lambda_m = 0$, which implies zero real money balances).

There are two channels through which a drop in bond pleadgeability affects real variables in the model. First, a lower λ_a reduces GM trade, firm revenue and firm entry, and thus raises unemployment. This is the case because lower bond pledgeability reduces the total amount of liquid assets held by households and, as a result, households' purchasing power. We dub this the *portfolio channel* because it captures the impact of changes in the household's asset portfolio. Second, a lower λ_a reduces the liquidity premium and, as a result, the corporate bond price. This, in turn, raises firms' borrowing costs, reduces firm entry, and raises unemployment; we dub this the *asset price channel* because it captures the impact of changes in the price of corporate bonds. Both the portfolio and asset price channel push unemployment up and output and sales down in response to drops in bond pledgeability.

The main takeaway of Figure 3, the impact of liquidity shocks strongly depends on the role of money: the response of the real variables is much larger in the model without money than in the monetary model. The reason can be seen in the bottom left panel of

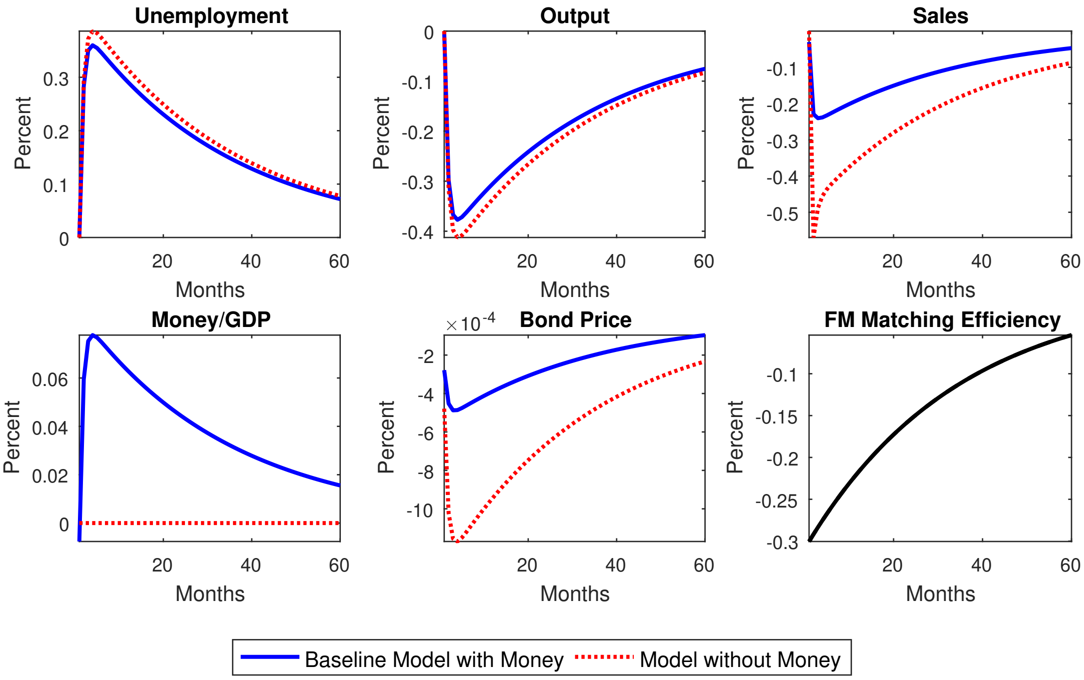

Figure 4: Funding Shocks.
Impulse response functions for an unexpected one standard deviation drop in the matching efficiency of the financial market. Output, sales, bond price, and FM matching efficiency are expressed as percentage deviations from steady state; unemployment and the money/GDP ratio are expressed as level deviations from steady state.

Figure 3: agents increase their money holdings to cope with lower bond liquidity. As a result, the portfolio channel is muted in the model with money, because the aggregate liquidity of households' portfolio adjusts upwards. This asset substitution insulates firm profit, firm entry, and aggregate unemployment from the liquidity effects of the drop in λ_a in the monetary model. Notice, however, that the asset price channel is still at work (bottom middle panel of Figure 3) and is actually smaller in the model with money where bonds are not the sole liquidity instrument. To sum up, both channels connecting bond pledgeability with real variables are stronger in the model without money. To give a quantitative sense, the increase of unemployment in the model with money is only 10% of the increase found in the moneyless model after an adverse liquidity shock of equal magnitude; similarly, the drop of output in the model with money is 24% and the drop of sales is 8.5% of the corresponding drops found in the moneyless benchmark.

Figure 4 depicts the responses of the economy to funding shocks: changes in the matching efficiency of the FM market, α_F. Following the logic of the liquidity shocks analysis, we perform the experiment in the baseline economy, as well as in an economy where money is absent, i.e., $\lambda_m = 0$. A lower α_F implies a larger number of firms that cannot issue bonds in the primary market. As a result, these firms will exit the market at the end of the period, which has a direct negative impact on output and unemployment. Moreover, since there are fewer corporate bonds available, the households' portfolio has lower liquidity, which lowers GM sales and further reduces output and increases unemployment. Effectively, funding shocks are a combination of both real firm-destruction shocks *and* liquidity shocks, which explains why their impact on the real economy is an order of magnitude larger than the impact of liquidity shocks. Liquidity shocks operate through firm entry but do not change the measure of operating firms directly; hence, their impact is bound to be smaller than that of funding shocks that operate through both margins. Moreover, the mitigating effect of money is also bound to be of smaller significance in the case of funding shocks: although agents can mitigate the effects of the portfolio channel through rebalancing, they cannot do anything about increased separations.

The main lesson of Figure 4 parallels the one learned from the analysis of liquidity shocks: the economy without money responds more strongly following a decrease in α_F than the economy with money. In terms of magnitudes, the increase of unemployment in the model with money is 7% lower than that found in the moneyless model after a negative funding shock; the drop of output in the model with money is 9% lower and the drop in sales is 58% lower than the corresponding drops found in the moneyless benchmark. There again two reasons for this: first, money offers a liquidity substitute to the reduction of bonds due to the negative α_F shock. As a result, in the economy with money total liquidity in the households' portfolio is greater, the impact of the shock on GM trade is less pronounced, and the effects on sales, output, and unemployment are smaller than in the economy without money. In effect, the existence of money dampens the propagation of financial shocks to the real economy as in the case of liquidity shocks. Second, the asset price channel is still at work and, as before, it is stronger in the economy without money in which the liquidity premium of corporate bonds is larger.

Finally, we investigate how the level of inflation affects the propagation of financial shocks to the real economy. To quantify this relationship, we study the impact of both liquidity and funding shocks under various inflation regimes. Figure 5 presents the impulse responses for one-time unexpected drops in λ_a and α_F under low levels of annual inflation: 1%, 4% (baseline), 7%, and 10%. Intuitively, higher inflation makes the propagation of financial shocks stronger due to the higher associated cost of carrying money. As inflation rises, agents pick a portfolio allocation that is more bond heavy. Thus, they are more exposed to negative financial shocks. When such a shock hits, it affects a larger fraction of their portfolio which leads to a greater decrease in their spending power. The corresponding decrease in sales and output is thus greater, as seen in Figure 5. A larger

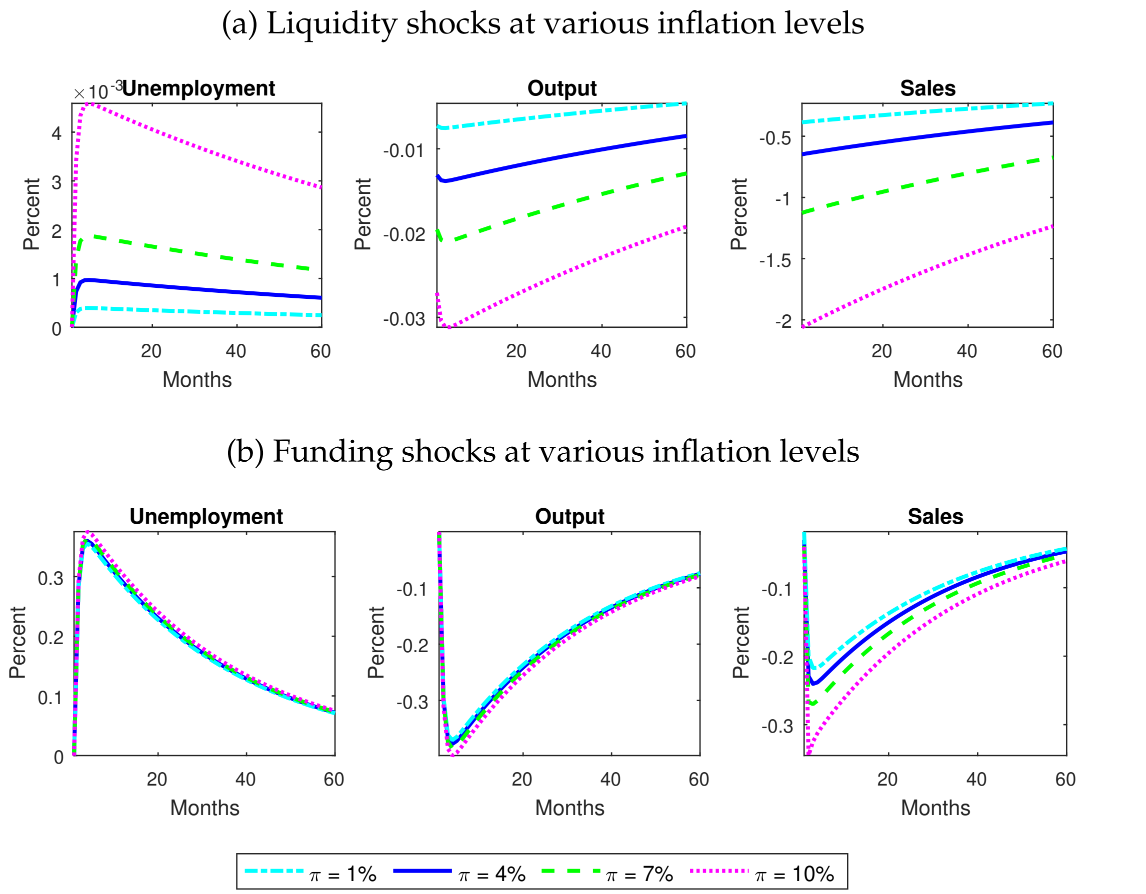

Figure 5: Liquidity and Funding Shocks at Various Inflation Levels.
Impulse response functions for an unexpected one standard deviation drop in the pledgeability of corporate bonds and the matching efficiency of the financial market for different levels of annual inflation. Output and sales are expressed as percentage deviations from steady state; unemployment is expressed as level deviations from steady state.

decrease in sales and output corresponds to lower incentives for firms to enter and consequently higher unemployment. For instance, a negative liquidity shock of the same magnitude would raise unemployment twelve times more under an annual inflation of 10% than it would under an annual inflation of 1%. Similarly, output drops by four times and sales drop five times as much when inflation is 10% than when it is 1%.

The main mechanism through which financial shocks affect the real economy in our model vis-a-vis the moneyless benchmark is the portfolio channel. In what follows, we provide empirical evidence for this channel by showing that households move away from less liquid assets to money in recessions. We also provide empirical evidence to support our quantitative result that financial shocks have larger impact on the real economy during periods of high inflation.

The left panel of Figure 6 plots the deviations from trend of three time series that

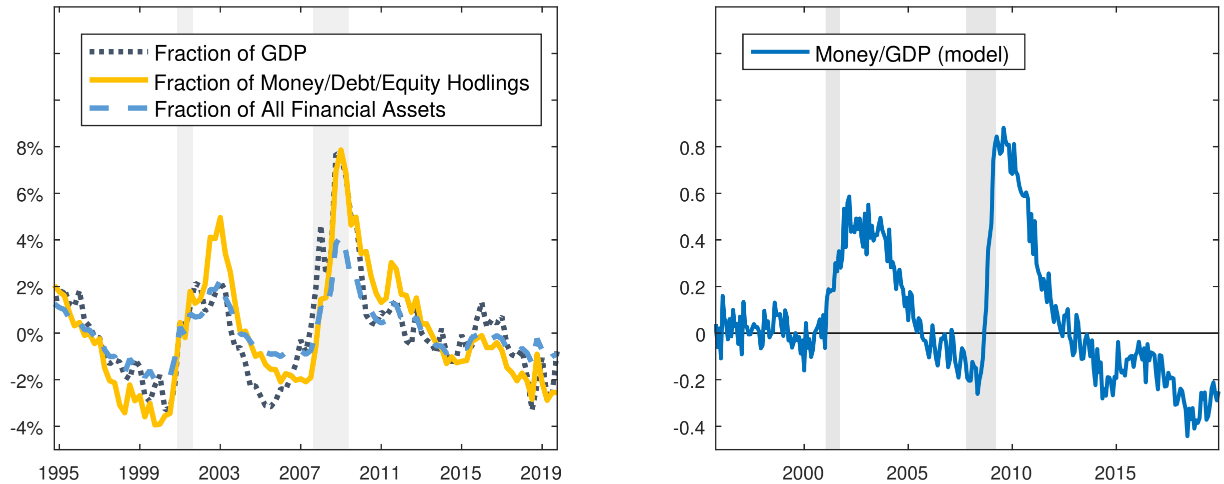

Figure 6: Money Holdings in the Data and in the Model.
The left panel plots deviations from the trend of aggregate monetary holdings as a fraction of GDP and financial assets. The right panel plots the model-generated ratio of money holdings to GDP when we feed both financial and liquidity shocks in the baseline model with money.

express aggregate monetary holdings as a fraction of nominal GDP, a fraction of monetary, debt and equity holdings, as well as a fraction of all financial assets. Our definition of monetary aggregates is the sum of currency, checkable deposits, time and saving deposits, as well as money market shares and we use household balance sheet data from the Board of Governors of the Federal Reserve System. Moreover, both the recessions of 2001 and 2007-2009 were periods of intense financial turbulence due to the burst of the dot-com and the housing bubble, respectively. The main point of Figure 6 is to provide direct empirical evidence in favor of the core model mechanism: in times of financial disruptions money holdings increase and agents substitute away from financial assets and towards money. Figures 3 and 4 show that this is exactly what happens to money holdings when financial shocks take place in the model. Hence, the core model mechanism seems in accord with the aggregate data. To further support this point, the right panel of Figure 6 plots the model-generated ratio of real money holdings to real GDP when we feed both the financial and liquidity shocks in the baseline model. Although the magnitude of the response is a little smaller than that in the data, it tracks the empirical behavior of the ratio qualitatively well.

The literature has also provided further empirical support for the substitution between money and other financial assets by looking directly at evidence from investor portfolios. In a recent empirical contribution, Gabaix et al. (2023) examine monthly security-level data on U.S. household portfolio holdings from a wealth management platform to analyze asset demand across an extensive range of financial assets. Several of their find-

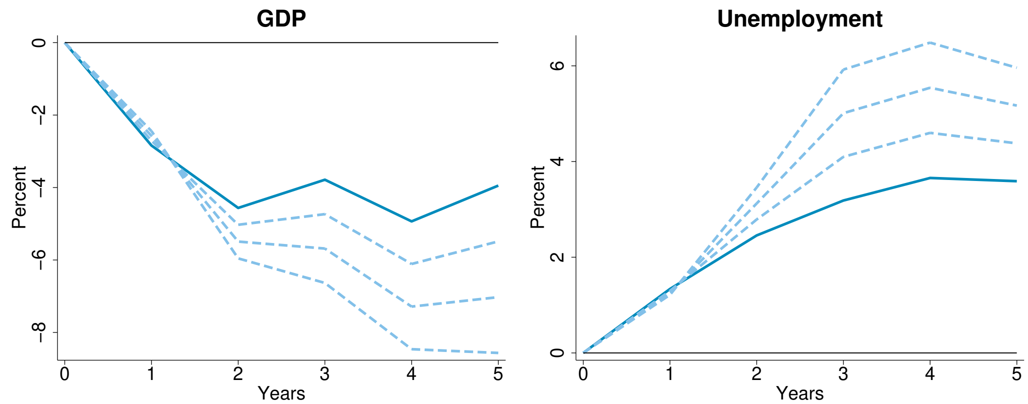

Figure 7: The Impact of Anticipated Inflation on the Severity of Financial Recessions. The responses of real GDP per capita and the unemployment rate upon a financial recession. The solid line shows the path when anticipated inflation is at its empirical mean (3.87%), and the dashed lines show the paths when anticipated inflation is perturbed +1, +2, and +3 percentage points above its mean.

ings are informative about the mechanism in our model: first, they find that, on average, investors sell risky assets during turbulent times. Second, in their sample, the average flows to liquid risky assets and cash are strongly negatively correlated with the time-series correlation being −71.0% (see Figure 10 on p. 19 of their paper). Finally, portfolio flows toward liquid risky assets fall during times of financial turmoil (in their sample, these are periods such as the last quarter of 2018 or the first quarter of 2020), while portfolio flows towards cash are positive during those same periods. As Gabaix et al. (2023) explain, the economic reason behind these results is that money is both a safe financial asset and a liquidity buffer used to smooth liquidity shocks (p. 20). Hence, the role played by money in our model is supported by the micro data on investor portfolios.

Next, we study the behavior of real GDP per capita and the unemployment rate during financial recessions under different levels of anticipated inflation, following the methodology and using the data of Jordà et al. (2013).[19] The dataset consists of 14 advanced economies with a sample period between 1870 and 2008 for real GDP per capita and between 1901 and 2008 for unemployment, while the responses are estimated using local projections (Jordà, 2005).[20] To quantify how the impact of a financial recession depends on anticipated inflation when the financial shock hits the economy, we interact the

[19] A "financial recession" is a recession that coincides with a financial crisis; see p. 6 in Jordà et al. (2013) and p. 1038 in Schularick and Taylor (2012).

[20] The dataset in Jordà et al. (2013) spans from 1870 to 2008 but does not include unemployment. We append that dataset with unemployment data available from 1901 in the Jordà-Schularick-Taylor Macrohistory Database (Jordà, Schularick, and Taylor, 2017).

financial recession indicator with the anticipated inflation rate in our regression model.[21] Figure 7 plots the average response paths of real GDP per capita and the unemployment rate upon a financial recession conditional on a broad set of macroeconomic controls. To gauge the impact of anticipated inflation, we plot the paths when anticipated inflation is at its empirical mean (the value is 3.87%) and when it is perturbed +1, +2, and +3 percentage points above the mean. The main takeaway of Figure 7 is that the adverse real effects of financial shocks are stronger when inflation is expected to be higher. Figure 5 shows that this is exactly what the model predicts. Hence, the data confirm this important model implication which can only arise in models where money is explicitly modeled.

5.3 The Importance of Financial Shocks

Our final exercise is to feed the estimated series of shocks we constructed in Section 5.1 into the model and simulate the economy's responses to financial shocks. We show the responses of sales and unemployment, which were used to identify the liquidity and funding shocks respectively, as well as the response of output that was not targeted. Moreover, since the importance of money is the central feature of this paper, we also study the responses of the model without money ($\lambda_m = 0$) and plot the difference in the responses between the baseline and the non-monetary model. This difference quantifies how much would be lost from the analysis of the real effects of financial shocks based on a moneyless model.

Figure 8 plots the results. To begin with, when we feed funding and liquidity shocks simultaneously, both models track relatively closely the movements in unemployment over the sample period (panel (a) of Figure 8). They also generally mimic the movements in GDP around the 2001 recession and the 2008 crash. Nonetheless, during both recessions the moneyless model overpredicts the responses in unemployment and GDP relatively more than the baseline model with money. In panel (b) of Figure 8, we graph the difference between the two models by subtracting the responses in the baseline model from the responses in the moneyless benchmark. This result highlights the important differences between the model with and without money in terms of the propagation of financial shocks to the real side of the economy — financial shocks have larger real effects in the model without money. This is especially true when we turn our attention to the series for sales. In that case, the baseline model tracks the data pretty well but the moneyless benchmark overpredicts movements in sales by an order of magnitude. Additionally,

[21] We follow Rocheteau, Wright, and Zhang (2018) and use the methodology of Hamilton, Harris, Hatzius, and West (2015) to estimate anticipated inflation as forecasts from an autoregressive model on observed inflation.

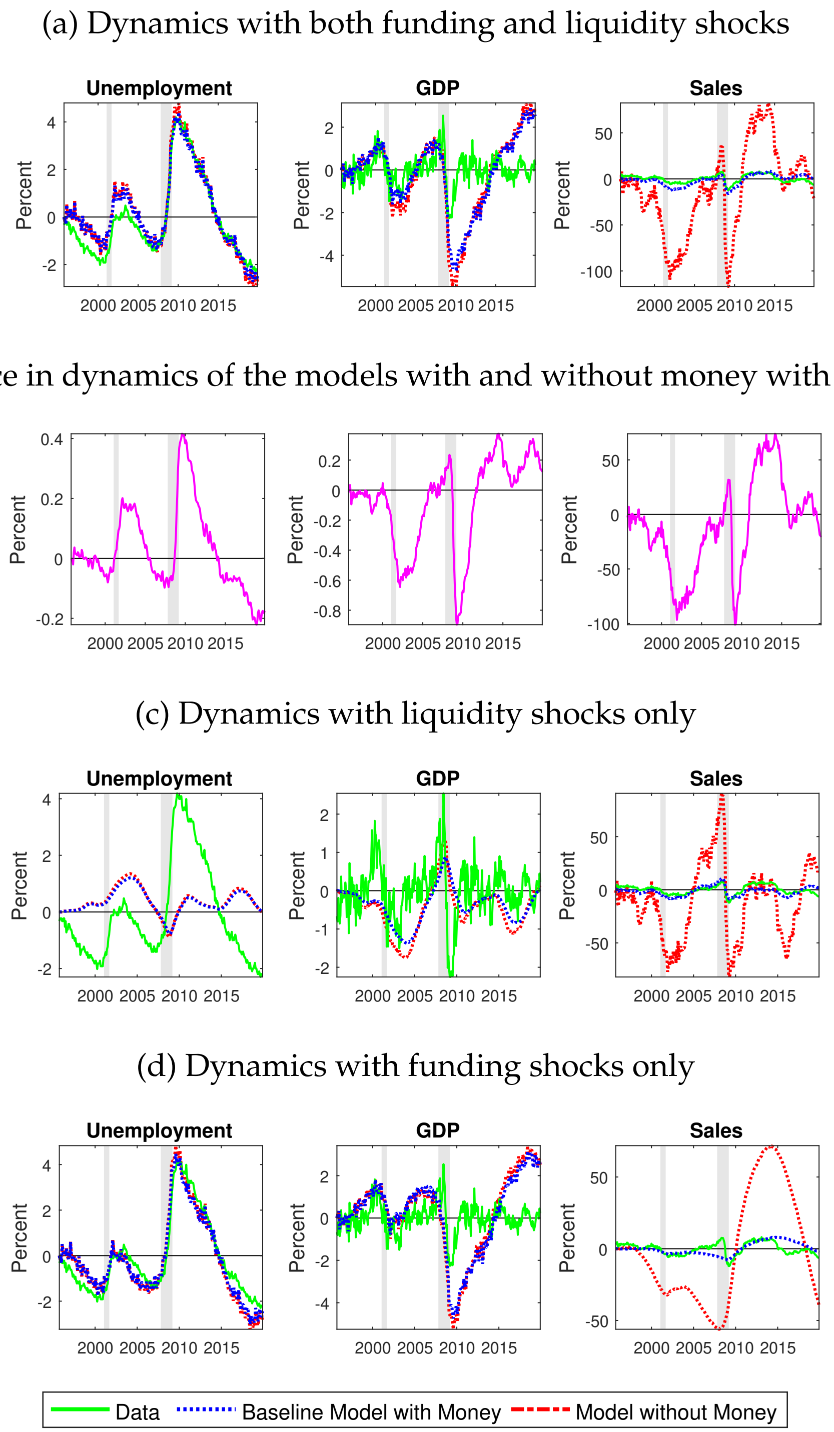

Figure 8: Dynamics Induced by Different Financial Shocks With and Without Money. Panels (a), (c), and (d) plot the responses of unemployment, GDP, and sales when we feed different series of innovations in the model. Panel (b) plots the differences in the responses of the moneyless benchmark and the baseline model in panel (a). The empirical series of unemployment and sales are detrended from a linear trend, while the empirical series of GDP is detrended using the Hodrick-Prescott (1997) filter.

since the portfolio channel of asset substitution is missing in the moneyless model, the responses of that model can be interpreted as our counterfactual estimates of the impact of financial shocks when there is not enough liquidity in the economy. The results suggest that if there had not been enough liquidity in the economy, the financial recessions in 2001 and 2008 would have been more severe: the unemployment rate would have increased by about 0.2-0.4 percentage points higher and GDP would have dropped by about 0.6-0.8 percentage points more.

Next, we focus on the dynamics induced by the constructed series of liquidity shocks alone (panel (c) of Figure 8). The first takeaway is that the moneyless model severely overestimates the responses of sales to liquidity shocks: without the smoothing effect of money, the liquidity of agents' portfolio moves several orders of magnitude more than in the data. Furthermore, the liquidity shock alone explains a relatively small part of the movements in unemployment. More importantly, though, it explains a sizeable part of the untargeted series for GDP, which shows that liquidity shocks have important macroeconomic effects. Finally, the difference between the GDP series induced by the monetary and the non-monetary model is not trivial, which shows that liquidity shocks cannot be studied effectively with a moneyless model.

Moving on to the last panel of Figure 8, we present the dynamics induced by funding shocks alone. The monetary model matches the unemployment series almost perfectly but it fails to replicate the series for sales. Moreover, regarding GDP, funding shocks do better than liquidity shocks pre-2009 (a result anticipated by the discussion of the innovations series in Section 5.1) but they overpredict the 2009 drop and do not track as closely the behavior of GDP post-2009 as liquidity shocks do. The model with money performs again better than the moneyless model in all cases, with the larger differences found in the time series for sales.

In summary, the model without money overpredicts the responses of the real economy to financial shocks in every experiment we run. This difference is particularly severe for the case of sales because these are the transactions that require a medium of exchange in both models.

6 Conclusion

An extensive literature in macroeconomics studies the real effects of disruptions in financial markets. Although the papers under consideration come from different strands of the literature, they all share a common feature: they employ frameworks where money is not explicitly modeled. Our paper contributes to the literature by revisiting this research question within the context of an economy where money plays an essential role. We argue that the absence of money may limit a model's ability to accurately evaluate the real effects of financial disruptions, since it deprives agents of a payment instrument that they *could* have used to cope with the resulting liquidity disruption.

To study the question at hand, we build on the work of Berentsen et al. (2011), which contains two of the essential ingredients our analysis should incorporate: a frictional labor market that gives rise to equilibrium unemployment, and a frictional product market that gives money an essential liquidity role. We extend this framework by assuming that firms face recruiting and operating costs, which they must cover by issuing corporate bonds. In our model, corporate bonds serve alongside money as means of payment or collateral, so their price includes a liquidity premium. This bond liquidity is crucial, as it determines the ultimate rate at which firms can borrow funds and the consumers' effective liquidity. Thus, our model captures *all* the salient features of the question we are after: equilibrium unemployment, an essential role for money, but also a liquidity channel that is crucial to the firms' ability to cover recruiting and operating costs and, thus, create jobs. We capture financial disruptions in our model in two ways: varying the (i) degree of bond pledgeability and (ii) the ability of firms to issue corporate bonds.

In this environment, we find that, depending on the nature of the shock, the existence of money dampens or even nearly eliminates the effects of financial shocks. Our main result stems from the fact that in our *monetary* model, agents are able to increase their money holdings and *substitute* the liquidity forgone due to the financial market disruption, a channel for which we also provide empirical support. Thus, we argue, working with a moneyless model does not come without loss of generality. We also find that high inflation regimes magnify the adverse real effects of financial shocks and we provide empirical evidence in favor of this result.

Appendix

A Equilibrium Out of Steady State

Money and bond market equilibrium The bond supply is endogenously determined by

$$A_t = b_{Lt}\frac{\kappa_R + \kappa_O}{\psi_t} + (1 - s_{Lt})\frac{f_{Ft}}{b_{Ft}}(1 - \delta)\frac{\kappa_O}{\psi_t}.$$

At a monetary equilibrium, the GM trade is given by

$$q_t = \min\{q^*,\, \sigma^{-1}(\lambda_{mt} z_t + \lambda_{at} A_{t-1})\},$$

and the money demand is characterized by

$$\varphi_t = \beta\varphi_{t+1}\left(1 + \lambda_{mt+1}\frac{f_{Gt+1}}{b_{Gt+1}}\left[\frac{u'(q_{t+1})}{\sigma'(q_{t+1})} - 1\right]\right),$$

which can be expressed as

$$z_t = \beta\frac{z_{t+1}}{1+\mu}\left(1 + \lambda_{mt+1}\frac{f_{Gt+1}}{b_{Gt+1}}\left[\frac{u'(q_{t+1})}{\sigma'(q_{t+1})} - 1\right]\right).$$

At a non-monetary equilibrium, $\varphi_t = 0$, $z_t = 0$, and $q_t = \min\{q^*,\, \sigma^{-1}(\lambda_{at} A_{t-1})\}$. Given the supply, the households' bond demand determines the equilibrium bond price:

$$\psi_t = \beta\left(1 + \lambda_{at+1}\,\frac{f_{Gt+1}}{b_{Gt+1}}\left[\frac{u'(q_{t+1})}{\sigma'(q_{t+1})} - 1\right]\right).$$

Labor and financial market equilibrium First note that, from

$$U^f_{1t}(d_t) = R_t - d_t - w_t - \kappa_F + \beta\frac{f_{Ft}}{b_{Ft}}(1 - \delta)U^f_{1t+1}\left(\frac{\kappa_O}{\psi_t}\right),$$

where

$$R_t \equiv y + \frac{f_{Gt}}{s_{Gt}}\,\eta_G(u(q_t) - q_t),$$

we have

$$U^f_{1t}\left(\frac{\kappa_R+\kappa_O}{\psi_{t-1}}\right)+\frac{\kappa_R+\kappa_O}{\psi_{t-1}}=U^f_{1t}\left(\frac{\kappa_O}{\psi_{t-1}}\right)+\frac{\kappa_O}{\psi_{t-1}} \tag{A.1}$$

$$=R_t-w_t-\kappa_F+\beta\frac{f_{Ft}}{b_{Ft}}(1-\delta)U^f_{1t+1}\left(\frac{\kappa_O}{\psi_t}\right). \tag{A.2}$$

Free entry to the FM implies

$$\kappa_F=\beta\,\frac{f_{Ft}}{b_{Ft}}\left[\frac{f_{Lt+1}}{b_{Lt}}\,U^f_{1t+1}\left(\frac{\kappa_R+\kappa_O}{\psi_t}\right)-\left(1-\frac{f_{Lt+1}}{b_{Lt}}\right)\frac{\kappa_R+\kappa_O}{\psi_t}\right],$$

which is, due to (A.1), equivalent to

$$\kappa_F=\beta\,\frac{f_{Ft}}{b_{Ft}}\left[\frac{f_{Lt+1}}{b_{Lt}}\left(U^f_{1t+1}\left(\frac{\kappa_O}{\psi_t}\right)-\frac{\kappa_R}{\psi_t}\right)-\left(1-\frac{f_{Lt+1}}{b_{Lt}}\right)\frac{\kappa_R+\kappa_O}{\psi_t}\right],$$

where

$$U^f_{1t}\left(\frac{\kappa_O}{\psi_{t-1}}\right)=R_t-\frac{\kappa_O}{\psi_{t-1}}-w_t-\kappa_F+\beta\frac{f_{Ft}}{b_{Ft}}(1-\delta)U^f_{1t+1}\left(\frac{\kappa_O}{\psi_t}\right).$$

The wage bargaining implies

$$\eta_L\left[U^f_{1t}\left(\frac{\kappa_R+\kappa_O}{\psi_{t-1}}\right)+\frac{\kappa_R+\kappa_O}{\psi_{t-1}}\right]=(1-\eta_L)\left[U^h_{1t}(m_t,a_t)-U^h_{0t}(m_t,a_t)\right],$$

which is, due to (A.2), equivalent to

$$\begin{aligned}&\eta_L\left[R_t-w_t-\kappa_F+\beta\frac{f_{Ft}}{b_{Ft}}(1-\delta)U^f_{1t+1}\left(\frac{\kappa_O}{\psi_t}\right)\right]\\&=(1-\eta_L)\left[w_t-b+\beta\left(\frac{f_{Ft}}{b_{Ft}}(1-\delta)-\frac{f_{Lt+1}}{s_{Lt}}\right)\left(U^h_{1t+1}(m_{t+1},a_{t+1})-U^h_{0t+1}(m_{t+1},a_{t+1})\right)\right].\end{aligned}$$

Solving this for w, utilizing (A.1), the bargaining solution, and the free entry condition, gives us

$$\begin{aligned}w_t&=(1-\eta_L)b+\eta_L R_t-\eta_L\kappa_F\\&\quad-\eta_L\beta\frac{f_{Ft}}{b_{Ft}}(1-\delta)\frac{\kappa_O}{\psi_t}+\eta_L\beta\frac{f_{Lt+1}}{s_{Lt}}\left(\kappa_F\frac{1}{\beta}\frac{b_{Ft}}{f_{Ft}}+\frac{\kappa_R+\kappa_O}{\psi_t}\right)\frac{b_{Lt}}{f_{Lt+1}}.\end{aligned}$$

Measures of sellers and buyers The matching functions in the LM, GM, and FM are given by $f_{Lt}=f_L(b_{Lt-1},s_{Lt-1})$, $f_{Gt}=f_G(b_{Gt},s_{Gt})$, and $f_{Ft}=f_F(b_{Ft},s_{Ft})$, where $s_{Gt}=$

$1 - s_{Lt}$, $b_{Gt} = 1$, $s_{Ft} = 1$, $b_{Ft} = \epsilon_t + 1 - s_{Lt}$, $b_{Lt} = \epsilon_t \cdot f_{Ft}/b_{Ft}$, and

$$s_{Lt} = \left(1 - \frac{f_{Lt}}{s_{Lt-1}}\right) s_{Lt-1} + \left(1 - \frac{f_{Ft-1}}{b_{Ft-1}}(1-\delta)\right)(1 - s_{Lt-1}).$$

B Details for the Empirical Evidence of Section 5.2

B.1 Money Holdings

Data The left panel of Figure 6 plots the detrended time series of aggregate money holdings as a fraction of nominal GDP, a fraction of money, debt and equity holdings, and a fraction of all financial assets. All are computed using the household balance sheet data from the Board of Governors of the Federal Reserve System, except for nominal GDP (which is from the U.S. Bureau of Economic Analysis; FRED Series GDP). The aggregate money holdings are the sum of checkable deposits and currency (FL153020005), time and savings deposits (FL153030005), and money market fund shares (FL153034005). Households' money, debt and equity holdings are the sum of aggregate money holdings (defined as before), debt securities (LM154022005), corporate equities (LM153064105), miscellaneous other equity (LM153081115), and mutual fund shares (LM153064205). Financial assets are households' total financial assets holdings (FL154090005). The aggregate money holding ratios are then detrended from a linear trend.

B.2 The Dependence of the Severity of Financial Recessions on Anticipated Inflation

Data The analysis is based on the cross-country panel data from Jordà et al. (2013), which are made publicly available on Moritz Schularick's personal website. The dataset covers the period of 1870–2008 at an annual frequency and 14 advanced economies: the United States, Canada, Australia, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. All the variables used in the analysis are available in this dataset, except for unemployment and anticipated inflation. We acquire the unemployment rate data from the Jordà-Schularick-Taylor Macrohistory Database (6th release; Jordà et al., 2017), which is available from 1901. Anticipated inflation is measured, using the methodology developed in Hamilton et al. (2015), as a one-step ahead forecast from a first-order autoregression model on past observed inflation, where inflation is defined as a percentage change of the consumer price index (CPI).[22]

Estimation The data consist of 97 recessions (including non-financial and financial recessions) in 14 advanced countries since 1870 (for the analysis of GDP) or 80 recessions since 1901 (for the analysis of unemployment). We estimate the cumulated responses of real GDP per capita and the unemployment rate upon a financial recession, conditional on a broad set of macroeconomic controls, using local projections (Jordà, 2005):

$$\Delta_h y_{it(r)+h} = \alpha_i + \theta_N N + \theta_F F + \sum_{j=0}^{p} \Gamma_j Y_{it(r)-j} + u_{it(r)}, \quad h = 1, \ldots, H, \tag{B.1}$$

$$\begin{aligned} \Delta_h y_{it(r)+h} = \alpha_i + \theta_N N + \theta_F F + \beta_{h,N}[N \times (\pi^e_{t(r)} - \overline{\pi^e})] + \beta_{h,F}[F \times (\pi^e_{t(r)} - \overline{\pi^e})] \\ + \sum_{j=0}^{p} \Gamma_j Y_{it(r)-j} + u_{it(r)}, \quad h = 1, \ldots, H. \end{aligned} \tag{B.2}$$

The notations are as follows. $t(r)$ refers to the calendar-time period associated with a peak of economic activity (or the start of the rth recession) and $t(r)+h$ for $h = 1, \ldots, H$ refers to the subsequent H years, some of which will be recessionary periods (those immediately following $t(r)$), and some of which will be expansion periods linked to the recovery from the rth recession. Following the specification in Jordà et al. (2013), we set $p = 1$ for the lags of control variables and examine the horizons until $H = 5$. $\Delta_h y_{it(r)+h}$ denotes the relevant measure of change h periods ahead in y for country i from the start of the rth recession. It is either the percentage point change, given by the difference in 100 times the logarithm of the variable, in log of real GDP per capita, or the simple time difference in the unemployment rate. α_i are country fixed effects, N is the indicator of non-financial recessions, F is the indicator of financial recessions, and u is the error term. $\pi^e_{t(r)}$ is the expected inflation rate at $t(r)$, i.e., at the onset of the rth recession, and $\overline{\pi^e}$ is its mean value in the data. The coefficients on the interaction terms between the non-financial/financial recession indicators and the expected inflation rate, $\beta_{h,N}$ and $\beta_{h,F}$, are the measures of the marginal effect of a unit increase in the expected inflation rate on the impact of non-financial/financial recessions, respectively. The vector Y, a set of macroeconomic controls, includes the first differences of likely nonstationary variables (such as real GDP per capita, unemployment rate, loans/lending, CPI, and investment) and the levels of likely stationary variables (such as government short- and long-term interest rates, current account to GDP ratio, and expected inflation).

[22] The results in Section 5.2 are robust to the number of past observations used to predict anticipated inflation in the AR(1) model. We present the results using past 25 observations. The results remain almost identical with 30, which is the number used in Rocheteau et al. (2018), or 20.

Tables B.1 and B.2 present the estimated paths of real GDP per capital and the unemployment rate upon non-financial and financial recessions, respectively. Figure 7 plots $\hat{\theta}_F$, $\hat{\theta}_F + \hat{\beta}_{h,F}$, $\hat{\theta}_F + 2\hat{\beta}_{h,F}$, and $\hat{\theta}_F + 3\hat{\beta}_{h,F}$ from the specification (B.2), that is, the estimated paths upon financial recessions when anticipated inflation is at its mean level (which is 3.87%) and when it is perturbed +1, +2, and +3 percentage points above its mean. The main lesson is that recessions—in particular, financial recessions—are more severe when inflation is anticipated to be higher at the onset of recessions.

Table B.1: Responses of Real GDP Per Capita

	Year 1	Year 2	Year 3	Year 4	Year 5
Specification B.1, without interaction terms					
Non-financial recession (N)	-1.701^{***}	-0.603	1.690	1.915	1.829
	(0.461)	(0.868)	(1.379)	(1.755)	(1.890)
Financial recession (F)	-2.854^{***}	-4.560^{***}	-3.750^{*}	-4.888^{*}	-3.882
	(0.665)	(1.250)	(1.985)	(2.527)	(2.722)
Specification B.2, with interaction terms	Year 1	Year 2	Year 3	Year 4	Year 5
Non-financial recession (N)	-1.732^{***}	-0.595	1.761	2.011	1.963
	(0.461)	(0.876)	(1.383)	(1.759)	(1.885)
Financial recession (F)	-2.840^{***}	-4.563^{***}	-3.784^{*}	-4.934^{*}	-3.946
	(0.663)	(1.260)	(1.989)	(2.529)	(2.711)
Non-financial recession	-0.0315	-0.423	-0.573	-0.667	-0.828
$\times$ Expected inflation ($N \times (\pi^e_{t(r)} - \overline{\pi^e})$)	(0.145)	(0.276)	(0.436)	(0.554)	(0.594)
Financial recession	0.133	-0.464	-0.950	-1.176	-1.540^{*}
$\times$ Expected inflation ($F \times (\pi^e_{t(r)} - \overline{\pi^e})$)	(0.201)	(0.382)	(0.603)	(0.767)	(0.821)
Observations, non-financial recessions	75	75	75	75	75
Observations, financial recessions	22	22	22	22	22
Observations	97	97	97	97	97

Notes: Standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table B.2: Responses of the Unemployment Rate

	Year 1	Year 2	Year 3	Year 4	Year 5
Specification B.1, without interaction terms					
Non-financial recession (N)	0.417	0.881	1.099	1.244	1.847
	(0.379)	(0.608)	(1.007)	(1.103)	(1.107)
Financial recession (F)	1.302^{**}	2.447^{***}	3.263^{**}	3.738^{**}	3.656^{**}
	(0.522)	(0.837)	(1.387)	(1.519)	(1.525)
Specification B.2, with interaction terms					
	Year 1	Year 2	Year 3	Year 4	Year 5
Non-financial recession (N)	0.480	0.897	0.961	1.098	1.728
	(0.374)	(0.617)	(1.002)	(1.099)	(1.110)
Financial recession (F)	1.337^{**}	2.456^{***}	3.186^{**}	3.657^{**}	3.590^{**}
	(0.513)	(0.847)	(1.375)	(1.508)	(1.523)
Non-financial recession	0.128	0.378^{*}	0.536^{*}	0.546	0.467
$\times$ Expected inflation ($N \times (\pi^e_{t(r)} - \overline{\pi^e})$)	(0.119)	(0.196)	(0.318)	(0.349)	(0.353)
Financial recession	-0.0409	0.334	0.912^{**}	0.943^{*}	0.790
$\times$ Expected inflation ($F \times (\pi^e_{t(r)} - \overline{\pi^e})$)	(0.169)	(0.279)	(0.453)	(0.496)	(0.502)
Observations, non-financial recessions	63	63	63	63	63
Observations, financial recessions	17	17	17	17	17
Observations	80	80	80	80	80

Notes: Standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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